ROGERS
KNW SERIES®
ROGERS MACHINERY COMPANY, INC. - PORTLAND, OREGON, USA

AIR-COOLED OIL-FREE ROTARY SCREW AIR COMPRESSORS

MODEL: _____ **SERIAL NO:** _____

INSTRUCTION MANUAL

Powered By
KOBELCO
Oil-Free Screw Technology

MODEL: KNWA0-EHR, KNWA0-EPXR, KNWA0-EHR2, KNWA1-GHR, KNWA1-GPXR, KNWA1-GHR2, KNWA2-DPXR, KNWA2-DHR2

Electric Rental Units

KOBELCO is the international trademark found on all products of Kobe Steel, Ltd.

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SAFETY PRECAUTIONS

Safety notices, marked with this symbol, are used in this publication to emphasize that a hazardous condition that could cause personal injury and/or damage to the equipment exists.

1. Read and understand the contents of this manual before installing, operating or maintaining the compressor.

2. Electricity and compressed air are dangerous. Prior to performing maintenance or service work, make absolutely sure that the electrical supply is disconnected and locked out, the air discharge service valve (customer furnished) is closed and locked out, and the compressor is relieved of all internal pressure.

3. Compressed air from this unit must not be used for breathing or food processing, unless additional filtration and monitoring is provided that meets the requirements of OSHA 29 CFR 1910 or FDA 21 CFR 178.3570.

4. Do not allow flammable, toxic or corrosive gases to enter the air inlet system or electrical devices.

5. Never attempt to work on compressor or remove guards, panels, covers, shields, etc. while the compressor is in operation.

6. Periodically confirm that all safety and alarm devices are operating properly.

7. Do not override any safety or alarm device.

8. Make certain all associated pipe and equipment beyond this compressor is compatible with maximum pressures and temperatures to be encountered during normal and adverse operation. Do not use plastic pipe in the compressed air system.

9. Keep doors closed during normal operation. The noise level inside cabinet exceeds 90 decibels (dbA) and the operating temperature of some components is sufficient to burn the skin.

10. Never assume it is safe to work on the compressor because it is not operating. Many installations have automatic start/stop controls, and the compressor may start at any time.

Instruction Manual

ROGERS KNW SERIES OIL-FREE ROTARY SCREW AIR COMPRESSORS

MODEL: KNWA0-EHR, KNWA0-EPXR, KNWA0-EHR2, KNWA1-GHR, KNWA1-GPXR, KNWA1-GHR2, KNWA2-DPXR, KNWA2-DHR2

NOTE: A companion publication, "Description of Operation" for the HMI/PLC program, contains detailed instructions on HMI operation and compressor controls.

Revisions			
Revision	Author	Date	Description
B	GEW	2022-Nov-02	Additions per requests from B. Centracco
0	GEW	2023-Feb-03	Release as-is pending clarifications
1	GEW	2023-Apr-24	Add Appendix A (performance data) current as of 4-23

1. General Description

1.1. Compressor

The **Rogers KNW Series** air compressor is a heavy duty, two-stage, rotary screw design that provides completely oil-free compressed air. Oil-free compressed air is guaranteed by a unique seal arrangement that separates the bearings and gear chambers from the compression section of each stage. The dual vent seal design ensures that no oil or its vapor can contaminate air that is being compressed.

The two-stage design provides higher output pressures at a lower operating temperature than would be available from a single-stage design. Both compressor stages are mounted on a heavy duty cast iron gear case for permanent alignment. The stages are driven through precision machined gears, selected for optimum operating speed to maximize efficiency and reduce rotor thrust. Timing gears are used to separate the rotors and to assist in reducing thrust on the rotors and the rotor bearings, thus extending bearing life.

Flange-mounted permanently aligned drive motor and compressor elements, coolers and piping, self contained lube oil system, compressor operating and safety controls, and related accessories, are mounted inside a sound attenuating steel cabinet. Compressor and motor mounting points are vibration isolated. Flexible connections between the compressor assembly and the cabinet ensure that no vibration, or related noise, is transmitted to the cabinet. The result is a very stable and quiet running package.

The KNW Series compressor includes a separately driven oil pump for drive gear, timing gear, and bearing lubrication. The lube oil pump starts first, then, after oil pressure is established, the compressor drive motor starts. Starting of the drive motor is delayed to allow pressurized lubrication of the bearings and gears during acceleration of the compressor. The pump is also timed to stop after the compressor. Oil pressure is maintained while the compressor coasts to a stop. Maximum component life is assured by thorough lubrication of moving components.

Another feature of the KNW Series air compressor is the capacity control system which controls discharge air pressure by regulating compressor air flow. A direct acting 4-way solenoid valve, constructed for dry air service, controls the position of the Capacity Control Valve (CCV). The CCV is a unique design which controls both the inlet air flow and discharge bleed-off, uses few moving parts, and provides for extended service intervals. See section 1.5 for a detailed description of the capacity control system.

The **Rogers KNW Series** compressor operator panel is a state-of-the-art control system combining robust industrial controls with leading edge operator interface (HMI) and programmable logic controller (PLC) technology. The HMI is a versatile touchscreen display with color graphics and user-friendly operation. The HMI shows all necessary compressor information in an easy-to-understand format.

1.2. Compressed Air Flow

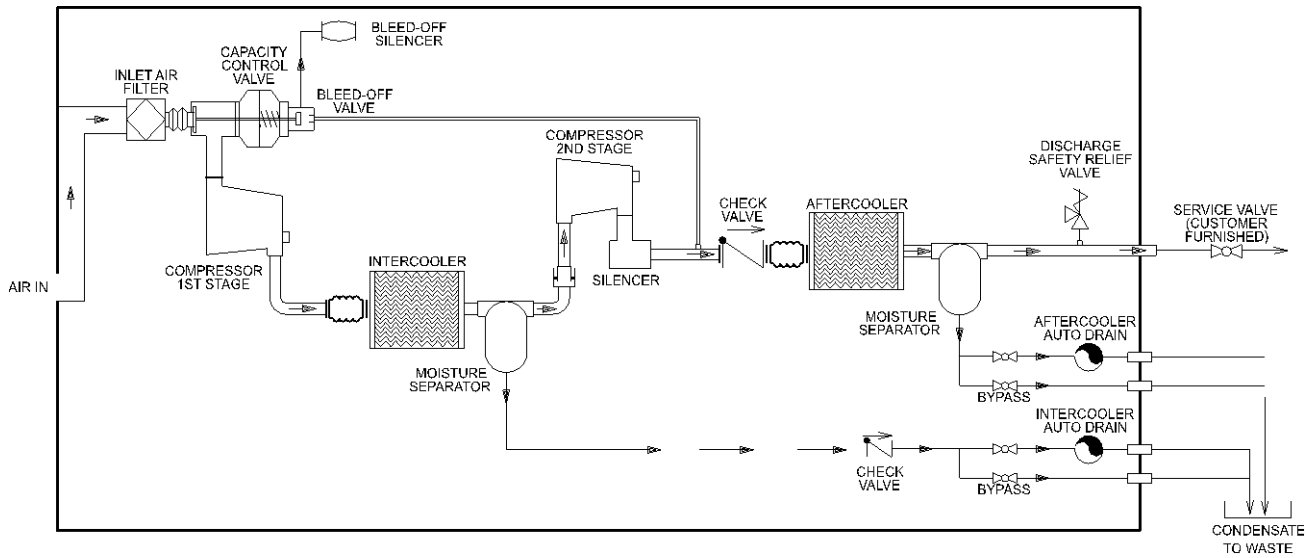

FIGURE 1 - COMPRESSED AIR FLOW

Air to be compressed enters an air inlet silencer through an opening in the cabinet. The air inlet silencer is a duct lined with sound absorbing material. The air then flows through a two-stage, high efficiency air filter. Filtered air flows through a flex connector into the capacity control valve, and then into the inlet of the compressor 1st stage.

The compressor 1st stage compresses filtered air to approximately 30 PSIG (2.11 kg/cm2). The compressed air is discharged into the intercooler where it is cooled to approximately 120°F (50°C). The cooled compressed air then passes through a moisture separator to remove any condensed moisture from the air stream before entering the compressor 2nd stage.

The compressor 2nd stage compresses interstage air to the final compressor outlet pressure, as controlled by PLC pressure settings. The compressed air then passes through the system check valve and an aftercooler, where it is cooled to approximately 15°F (8°C) above cooling water temperature. The compressed air exits the aftercooler into a moisture separator, where condensed moisture is removed before the air exits the unit to the plant air system. An ASME safety valve is located downstream of the check valve.

The compressed air circuit is protected by the following discrete devices:

- Discharge high air pressure switch
- Discharge safety relief valve

The PLC (see Description of Operations) monitors the compressed air circuit for:

- 1st Stage Suction air pressure
- Interstage air pressure
- Compressor Outlet air pressure
- Inlet air temperature
- 1st Stage discharge air temperature
- 2nd Stage Suction air temperature
- 2nd Stage Discharge air temperature
- Compressor Outlet air temperature

The monitored temperatures and pressures are displayed on the HMI. The PLC continuously monitors for high temperatures, providing a warning if a temperature approaches the design maximum and a shutdown if any reaches the limit. Compressor outlet air pressure is monitored to provide load and unload pressure control and a high outlet pressure alarm.

1.3. Cooling Air Flow

A separate electric motor driven fan draws ambient air into the cabinet through louvers on the side or end of the cabinet. The air cools the compressor motor and the interior of the cabinet, then passes through the fan and into the intercooler, aftercooler, and lube oil cooler, which are located side by side in the top of the cabinet or on its other end past the fan. Hot air is directed out through the compressor roof.

When the compressor unloads, hot air is discharged through the bleed-off silencer, pulled through the fan and exhausted. A temperature switch shuts down the compressor if the air temperature inside the cabinet exceeds 180°F (82°C).

1.4. Oil Flow for Lubrication

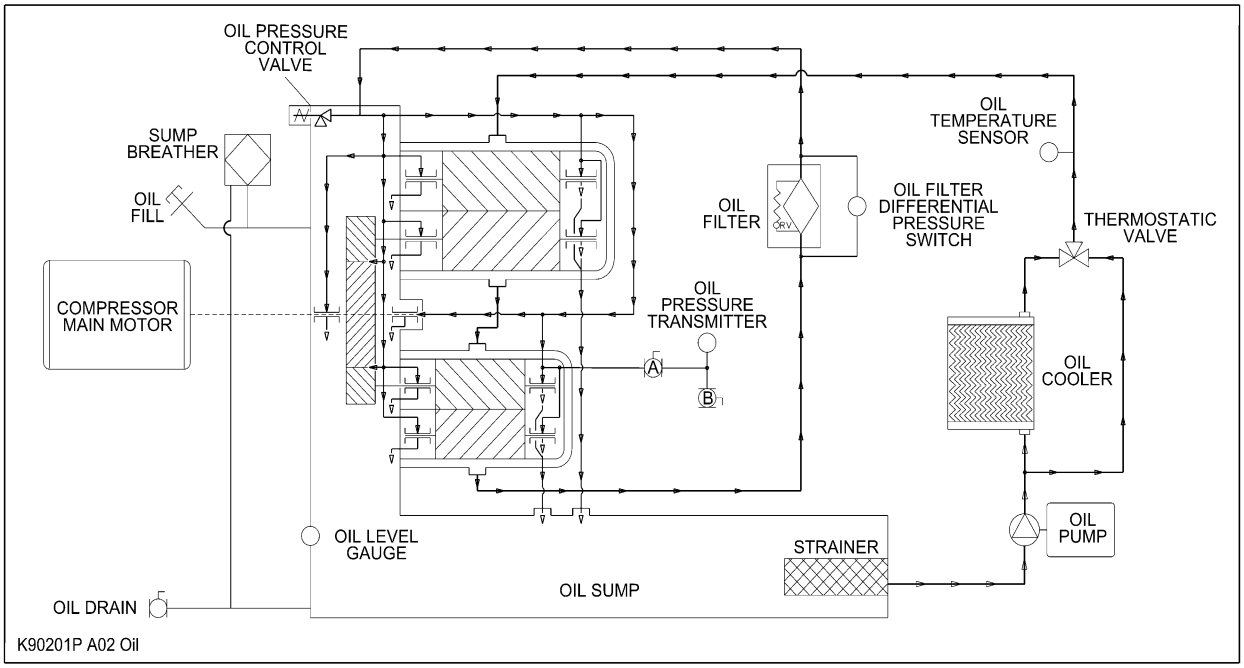

FIGURE 2 - OIL FLOW

Oil for bearing and gear lubrication is stored in the oil sump, located in the lower section of the main gear case/compressor housing. A sight gauge, located on the side of the oil sump, is provided to check oil level. Lube oil is drawn from the sump by a separate motor-driven oil pump. A strainer is provided in the oil sump on the oil pump suction line.

An oil thermostatic valve and air cooled oil cooler control oil temperature to approximately 115°F (45°C). Cooled oil enters the compressor 1st stage cooling jacket then the 2nd stage cooling jacket. The oil is then filtered by a high efficiency microglass oil filter, featuring a full flow design incorporating a spin-on filter element and an internal relief valve. A differential pressure gauge with switch is used to check oil filter ΔP and generate an HMI alert to service the oil filter.

After filtration the oil enters the compressor oil passages. An oil pressure control valve is provided to regulate a constant pressure for component lubrication by returning excess oil back to the sump. The oil flows through internal passages, and external tubing, to lubricate all bearings, timing gears, and drive gears.

An oil pressure transmitter is wired to the PLC to monitor the lube oil pressure. Oil pressure is monitored for alarm shutdown if oil pressure can not be achieved during starting or is too low while the compressor is operating. A block valve (A) and sample valve (B) are provided to test the operation of the alarm.

The PLC monitors oil temperature which is displayed on the HMI. A warning is provided as the temperature approaches maximum operating temperature and a shutdown if it reaches the limit.

1.5. Capacity Control Valve

The capacity control system consists of an inlet capacity control valve (CCV) with an integral bleed-off valve, a 4-way solenoid valve, and a shuttle valve. Opening (loaded) and closing (unloaded) of the CCV is directly controlled by the pressure difference in two chambers separated by a diaphragm. Pressure to the spring chamber (A) or the operating chamber (B) is controlled by the 4-way solenoid valve which is controlled by the PLC. The PLC monitors compressor operating conditions and compressor outlet air pressure to determine when loaded or unloaded operation is required.

When the compressor is off, the spring in the CCV holds the inlet valve (1) closed and the bleed-off valve (2) open. The 4-way solenoid valve (3) is de-energized. When the compressor is started, vacuum at the operating chamber (B) helps hold the CCV in the unloaded position.

The compressor remains unloaded after the compressor drive motor starts. After the compressor reaches full speed, load control is enabled.

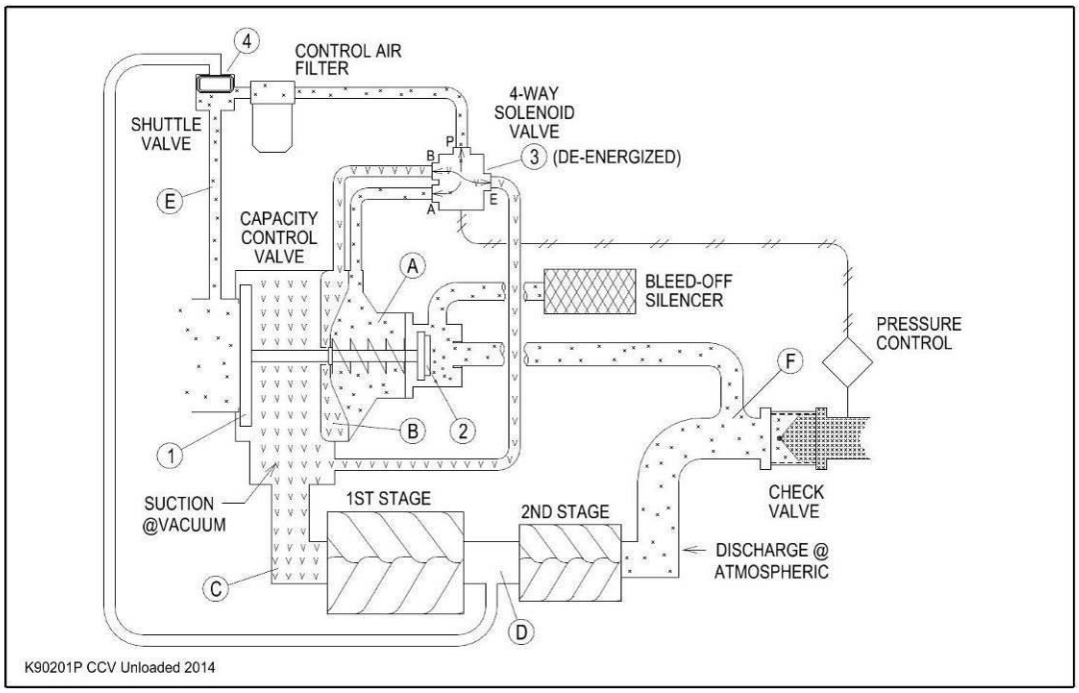

FIGURE 3 - COMPRESSOR UNLOADED

To load, the 4-way solenoid valve (3) energizes, the CCV spring chamber (A) is disconnected from atmosphere and is connected to 1st stage inlet vacuum. The vacuum in spring chamber (A), and on the inside of the inlet valve disc, help to pull the inlet valve (1) open while closing the bleed-off valve (2).

Air is now drawn into the compressor stages through the inlet air filter, compressed, and discharged through the check valve to the air piping system. As air is compressed, interstage pressure (D) increases, transferring the shuttle valve (4) and pressurizing the operating chamber (B), keeping the capacity control valve open.

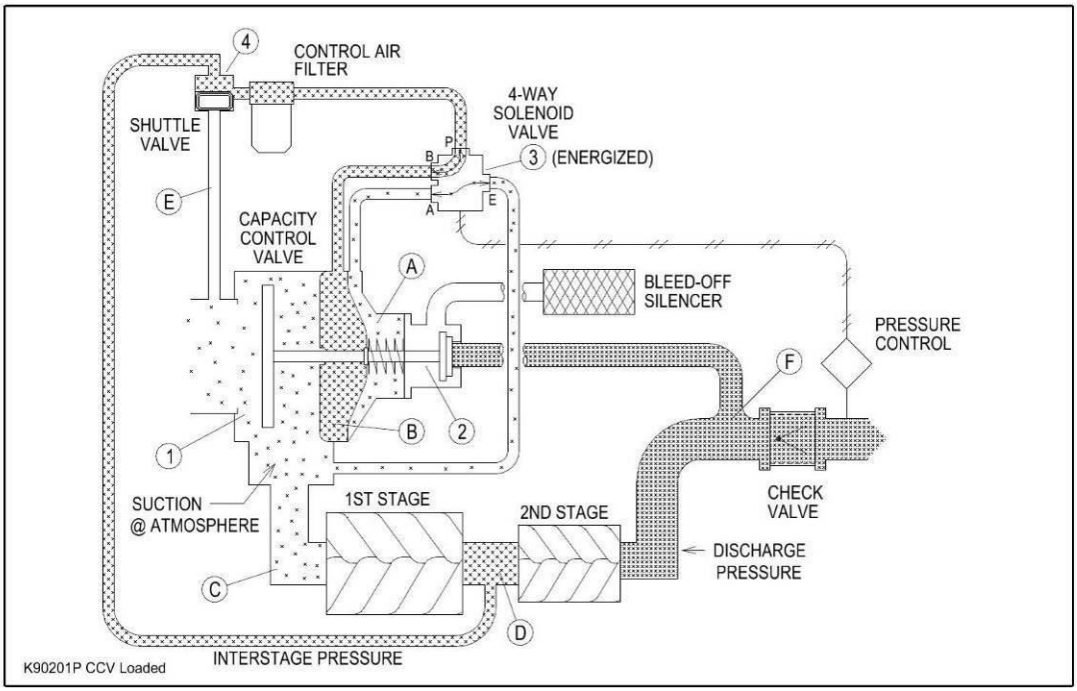

FIGURE 4 - COMPRESSOR LOADED

When the compressor is running, compressor outlet air pressure is monitored by a pressure sensor on the air piping. When the compressor outlet air pressure reaches the upper limit of the desired operating range, the 4-way solenoid valve is de-energized, venting the operating chamber (B) to atmosphere and pressurizing the spring chamber (A). The inlet valve (1) closes and bleed-off valve (2) opens. As the inlet valve closes a vacuum develops at the 1st stage inlet which keeps the CCV in the unloaded position.

When unloaded a slight amount of air is drawn through orifices in the inlet valve to cool the compressor during unloaded operation. The air flow (F) is vented to atmosphere out of the bleed-off silencer. The check valve prevents plant compressed air system air pressure from pressurizing the compressor.

1.6. Monitoring and Limiting Devices

See compressor electrical schematic for a complete list of monitoring devices connected to the PLC.

Total compressor running hours, total compressor loaded hours, and the count of load/unload cycles can be viewed on the HMI.

The compressor control panel includes pilot lights to indicate status, including "Running", "Loaded", and "Alarm". The HMI includes an 'LED Test' button, which tests for proper

operation of the pilot lights by briefly illuminating all lights and. The operation of the compressor is not affected by an LED test.

1.7. Alerts and Alarms

An 'Alert' condition indicates that the compressor requires attention, but continued operation will not harm the compressor. An 'Alarm' condition indicates that continued operation could be dangerous to the compressor, and immediately shuts down the compressor. The compressor cannot be operated until the alarm condition is corrected.

For a complete listing of alarm and alert conditions, see the Description of Operations for the PLC program. The PLC program number is shown on the HMI Title screen and labeled on the front of the PLC.

1.8. Component Locations

Compressor layout and piping design varies by model. For the locations of external components such as cooling air intake and outlet, see the assembly drawing for the specific compressor. For the location of internal components such as motors, see the partsbook.

1.9. Freeze Protection / Cold Ambient

To allow continued operation and prevent freezing damage when surrounding air temperature is low, this compressor includes:

- Cooling fan variable-frequency drive, which reduces cooling air flow as process air temperature drops. Controlled by PLC. See Description of Operations for details.
- Electrical enclosure heater with integral thermostat
- Oil sump heater with oil temperature thermostat
- Heat trace on cooler separators and drain lines, controlled by external temperature switch. Turns on when air temperature in the cabinet is low to prevent condensation from freezing and blocking drains
- Heat pad on cooling fan VFD heat sink, controlled by external temperature switch

A separate 120V power input can be used used for heat pads, heat trace, and sump heater, allowing the compressor to be safely left in cold areas when not connected to three-phase power. Input is through a NEMA5-15P plug mounted in the electrical enclosure wall which can be connected to a standard extension cord. On some models, this power connection is required to run the freeze protection; see electrical schematic.

The freeze protection circuit must be provided with power if the compressor is exposed to temperatures below +40°F.

1.10. Back Pressure Regulator Valve

Most rental units include a Kimray back pressure regulator valve, which reduces rapid load/unload cycling by venting excess compressed air when outlet pressure rises. This valve is set to pilot the system at the desired operating pressure. Valves are factory set at default compressor operating pressure of 125PSI.

To disable the back pressure regulator valve, close the ball valve ahead of it from the compressor air outlet pipe.

To adjust the back pressure regulator valve setting:

1. Set compressor unload pressure to desired operating pressure.

2. Make sure the ball valve to the back pressure regulator valve is open. Run the compressor and allow system pressure to reach desired value; if required, open bleed valve at receiver to ensure compressor stays loaded.
3. Turn the adjusting screw on the top of the valve to raise or lower the pilot threshold. There is a pressure gauge on the valve.
4. Close ball valve at compressor outlet. Confirm that back pressure regulator valve opens and compressor does not unload.
5. Open ball valve at compressor outlet.

2. Installation

2.1. Inspection

Immediately upon receipt, the compressor should be inspected for damage. If any damage is found, claims should be made against the carrier.

2.2. Handling

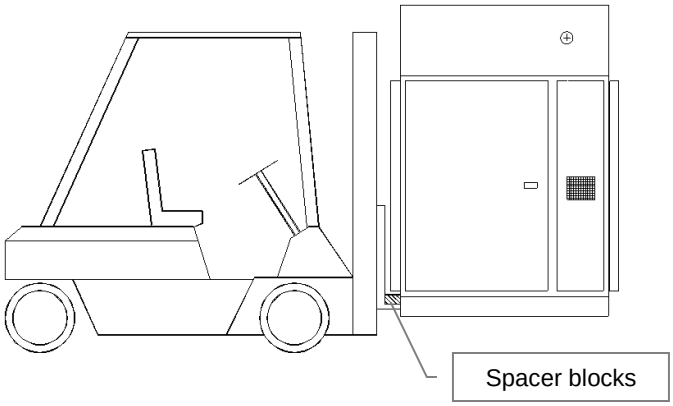

FIGURE 11 - FORKLIFT HANDLING

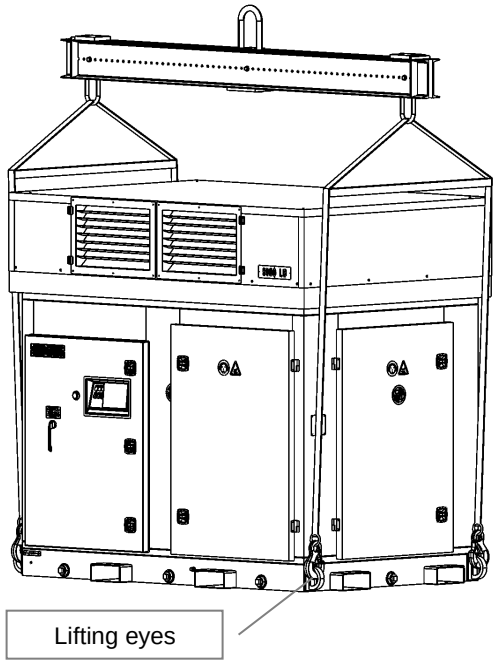

FIGURE 12 - CRANE HANDLING

The compressor unit is equipped with forklift slots for ease in handling. Spacer blocks should be placed between the compressor and forklift mast to ensure the cabinet will not be damaged during handling.

When handling the unit with an overhead crane, use the lifting eyes on the corners of the compressor base. Spreader bars should be used to prevent damage to the compressor cabinet.

2.3. Foundation

The compressor should be mounted on a flat, level floor capable of supporting its full weight. Holes are provided in the forklift slots for securing the compressor to the mounting

surface. The compressor air end and motor assembly is vibration isolated from the cabinet, frame, and base. Additional isolation is not required.

2.4. Location

The unit should be installed in a well ventilated location, free from excessive dust or dripping liquids. Do not install in an area where chlorine gas, hydrogen sulfide gas, sulfur dioxide gas, highly concentrated ozone, or any other toxic, corrosive or flammable gasses are present. It is important to provide a source of clean intake air. Any contaminates in the atmosphere will be compressed with the air.

A remote source of clean inlet air to the compressor may be required. To achieve this a duct may be connected to the air inlet. If the duct is routed to provide air from outdoors, a weatherproof intake hood with screen is required. Duct friction loss shall not exceed 3" H2O at rated inlet flow.

The compressor must be protected against high ambient temperatures above 104°F, or low ambient temperatures below -40°F, and if exposed to temperatures below +40°F the freeze protection circuit must be provided with 120V power (see section 1.9 and electrical schematic).

The doors open approximately 120 degrees and are provided with lift off hinges. For ease of maintenance provide ample clearance around the compressor. If possible, overhead clearance for lifting apparatus should be available. The minimum recommended service clearances are shown with the unit dimensions on the compressor assembly drawing.

2.5. Cooling Air

The compressor should be located where sufficient ventilation is available to cool the compressor. The cooling air inlet and discharge must not be blocked. The warm air exiting the cooling air outlet must be prevented from being drawn into the cooling air inlet or compressor air inlet. Ventilation may need to be provided if the compressor is installed indoors and the compressor room temperature exceeds 104°F (40°C) during compressor operation.

2.6. Compressor Air Outlet Piping

The compressor is equipped with an internal check valve. Compressor outlet air pressure is controlled by the PLC monitoring an internal pressure transmitter.

CAUTION:  **Do not install an additional check valve between the compressor and the plant compressed air system piping. Doing so will prevent correct compressor operation and may damage the compressor.**

A flexible connection is required between the outlet of the compressor and the plant compressed air system piping. The outlet air piping must be properly supported to prevent strain on the compressor piping or cabinet. For safe servicing of the compressor a manual isolating valve must be installed in the outlet air piping at a convenient location close to the compressor.

Condensation will occur in the downstream piping. Vertical pipe runs, and low points in the piping system, should be equipped with drop legs and drains for moisture traps. If multiple compressors are piped into a common discharge header, the connections from the

compressors should be to the top of the header. The header should be equipped with drop legs and drains for moisture traps. See figure 13.

2.7. Air Receiver

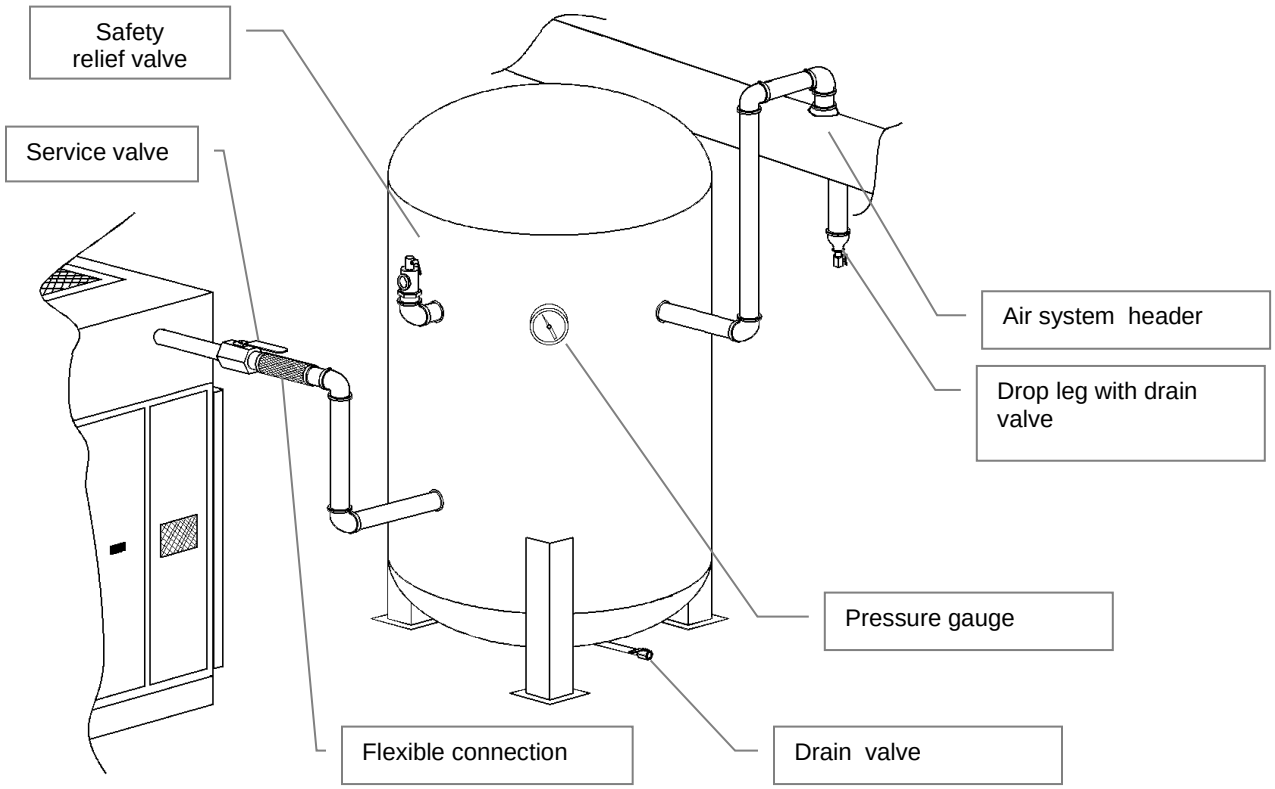

FIGURE 13 - TYPICAL AIR RECEIVER CONFIGURATION

A properly sized air receiver should be located as close to the discharge of the compressor as possible, and before any air treatment accessories such as filters and dryers. The piping from the compressor air outlet should be connected near the bottom of the receiver and piping to the plant compressed air system should be connected near the top of the receiver. The receiver must have provisions for draining accumulated condensate.

WARNING: The receiver must be equipped with an approved (ASME) safety valve. The compressor owner is responsible for the proper sizing, installation, and maintenance, and for periodic inspection and testing, of the safety valve. A pressure gauge and drain valve are also required.

Generally the receiver should be sized for a minimum of 2 gallons of storage for each cubic foot per minute of compressor air delivery. The size of the air receiver will directly affect the load cycle time of the compressor. Increasing the capacity of the air system will result in fewer load cycles, reduced wear on the compressor components, and improved system stability.

NOTICE: It is the compressor owner's responsibility to:

1. Verify that the receiver and the receiver installation comply with the applicable local, state, and national codes.
2. Obtain the proper licenses for the receiver.

3. Arrange periodic inspections necessary to maintain those licenses.

2.8. Wiring

It is the compressor owner's responsibility to ensure a safe installation that complies with applicable local codes and the National Electrical Code (N.E.C.). This includes properly sized short circuit and ground fault protection, power connection wire sizing, and equipment grounding. The wiring schematic and CSA label, provided with the assembly, must be consulted. Be sure the motors are wired for the proper voltage and agree with the plant power system.

Incoming three-phase power is connected to the compressors through Cam-Lok style power plugs located on the side of the electrical enclosure. On larger models, 2 incoming wires per phase are required.

Power grounding is also through a Cam-Lok plug located with the 3-phase power connection. Frame grounding connection can be made to a 1/2"UNC ground connection on the compressor base, usually located below the electrical cabinet and identified by a label.

The compressor PLC will automatically control the starting, operating, and stopping sequences. The controller also monitors critical parameters during operation and provides for protection of the compressor in the event of a problem. The Description of Operation provides more information on the controls.

3. Start-Up

3.1. Pre-start Checks

NOTICE: It is mandatory to have a factory trained representative present during initial start-up.

Prior to starting, the installation must be complete. Refer to section 2 for installation requirements.

a. Electric power must be turned off and locked out during initial checks.
b. Remove all loose items left in and around unit during installation. Clean inside of cabinet if necessary.
c. Check oil level in gear case sump. The oil level sight gauge is located at the bottom of the gear case and can be checked by opening the right front door. The oil level must be maintained between the Min. and Max. lines. Note: If the compressor has been off for an extended time the oil may be at or above the Max line due to oil draining back from the cooler. Check oil level again after the oil pump has been started.

   If necessary add oil. Oil type for initial fill is shown on a label on the sump breather housing. Do not remove oil fill plug while compressor is running. Do not overfill. DO NOT MIX OILS. If changing to different oil, replace completely with an approved alternate.
d. Check electrical wiring to all motors and transformers for proper voltage connections.
e. Check all wiring connections for tightness.

f. Confirm service valves for the automatic condensate drain valves are open.

g. Manually rotate cooling fan and main motor coupling. Confirm that both turn freely and that there are no interferences or unusual noises.

h. Turn on electric power to unit. Confirm HMI operation, showing proper model number, serial number, and program number.

i. Perform LED Test (found in Terminal Options, see Description of Operations manual for more information). Confirm that all pilot lights operate.

3.2. Initial Start-up

NOTICE: The compressor has three motors that start in sequence. The sequence is event driven and controlled by the PLC. For details consult the "Description of Operation" manual for the PLC program provided for the compressor.

a. Press the Start button. The oil pump will start. Observe for proper rotation. Press the Stop button. Check for oil leaks. If oil pump rotation is incorrect interchange two of the conductors supplying power to the panel.

NOTICE: Factory motor connections are made to ensure correct rotation of all motors when incoming power is connected in the proper phase sequence.

WARNING: **Conductors supplying power to the starter panel are HIGH VOLTAGE. Power connections and motor connections should only be made by qualified personnel, with the supply power shut off; properly disconnected, locked out, and tagged out.**

b. Press the Start button. When oil pressure reaches 20 psi the compressor motor will start. Press the Stop button and observe the compressor motor for correct rotation. Rotation is counter-clockwise facing the compressor shaft. If necessary swap main motor leads to reverse rotation.

c. Press the Start button. After the compressor has accelerated to full speed, the cooling fan will start. Check the fan for correct rotation.

d. After the cooling fan starts, load control will be enabled. Open the system valve(s) as required to allow full load operation at the highest compressor outlet pressure below the unload pressure. Operate the compressor at least 1/2 hour at full load, allowing temperatures stabilize.

e. Complete Start-Up Report. Keep a copy for your records and send the original to the factory.

4. Operating Instructions

4.1. Starting the Compressor

Times shown in this section are typical for most installations, but are fully adjustable.

NOTICE: Unloaded starting is automatic. It is not required to select "Manual Unload" in order to start the compressor.

a. Open the system air valve if it is closed. (Located external to the compressor cabinet).

b. Turn power on. Confirm HMI operation. Check that all temperatures read normal.
c. Press the Start button. The oil pump will start. Check oil pressure. The RUN light will turn on.
d. The compressor motor will start when oil pressure is established.
e. The fan motor will start after the compressor is up to speed.
f. After the fan starts load control is enabled. If system pressure is below the unload set point the compressor will load. The LOAD light will turn on.
   Note: If manual unload is selected the compressor will not load.
g. The compressor will unload when system pressure reaches the unload pressure setting. The LOAD light will turn off.

4.2. Stopping the Compressor

a. Press the Stop button. If the compressor is loaded, it will unload and the LOAD light will turn off.
b. 5 seconds after unloading the compressor motor starter will de-energize. If the compressor had run unloaded for at least 5 seconds the motor starter will stop when the Stop button is pressed. The compressor will coast to a stop.
c. The lube oil pump continues to operate for 25 seconds after the compressor starter is de-energized. This allows pressure lubrication of the compressor bearings and gears during coast down.
d. The lube oil pump continues to operate for 25 seconds after the compressor starter is de-energized. This allows pressure lubrication of the compressor bearings and gears during coast down.

WARNING: When compressor service is being performed the air service valve must be closed and the power disconnected. Safety procedures must be strictly followed, with lock-out and tag-out procedures required.

4.3. Automatic Stop

If the compressor has run unloaded for the duration of the Standby delay, it will enter Standby mode. The compressor will shutdown following the normal sequence, after which the STANDBY light will turn on (if present) or the HMI will show 'STANDBY ACTIVE'.

WARNING: "STANDBY ACTIVE" indicates that the compressor may start automatically at any time. THE COMPRESSOR IS NOT OFF. Do not perform service if STANDBY is indicated.

The default delay time preset based on the KNW model. The set point is adjustable and can be modified using the HMI (see Description of Operations).

If the system pressure drops below the Load setpoint, the compressor will automatically restart.

5. De-installation

To shut down and disconnect the compressor prior to removing it from a site:

a. Press the "Stop" button to shut down the compressor.
b. Shut off electrical power to the compressor at the external supply circuit breaker; follow standard lock-out and tag-out procedures.

WARNING: Conductors supplying power to the starter panel are HIGH VOLTAGE. Power disconnection should only be made by qualified personnel, with the supply power shut off; properly disconnected, locked out, and tagged out.

c. Disconnect power wiring to the compressor at the Cam-Lok connections.
d. Close the service valve at the compressor air outlet pipe. If there is air pressure in the downstream air pipe, bleed off pressure before disconnecting air piping at the compressor.
e. Disconnect the flexible connector from the compressor air outlet pipe.
f. When moving the compressor, use the same procedures as described in section 2.2, Handling.

6. Electrical Controls

NOTICE: For a detailed description of HMI operation and navigation see the “Description of Operation” Manual for the PLC program provided with the compressor. The program number can be found on the KNW Title page accessible using the NAV menu, and is shown on a label on the back of the HMI.

6.1. Compressor Control Panel

KNW Series air compressors come with a color HMI with touch screen. The HMI shows current operating conditions, pressures, and temperatures. Messages to direct the operator for service, pre-alarms, and shutdowns will be shown when necessary. Required settings for pressure control, temperature alarms, and control time delays are viewable and may be modified using the touchscreen. The HMI will automatically ‘dim’ to a sleep condition if inactive, and awakens on any touch contact.

The Beijer X2-Pro7 is the standard HMI used for KNW Series air compressors.

Pilot lights, viewable from a distance, are provided on the control panel for quick indication of operating conditions, and an audible alarm is provided for annunciation. Push buttons are provided for specific control functions, allowing continued compressor operation in the event that the HMI is off-line.

HMI Maintenance

The HMI uses an LCD (liquid crystal display) with LED backlighting. LCD’s are sensitive to heat and direct sunlight. Maximum ambient temperature is 120°F (50°C). The compressor is to be located indoors and care should be taken that direct sunlight does not shine on the HMI. The touchscreen is a polyester film and is sensitive to abrasion. Do not wear gloves when operating and do not press on the screen with hard or sharp objects. A replaceable screen overlay is available to extend the service life of the touchscreen. **Use only a clean soft cloth and mild detergent to clean the screen**.

If the HMI requires replacement, disconnect the communication cable, the DC24V power connector and the grounding wire. Use a Phillips screwdriver to remove the four mounting clips.

6.2. Programmable Logic Controller

A programmable logic controller (PLC) is used to monitor and control compressor operations. The PLC includes digital inputs and outputs to monitor compressor conditions and control the starter and solenoid valves. PLC varies by model and year of construction; see compressor electrical schematic. Allen-Bradley PLCs are used in all KNW compressors.

6.3. Wye-Delta Main Motor Start (HR Models)

Compressors with a 'HR' model designation are provided with an open transition wye-delta starter to operate the main motor.

For a wye-delta starter the transition from wye (start) to delta (run) is controlled automatically by the PLC and the transition delay is set using the HMI. The delay shall be set such that the motor reaches full speed before transition occurs. The maximum delay permitted is 28 seconds. Motor overload protection is provided by a thermal overload relay that is set at 58% of motor nameplate full load amps. The overload relay has a reset button that must be pressed to reset an overload trip.

6.4. Selectable Power Operation (PXR Models)

For compressors with a 'PXR' model designation, main motor speed is controlled by a variable-frequency drive. The drive operates the motor at a speed determined by horsepower when loaded, and at minimum speed when unloaded. Horsepower is selectable from the HMI from several preset values, with the maximum equal to the nameplate horsepower of the main motor, and should be chosen based on compressed air volume requirements. See compressor Description of Operations for details.

6.5. Fan and Oil Pump Starters

X-line starters are provided for starting the oil pump and the cooling fan. The starters include adjustable overload protection, which are set to the full load amps of the motor service factor. The overload relays have a reset button that must be pressed to reset an overload trip.

Before an overload or starter fault alarm can be reset at the control panel, the overload or fault at the starter must be reset.

7. Maintenance

NOTICE:	Service intervals shown are the maximum recommended for most installations. Operating conditions at some installations may require more frequent servicing. The compressor should be inspected regularly and serviced as conditions require.

7.1. Daily

NOTE: DO NOT USE THE COMPRESSOR CABINET FOR STORAGE.

a. Check that pressures and temperatures are within normal parameters.

b. Adjust or service as required or indicated.

c. Check for proper operation of the intercooler and aftercooler automatic drain valves. The valves should pulse briefly each 1-2 second while the compressor is loaded.

   The intercooler automatic drain will not operate while the compressor is unloaded. The intercooler drain line has a check valve to prevent backflow of drained condensate while the compressor is unloaded. Inspect the check valve for proper operation.

CAUTION: **Do not operate the compressor with the service valves closed to the automatic condensate drain valves. If it is required to operate the compressor without automatic drains, open the drain bypass valves.**

d. Check operation of capacity control valve by observing load/unload cycle. Press manual unload if necessary to unload compressor.

e. Test pilot lights by pressing LED Test key on HMI Terminal Options page.

7.2. Weekly

a. Inspect interior of the compressor cabinet for abnormal conditions including excessive dust, leaks, and loose parts.

b. Drain condensate in control air filter.

c. Check oil level.

d. Air filter or oil filter must be changed if the HMI displays a filter service alert.

7.3. Monthly

a. Review event list for alerts and unreported shutdowns.

b. Inspect control air filter.

c. Inspect oil sump breather element. Some oil on the outside of the element is normal. Replace the element if saturated.

d. Email daily operating records to the factory, keeping copy for your file. The daily operating records are regularly reviewed by trained service personnel to look for unusual trends and to assist in preventive maintenance. This lifetime service is included in the purchase price of the compressor assembly and will aid in providing long, economical and trouble free operation of the compressor.

7.4. Yearly

WARNING: **Do not perform maintenance procedures while power to the compressor is energized. The compressor must be off, and power disconnected, before servicing can be performed. For the safety of the maintenance personnel, lock-out and tag-out procedures must be strictly followed.**

a. Drain sump and fill with new oil. Oil should be drained while hot. See section 7.5 for lubricant information.

b. Replace oil filter and gasket.

c. Inspect discharge check valve for wear; repair or replace as required.

d. Dismantle and inspect capacity control valve assembly. Replace diaphragm, V packings, bushings and Teflon seat. Inspect shaft for wear.

e. Replace shuttle valve diaphragm.
f. Replace 4-way solenoid valve.
g. Replace balance pistons diaphragms.
h. Replace check valve on intercooler condensate drain line.
i. Check daily operating records for intercooler and aftercooler efficiency. Clean cooler cores if required. The preferred method of cleaning the exterior is to blow the core off with compressed air in a direction parallel to the fins in order not to damage them. If a pressure washer is used care must be taken to avoid wetting any electrical connections. Contact your local distributor for more information.
j. Check daily operating records for oil cooler efficiency. Clean cooler core exterior if necessary. If the inside of the oil cooler needs cleaning, disconnect the cooler from the oil plumbing. Oil passages, when slightly fouled, are to be cleaned with ethylene perchlorate or an equivalent solvent. Cleaning time is between 10 and 30 minutes. After cleaning, blow out the solvent with compressed air.

WARNING: Take care when using solvent so that it is not allowed to contaminate the surrounding areas. Consult the solvent supplier's Material Safety Data Sheet for application and disposal requirements.

k. Inspect safety valve for abnormal wear or damage.

WARNING: Federal, State, and Local regulations require periodic testing of the Safety Valve by a certified testing agency. It is the responsibility of the compressor owner to have the valve properly tested at the mandated intervals.

l. Motor lubrication should be per the motor manufacturer's recommended intervals. Some models are equipped with automatic motor greasers; if your compressor has automatic motor greasers, check the grease level remaining and replace if required.
m. Test low oil pressure shutdown while the compressor is running. With normal oil pressure showing on the HMI, close the oil pressure transmitter isolation valve and lower oil pressure by slowly opening the oil sample valve (see figure 3). Alarm should occur, and the compressor shut down, when pressure is lowered to below 20 PSIG.
n. Test all temperature shutdowns by individually lowering the set points for each temperature alarm, to lower than ambient. Confirm that the alarm list shows the proper message as a currently active alarm. Return the set point to required value and reset the alarm before testing the next shutdown.
o. Reset unloading system service counter to zero. For details refer to the Description of Operation manual for the installed program.

7.5. Lubrication Oil

The correct oil for lubrication is a quality turbine oil, containing rust and oxidation inhibitors and corresponding to ISO VG 68. DO NOT mix different brands or grades of oil. The compressor was initially filled with 76 Products Company turbine oil ISO VG 68 having a viscosity of 336 SUS @ 100°F (38°C). If necessary to add oil and this brand is not available, drain completely and refill with a suitable replacement. **DO NOT MIX OILS.**

WARNING: Do not add or drain oil while the compressor is operating. The compressor must be off, and power disconnected, before servicing can be performed. For the safety of the maintenance personnel, lock-out and tag out procedures must be strictly followed.

The capacity of the lube oil system is approximately 7.75 gallons (29 liters) for the KNWA0, 11 gallons (42 liters) for the KNWA1, or 24 gallons (91 liters) for the KNWA2.

The oil level viewed on the sight gauge will vary when the compressor is operating. Fill the sump to the upper limit of the gauge then run the compressor. Stop the unit and add oil as necessary to maintain the oil level near the center of the sight gauge while the compressor is running.

7.6. Filters

WARNING: Do not service the filters while the compressor is operating. The compressor must be off, and power disconnected, before servicing can be performed. For the safety of the maintenance personnel, lock-out and tag out procedures must be strictly followed.

Inlet Air Filter

Inspect the inlet air filter monthly. The filter is a two stage filter with a washable foam pre-filter and a paper main element. Clean the pre-filter as needed and allow it to dry completely before installing. Replace the filter annually or if a "Check Inlet Air Filter" alert is present. Ensure that the attached gasket it is not damaged when replacing the filter.

Oil Filter

The oil filter head includes a pressure differential switch. If the switch trips, indicating a dirty filter, the HMI will display a “Check Lube Oil Filter” alert. In normal operation the filter element should be replaced annually. When replacing the filter element also install the new gasket provided with the filter.

Sump Breather

Inspect the sump breather element monthly. If the element is saturated it should be replaced. A small amount of oil may be present in the housing outside the filter; this is normal and will drain back to the sump.

Control Air Filter

Inspect element monthly. Replace annually, or if saturated with condensate.

8. Standby and Stored Units

8.1. Standby Units

Back-up or stand-by compressors must be run weekly to assure that no condensation is allowed to accumulate internally. When operated, a stand-by unit should be allowed to reach full operating temperature for 30 minutes.

8.2. Short-term Storage

For storage intervals of one month or less, if power is available, open the manual drains on the bottom of automatic drain traps and run the unit fully loaded for 15 minutes.

8.3. Long-term Storage

a. Before stopping, bring the unit to normal operating temperatures, then open the manual condensate drains. Operate loaded for 5 minutes while discharging to atmosphere.
b. Stop the unit and add a vapor phase corrosion inhibitor oil additive.
c. Run the compressor unloaded 10 minutes.
d. Stop the compressor.
e. Install pipe plug or cap on air outlet pipe.
f. Install moisture barrier (plastic sheeting) on inlet air panels, cooling air outlet grill and bleed-off silencer.
g. Install silica gel desiccant bag in the 1st stage discharge and 2nd stage suction piping at inspection blind flanges.
h. Place silica gel desiccant bags inside compressor cabinet and electrical enclosure.
i. Place warning label on front of unit stating: "CAUTION: Remove silica gel packs and moisture barriers, change oil, and replace drain plugs before restarting unit."
j. Replace silica gel packs every 2 months.
k. Turn main motor shaft, by hand, at least two full revolutions every month.

9. Typical Operating Conditions

Operating Temperatures and Pressures for KNW Air-Cooled A0 - A2

Many factors can affect operating temperatures and pressures and acceptable normal operating conditions can not be defined for every compressor installation. Gear arrangement, operating set points, ambient conditions at installation location and elevation, etc., can all affect running conditions. For example rapid load cycling will result in lower operating temperatures, installation at high elevation results in lower pressures and may increase operating temperatures.

For diagnostic purposes it is best to periodically record operating temperatures and pressures. A minimum of once daily is recommended. Do not depend on one set of readings to diagnose a problem. It is best to establish a baseline and examine the data for trends that can not be explained by normal changes of conditions external to the compressor. Especially look for simultaneous changes to more than one reading. For convenience, the compressor HMI may be provided with trend charts or data logging capability (see Description of Operations for your application). Factory test readings are

available for comparison to site readings. Contact your local distributor for more information.

Pressures and temperatures shown are typical for an average compressor installation. Ambient temperature 70°F, 500' elevation. Set 125 PSIG unload to 115 PSIG load, operating 75% loaded.

See Description of Operations for more information on alerts and alarms.

Pressures:	*Loaded Value*	*Unloaded Value*	*Alert/Alarm Setting*	*Alert/Alarm, Notes*
1ST Stage Suction (Air)	0" ~ 18" H_2O Vacuum	24" ~ 26"Hg Vacuum	> 2 PSIG	Alarm 'Running In Reverse'
			> 50"H_2O or < -50"H_2O	Alarm 'Undirected Run Detected' (when stopped)
			> 25"H_2O	Alert 'Check Inlet Air Filter'
2nd Stage Suction (Air)	25 ~ 35 PSIG Pressure	13" ~ 15"Hg Vacuum	> 50 PSIG (at switch)	Alarm 'High 1st Stage Discharge Pressure')
			< 10 PSIG	Alert 'Failed To Load' (when loaded)
			> 10 PSIG	Alert 'Failed To Unload' (when unloaded)
Compressor Outlet (Air)	90 ~ 125 PSIG (Adjustable with load/unload setpoints; see Description of Operations)		> 156 PSIG (at switch)	Alarm 'High Compressor Outlet Pressure'
			> 153 PSIG	Alert 'Compressor Over Pressure'
Lube Oil	30 ~ 33 PSIG (Adjustable oil pressure control valve)		< 20 PSIG	Alarm 'Low Lube Oil Pressure'

Temperatures	*Operating Value*	*Alert (prealarm)*	*Alarm (shutdown)*
Inlet (Air)	75°F	> 122°F	N/A
1ST Stage Discharge (Air)	350°F	KNWA0: > 455°F KNWA1: > 412°F KNWA2: > 412°F	KNWA0: > 464°F KNWA1: > 421°F KNWA2: > 421°F
2ND Stage Suction (Air)	105°F	> 140°F	> 150°F
2ND Stage Discharge (Air)	365°F	KNWA0: > 455°F KNWA1: > 446°F KNWA2: > 446°F	KNWA0: > 464°F KNWA1: > 455°F KNWA2: > 455°F
Compressor Outlet (Air)	85°F	> 125°F	> 200°F
Lube Oil (Thermostatic valve)	110°F	> 170°F	> 180°F
Cabinet (Air)	75°F	N/A	> 180°F, non-adjustable (switch)

10. Troubleshooting

This table focuses on mechanical faults and conditions. For electrical faults that will cause an alarm or alert message on the HMI, see the Description of Operations.

10.1. Compressor

CONDITION	POSSIBLE CAUSE	SUGGESTED REMEDY
Unit will not start.	1. Low supply voltage. 2. Power failure. 3. Programmable controller problem. 4. Compressor in alarm. 5. Compressor in Remote Mode. 6. Compressor in Standby	1. Check fuses or circuit breaker. 2. Check for proper voltage and connections. 3. Check PLC for proper operation. 4. Reset alarm condition. 5. Check that remote control is enabled and a remote run signal is present. 6. Check pressure settings or manual unload selection.
Compressor shuts down on motor overload.	1. Low voltage. 2. 1st or 2nd stage not in order. 3. Operating pressure set too high. 4. 2nd stage suction temp too high. (Dirty Intercooler). 5. High intercooler pressure. 6. Low intercooler pressure. 7. Faulty motor.	1. Check for proper voltage and connections. 2. Check all operating parameters for abnormal conditions. 3. Lower pressure within limits of motor. 4. Clean intercooler. 5. Replace 2nd stage air end. 6. Replace 1st stage air end. 7. Repair or replace motor.
Compressor shuts down on high cabinet temperature.	1. High ambient temp. 2. Dirty coolers. 3. Obstructed cooling air flow. 4. Air leaking from bleed-off silencer when loaded.	1. Maximum 104° F (40° C). 2. Clean coolers (see section 6.4). 3. Check for and remove any foreign material blocking air flow. 4. Rebuild CCV.
High inlet air temperature.	1. High ambient temp.	1. Maximum 104° F (40° C). Check for recycled cooling air; consider using external inlet air source.
High 1st stage discharge air temperature.	1. Inlet filter plugged. 2. High ambient temp. 3. 2nd stage worn or damaged. 4. Balance valve open (if provided)	1. Change filter elements. 2. See High Inlet Air Temperature. 3. Replace 2nd stage air end. 4. Adjust balance valve.
High 2nd stage suction air temperature.	1. Dirty intercooler core. 2. Obstructed cooling air flow. 3. High ambient temperature.	1. Clean intercooler (see section 6.4). 2. Check for and remove any foreign material blocking air flow. 3. See High Inlet Air Temperature.
High 2nd stage discharge air temperature.	1. High second stage discharge pressure. 2. Dirty intercooler core. 3. 1st stage damaged. 4. Defective discharge check valve.	1. Lower operating pressure to normal. 2. Clean intercooler (see section 6.4). 3. Replace 1st stage air end. 4. Repair or replace check valve.
High compressor outlet air temp.	1. Dirty aftercooler core. 2. Obstructed cooling air flow. 3. High ambient temperature.	1. Clean aftercooler (see section 6.4). 2. Check for and remove any foreign material blocking air flow. 3. See High Inlet Air Temperature.
High oil temperature	1. Oil level too high. 2. Dirty oil cooler core. 3. Gearcase sump breather element plugged. 4. Obstructed cooling air flow.	1. Lower oil level to center of sight gauge. 2. Clean oil cooler (see section 6.4). 3. Replace element. 4. Check for and remove any foreign material blocking air flow.

CONDITION	POSSIBLE CAUSE	SUGGESTED REMEDY
Failure to load.	1. 4-way solenoid valve defective. 2. Capacity Control Valve diaphragm ruptured. 3. Capacity Control Valve bushings defective. 4. Trouble with pressure transmitters. 5. Manual unload selected. 6. PLC Control not sending signal to unloading valve. 7. Unloading valve relay defective. 8. Ruptured shuttle valve diaphragm.	1. Repair or replace unloading valve. 2. Replace diaphragm. 3. Repair Capacity Control Valve. 4. Check transmitter connections and wiring. 5. Press load button. 6. Check output to unloading valve relay for voltage. 7. Replace unloading valve relay. 8. Rebuild or replace shuttle valve.
Air leaking from bleed-off silencer when loaded.	1. Capacity Control Valve bushings defective. 2. Damaged bleed-off valve disc. 3. Leak in control tubing. 4. Leaking diaphragm in shuttle valve. 5. Leaking diaphragm in CCV. 6. 4-way solenoid valve defective.	1. Repair Capacity Control Valve. 2. Install new bleed-off valve disc. 3. Check for and repair tubing leaks. 4. Replace shuttle valve. 5. Rebuild CCV. 6. Replace 4-way solenoid valve.
Abnormal noise from compressor element.	1. Coupling problems. 2. Gear trouble 3. Bearing trouble.	1. Inspect and repair coupling. 2. Overhaul gear assembly. 3. Replace affected stage.
Abnormal noise from oil pump.	1. Oil level too low. 2. Defective pump. 3. Damaged coupling.	1. Add oil to recommended level. 2. Replace pump. 3. Replace coupling.
Abnormal noise from capacity control valve when loading.	1. Bushings worn in capacity control valve. 2. 4-way solenoid valve trouble. 3. Control tubing leaks.	1. Rebuild valve. 2. Replace 4-way solenoid valve. 3. Check tubing and correct faults.
Safety valve lifts in normal operation.	1. Pressure settings too high. 2. Defective pressure transmitter. 3. Service valve to air system closed.	1. Set load and unload settings to proper range for motor horsepower. 2. Replace transmitter. 3. Open valve.
Oil level rises without adding oil.	1. Condensation in oil.	1. Check oil operating temperature. Change Oil.
Oil pressure drops during operation.	1. Oil level too low. 2. Oil filter plugged. 3. Oil pressure control valve defective. 4. Oil leak. 5. Oil pump defective. 6. Oil cooler dirty.	1. Add oil to maximum level. 2. Replace filter element. 3. Repair or replace valve. 4. Locate and repair leak. 5. Replace pump. 6. Clean cooler (see section 6.4.h).
Oil leakage from air vents on stage.	1. Sump breather element plugged. 2. Oil level too high. 3. Faulty discharge check valve.	1. Replace element. 2. Lower oil level to center of sight gauge. 3. Repair or replace check valve.
Oil leakage at main drive shaft seal.	1. Sump breather element plugged. 2. Shaft seal worn. 3. Worn bull gear bearings.	1. Replace element. 2. Replace shaft seal. 3. Replace bull gear bearings.
Unit shuts down for no apparent reason.	1. Unloading timer timed out, Standby. 2. Intermittent power outage. 3. Faulty stop button or stop button wiring.	1. Unit designed to shut down if unloaded for 15 min. Consult your local distributor. 2. Compressor must be manually restarted after power is restored. Automatic restart is available; consult your local distributor. 3. Inspect and repair as needed.
Low capacity.	1. Dirty air inlet filter. 2. Defective bleed-off valve disc. 3. Defective diaphragm in capacity control valve. 4. Aftercooler core leaking.	1. Clean or replace element. 2. Replace disc. 3. Replace diaphragm. 4. Replace aftercooler.

CONDITION	POSSIBLE CAUSE	SUGGESTED REMEDY
Compressor back spins on shutdown.	1. Defective discharge check valve.	1. Repair or replace.
Intercooler pressure below normal or pulsating.	1. Dirty air inlet filter. 2. Defective 1st stage 3. Pressure transmitter malfunction. 4. Leak in intercooler moisture drain line check valve. 5. Leaking diaphragm in shuttle valve.	1. Clean or replace elements. 2. Replace 1st stage. 3. Check transmitters, wiring, IO Blocks. 4. Repair or replace check valve. 5. Replace shuttle valve.
Intercooler pressure above normal.	1. High 2nd stage inlet temp. 2. Defective 2nd stage. 3. Balance valve open. 4. Pressure transmitter malfunction.	1. See above. 2. Replace 2nd stage. 3. Adjust balance valve. 4. Check transmitters, wiring, IO Blocks

10.2. PLC

CONDITION	POSSIBLE CAUSE	SUGGESTED REMEDY
PLC “OK” light off.	1. Control circuit fuse blown. 2. Loose Wiring Connection 3. Overload on power supply. 4. Faulty power supply 5. Faulty transformer.	1. Replace any blown fuses. 2. Tighten Wiring Connections. 3. Check DC circuit for excess load or short circuit. 4. Measure output of power supply. Must be DC24V +/- 0.5V. 5. Check transformer voltage.
PLC “RUN” light off.	1. PLC RUN/REM/PROG switch not in “RUN” 2. No PLC program. 3. System fault.	1. Check switch. 2. Check EPROM installation. 3. Cycle PLC power.
HMI: Screen blank.	1. Backlight off (Normal Sleep Mode) 2. Backlight off, touch does not awaken 3. No control power. 4. Fuse blown.	1. Touch the screen 2. Cycle HMI power. If backlight remains off replace display. 3. Check control power circuit. 4. Replace fuse.
HMI: Dim screen	1. Display in sleep mode. 2. No backlighting. 3. Faulty display.	1. Touch screen. 2. Adjust backlighting brightness 3. Replace display.

APPENDIX A: Performance Data

This table shows typical performance data values. For exact data, consult serial-number-specific documentation for your compressor including electrical drawing.

Model	*A0-EHR*	*A0-EPXR*	*A1-GHR*	*A1-GPXR*	*A2-DHR*	*A2-DPX2*
Pressure	40 - 135 PSIG	40 - 135 PSIG	40 - 135 PSIG	40 - 135 PSIG	40 - 150 PSIG	40 - 150 PSIG
Capacity @ 125PSI (CFM)	401	401	812	812	1585	1585
Capacity @ 125PSI (m^3/min)	11.36	11.36	22.99	22.99	43.92	43.92
Voltage	480V 3-phase (Optional: AC120V for freeze protection)					
Full Load Current (A)	145	155	265	260	510	530
Minimum Circuit Ampacity for Wire Sizing (A)	174	202	338	329	658	658
Maximum Allowable Overcurrent Protection	250A fuse / 350A circuit breaker	300A fuse / 400A circuit breaker	450A fuse / 7000A circuit breaker	450A fuse / 7000A circuit breaker	800A fuse / 1500A circuit breaker	800A fuse / 1500A circuit breaker
Installed Overcurrent Protection	250A circuit breaker	250A circuit breaker	400A circuit breaker	400A circuit breaker	800A circuit breaker	800A circuit breaker
Noise level @ 1 meter (dBA)	79	79	85	85	85	85
Approximate weight (lb)	5,000	6,000	8,700	8,700	13,000	13,500
Operating temperature	-20ºF to 105ºF [-29ºC to 40ºC]	-20ºF to 105ºF [-29ºC to 40ºC]	-20ºF to 105ºF [-29ºC to 40ºC]	-20ºF to 105ºF [-29ºC to 40ºC]	-20ºF to 105ºF [-29ºC to 40ºC]	-20ºF to 105ºF [-29ºC to 40ºC]

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