# **INSTRUCTION MANUAL**

FOR

NORRIS CYLINDER COMPANY

CUSTOMER P.O.: LP00021671

AJAX TOCCO MAGNETHERMIC S.O. #76-1031

2016

<u>JEE</u>

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OPERATING INSTRUCTIONS PRO ECO 240W 24V 10A, R.T.Nr. 1481520000/00/09.13

\*PLEASE NOTE THAT IT IS THE END USERS' RESPONSIBILITY TO KEEP ALL COPIES OF LICENSED SOFTWARE

#### NOTICE

These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with the installation, operation, or maintenance of this equipment.

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the:

SERVICE MANAGER
AJAX TOCCO MAGNETHERMIC CORPORATION
1745 OVERLAND AVENUE, N.E.
WARREN, OH 44483

TELEPHONE: 330-372-8511 FACSIMILE: 330-372-8623

E-MAIL: Service@ajaxtoccomag.com

Note: This order includes components which are only part of an overall system. The purchaser is responsible for the safety of the overall system. Specifically, it is the responsibility of the purchaser to provide and install:

- A) Guarding as required for the induction coil in accordance with National Electrical Code article 665-25.
- B) Guarding as required for the electrical interconnection (i.e. bus, cable, water cooled leads) between the power source and the induction coil in accordance with National Electrical Code article 665-64(b), to include any bus stubs extending outside of cabinets.
- C) Grounding of non current carrying frame members as required in accordance with National Electrical Code article 665-26.

See also the Safety Devices section of this Manual. If you have any questions about complying with any of these safety procedures, please contact the Ajax Tocco Service Manager.

Author: MRG Revised: 8/7/03 Approver: RRL SU-22-0022-5

7/2/92 Sheet 1 of 1

NORRIS CYLINDER SECTION NO. 2 76-1031 SHEET NO. 1

# **Description of Equipment**

**APPLICATION:** Heating Carbon Steel Billets Prior to Forging

MATERIAL: Carbon Steel

**BILLET SIZES:** 6.00" to 8.5" RND, 6.00-7.657 RCS

5.00" to 12.00" long

**PRODUCTION** 

**RATES:** 13000 lbs/hr based on heating the 6.00" to 8.5" RND, 5.00 -12.00" long billets

at 85 billets/hr

**TEMPERATURES:** Initial: 70°F

Final Mean: 2200°F

**POWER** 480 volts, 3 Phase, 60 Hertz **AVAILABLE:** 34,500 volts, 3 Phase, 60 Hertz

Billets of **identical length and diameter** will be delivered end-to-end to the infeed conveyor by a customer supplied method. The infeed conveyor will feed billets to the billet loader assembly where the billets will be pushed through the induction heating coils.

Upon exiting the coil line, the heated billets will exit onto a discharge conveyor and be carried through a de-scale provided by client. The billet temperature will be measured upon exiting the descale by an **infrared temperature monitor** and accepted or rejected. If rejected, the billets will be directed into a customer supplied reject bin. If accepted, the billets will advance to be forged.

The above sequence of operation will continue until the system runs out of billets or the operator stops the system.

#### SAFETY DEVICES

Many types of safety devices are built into your Ajax Tocco induction equipment. These include such things as electronic limits, trips or interlocks; door switches; mechanical key interlocks; temperature trip switches; water pressure switches; ground detectors; and mechanical and electrical guarding. These safety devices, interlocks, and guards are designed to provide protection for the operator and the equipment in accordance with the National Electrical Code and the NFPA Electrical Standard For Industrial Machinery.

All cabinets having induction heating power circuit voltage within have either a mechanical key interlock system or a door limit switch on each hinged access door. The intent of the interlock or limit switch is to remove power from the cabinet prior to entry. When a main breaker is used to feed the equipment, the limit switch is used to trip the undervoltage release coil on the breaker when the door is opened. On units not having a main breaker, a key system is used. The main power switch must be opened in order to release a key which will provide access to the cabinet. Bolt on panels are not protected by a key or switch and power must be disconnected manually prior to their removal. In cabinets containing capacitors, it is necessary to discharge the capacitors before working in the cabinet. See the capacitor section of this manual for the discharging procedure.

When performing any work around the equipment, including the capacitors, transmission lines, and induction coil itself, the main disconnect switch must be locked out. It is not enough that the power supply is simply not running; it must be locked out before touching **anything** in the load circuit.

For installations where multiple coils are powered from a single power supply, please note the following. If work is to be performed on an unpowered coil while another coil is to be powered, the unpowered coil is to be locked out before touching it. This is accomplished by either disconnecting the coil power leads or power bus at the power supply end or by locking out selection of that coil at the coil selector. In both cases, the coil terminals must be shorted together and securely tied to ground potential.

Removal of the main power to the equipment may not remove all voltages from the unit. It is possible for a tuned resonant circuit to pick up energy broadcast through the air. If the broadcast frequency is close to the tank circuit resonant frequency, the tank circuit voltage can ring up to quite high levels. Therefore, if there is equipment nearby capable of broadcasting high frequency energy, such as another induction system, and if it is necessary to open the capacitor cabinet, or work near the coil or transmission lines, then both legs of the capacitor/coil bus must be grounded. In cabinets, control voltages may be present; and those with a source outside the cabinet should be brought into the cabinet with yellow interconnection wire.

The energy broadcast from induction equipment may cause interference with pacemakers. Anyone wearing a pacemaker should consult the manufacturer of the pacemaker before working around induction equipment.

Differential pressure switches are provided in each water cooled cabinet as well as on a heating fixture or melting furnace. This switch is set to cut off the output power if the pressure differential falls below the nominal pressure required for proper operation. Some equipment also has a water temperature switch designed to cut off output power if cooling water exceeds a set temperature.

Where Ajax Tocco supplies a complete system, mechanical guards are provided to prevent accidental contact with moving parts as well as high voltage connections. Where Ajax Tocco supplies only components as a part of an overall system, guarding is to be supplied by the purchaser. In some installation, an entire area is fenced off and restricted rather than individually guarding pieces of equipment. It is the responsibility of the purchaser to ensure that all guards provided by Ajax Tocco are installed before operating the equipment and to supply any additional guarding required.

Where necessary, Ajax Tocco Magnethermic has supplied warning signs. It is the purchaser's responsibility to make sure that these signs are kept visible, legible, and securely fastened to the equipment to which they are mounted. If at anytime the sign(s) have disappeared or become illegible, it is the purchaser's responsibility to obtain and mount new ones.

Per Article 665 of the National Electrical Code (NEC), induction heating and melting equipment is not to be installed in hazardous locations as defined in Article 500 of the NEC. As induction power supplies, heated parts, or molten baths can be a source of ignition, flammable fluids should not be used around induction equipment.

**IMPORTANT**: These interlocks and safety devices must be maintained in working order and all bolt on panels must be in place. It is the responsibility of the purchaser to ensure that all safety devices are operable. Equipment is not to be operated unless all safety devices, interlocks, and guards are installed. These must not be removed, jumpered, or disabled in order to operate the equipment.

# GENERAL SAFETY PRACTICES FOR MELTING APPLICATIONS ST-22-0036 REVISION 01 01.07.08

# AJAX TOCCO MAGNETHERMIC 1745 OVERLAND AVE N.E. WARREN, OHIO 44483

TELEPHONE: (330) 372 8511 FAX: (330) 372 8608

#### I. METAL SPLASH AND EXPLOSION WARNINGS:

- A. Do not put anything into this furnace which contains moisture or might be suspected of containing moisture. An explosion may result which could cause serious burns, injury or death to personnel and extensive property damage.
- B. Do not use any ladle, tundish, launder, etc. which may contain moisture or might be suspected of containing moisture. An explosion may result which could cause serious burns, injury or death to personnel and extensive property damage.
- C. Proper fire and heat resistant head wear with face guards and clothing must be worn at all times while working on or near the furnace and related equipment. Molten metal splash may occur which could cause serious burns, injury or death to personnel.
- D. Proper shielding must be supplied at the intersection points of all pour spouts, fill bowls, launders and molten metal pumps. Shielding must be positioned in order to shield workers from molten metal splash. Failure to do so could cause serious burns, injury or death to personnel and extensive property damage.
- E. An Emergency Molten Metal Run Off Pit is recommended in order to provide safe handling of molten Iron in the event of a possible furnace leak. The floor under the furnace should be kept dry and sloped to a Dry Emergency Pit that is large enough to handle the full furnace metal capacity. Failure to do so could result in a fire or explosion which could cause serious burns, injury or death to personnel and extensive property damage.

#### II. HEAVY MOVING EQUIPMENT WARNINGS:

- F. Do not stand on or near the furnace or drive system during furnace tilting, rotating or transfer. Serious injury or death may result due to heavy moving equipment.
- G. Do not leave loose tools or equipment on the furnace at any time. These items are subject to fall free during furnace tilting, rotation or transfer and could cause serious injury or death to personnel and extensive property damage.
- H. All electrical limit switches should be inspected regularly in order to maintain proper operation. Proper limit switch operation is necessary in order to control the movement of the furnace and related equipment. Failure to do so could cause serious injury or death to personnel and extensive property damage.
- I. Warning alarm lights, bells or horns must be inspected regularly in order to maintain proper operation. These warning devices provide sufficient warning to personnel to avoid pinch points due to heavy moving equipment. Failure to do so could cause serious injury or death to personnel.

#### III. HYDRAULIC EQUIPMENT WARNINGS:

J. All hydraulic fluid used on or near the furnace must be of the fire resistant type in order to prevent fires which could cause serious burns, injury, or death to personnel and cause extensive property damage.

- K. When doing any maintenance on the furnace, the hydraulic power unit must be denergized and locked out. Please note that all build-up pressure in the system must be purged to relieve any potential energy from the system. Failure to do so could cause serious injury or death to personnel and extensive property damage.
- L. All hydraulic hose and interconnecting lines should be inspected for wear or leakage. Hydraulic control lines carry high pressure fluid which could cause serious injury in the event of an accidental leak. Any fluid spills should be cleaned up as soon as possible in order to avoid any slipping hazards which could cause serious injury or death to personnel.

#### IV. GENERAL FURNACE OPERATIONS:

- M. Furnace platforms are to be kept clear of tools and related equipment which could create a possible tripping hazard which could cause serious injury or death to personnel.
- N. Do not drive any heavy fork lift tractors or place any heavy equipment on the furnace platforms. Structural failure could occur which could cause serious injury or death to personnel and extensive property damage.

#### V. ELECTRICAL SAFETY DEVICES:

- O. Many types of safety devices are built into your Ajax induction equipment. These include such things as electronic limits, trips or interlocks; door switches; mechanical key interlocks; temperature trip switches; water pressure switches; ground detectors; and mechanical and electrical guarding. These safety devices, interlocks, and guards are designed to provide protection for the operator and the equipment in accordance with the National Electrical Code and the NFPA Electrical Standard For Industrial Machinery.
- P. All cabinets having induction power circuit voltage within have either a mechanical key interlock system or a door limit switch on each hinged access door. The intent of the interlock or limit switch is to remove power from the cabinet prior to entry. When a main breaker is used to feed the equipment, the limit switch is used to trip the under voltage release coil on the breaker when the door is opened. On units not having a main breaker, a key system is used. The main power switch must be opened in order to release a key which will provide access to the cabinet. Bolt on panels are not protected by a key or switch and power must be disconnected manually prior to their removal. In cabinets containing capacitors, it is necessary to discharge the capacitors before working in the cabinet. Failure to do so could cause serious injury or death to personnel.
- Q. When performing any work around the equipment, including the capacitors, transmission lines, and induction coil itself, the main disconnect switch must be locked out. It is not enough that the power supply is simply not running; it must be locked out before touching anything in the load circuit. Failure to do so could cause serious injury or death to personnel.
- R. Removal of the main power to the equipment may not remove all voltages from the unit. If it is necessary to open the capacitor cabinet, or work near the coil or transmission lines, discharge the capacitors by temporarily shorting the bus to ground with an insulated probe. In cabinets, control voltages may be present; and

- those with a source outside the cabinet should be brought into the cabinet with yellow interconnection wire.
- S. The energy broadcast from induction equipment may cause interference with pacemakers. Anyone wearing a pacemaker should consult the manufacturer of the pacemaker before working around induction equipment.
- T. Differential pressure switches are provided in each water cooled cabinet. This switch is set to cut off the output power if the pressure differential falls below the nominal pressure required for proper operation. Some equipment also has a water temperature switch designed to cut off output power if cooling water exceeds a set temperature.
- U. Where Ajax supplies a complete system, mechanical guards are provided to prevent accidental contact with moving parts. Where Ajax supplies only components as a part of an overall system, guarding is to be supplied by the purchaser. In some installation, an entire area is fenced off and restricted rather than individually guarding pieces of equipment. It is the responsibility of the purchaser to ensure that all guards provided by Ajax are installed before operating the equipment and to supply any additional guarding required. All exposed electrical connection points must be shielded and/or insulated at final field assembly in order to prevent electrocution of personnel.
- V. Where necessary, Ajax Magnethermic has supplied warning signs. It is the purchaser's responsibility to make sure that these signs are kept visible, legible, and securely fastened to the equipment to which they are mounted. If at anytime the sign(s) have disappeared or become illegible, it is the purchaser's responsibility to obtain and mount new ones.
- W. Per Article 665 of the National Electrical Code (NEC), induction heating and melting equipment is not to be installed in hazardous locations as defined in Article 500 of the NEC. As induction power supplies, heated parts, or molten baths can be a source of ignition, flammable fluids should not be used around induction equipment. Failure to do so could cause serious injury or death to personnel and extensive property damage.
- X. IMPORTANT: All interlocks and safety devices must be maintained in working order and all bolt on panels must be in place. It is the responsibility of the purchaser to ensure that all safety devices are operable. Equipment is not to be operated unless all safety devices, interlocks, and guards are installed. These must not be removed, jumpered, or disabled in order to operate the equipment. Failure to do so could cause serious injury or death to personnel and extensive damage.

# The AC Ground Detector (SC# 75401A25)

#### System Overview

This system is equipped with an AC ground detector. If the system is supplied with a ground test wand, then a DC ground detector is also provided along with a ground selector switch. Each has a separate function to perform in the system. The AC ground detector is operational when the Ground Selector Switch is in the RUN mode, and is used to monitor leakage current to ground as described below. The DC ground detector is operational with the Ground Selector Switch in the TEST mode (when power is off), and is used to ensure that the bath is at ground potential, as well as to monitor water conductivity and refractory condition. This section of the Instruction Manual describes the operation of the AC ground detector. For operation of the negative high voltage DC (NHVDC) ground detector, see the DC ground detector section of this manual.

#### WARNING:

It is essential that the bath be electrically tied to ground to avoid possible electric shock when inadvertently inserting tools into the molten metal with power on.

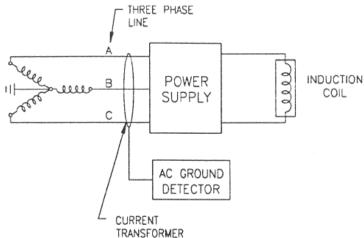
Do not slag, charge, scrape, check for grounds, or in any way make electrical contact with the molten metal bath while power is on.

When it is necessary for an operator to make contact with the charge of a potentially live furnace, insulating gloves suitable for working with electrical equipment of the same potential as the coil or higher, must be worn.

The introduction of a ground detector circuit, be it AC or DC, is by no means intended to make the induction equipment operator safe. The purpose of a ground detector circuit is to monitor leakage current to ground in order to provide some degree of protection against catastrophic equipment failure from high ground current. With the presence of leakage currents typical in industrial environments, such as caused by cooling water, wet refractory, etc., the detection of human body resistance is virtually impossible. See also the Safety Devices section of this manual.

#### The AC Ground Detector

The AC ground detector operates in a manner similar to a Ground Fault Interrupter (GFI) used in many residential applications, but with two major differences. First, the AC ground detector operates faster than a residential GFI. Second, whereas the residential GFI monitors a single phase, the AC ground detector monitors a three phase line. Sketch #1 shows how this is accomplished.



Sketch #1

A single current transformer (CT) is installed around all three incoming phases. The output of this CT is therefore a current which is proportional to the sum of the currents on the three phases. With no ground leakage, any current entering the power supply on one of the phases, must return on one of the other two phases. The net current through the CT is thus zero, with no ground leakage.

In the presence of leakage current to ground, the sum of the three phase currents is no longer zero, and the CT puts out a signal to the ground detector circuit board.

In order for this circuit to operate, the incoming three phase line supply must be derived from a wye connected secondary of a supply transformer with an earth grounded neutral. This grounded neutral is the **first** ground on the system. The function of the AC ground detector is to detect a **second** ground on the system.

A ground current meter gives an indication of leakage current to ground. The meter reading is fairly linear with increasing leakage current, but does however vary with power supply output voltage, since this output voltage is the driving force for the leakage current. In TEST mode, the same meter is used to monitor the DC ground detector. Comparing meter readings from the AC ground detector and the DC ground detector can yield useful information about the furnace condition.

The AC ground detector is operational at all times, except when the Ground Selector Switch (if used) is in the TEST mode. When high frequency power is off, a contactor grounds the load through a 20 ohm resistor and circuit breaker. The circuit breaker in series with the resistor limits the voltage to ground in the event of a component failure, while the 20 ohm resistor offers enough impedance in the ground path that the AC ground detector can still be used to actively monitor the circuit.

When power is off, the Ground Selector Switch may be put into the TEST mode, which opens the load grounding contactor and activates the DC ground detector.

When the AC ground detector detects a second ground on the system, contacts on the circuit board stop the inverter then trip the main breaker undervoltage release (UVR) disconnecting the power supply from the line. The small circuit breaker in series with the 20 ohm grounding resistor also has auxiliary contacts which will trip the main breaker UVR. If the main breaker trips, the following steps should be taken in the order listed.

- 1. Make a visual observation of the load. With an ohmmeter, check the furnace and output bus for possible grounds.
- 2. Reset the ground detector. If the main breaker enable light is not on, open the cabinet door and check the small circuit breaker in series with the 20 ohm resistor. If this is tripped, troubleshoot the power supply for shorted components.
- 3. If the system has a DC ground detector, put the Ground Selector Switch into TEST mode. Use the DC ground detector to check for a ground condition in the load. (See the DC ground detector section of this manual).
- 4. Close the main breaker. If the AC ground detector immediately trips again, disconnect the load, reset the ground detector, and close the breaker again. If the breaker still trips, the problem is inside the power supply. If the breaker does not trip, the ground problem is in the load. Be sure to reconnect the load before trying to turn on high frequency power again.

If the ground condition is not immediately apparent, consider the following.

a. Is there alot of metallic dust or chips lying in the area? This can create a ground path of low enough resistance to trip the ground detector, especially if the area has gotten wet along with the metallic dust or chips. The area around the furnace and bus should be kept reasonably clean and dry.

- b. Have there been electrical arcs which could carbonize insulation material? Often, an arc will blacken insulation and cause it to become a conducting path to ground.
- c. Is the refractory wet? Damp refractory will increase leakage current, but will not generally trip the ground detector. However, the increased leakage current can combine with other ground current sources to trip the ground detector.
- d. Does the water conductivity meet the requirements specified in the water section of this instruction manual? Increased water conductivity will again increase leakage current and may combine with other ground current sources to trip the ground detector.
- e. Has any hose been replaced on the equipment? If cooling hose which is conductive has been introduced into the system, it will increase the leakage current, and again may combine with other sources of ground current to trip the ground detector. Cooling hose must be nonconductive. The inside layer of the hose must read infinity across a 1 mm distance when using a Simpson meter. Also, short pieces of hose will increase leakage current. As a rule of thumb, hoses should be at least 36" long.

While the AC ground detector will have some response to high water conductivity, conductive hose, or wet refractory, it is much less sensitive than the DC ground detector to these types of leakage current. The DC ground detector should be checked periodically to monitor these items.

After correcting the ground condition, put the Ground Selector Switch back to RUN mode, and energize the unit at minimum power. Turn the power up slowly, watching the ground current meter.

In order for the AC ground detector to detect a ground in the furnace, it is imperative that the bath be grounded. The integrity of the ground probes should be checked periodically using the DC ground detector.

A built-in diagnostic test circuit may be triggered, either from an external or circuit board located test pushbutton, to send a slug of current out through a CT test loop. When fired, with high frequency power either on or off, this slug of current is of sufficient magnitude to appear at the detector input as a ground fault. Thus, nearly the entire operation of the AC ground detector may be verified at any time.

#### Theory of Operation

The AC ground detector is designed to sense neutral referenced differential AC ground fault current (stepped down by the CT) through a series connected pair of center-tapped (to circuit board ground), 5 ohm burden resistors. Note that an earth grounded neutral of a Wye-connected secondary (or equivalent thereof) must be provided directly on the line upstream of the unit. This serves as the first ground on the system. With reference to schematic U-02-0967, the fault current is seen as being represented by an AC voltage signal.

Full-wave rectified and clipped at 12 volt zener diode D5, a representative (raw DC) voltage signal now appears both at the (+) input to a LM311 voltage comparator, IC U1, and op-amp, IC U2. Also, at the comparator (-) input (U1-3), is a voltage reference fixed at .53 VDC. If, after the detector has been reset, the peak voltage level of the representative (raw DC) signal (U1-2) exceeds the fixed reference voltage (U1-3), a high going (fault) signal will appear at the comparator output (U1-7). This will extinguish relay K1, the green Reset LED, and the detector output 4N37 optoisolator, IC U6. Q1 transistor and the red Fault LED turn on. IC U1 is then latched as the result of negative bias applied at its reference via opto-isolator IC U5. IC U1 may be unlatched by virtue of a dominant positive bias being applied at U1-3 through either the actuation of the circuit board pushbutton PB2, or the (U4) optically isolated external Reset pushbutton, provided the actual fault has been cleared. When U1 is unlatched and no fault exists, the opto-isolator U6 output is on (conducting) and the signal, as blocked by diode D4 to the power supply control, is allowed to go to a logic low. When U1 is latched and there has been a fault, IC U6 is off and the signal to the power supply logic is momentarily driven high by application of its +15 (logic) voltage, through resistor R12, and coupled by capacitor C17. See Sketches 7 and 8.

Solely for the sake of the CT Test Loop circuit, a filtered zener regulated +30 volt DC supply is created at R5 and D15 and appears charged at the anode of SCR Q2. When either circuit board pushbutton PB1 or U3 optically isolated external test pushbutton is actuated, a signal is applied to the gate of Q2 through resistor R6. At this time, Q2 is fired and a discharge pulse slug of current is directed through the CT Test Loop. C3 and C4 electrolytic capacitors must now recharge through R5. The associated RC (charge) time constant dictates a 30 second delay prior to any re-firing of Q2. R33 and C16 provide an SCR snubber circuit, and inductor L1 insures the reset of Q2. The red Test LED D9, through R15, blinks to indicate Q2 has fired.

The gain of the non-inverting meter Op-Amp circuit, chiefly comprised of IC U2, is figured to deliver 0-5 ma through R35 to the monitor meter when AC ground leakage current ranges between .05-.90% of maximum (110% base) I-Line amps.

A time delay off relay K2 is provided mainly for an interface between the power on signal from the control logic and the external power output bus grounding contactor R1. The K2 relay also serves as a permissive signal for when the UVR circuit may be tripped as the result of an AC ground fault.

#### Description of Operation

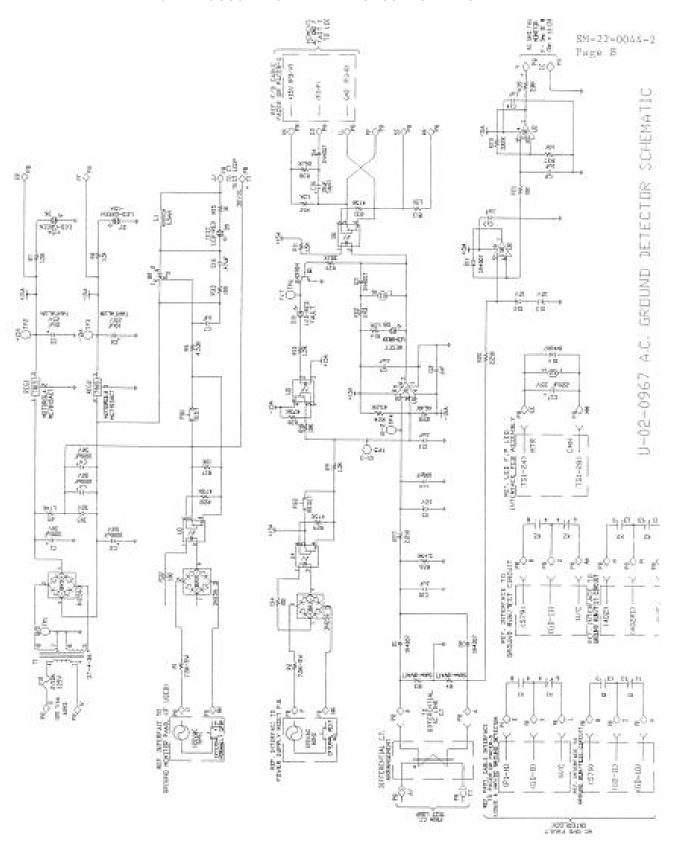
Based on the ability to continuously monitor the three phase, 60 Hz differential line current, the AC ground detector is designed to sense neutral referenced AC ground fault current. Sent directly to the power supply logic, via the F/B cable, is an optically isolated momentary ground fault signal which occurs at a sensed threshold of 1.45 Vrms across the input to burden resistors. Also available to the protection cable is a back-up latched relay signal. The AC ground detector signal is annunciated as a ground fault on the power supply front panel. The detector induces the shutdown of the power supply within a fraction of a cycle of the power supply high frequency output, in order to limit the build-up of fault energy. Thus, the power supply and transformerless system are protected. Once the fault has cleared and with high frequency power off, the detector may be reset, either externally (at the power supply Power Off/Reset pushbutton) or from a pushbutton PB2 (typically used for bench test) located on the circuit board.

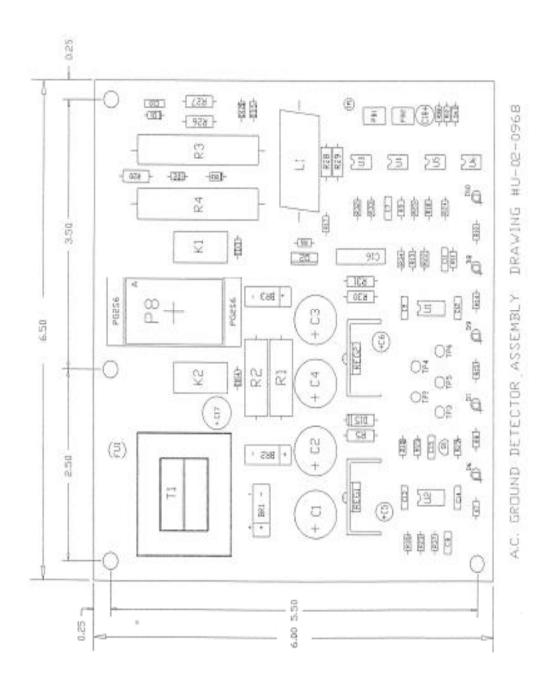
An external 0-5 maDC ground current meter output is provided for the purpose of monitoring relatively low levels of AC leakage current that may exist prior to an actual AC ground fault.

Provided are test points for: GND, FLT, +15A, -15A (voltage

supplies); U1-3 (reference); and U1-2 (signal). Also provided are five on-board LED's: +15A (green), -15A (green), Reset (green), Fault (red), and Test (red). All wiring to and from the circuit board is directed through a 38-pin Elco connector, P8 keyed as PG2S6. With the elimination of pots and thus set-up procedures, the assembled AC ground detector requires only a simple test procedure.

In the event of a ground fault indication, before attempting to go through the test procedure, carefully examine the system to ensure that there is not in fact a ground condition.





# U-02-0988 TEST PROCEDURE FOR AC GROUND DETECTOR SC #75401A25

#### I. Equipment Required

- A. Volt-Ohm meter capable of measuring 250 VAC and 250 VDC.
- B. Elco connector SC #38821A05, Pins SC #38884A00.
- C. Power cord, Belden #17406 or equivalent.
- D. Variable power supply, 0-5 VDC @ 500 ma.
- E. Various jumpers complete with test clips.

#### II. Procedure

- A.With caution, apply 120 VAC + 10% input to P8-D and P8-W. Green power supply LED's, D6, +15A; and D7, -15A, on.
- B.Press PCB Reset pushbutton, PB2. Green Reset LED, D8, on. Red Fault LED, D10, off.
- C.Jumper P8-JJ to P8-TT.
- D.Measure within the range +.23 to +.84 VDC at T/P U1-3, as referenced to T/P Gnd. Measure +15 VDC +2% and -15 VDC +2% respectively at T/P's +15A and -15A as referenced to T/P Gnd. Measure zero VDC at T/P U1-2.
- E.Fire CT test loop by pressing PCB Test pushbutton PB1. Red Test LED, D9, blinks momentarily.
- F.Apply +2.75 VDC @ 300 ma from P8-A to P8-B. Relay K1 should become de-energized. Red Fault LED, D10, on. Green Reset LED, D8, off. K1 relay contacts should change state. See schematic U-02-0967 to verify this.
- G.With the conditions of Step F above, measure LM311 voltage comparator reference once again. Measure -9.70 VDC +10% at T/P U1-3 as referenced to T/P Gnd.
- H.Remove +2.75 VDC supply from P8-A and P8-B. While exercising caution, momentarily apply 120 VAC +10% across P8-P and P8-NN to reset the detector. Green LED D8, Reset on. Red LED D10, Fault off.
- J.Jumper +15A T/P to P8-KK. Jumper Gnd T/P to P8-SS.

K. Measure the following levels as referenced to T/P Gnd:

+4.0 to +10 VDC from P8-DD +.10 to 1.2 VDC from P8-PP Zero VDC from P8-RR and P8-LL

- L.Apply -2.75 VDC @ 300 ma from P8-A to P8-B. Detector should become tripped once again as described in Step F above.
- M. Measure the following levels as referenced to T/P Gnd:

+14.70 VDC +5% from P8-DD +15.00 VDC +5% from P8-PP Zero VDC from P8-RR and P8-LL

- N.Measure 14.40 VDC +5% from P8-Y to P8-CC.
- O.Using ohm meter, verify that the de-energized relay contact states at P8-E, -X, -L, -R, -Z, and -V are as indicated on schematic drawing.
- P.Change supply level from -2.75 VDC to +0.19 VDC as in Step L above. Press reset pushbutton PB2. Measure +3.0 VDC +10% from P8-Y to P8-CC.
- Q.While exercising caution, momentarily apply 120 VAC +10% across P8-U and P8-HH to fire CT test loop. Red test LED, D9, blinks momentarily.
- R.Using ohm meter, verify that the energized relay contact states at P8-E, -X, -L, -R, -Z, and -V are opposite that indicated on schematic drawing.
- S.Apply +24 VDC from P8-EE to P8-MM. K2 relay should become energized. Verify that energized relay contact states at P8-R, -Z, -AA, -N, -M, and -T are opposite that indicated on schematic drawing.
- T.Remove +24 VDC from P8-EE to P8-MM. K2 relay should be deenergized after a delay of approximately 1 second.
- U.Remove Elco connector, 120 VAC, DC power supply and jumpers. This concludes the test procedure.

#### **SAFETY DATA SHEETS**

(FORMERLY MATERIAL SAFETY DATA SHEETS)
SU-22-0002
REVISION 05
04.16.04

AJAX TOCCO MAGNETHERMIC 1745 OVERLAND AVE N.E. WARREN, OHIO 44483

TELEPHONE: (330) 372 8511 FAX: (330) 372 8608

#### SAFETY DATA SHEETS (SDS)

Although Ajax TOCCO Magnethermic Corporation is not a chemical manufacturer or importer, we do provide SDS sheets (formerly MSDS sheets) for all items identified as hazardous materials in the form as supplied to you. These data sheets as required are sent under separate cover to the attention of the plant manager/safety director of the "ship to" address on your purchase order, unless otherwise specified. That person should be aware of worker "right to know" laws and the OSHA Hazardous Material Communications Standard.

If you re-sell or re-distribute any of the hazardous materials, you should provide a copy of the appropriate SDS, or MSDS, and warning labels to the recipient advising them of their obligation to communicate the information provided.

Ajax TOCCO Magnethermic Corporation also has on file SDS and/or MSDS sheets on materials not considered hazardous in the finished form supplied in our equipment. If you desire to have copies of SDS sheets for any of these materials supplied to you by Ajax TOCCO, please send your request in writing, stating what materials you are interested in, to Ajax TOCCO Magnethermic Corporation, 1745 Overland Avenue N.E., Warren, Ohio 44483, Attention EHS Manager.

#### COIL SAFETY

- 1. Where Ajax Tocco supplies a complete system, mechanical guards are generally provided to prevent accidental contact with moving parts as well as high voltage connections. Where Ajax Tocco supplies only components as a part of an overall system, guarding is to be supplied by the purchaser. In some installations, an entire area is fenced off and restricted rather than individually guarding pieces of equipment. It is the responsibility of the purchaser to ensure that all guards provided by Ajax Tocco are installed before operating the equipment and to supply any additional guarding required.
- 2. It is possible for a tuned resonant circuit to pick up energy broadcast through the air. If the broadcast frequency is close to the tank circuit resonant frequency, the tank circuit voltage can ring up to quite high levels. Therefore, if there is equipment nearby capable of broadcasting high frequency energy, such as another induction system, then both legs of the bus must be grounded before working on the coil.
- 3. Water cooled equipment is not to be energized without adequate water flow.
- 4. Per Article 665 of the National Electrical Code (NEC), induction heating and melting equipment is not to be installed in hazardous locations as defined in Article 500 of the NEC. As induction power supplies, heated parts, or molten baths can be a source of ignition, flammable fluids should not be used around induction equipment.
- 5. Interlocks and safety devices must be maintained in working order. It is the responsibility of the purchaser to ensure that all safety devices are operable. Equipment is not to be operated unless all safety devices, interlocks, and guards are installed. These must not be removed, jumpered, or disabled in order to operate the equipment.

7/9/92 SH-22-0025-1 SHEET 1 OF 1 REVISED: 8/17/03 SKH-12-0013-3

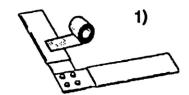
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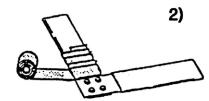
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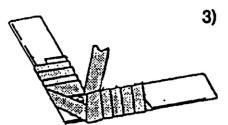
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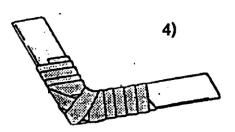
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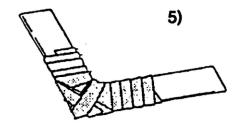
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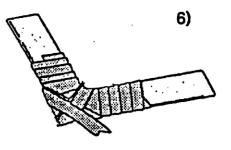


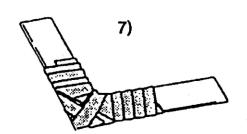










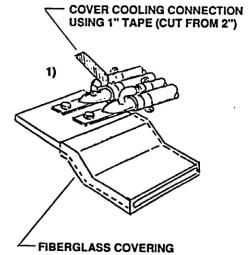


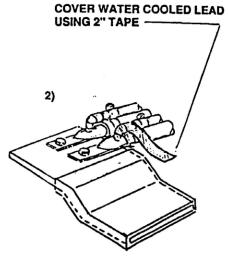
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10"	52FT

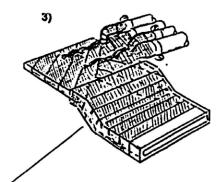
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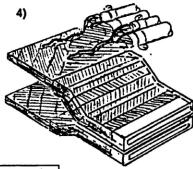
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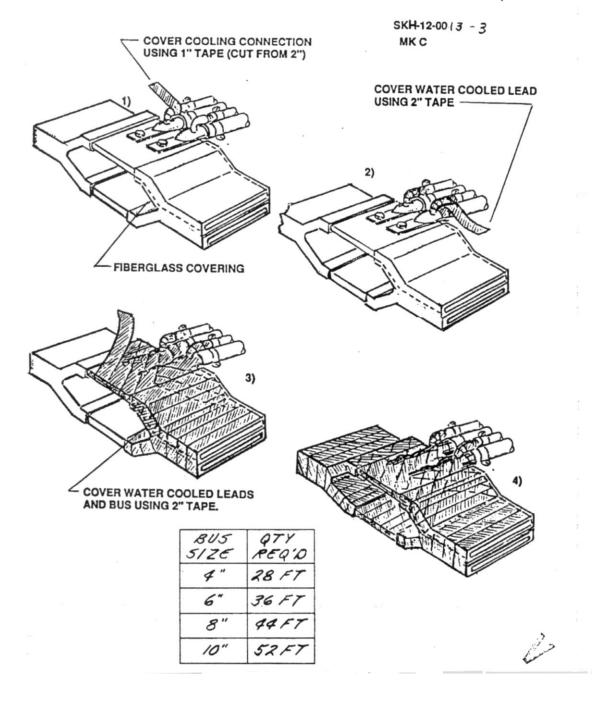


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8"	36 FT
10"	42 FT





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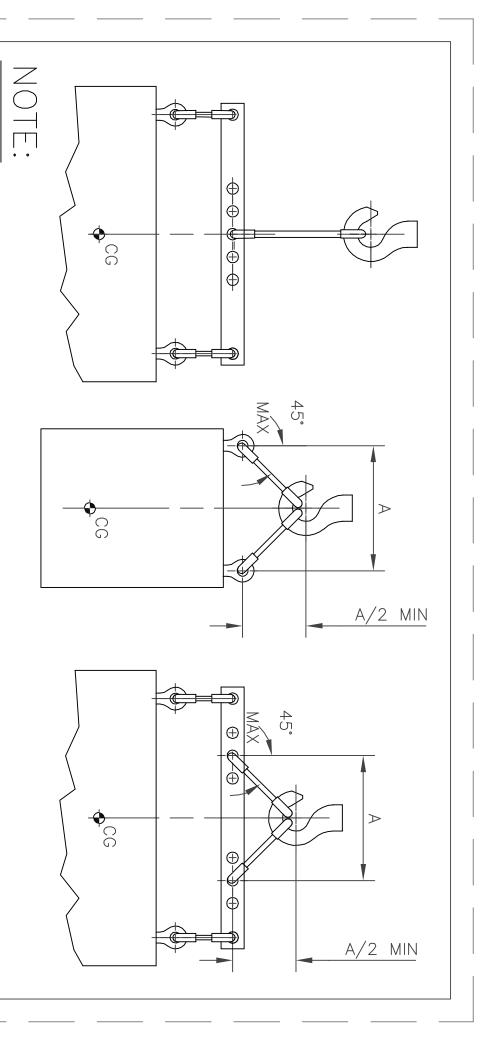
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LIFTING INSTRUCTIONS THE HORIZONTAL COMPRESSIVE PROVIDE THE VERTICAL LIFT. THIS IS NECESSARY ON LONG LINEUPS TO REDUCE BETWEEN THE LIFTING COMPENSATE FOR UNEQUAL WEIGHT DISTRIBUTION USE SPREADER OR SPANNER BARS AS ETWEEN THE LIFTING CABLES VERTICAL MUST NOT EXCEED TENSION AND COMPRESSIVE AJAX MAGNETHERMIC LOAD. ADJUST THE (OR CHAINS OR 45 DEGREES TO /E LOAD ON SECTIONS. CORP

WARREN, OH. DRN.

DATE: DWG. NO.SU13-0002-

BY: RJK

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# AJAX TOCCO MAGNETHERMIC CORPORATION

# INSTALLATION CHECKLIST - PACER & PACER HF & RF

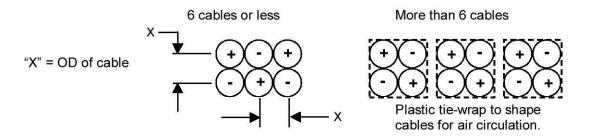
# ELECTRICAL

1.	Is all el # <u>H-02-</u>	ectrical interconnection complete per ATM Drawing 12424?						
2.		frequency interconnection (cables, bus, water-cooled been installed in accordance with SU-02-0029?						
	NOTE:	5 KV Belden (No. 8866) cable may be used for high voltage feedback wires #11 and #12.						
3.	Are guard	s installed?						
4.	Have 3 phase supply lines been connected to the frequency converter main breaker?							
	NOTE:	Phase rotation must be A, B, C, left to right, across the top of the breaker.						
5.	Are cabin	ets properly grounded?						
WATE	<u>R</u>							
6.	Is water	piping complete per ATM Drawing # <u>H-03-10897.</u>						
	NOTE:	Piping should be sized to allow adequate differential at each system component. Flush lines before connecting to equipment. Please read water instruction manual (WIM-1) before installing. Be sure to read directions for site selection and installation supplied with evaporative cooling towers.						
7.	Are strai	ners installed in supply lines?						
8.	Has inter	connecting piping been checked for leaks?						
9.	Has syste	m water pump been checked for rotation?						
10.	Are all h	ose clamps non-magnetic?						
11.	Is all ho	se non-conductive?						

AUTHOR: RRL REVISED: 8/2/99
APPROVER: PMH SU-22-0006-6
2/12/93 SHEET 1 OF 1

# **HIGH FREQUENCY POWER WIRING NOTES:**

- 1. Power cables to be run in open air or non-magnetic conduit or cable tray.
- 2. Wiring losses and voltage drop are dependent upon cable geometry and spacing. To minimize voltage drops, all cables (except air cooled coax) are to be close spaced, interleaved, and polarized as shown below. If larger voltage drops are required, the spacing and orientation of the cables may be different.



Cables should not be used that exceed the following diameters.

Cable Size	OD (inches
1/0	.550
2/0	.600
4/0	.752
262 MCM	.802
350 MCM	.900
535 MCM	1.140
750 MCM	1.270

- 3. Voltage rating of conductors and number of conductors needed per leg in open air or conduit is specified on the electrical interconnection diagram, as well as ampacity.
- 4. Temperature rating of cables is to be 85° C or higher.
- 5. Running a large quantity of cables in separate conduits is permitted only after consultation with Ajax engineering for possible effects of added losses.
- 6. If <u>any portion</u> of a continuous run of cable is run underground or in conduit, the given cables must be sized for conduit operation @ 73% of open air rating.
- 7. Shielded cable is to be <u>avoided</u> in high frequency power cables.
- 8. Plain strand or extra-flex cable is acceptable. Outer diameter of copper should be as great or larger than cable specified in the National Electrical Code. Note that some new processes that compress copper strands into compacted diamond shape resulting in full "MCM" rating at lower cable OD will not work as well as a full stranded cable at high frequencies. See Table 8, NEC.
- 9. 30° C ambient is assumed in all cable selections. Consult Ajax engineering for derating at higher temperatures.
- Power cables should not be routed near handrails, building columns, etc. Maintain a minimum of 8 inches (200 mm) clearance between power cables and structural steel when cables are close spaced and polarized as shown in Item
   If the spacing between cables is greater or the cables are non-polarized, then the minimum clearance will exceed 8 inches.
- 11. If air cooled coaxial cable is used, maintain at least one inch (25 mm) air space around each cable for cooling.

Author: KEB Revised: 5/03/00, 10/12/00
Approver: RRL SU-02-0029-02
12/04/92 Sheet 1 of 1

# AJAX TOCCO MAGNETHERMIC CORPORATION

WATER REQUIREMENTS												
		IMUM R FLOW	MAXIMUM INLET TEMP.		TEMPERATURE RISE		1000 BTU/HR=1	CONDUCTIVITY MICROMHO/CM		APPROXIMATE CAPTIVE WATER		
EQUIPMENT	LPM	GPM	°C	°F	°C	°F	MBH HEAT LOAD (MBH)	MIN.	MAX.	LITERS	GAL	% GLYCOL BY VOLUME
ZONE CONTROL HEATING SYSTEM	945	208	40	105	13.8	7.1	628.4	50*	100*	284	75	30
TOTALS	945	208	40	105	13.8	7.1	628.4	50*	100*	284	75	30

NOTE: FLOWS TO BE AS SHOWN +10%, -0%

SU-22-0047 10/27/95

- \*SEE POWER SUPPLY SECTION OF THIS MANUAL FOR CONDUCTIVITY REQUIREMENTS OF WATER THROUGH POWER SUPPLY
- \*\*SHEET INCLUDES ALL ONLINE AND OFFLINE COMPONENT
- \*\*\*DATA NOT INCLUDED IN TOTALS(BOTH SIZES OF COILS WILL NEVER RUN AT THE SAME TIME)

# INSTALLATION, OPERATION, AND MAINTENANCE OF THE WATER SYSTEM SU-22-0077 REVISION 06

05.12.09

AJAX TOCCO MAGNETHERMIC 1745 OVERLAND AVE N.E. WARREN, OHIO 44483

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Gallons per Lineal Foot

Methods 1 - 4

# **CONDUCTIVITY CONSIDERATIONS**

#### INTRODUCTION

Water has been used for many years by induction heating and melting industries as the least expensive and most effective medium for transferring electrical losses in the form of heat. In recent times, however, high quality industrial water has become more valuable. The water system should be given as much planning and consideration as any other part of the installation.

It is the object of this manual to describe the water system used with induction equipment, to provide a <u>minimum</u> set of design parameters which the systems must meet, to describe the effects of water quality, and to set minimum water quality standards.

The water must be clean, since debris tends to clog the small cooling passages in the electrical parts. Strainers are to be located during installation at each component inlet. Water must be supplied continuously at the required differential pressure and rated unit flow for each piece of equipment. Peaks of water demand elsewhere in the plant must not rob the equipment of supply.

Water temperatures as listed should be observed. It should be noted that very cold inlet water causes condensation to form on the water-cooled electrical components. If condensation forms on a coil or other electrical components, it increases the chances of arcing.

The effort expended now on your cooling system will be paid back many times over the years. Please feel free to call upon Ajax Tocco Magnethermic (ATM) for any assistance you may require.

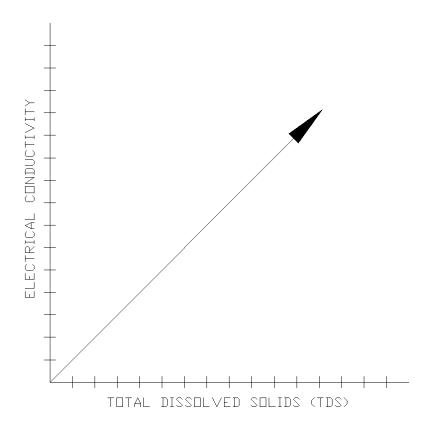
# **EFFECTS OF WATER QUALITY**

The three detrimental effects of poor water quality in equipment cooling paths are: reduction of the heat transfer and subsequent damage to the components from overheating, electrochemical corrosion of tubing, and degradation of the electrical performance of the equipment because of cooling water with high electrical conductivity. All three of these effects are directly related to impurities in the water.

A reduction in the heat transfer in the water-cooling path may be caused by scale formation, fouling due to products of corrosion, or fouling due to biological growth. When this fouling does occur, in order to maintain the same heat transfer rate, the temperature difference between the water and the component must increase. As the fouling continues to build up, the temperature increases until the component fails. This process is further aggravated by the reduction of water flow due to a reduction in the cross sectional area of the path.

Electrochemical corrosion is the deterioration of solids by liquid electrolytes. In this case, the electrolyte is the contaminated cooling water, which attacks the metal components in the system. Under severe corrosive conditions the components can corrode or "rust" through in less than a year's time.

High electrical conductivity is directly proportional to the amount of dissolved solids in water. Resulting problems are the distortion of the electric control signals to solid-state devices and the desensitizing of the ground detector circuits.



# WATER CHARACTERISTICS

# **DEFINITIONS**

<u>CORROSION</u> is the destructive attack of a metal by electrochemical reaction with its environment. A current (called corrosion current) flows through the electrolyte (the cooling water). Corrosion occurs where current enters the electrolyte from the metal, which is the anode. Flow of corrosion current can be caused either by an externally applied voltage, such as inside a power supply, or by the voltage due to galvanic action from non-uniformities in steel piping.

**EROSION** is deterioration caused by physical means such as high water velocity (greater than 8-10 feet per second (2.5-3 meters per second)).

**ELECTROLYSIS** is the separation of an electrolyte into its constituents by passing a current through it. Some people mistakenly use this term to mean corrosion.

**CONDUCTIVITY** is the most important characteristic of cooling media for induction systems. It is measured in micromhos/cm or microsiemens (uS/cm). Minimum and maximum limits for conductivity vary with the specific type of equipment; exact requirements can be found in the separate Water Requirements section of your instruction book.

TOTAL DISSOLVED SOLIDS (TDS) refers to the amount of ions in the water. This is generally measured in parts per million (milligrams per liter). Since ions are good charge carriers, higher total dissolved solids means higher conductivity water. In fact, total dissolved solids and conductivity are so closely related, that quite often dissolved solids will be reported on a water analysis, when the actual measurement made was micromhos/cm of conductivity. This is done because conductivity is very easy to measure with a simple meter. Sometimes total dissolved solids is reported as grains per gallon. To convert this to parts per million, multiply by 17.1.

# RELATIONSHIP OF TOTAL DISSOLVED SOLIDS, HARDNESS, ALKALINITY, CONDUCTIVITY

While there are often trace amounts of various minerals in water, three cations (calcium, magnesium, and sodium), and three anions (bicarbonate HCO<sub>3</sub>, sulfate SO<sub>4</sub>, and chloride CI) account for nearly all impurities in water. These ions can be combined in nine possible ways. The nine compounds and their effects are as follows:

# <u>TOTAL</u>

# <u>DISSOLVED</u>

<u>SALT</u>	<u>HARDNESS</u>	<u>ALKALINITY</u>	<u>SOLIDS</u>	<u>CONDUCTIVITY</u>
Calcium Bicarbonate	Yes	Yes	Yes	Yes
Magnesium Bicarbonate	e Yes	Yes	Yes	Yes
Sodium Bicarbonate	No	Yes	Yes	Yes
Calcium Sulfate	Yes	No	Yes	Yes
Magnesium Sulfate	Yes	No	Yes	Yes
Sodium Sulfate	No	No	Yes	Yes
Calcium Chloride	Yes	No	Yes	Yes
Magnesium Chloride	Yes	No	Yes	Yes
Sodium Chloride	No	No	Yes	Yes

<u>HARD WATER</u> refers to water that contains magnesium or calcium ions, which combine with fatty acids in most soaps to produce an insoluble precipitate. <u>SOFTENING</u> water (an ion exchange process) just replaces these ions with sodium. The sodium fatty acid compounds are soluble. This does not change the conductivity. Lowering the conductivity requires removing the ions (ion absorption process) through the use of a deionizer (also called demineralizer).

Whereas a deionizer removes minerals from water, distillation removes water from minerals. Distillation kills organic matter, but there is no practical difference between distilled and deionized water as used in induction systems.

Since calcium bicarbonate gives water both hardness and alkalinity, it is by convention in the water treatment industry to report "hardness as CaCo<sub>3</sub>" or "alkalinity as CaCO<sub>3</sub>". In practice, most of the hardness really is from calcium carbonate, which is nothing more than dissolved rocks. (Carbonates, CO<sub>3</sub>, are insoluble in water. In the presence of carbon dioxide however, carbonates are transformed into bicarbonates (HCO<sub>3</sub>), which are soluble. When water is evaporated in analyzing the impurities, carbonates are obtained when the actual impurities were present as bicarbonates.)

# **EFFECTS OF IMPURITIES**

# **CONDUCTIVITY**

High total dissolved solids cause high conductivity. If DC potentials are present in induction equipment, high conductivity water will lead to corrosion of pipe nipples. High water conductivity can result in nuisance ground detector tripping, and in distortion of control signals. In induction systems, water is intended to be a coolant, not a current path.

# **HARDNESS**

The solubility of calcium bicarbonate in water depends on pH, alkalinity, and temperature. If the water is over saturated with calcium bicarbonate, calcium carbonate will form on the piping interior. This deposited scale will restrict water flow and decrease heat transfer. This is particularly detrimental because the scale will tend to be deposited on those surfaces that are already the hottest.

# **SUSPENDED** SOLIDS

Solids that are insoluble but remain in suspension due to turbulence of water, are termed suspended solids. These solids may accumulate in cooling system equipment, particularly low points, causing clogging and reducing heat transfer. Suspended solids in makeup and circulating water may be removed by filtration. Small side stream filters at the pump are generally very effective.

# **ACIDITY**

Occasionally water will be encountered that contains a large amount of free mineral acid. Acidity is evidenced by effervescence when in contact with carbonates. This renders the water quite corrosive. When a standard determination of pH indicates an acidic condition, the water should be neutralized with an alkaline agent until it falls within the allowable limits. The measure of pH of a solution is a measure of the acidity of the solution. Acid solutions have a pH less than 7.

# **ALKALINITY**

In circulating water-cooling systems, alkalinity is one of the major factors contributing to the precipitation of calcium carbonate as scale. In general, the higher the alkalinity, the greater the tendency for scale to form and the higher its acid-neutralizing power. If the alkalinity is determined to be in excess, treatment of the water with acid may be necessary.

# **SLIME AND ALGAE**

Biological fouling can often occur in once-through and open recirculating systems. It is formed by the excessive growth or accumulation of lower forms of plant life, i.e., algae, fungi, and bacteria. Non-chlorine type of chemicals may be used for control of these growths to avoid loss in heat transfer and to minimize biological fouling on metal surfaces. The growth of organisms on piping creates differential oxygen concentration cells that result in serious pitting of the metal surfaces. Closed systems seldom, if ever, suffer from this type of fouling.

# **DISSOLVED OXYGEN AND CORROSION**

Corrosion is accelerated by dissolved gases such as oxygen, ammonia, carbon dioxide, or sulfur dioxide; dissolved solids, and high temperature. The gases mentioned cannot be removed by mechanical means because they tend to ionize in the water.

A thin deposit of calcium scale will effectively reduce corrosion, but the amount of deposit is difficult to control and the scale will reduce both water flow and heat transfer. A measure of corrosiveness of water is the Langelier index. The Langelier saturation index is the difference between the actual pH of a sample, and the pH the water would have if it were exactly saturated with calcium bicarbonate. If the Langelier index is positive, the water deposits calcium carbonate on the piping. If the Langelier index is negative, the piping will be corroded in the presence of dissolved oxygen.

It is worth noting that in most cases of severe corrosion, oxygen is the main contributor. Oxygen dissolves in water in proportion to its partial pressure in air. Therefore, all water that has been in contact with the atmosphere contains dissolved oxygen. All Ajax supplied water systems include air separation to remove entrained air to prevent it from becoming dissolved. For the same reason, it is important to install automatic air vents (Spirotherm #SPIROTOP VTP050FT or equivalent) onto stand pipes at all high points in the interconnecting piping where air may accumulate when the system is initially filled or refilled after water loss.

Where corrosion is a possible problem, ATM recommends one of two methods for removing dissolved oxygen from the water. For small systems, an oxygen removal ion absorption cartridge can be used in a side stream around the pump. These are available as an option from ATM. For larger systems, ATM recommends a chemical treatment package that includes an oxygen scavenger. For more information on this, see the startup procedure, or contact the ATM Service Department.

Another major contributor to corrosion problems is leaks. Dissolved oxygen in the system will combine with the piping to form corrosion products, but the reaction will quickly stop when the supply of dissolved oxygen is used up. Constant additions of makeup water or opening of the system introduces more dissolved oxygen, which continues the process. If the system is not tight, neither a cartridge treatment nor a chemical treatment will be effective.

An ion absorption cartridge should not be used in the recirculating system if chemical treatment is used. The cartridge will absorb the chemicals, and the chemicals will deplete the cartridge. If chemical treatment is used, it is recommended that the ion absorption cartridge be placed on the makeup line to minimize the requirement for chemicals.

Chromates and nitrates should not be used for corrosion control because they increase the electrical conductivity of the water beyond allowable limits. For the same reason, sodium sulfite should not be used as an oxygen scavenger. Phosphates should also not be used, since in the presence of high calcium concentrations they will precipitate as a sludge.

# WATER QUALITY REQUIREMENTS

Many types of water systems are suitable for use with induction equipment as long as the quality of water that is used in the system meets the following recommended specifications.

Various additives could be used in a cooling system for pH control, freeze protection, corrosion prevention, etc. The following standards apply to the total system cooling fluid, including these additives and not just the water.

# COOLING FLUID CHARACTERISTICS

In order to obtain satisfactory operation over an extended period of time, the following fluid characteristics should be met.

- I. Maximum total hardness as CaCO<sub>3</sub> 100 ppm
- 2. Maximum total dissolved solids 200 ppm
- 3. Maximum electrical conductivity 300 micro mho/cm\*
- 4. Minimum electrical conductivity 100 micro mho/cm\*
- 5. Maximum pH 9.0
- 6. Minimum pH 7.0
- 7. Maximum suspended solids 10 ppm
- 8. No traceable ammonia
- 9. No traceable oxygen

\*NOTE: Solid state power supplies with D.C. links require water conductivities between 20 and 50 micro mho/cm (deionized water mixed with 30% ethylene glycol). See the water requirements section of your instruction manual for specific conductivity requirements for your equipment. If needed, this can be accomplished by providing a separate deionized water system for the power supply, or by deionizing and treating the whole system. However, if your system contains ferrous components, this option is not available. Please contact ATM @ 1-800-547-1527 and ask for the Service Dept. for assistance.

# **SYSTEM CHARACTERISTICS**

The cooling system shall be designed so that the ATM supplied equipment requiring cooling water is provided with:

- 1. A maximum inlet temperature as specified on the water diagram drawing.
- 2. A minimum inlet temperature above the dew point to avoid condensation.
- 3. Flow as specified on the engineering water diagram drawing or on the equipment installation drawing.
- 4. A maximum pressure of 70 psig (480 kpa) at inlet to equipment. Pressures greater than 70 psig may cause leaks at hose connections.
- 5. Supply and drain piping designed for a flow velocity ranging between 4 ft./sec. and 7 ft./sec. (122 cm/sec. and 213 cm/sec).
- 6. Automatic air vents (Spirotherm #SPIROTOP VTP050FT or equivalent) inserted at all system high points, i.e., at any point where air is likely to become trapped.

#### **EQUIPMENT**

Many types of water systems are available, but they fall into three broad categories; open, closed, and sealed.

# OPEN

In an open system, water is in intimate contact with the atmosphere. An example of this would be a system with an open evaporative cooling tower.

The open water recirculating system is not recommended for use directly on induction equipment, but is often used as a source of raw water. Since the system is open to the atmosphere, oxygen is dissolved into the water, increasing the corrosiveness of the water.

As water is evaporated from the system, more water has to be added for makeup, which causes an increase in the hardness and an increase in the conductivity of the water. Periodic blow down of the system to drain off part of the water, thus reducing the concentration of solids, is required.

As the water becomes harder it causes scale to build up on the inside of the water-cooling tubes and hoses. This buildup restricts the water flow and also insulates the cooling water from the equipment to be cooled. This causes the equipment to run hotter. It also causes the rubber hoses to harden and increases the possibility of them leaking or blowing off.

Slime and algae can be a problem in an open system. They tend to clog the water passages and cause pitting in the inside surfaces of the piping. To control the slime and algae, these systems are usually treated with non-chlorine type of chemicals.

Glycol, for freeze protection, is not used in open systems.

# CLOSED

In a closed system, there is some air in the system, but care is taken not to allow the air and water to come into intimate contact. This involves such precautions as making sure the return line to the reservoir is under the tank water level. The reservoir in such a system serves three functions. First, it allows for expansion of the water due to heating. Second, the reservoir is a very effective means of air separation. Third, the reservoir is a convenient fill point for the system.

These systems are generally small, and usually plumbed entirely with nonferrous piping. They are either filled with distilled or deionized water, or else the water conductivity is maintained through the use of a cartridge deionizer. In a properly designed system, there is such little movement between the air and the water, that cartridge removal of dissolved oxygen is effective. In this type of water system, the reservoir must be at the high point, or capable of holding all the water above it. A small amount of water is still lost to evaporation. Non-inhibited Ethylene Glycol may be used for freeze protection.

Caution: To prevent damage, the reservoir must be vented if it is to be filled from a pressurized source. NEVER USE AUTOMOTIVE-TYPE GLYCOL SUCH AS PRESTONE© ANTIFREEZE as it contains corrosion inhibitors that increase the conductivity of the solution.

# **SEALED**

A sealed pressurized system is the most sophisticated type of water system. In this type of system, there is no reservoir. A bladder lined expansion tank is used to allow for expansion of the water when it is heated. The air in the tank (separated from the water by a bladder) pressurizes the system.

The basic components of this system are a recirculating pump and motor, bypass line, air separator, air vent, expansion tank, pressure-reducing valve, and pressure relief valve. Shut-off and check valves are used at the inlet and outlet of the pump for isolation when servicing. A typical pump station schematic may be found at the end of this section. The specific schematic for your system may vary slightly.

Starting from the pump station outlet, water enters the heat exchanger where it is cooled. Note the exchanger position ahead of the water-cooled equipment. From the cooler outlet the water divides up and enters each piece of water-cooled equipment where it picks up heat. It then enters a common manifold and returns to the pump station. Here entrained air in the water is removed by the air separator working on a bypass line around the pump and the air is eliminated through the float vent. A tank is connected to the pump suction to allow for expansion of the heated water. This is also the point where the system is most conveniently filled through an automatic pressure reducer preset to maintain 12 psi\* (83 kpa). A pressure relief (preset to 25 psi)\* (173 kpa) is installed in the pump inlet line as part of the pump station protection.

\* If any part of the water system is more than 24 feet (7.3 meters) higher than the reducer valve and relief valve, the above settings will change.

Non-inhibited Ethylene Glycol may be used where necessary for freeze protection (see Maintenance Section for Winter Protection).

# **EMERGENCY WATER**

An emergency back-up system is required for melting furnace coils and some types of heating coils. The system should provide emergency water for switchover whenever a failure of the normal system occurs. See the Installation Section.

# **HEAT EXCHANGERS**

# **EVAPORATIVE HEAT EXCHANGER**

The closed circuit cooling tower is often used to cool and conserve recirculated fluid. The induction system water is passed through the coil of the unit. The cooling water in the pan at the bottom of the unit is pumped up to distribution spray nozzles at the top and cascades over the cooling tubes. Air is forced over the cooling coil by a blower and evaporates a small percentage of water, absorbing the latent heat of vaporization and discharging the heat to the atmosphere. The mist that is carried by the air is removed as it passes through the eliminators at the unit discharge.

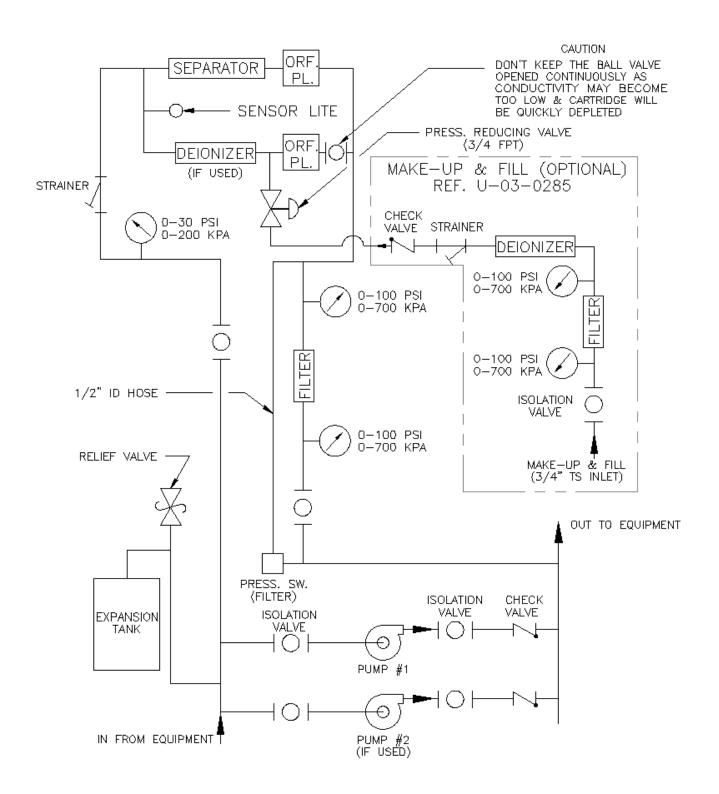
# WATER-TO-WATER HEAT EXCHANGER

If an abundance of clean raw water is available, a water-to-water heat exchanger may be used in place of an evaporative type. Raw water is passed through one side of the heat exchanger, and recirculated water is passed through the other. Conductivity requirements do not apply to this raw water unless it cools other induction equipment. Service valves should be supplied on the inlet and outlet of the raw water. Ajax Tocco uses a temperature controlled solenoid valve at the raw water outlet to control the temperature of the re-circulated water. The temperature switch for this valve is located in the re-circulating water outlet line.

Water-to-water heat exchangers are of three basic types: shell and tube exchangers, plate and frame exchangers, or brazed plate heat exchangers.

# **OTHER**

On occasion other types of cooling equipment may be used, such as water-to-air (radiator) type heat exchangers. Depending upon the system requirements, combinations of different heat exchangers may be used. This usually occurs where it is necessary to isolate the water to one piece of equipment from the rest of the water system.



# **INSTALLATION OF THE WATER SYSTEM**

# **GENERAL AND PIPING**

# PIPE SIZES ARE NOT TO BE TAKEN FROM SCHEMATIC DRAWINGS OR EQUIPMENT INLET

<u>SIZES</u>. The system is to be installed in accordance with the appropriate interconnection schematic diagrams. Adequate planning and layout of the water system must be made prior to installation of the equipment. The total system and component water flow is listed in the instruction manual or on the water schematic.

The following discusses installation requirements. The person responsible for the installation engineering must investigate all federal, state, and local codes to be sure the installation will comply.

When the solenoid activated source to drain emergency water system is used, it will require the dumping of some of the system water. If the system water has been treated to prevent scale, corrosion, or slime, the concentration of pollutants may exceed what is permitted by code to be discharged directly into the plant drain. In this event, the emergency drain water will have to go to a suitable waste treatment.

Non-ferrous piping is always preferred for water-cooled electrical equipment. Rigid copper tubing, type K or type L, and schedule 80 CPVC plastic are recommended. See the Maintenance Section of this manual when using CPVC piping with glycol in the system. Stainless steel is also an excellent choice, but is generally not used because of cost. Where larger pipe sizes are required for the installation, black iron pipe is an economical choice. When black iron pipe is used, it should be properly treated to minimize corrosion. BLACK IRON PIPE IS NOT TO BE USED FOR WATER WHICH IS BELOW 100 MICROMHO/CM CONDUCTIVITY. DO NOT USE ALUMINUM OR GALVANIZED PIPE AND FITTINGS.

A major cause of system startup problems has been pipe dope or Teflon tape getting into strainers. Either type of sealant may be used at threaded joints; however, care should be taken to avoid getting pipe dope or Teflon tape onto the very end threads.

Pipe sizes are not to be taken from schematic drawings or equipment inlet sizes. Pipe sizes should be determined by the installer based on the number of fittings, the length of the run, and the elevations so that the required differential can be achieved at each component. <a href="https://doi.org/10.1007/jhtml.com/">THE TOTAL INTERCONNECTION PIPING PRESSURE DROP MUST NOT EXCEED 10 psi (68 kpa).</a>

Before coupling any of the water-cooled equipment, each component should be thoroughly flushed to remove any contaminants. All interconnecting piping should be flushed just prior to connection. Strainers are to be used for all major system component inlets. Refer to the Maintenance Section for cleaning instructions.

All working parts of the system should be arranged for convenient operation, inspection, lubrication, repair, and ease of maintenance. All piping should be sized in accordance with good industrial piping practice and installed to allow flexibility for expansion and contraction between component parts of the system. Remember, the interconnection piping is to be sized so that the specified pressure differential is available.

If any part of the induction water-cooling system is exposed to temperatures below 32°F (0° C), provisions should be made to insure against water freeze-up. Insulation and/or heat tape should be installed on outdoor piping to the cooler. See the Maintenance Section for winter protection.

# **PUMP STATION**

The pump station is an integral unit and needs interconnection only. The pump, expansion tank\*, air separator, and piping are mounted on a common base which requires a firm, level floor. The station should be installed near the electrical equipment and heat exchanger.

\*NOTE: Where components are located at extremely high elevations in relationship to the pump station, higher prefill pressure or remote location of the expansion tank to a higher point may be required.

Electrical connections are to be made in accordance with the appropriate electrical diagrams. The size of control wiring is to be a minimum of 14 awg. All wiring is to be selected and supplied by the customer in accordance with accepted engineering practices.

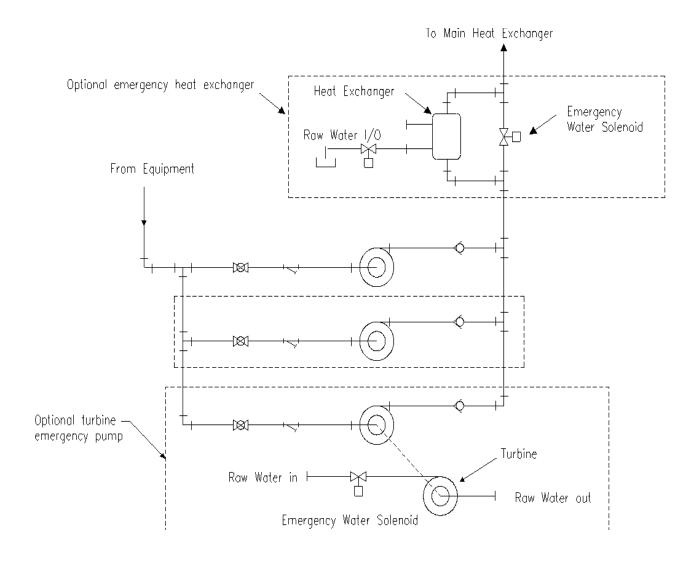
# EMERGENCY WATER - GENERALLY NOT REQUIRED BY HEATING EQUIPMENT

Two precautions are recommended, either as options by ATM or by the customer. The first measure uses two identical pumps installed in parallel, using one as a standby. The second measure is the provision of a water supply to be used during emergencies. The second measure qualifies as an emergency water supply.

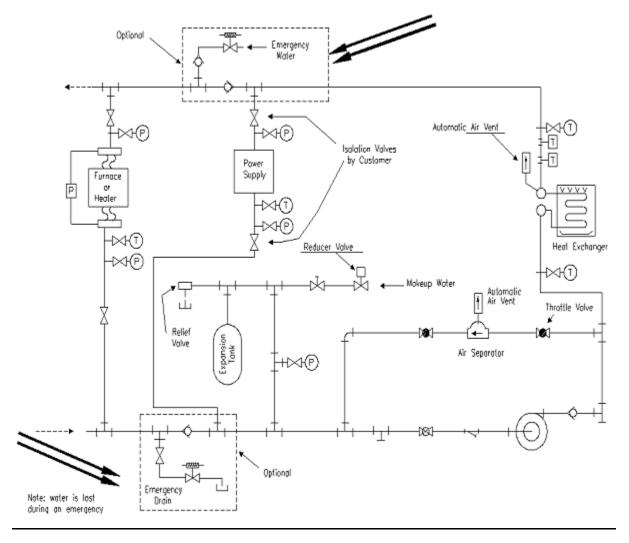
An emergency is defined here as a complete power shut down with either a hot lining, or molten metal in at least one furnace. The water system under these conditions has to carry away the energy lost by conduction through the furnace linings. Since this energy loss is about 10, or 15% of the normal losses, a small turbine, or gas driven pump can be used in parallel with the pump station to provide the necessary water flow. This provides the flow, and keeps the system closed. A water-to-water heat exchanger must also be used to remove the heat from the process water. The sketch shows this in schematic form.

Another way of providing water in an emergency is to supply inlet and outlet solenoid valves with check valves to force the flow in the proper direction. The sketch provided shows this. The short run is nicely cared for by this scheme, but the system is opened to the atmosphere, and recovery from an emergency is painful. Glycol is lost if used, the water is saturated with oxygen, and free air has been introduced to the entire system.

Small low capacity systems can probably justify using the latter method, and maybe even think about using a completely manual valving scheme, but larger systems easily justify the up front expense of the internal pump.



NOTE: When the turbine pump is used, solenoid operated valves are used to supply water to the turbine and the heat exchanger if it is used. If a water to water heat exchanger is being used for the main system cooling, the emergency heat exchanger may not be necessary.



Schematic Water Diagram

for a System with the

Least Desirable Emergency Source

#### WATER SUPERVISION

Note that valves, pressure gauges, and thermometers are to be supplied and installed by the customer unless otherwise specified. Thermometers may be either bulb or bimetallic with a range of about 30° to 240°F. (0 to 115 °C).

Pressure gauges should have a range of 0 to 100 psig (0 to 700 kpa) and be installed with gauge cocks. The devices should be readily accessible for maintenance purposes.

# **EVAPORATIVE HEAT EXCHANGER**

Refer to manufacturer's instructions for unit location, as they must be located so there is an unimpeded supply of air to all fans. When units are located close to adjoining building walls, discharge air from the unit must be carried above the walls to prevent warm, saturated discharge air from being deflected back to the fan intakes. Note that the heat exchanger's position is ahead of the furnace and other water-cooled components in the water system.

All piping to and away from the unit must be insulated sufficiently to prevent freezing in the piping during cold weather conditions. Heat tapes in critical areas may also be required. See the Maintenance Section for winter protection.

It is most important that an adequate steel supporting structure for mounting be provided for the evaporative heat exchanger. Refer to the manufacturer's instructions for weight loading diagrams, suggested steel supports, holes in frame, and necessary foundation beams. Sufficient clearance must be provided at the end of the unit for tube bundle removal or pan immersion heater removal.

Because rigging procedures vary with each exchanger size, adhere to the manufacturer's specific lifting recommendations. Since most units are broken down for shipment, field assembly of sections is required. Check to make sure the motor shafts are parallel to fan shafts and are in alignment. Check the rotations of the motors and the belt tension. Adjust the float makeup valve to obtain the proper pan water level. The operating water level in the pan is approximately 5 inches (12.7 cm) below the centerline of the overflow connection. Two 3/4 inch pipe fittings have to be located in the cooling outlet water line near the exchanger for installation of temperature controller capillary bulb therm-o-wells (which are supplied with the exchanger). Vents with valves must be supplied and installed by the customer in the supply and return lines of the heat exchanger. These vents will aid in bleeding air when filling the system. Electrical interconnection is shown on the water system control schematic. See the manufacturer's maintenance manual for further information.

# **OPERATION OF THE WATER SYSTEM**

# SYSTEM PREPARATION AND INITIAL FILLING

To avoid water system problems it is very important to get off to a good start. A good start-up procedure, like the one given below, can eliminate much of the confusion and frustration associated with water systems.

- 1. The following procedure assumes that the water system is a closed recirculating system.

  The steps outlined below should be accomplished in a timely manner. It is important that the system not be left open to the atmosphere any longer than absolutely necessary. To do so would negate the beneficial effects of the procedure.
- 2. Fill and flush out the system thoroughly with warm (80° to 120°F) (27° to 50°C) tap water.
- 3. Clean all strainers.
- 4. If no chemical treatment of the water system is planned, proceed to step #7. If the piping or heat exchanger equipment includes ferrous components, chemical treatment of the water to minimize corrosion is strongly recommended.
- 5. Drain the water from the system, then add warm tap water with a solution of either Diversey CL-658 or Calgon CSC-400. Follow manufacturer's directions for use.
- 6. Drain the system and flush it with tap water until water in system is clear and conductivity and pH are similar to tap water.
- 7. Immediately fill the system with water of the quality specified in the "Water Requirements" section of this manual. If chemical treatment is used, the system should be filled with demineralized water of less than 30 micromho conductivity\*; followed by sufficient quantity of Diversey CW-4745 low conductivity treatment or Calgon LCS-70 or equivalent to provide 30 to 40 ppm DEHA free residual. Follow manufacturer's recommendations.

For sealed systems, filling of the system is accomplished through a prefill pressure-reducing valve located on the pump suction side. This point is noted on the pump station assembly drawing. Glycol and/or water is introduced at this point with all but the emergency valves open and all the high points of the system vented so that no air pockets are present. When all the air pockets are removed and the system is completely filled with glycol and/or water, close the vents. See the start-up procedure.

An alternate method of filling is a gravity fill. This method must be done at the highest point in the system and may be awkward to perform. For this method, a valve is placed at the highest point in the system and the fill water is poured in at this point.

After checking for proper rotation, the re-circulating pump may be started. When starting the pump, observe the pressure gauge on the pump suction. If this pressure varies when the pump is started, there is still significant air in the system.

Caution: Do not continuously operate vertically mounted pumps until all air has been removed from the system. To do so will damage the pump seal. As the pump continues to operate, the air separator will remove the initial air in the system. As this happens the pressure at the pump suction will be reduced so the pump suction is again at approximately 12 psig (83 kpa).\* When the pump can be started with little or no variation of the suction pressure, the system is free of air. Final adjustment of the suction pressure will be made by opening the feed valve to the pressure-reducing valve.

Once the system is initially filled, the pressure at the equipment should be checked. It may be necessary to adjust the flow on each component in order to obtain the proper differential pressure across each one. The system static pressure will be maintained between 12 psig (83 kpa) and 25 psig (173 kpa) by the interaction of the pressure reducing and pressure relief valves.

# NORMAL OPERATION

The main functions which must be performed on a daily basis are: checking the suction pressure before and after starting the pump and checking all system temperatures and pressures initially and at operating conditions. Note that the suction pressure will vary between 10 psig (69 kpa) and 25 psig (173 kpa),\* depending on the average recirculating water temperature. Low pressures may be reached on very cold days.

Abnormal operation will occur for the following conditions: the water pump will trip off only on electrical power failure, overload on the motor, or high pressure. If the water pump trips off, the emergency water system should be used immediately if there is

molten metal in the furnace or hot parts in the coil. The furnaces are protected by differential water pressure switches that will remove power if the pressure differential decreases to less than the design point.

\* Will change if pieces of equipment are on different elevations.

The main operations which must be performed are: starting the water pump before applying power to the unit and shutting down the water pump after the furnace has cooled at least a couple of hours after power is off. Exit temperatures of the cooling water should be checked daily. When the unit is running at full power, the exit water temperature must not exceed 155°F (68.3°C) for the coil, transformers, and leads. Capacitor water must be limited to 120°F (48°C) exit temperature.

<u>NOTE:</u> Remember to check temperatures daily for the first week after start-up for future reference. Record water flow and inlet and exit water temperatures whenever practical.

The emergency water system should be visually checked weekly. An emergency system will only work with all hoses connected and no leaks. In the event of hose failure or blow-off, an attempt to replace the hose should be made, or at least maintain some water flow to protect hot coils. The operation of the emergency system should be checked as regularly as practical.

Frequent inspection of all system strainers is required, especially during the first few weeks after initial start-up.

# **COOLER OPERATION**

Evaporative coolers, when used, are factory preset and require few adjustments. The outlet line from the cooler will have two bulbs installed to control the outlet temperature of the cooler. One bulb will be set to turn on the spray pump about 10°F (5.6 C°) below the required equipment inlet water temperature. The second bulb will be set to turn on the blower motor about 5°F (2.8 C°) below the required equipment inlet temperature. The blower will remain on until the water drops under 5° (2.8 C°) below the required equipment inlet temperature. The spray pump will stay on until the water temperature drops to 10° (5.6 C°) below the required equipment inlet water temperature.

A thermostatically controlled electric heater in the spray water pump turns on at approximately 40°F (4.4 °C) to prevent freeze up in cold weather, and a float operated valve controls the sump water level. After a few days of operation, the float ball may need adjustment in order to maintain the operating level 5 inches (12.7 cm) below the centerline of the overflow connection.

The main recirculating water (being within a closed system) does not evaporate and requires no blow-down to reduce buildup of solids. The sump water is an open system and does require periodic introduction of fresh water. The better the quality of the initial water, the less drainage of sump water is required. Refer to the evaporative cooler instruction manual. The sump drain valve is set to allow enough bleed-off to eliminate scaling the sump.

# MAINTENANCE OF THE WATER SYSTEM

# **GENERAL**

When installed properly, only routine maintenance is required on the water system. When started up, the water flow and inlet and exit temperatures of water paths should be recorded and filed for future reference. Daily inspection is required until the equipment has been in continuous service for two months. The maximum outlet water temperature for the induction equipment supplied is 155°F (68.3°C). This temperature will only be realized when the equipment is running at maximum power and when the charge is at the highest temperature for which it was designed. If the system pressure decreases after start-up, check all system strainers to be sure they are clean.

After the equipment has been in service for some time, water flows and/or exit water temperatures may vary due to residue buildup in the cooling tubes or line pressure variations. To prevent any of these factors from causing problems, it is important to monitor inlet and exit water and the quality of the water in the system.

The dissolved oxygen, conductivity, pH, hardness, and dissolved solids in the system should be monitored and maintained within the limits as stated earlier in the Water Quality Requirements. Water quality can be maintained by treating the water, or, as an alternative, dumping all or part of the water and making it up with Water that is better than the quality required. Periodic monitoring of pH and conductivity is recommended. These should also be plotted to detect trends in water quality. Equipment is available as an option from ATM for monitoring conductivity.

If system pressures change, the cause is either less pump flow or a gradual buildup of rust and scale in the cooling water piping due to poor water quality. If the cooling water temperature has increased, the cause is usually either a reduction of water flow (due to blockage) or operation of equipment at higher than design power rating.

If the flow of water through the cooling system falls below that required for your equipment and the pump pressure has increased, the probable cause is mineral deposits restricting the effective size of the tubes. This must be corrected immediately since these deposits not only interfere with water movement, but act as insulation which further reduces the efficiency of the coolant. The two types of cooling tube contamination most frequently encountered are mineral deposits and sediment.

SHOULD WATER PATHS BECOME REDUCED OR BLOCKED, EITHER BACK FLUSHING OR CHEMICAL FLUSHING MAY BE USED TO CLEAR THE PATH.

# **BACK FLUSHING**

Back flushing is used as a means of removing sediment from a cooling circuit by reversing the normal flow of water with air pressure. Attach an air line to any convenient connection point near the water supervision equipment on the coil side of the outlet valve of the faulty circuit. Turn the outlet valve off and turn the air on sufficiently to blow the water vigorously backward through the circuit. Remove the air pressure and open the outlet valve. See if the flow has increased and if not, repeat the above process several times. This procedure will usually break up and remove small

particles, such as rust, that are interfering with normal water flow but not scale formations. Should the flow remain below normal, chemical flushing should be used.

# **CHEMICAL FLUSHING METHOD**

Citric Acid flushing is used to loosen scale, salt deposits, or algae from the water piping. ATM has trained Service Engineers capable of providing this service. The ATM Service Department should be consulted prior to attempting this procedure. The procedure for chemical flushing as used by ATM is as follows:

ATM is as		ows:
A.	IN	ITIAL CHECKS
		Conductivity Check (document)
		PH Check (document)
		Indications of freezing water lines
		Inlet Pressure (document)
		Outlet Pressure (document)
		Trace & mark each water path
B.	FL	USHING
		Confirm path (with air if necessary)
		Drain path
		Air Flush Path
		Flush path, note flow (document)
		Flush with fresh water
		Air flush
		Re-connect line to header & component
C.	PC	OST CHECK(s)
		Conductivity check (document)
		PH Check (document)
		Inlet Pressure (document)
		Outlet Pressure (document)

□ WM1 provided to customer (H<sub>2</sub>O specification sheet)

Check for leaks

# **WINTER PROTECTION**

If water-cooled equipment is exposed to freezing conditions, it must be protected. This is accomplished by mixing glycol with the water in the cooling system. Because of the low conductivity requirements with induction equipment, only uninhibited glycols should be used. (Do not use commercial or automotive type antifreezes. These have additives for corrosion protection that are too highly conductive for use in induction equipment. Refer to the section of this manual on water conductivity. Note also that water mixed with pure glycol will have a lower conductivity than the water alone.)

Non-inhibited Ethylene Glycol is used for freeze protection. Typical glycols that are acceptable are:

- Dow Chemical Company Low Conductivity Grade Ethylene Glycol Product Code #30499.
   (ATM SC# 82260A00)
- 2. Dow Chemical Company Propylene Glycol, Product Code #70511.

These two types of glycol are miscible in each other; there is no problem mixing the two types in the equipment supplied by Ajax. Some compositions of plastic piping, particularly CPVC, may be susceptible to environmental stress cracking when used with higher concentrations of propylene glycol. The piping supplier should be consulted to ensure compatibility.

# MAINTENANCE OF THE WATER SYSTEM

Please note the precautionary information supplied with glycol. Glycol is flammable, and when it is used precautions must be taken to reduce the risk of fire. The major fire hazard occurs when the solution of glycol and water is sprayed over hot objects. The incidence of this can be almost eliminated if good maintenance procedures are incorporated to ensure hoses don't fail and water paths don't leak for long periods of time without correction.

# TYPICAL CONCENTRATIONS REQUIRED TO PROVIDE PROTECTION AT VARIOUS TEMPERATURES

		PERCENT VOLUME GLYCOL CONCENTRATION REQUIRED					
		FOR FREEZE	PROTECTION	FOR BURST PROTECTION			
TEI °F	MP °C	ETHYLENE GLYCOL	PROPYLENE GLYCOL	ETHYLENE GLYCOL	PROPYLENE GLYCOL		
20	-7	16%	17%	11%	11%		
10	-12	25%	26%	17%	18%		
3	-16	30%	31%	21%	22%		
-10	-23	39%	41%	26%	28%		
-20	-29	44%	45%	30%	30%		
-30	-34	48%	49%	30%	33%		
-40	-40	52%	51%	30%			

Glycol-water solutions become slushy instead of having sharp freezing points, and are known to provide burst protection to temperatures well below the published freezing temperature. While freezing temperature is dependent only upon fluid characteristics, burst protection is affected by other factors such as provision for volume expansion, piping material, and rate of cooling. For most systems however, glycol will provide burst protection to the temperatures shown in the above chart.

ATM recommends a mixture of 30% ethylene glycol, which provides burst protection to -40° for most systems. Extremely high levels of concentration are not necessary and are not recommended; at high concentrations, the freezing point actually increases. A pre-mix of ethylene glycol and deionized water is available though the ATM Spare Parts Department.

# MAINTENANCE SCHEDULE

RECOMMENDED TIME INTERVALS	Daily	Weekly	Monthly	Every 3 Months
System Pressure and Temperature	Х			
Check Hoses		Х		
Tighten Hose Connections			Х	
Replace Defective or Worn Hose		AS RE	QUIRED	
Flush out System		AS RE	QUIRED	
Check for Leaks and Clean Strainers		Х		
Grease Pump Bearings				Х
Test Water Safety Devices		Х		
Measure and Plot Water* Quality; Treat if Required			Х	
Clean and Inspect Vent Tube and Float Valve				х
Check Relief Valve Operation				Х
Heat Exchanger-Refer to Vendor Instructions				

# MAINTENANCE OF THE WATER SYSTEM TROUBLESHOOTING GUIDE

-	MAINTENANCE OF THE WATER SYSTEM TROUBLESHOOTING GUIDE							
SYMPTOM		CAUSE		CORRECTION				
No discharge from pump.	a. faulty	Pump speed too low, motor.	a. electr	Correct wrong or poor ical connection.				
	b.	Pump not primed.	b. and v	Fill pump with water ent air.				
	c. high.	Discharge head too	c. in pip	Check for obstruction ing.				
	d. than d	Suction lift greater design.	d.	Relocate pump.				
	e.	Impeller clogged.	e. and d remo	Back flush with water lisassemble pump to ve.				
	f. incorr casin	Pump rotation ect. See arrow on g.	f. direct	Reverse motor ion.				
Insufficient pump discharge.	a. stuffir	Air leak in suction or ng box.		Tighten connection eplace defective ets or seals.				
	b.	Pump speed too low.	b.	See 1a. above.				
	c. high.	Discharge head too	C.	See 1c. above.				
	d.	Impeller clogged.	d.	See 1e. above.				
	e. Ioose	Impeller damaged or	e. tighte	Replace impeller or n.				
	f. backv	Pump rotating vards.	f.	Check pump rotation.				
		Insufficient NPSH (NET TIVE SUCTION HEAD) or ed suction line.	g. clear	See 1d. above or suction line.				
	h. small.	Impeller diameter too	h. and ir	Check pump curve mpeller size.				
	I. cleara	Excess impeller ance.	I. when	Readjust end play applicable.				
3. Insufficient pump pressure.	a.	Speed too low.	a. conne	Check motor and ection.				

	b.	Air in water.		Check for leaks in on line or onents. See 8.
	C.	Mechanical defects.	C.	Replace worn parts.
	d. small.	Impeller diameter too	d.	See 2g. above.
	e.	Excessive water flow.	e. valve	Check all regulator settings in system.
	f. backv	Pump rotating vards.	f.	Check pump rotation.
4. Excessive motor power.	a.	Motor speed too high.	a. Repla	Internal motor wiring. ace motor.
	b. rating	Head lower than , pumps too much water.	b. Resis	Check pump curve. t water flows.
	C.	Mechanical defects.	c. shaft.	Worn bearing, bent
<ol><li>Excessive pump vibration or noise.</li></ol>	a. rotatir	Foreign matter ng with impeller.		ean out pump.
	b.	Damaged impeller.	b. Re	eplace impeller.
	c. high.	Discharge head too	c. from	Clear obstruction outlet piping.
	d.	Magnetic hum.	d.	Check motor.
	e. discha	Unsupported suction or arge piping.	e. secur	Add supports and e piping.
	f.	Pump cavitation.	close	Bleed off air. Make all manual vents are d and auto-vents are aking air into the m.
	g. backv	Pump rotating vards.	g.	Check pump rotation.

6. Pressure gauge.	a. exces	Broken gauge from sive vibration.	a.	Replace gauge.
	b.	Air in system.	b.	Vent air.
	C.	Faulty pump.	C.	Check impeller.
7. Excess outlet water temperature.	a. flow.	Reduction of water	a. flush.	Back or chemical
	b. power	Operation over rated r.	b. 100%	Do not over rate over KW.
	c. syster	Trapped air in the m.	C.	Bleed air.
8. Excess air in system.	a. comp	Leak in system onent.	a.	Reseal.
	b. vent.	Clogged or leaking air	b.	Unclog or replace.
	c. separ	Ineffective air ation.	c. and m	Check air separator naximum flow.
9. Pressure relief valve operation too often.	a.	Faulty valve.	a. Re	place.
	b.	Incorrect valve.	b.	Check rating.
	c. press	System prefill ure too high.	c. psig.	Prefill system to 12 (83 kpa)
	d.	Excess temperature.	d.	Investigate eating.
10. Pump inlet pressure gauge indicates zero or less.	a. press	Loss of precharge ure.	a. (83 kp	Recharge to 12 psig.
	b.	Faulty float vent.	b.	Replace.
	C.	Leak in system.	C.	Fix leak.
	d.	Broken gauge.	d.	Replace.
	e. tank.	Leaking compression	e.	Fix or replace tank.

11. Float vent always bleeding air.

Dirt in seal. a.

a. Clean.

Air in system. b.

b. Bleed.

Faulty. C.

c. Replace or install temporary gate valve for manual bleed.

# PROCEDURE FOR FILLING A SEALED WATER SYSTEM WITH GLYCOL

Four methods for filling a closed recirculating water system are given below; however, there may be other successful methods. A convenient connection for filling an ATM system that utilizes a floor mounted pump station is at the "prefill" or "makeup" water connection that is tee'd from the expansion tank and has a gate valve. Most any other tee connection into the system with a valve will work.

The first information needed is the amount of glycol for adequate freeze protection.

If a system requires 30% glycol, then knowing the approximate total system volume determines the amount of glycol. The following information will help to find the total system volume.

### INTERCONNECTING WATER PIPING - GALLONS PER LINEAL FOOT

<u>Size</u>	1/2	3/4	1	11/4	1½	2	2½
Copper Tube	.012	.025	.043	.065	.092	.161	.250
Steel Pipe	.016	.028	.045	.078	.105	.172	.250
Size	3	4	5	6	8	10	12
Copper Tube	.357	.625	1.00	1.40	2.43	3.78	5.40
Steel Pipe	.385	.667	1.00	1.50	2.63	4.20	5.90

Typical Ajax equipment capacities can be determined from the separate Water Requirement Section of this instruction manual. A pre-mix of ethylene glycol and deionized water is available though the ATM Spare Parts Department.

Purchase the amount of pure ethylene or propylene glycol required for the percent solution of the total volume figured above and fill by one of the following methods. (Refer to the maintenance section of this manual on winter protection and operation and particulars on the type of glycol acceptable.) Automotive antifreeze is not acceptable because it contains corrosion inhibitors that increase conductivity.

# PROCEDURE FOR FILLING A SEALED WATER SYSTEM WITH GLYCOL

## METHOD 1

Pumping the glycol from a container or drum into the system at the prefill valve connection requires a small auxiliary pump that can be found at many hardware stores or plumbing supply houses. It may be rated at several gallons per minute and 20 feet (6.1 meters) head. If the system is already full, it is necessary to bleed enough water to allow for the glycol. This may be done at an equipment connection or from a plug in the bottom of the separator. When enough glycol has been added plus the initial 12 psig (83 kpa)\* precharge on the system (see initial filling), the valve is closed.

## METHOD 2

A manual method for filling the system with glycol is to pour it in at the high point of the system through a funnel. Again, it is assumed that part of the system has been drained and there is an opening at the high point such as the air bleed vent at the evaporative cooler. The prefill/make-up water is used to set the precharge on the system by using city or plant water supply pressure.

## METHOD 3

A standard air-operated transfer pump used in 55 gallon drums can be used for filling the system by the same procedure as above.

### METHOD 4

For a case where a pump is unavailable, plant air can be used to inject glycol into a system by pressurizing the glycol container. A steel tank rated at 120 psi (8.44 kg/cm²) with an air pressure fitting or disconnect and a valve are needed at the top of the tank. A fill plug for pouring in glycol is needed at the top of the tank also. The bottom tank fitting is connected to a tee fitting in the system or to the prefill/make-up connection as in Method 1. When the tank is filled with glycol and air pressure is applied, it will be blown into the system provided enough water has been bled to accommodate it and air venting is done (as in Method 1). Again, the precharge pressure on the system must be obtained. This method should be considered a last resort since it introduces air into the system.

<sup>\*</sup> Value may increase depending on the elevation of components in the system.

#### **CONDUCTIVITY CONSIDERATIONS**

- 1) In both semi-open and closed water systems having a requirement of 50 micromho water, an initial fill of 1 to 30 micromho water will rise in conductivity to some equilibrium level.
- 2) On one end of the spectrum is the following system.
  - A) Small capacity in gallons of water.
  - B) Pipes coated with 30% glycol.
  - C) All stainless, copper and brass, or plastic pipes and water carrying components.
  - D) Good job of flushing loose solder and debris from system before fill with DI water.
  - E) Relatively small amount of solder on pipes exposed to water on inside walls.
- 3) For the conditions of (2), water conductivity will stabilize below 50 micromhos and stay there. Checking water conductivity every 6 weeks (small sample into a cup and check with hand held conductivity checker) will verify this. Note that, although a conductivity monitor may be on equipment to give alarm at 50 micromho and trip power off at 75 micromho, an independent manual check is still advised. The conductivity sensor is subject to collecting debris between prongs and eventually erodes due to presence of DC potential between prongs. In other words, it also must be maintained.
- 4) On the other end of the spectrum is the following system.
  - A) Large capacity in gallons of water.
  - B) Pipes still coated with 30% glycol.
  - All stainless, copper and brass components, but larger quantities of copper and brass.
  - D) Loose solder and other conducting residue still in system.
  - E) Large amounts of soldered joints with solder exposed to water on inside walls.
- 5) For the conditions of (4) water conductivity may rise above 50 micromho in a week. When this occurs, conductivity must be reduced, preferably into the 20 micromho area. Two methods are as follows.
  - A) Purchase a bypass demineralizer branch circuit for the de-I water pump station. This branch circuit includes a valve for manually gating water through the branch circuit. About 1 gpm is recirculated until system conductivity reaches 20 micromho. If this branch is left on continuously, water may reach zero conductivity. This causes an undesirable removal of particles from the system piping and frequent replacement of demineralizer cartridge. Periodic maintenance to 20 micromho, allowing gradual rise to 75 micromho etc., is a way to regulate the system with long cartridge life and no significant loss from pipe walls.
  - B) For larger users (many systems) a separate makeup water pump station (portable), of low gpm, with an exit demineralizer is used. This is connected to act in place of the system pump during maintenance. This allows reduction to 20 micromho without any significant addition of new de-I water or glycol. The higher the gpm capability of the makeup pump station, the faster conductivity reduction is accomplished.

- 6) Some users elect to run their system to 100 micromho or more before reducing to 20 micromho. The obvious tradeoff is much longer periods of time between water quality maintenance vs. greater loss of material from some replaceable hose barbs in the system. Periodic inspection of hose barbs will bell the user the wisdom of his choice.
- 7) The option of not demineralizing existing water within a system requires periodic draining of system water and replacement with premixed water/glycol mixture. This is adequate where infrequent, small amounts are required. Obviously, the greater the amount required, the less sense this makes from a cost standpoint. KNOWLEDGE OF HOW YOUR SYSTEM CONDUCTIVITY VARIES IS ESSENTIAL TO DETERMINING WHAT IS THE BEST ANSWER FOR YOU.

#### INITIAL FILL AND STARTUP PROCEDURE

- 1. Before installing, filling, or operating the equipment, the user should read Ajax Instruction Manual WIM-1, which covers general water specifications and proper preparation of system piping.
- 2. The system is shipped with the bypass filter element not installed. Before filling, the filter element should be installed. If a bypass deionizer is used, the deionizer cartridge should not be installed at this time. If the makeup line includes the optional makeup filter and deionizer, only the filter element should be installed before filling. The deionizer cartridge should not be installed at this time.
- 3. The ball valves to the pump bypass loop should be fully open.
- 4. Initial fill of the system should be filtered water from a separate source, which meets the water quality characteristics required for the equipment. If the source of water is questionable, contact Ajax Magnethermic, and ask for the Service Manager.
- 5. Filling of the system is done through the automatic makeup valve. Start filling the system with water, while venting air from all high points in the piping. Continue until all air has been vented and the system has stabilized to 12 psi (83 KPa). This setting is sufficient pressure where the highest point in the system is not over 24 ft. (7.3 M) above the pump station.
- 6. Manually open the pressure relief valve and bleed system down below 12 psi (83 KPa) to verify operation of pressure reducing valve which should maintain the system at 12 psi (83 Kpa).
- 7. Jog each pump to verify correct direction of rotation.
- 8. Start the recirculating pump (start Pump #1 if two pumps are used). If the pump starts to cavitate, turn it off and vent the system at all high points again.
- 9. Repeat Step #8 until air is out of the system. If two pumps are used, shut down Pump #1 and verify operation of Pump #2.
- 10. If an optional pressure switch is used for automatic pump switching, it should be set at this time to trip if the pressure falls below 70 psi (483 KPa).
- 11. If the optional deionizer is used, the cartridge should be installed at this time. (If chemical flushing or passivation is anticipated, do not install the deionizer cartridge until after the chemical treatment has dissipated). Shut off the pump and close the two ball valves to the bypass loop. Shut off the supply of makeup water. Install the deionizer cartridge in the bypass loop. If there is a deionizer cartridge in the makeup line, install it at this time.
- 12. During normal operation, the pressure reducing valve and the pressure relief valve will automatically maintain the system static pressure between 12 psi (83 KPa) and 25 psi (172 KPa) by adding or bleeding off water as required. The necessity of manually adding makeup water is eliminated.
- 13. In normal operation, the two ball valves to the bypass loop should be open. These valves are closed only for maintenance.

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#### MAINTENANCE OF WATER QUALITY

The water pumping station supplied by Ajax includes several features which are designed to maintain the quality of the recirculating water to minimize equipment problems. These features are described below.

The pump station has a bypass loop in parallel with the pump, such that a small amount of water (approximately 4 GPM) (15 LPM) is continually bypassed through the loop, which consists of a filter, air separator, and vent. Flow through the bypass loop is controlled by orifices in the piping; the ball valves in the loop should remain fully open in normal operation. The valves are used strictly for isolating components for maintenance. When performing maintenance, such as replacing a filter element, in addition to closing the ball valves, it is necessary to also shut off the supply of makeup water since the makeup is introduced through the bypass loop.

Various options are available depending upon the water quality requirements, the size of the system, and the piping material. See also the water requirements section of this manual. These options are described below.

#### FILTER

The filter element is a disposable 5 micron element in a stainless steel housing. In normal operation, the filter has approximately 4 - 5 GPM (15 - 20 LPM) of water passing through it. Pressure gauges are provided on either side of the filter. The element should be changed whenever the pressure drop across it gets to 20 psi (140 KPa) or more. Replacement filter elements are available through Ajax; Part Number SC 52353A02. The filter element is shipped loose and must be installed before filling the system.

#### AIR SEPARATOR AND VENT

A tangential type air separator and industrial air vent are used to remove entrapped air from the system. Flow through the air separator is maintained at approximately 4 GPM (15 LPM) by an orifice in series with the separator. To assist in removing entrapped air, it is also recommended that vents be placed at system high points and at points where piping changes elevation. See WIM-1.

## OPTIONAL ITEMS

#### Makeup Filter

Makeup water should be supplied through a filter. Five microns is recommended. A makeup filter is available from Ajax as an option. It is identical to the bypass filter, and uses the same replacement elements.

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#### Bypass Deionizer

If the recirculating water must be below 50 micromhos per centimeter, a bypass deionizer is recommended. Ajax has available a disposable cartridge mixed resin bed deionizer to maintain water conductivity at acceptable levels. The cartridge also removes dissolved oxygen to minimize corrosion in the system. Flow through the cartridge is maintained at approximately 1 GPM (4 LPM) by an orifice in series with the cartridge. Deionizer cartridges are shipped loose and should be installed after the system is filled. Replacement cartridges must be of the same type as original equipment. These may be obtained from Ajax by ordering Part Number SC 52352A03.

The cartridge housing contains an indicating light which should be wired to a 115 volt outlet. This light is on for normal operation, and will go out when the cartridge needs replaced. Cartridge life will vary greatly depending upon amount and hardness of makeup water used. When a fresh cartridge is inserted, it should be run for 4 - 6 hours whether the indicating light goes out or not. This is because the cartridge may not be able to remove all ions in one pass if the water is highly conductive.

Cartridges do have a shelf life. Before using, check the date on the protective wrapping.

As an added safety, a 40 mesh strainer is provided downstream of the deionizer. The strainer does not need cleaning unless sediment is visible through the housing.

Deionizer cartridges are intended to <u>maintain</u> water quality. For all but the smallest systems, distilled or deionized water from a separate source should be used for the initial fill of the system.

#### Makeup Deionizer

When a deionizer cartridge is used in the bypass loop, another cartridge on the makeup line is not necessary. A makeup line deionizer cartridge is used only when there is no deionizer in the bypass loop, which is the case when water quality requirements are 300 micromho per centimeter, or if chemicals are used in the recirculating system. On some larger systems, corrosion inhibiting chemicals may be used in the water systems. The deionizer cartridges are not compatible with these chemicals. When chemical treatment of the water is necessary, the bypass deionizer is not used. Instead, the bypass deionizer housing is left in place, and used as a dosing pot for making the chemical additions.

#### Pressure Switch

A differential pressure switch is available as an option. This can be connected across the bypass filter, providing a SPDT contact which can be used for an alarm signal.

All of the above components are compatible with ethylene glycol or propylene glycol used in cooling systems.

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## SAFETY PRACTICES FOR INSTALLATION AND MAINTENANCE

- 1) SAFE SYSTEMS OF WORK GENERAL
- 2) SPECIAL NOTES
- 3) INSTALLING AND DISMANTLING MACHINERY
- 4) LIFTING AND HANDLING
- 5) MAINTENANCE
- 6) ELECTRICAL SAFETY
- 7) ELECTRICAL CHECKING PROCEDURE

Author: RCO Approver: TEB 10/25/02 Revised: SU-22-0100 Sheet 1 of 10

## 1) GENERAL

Advice is given on a variety of tasks, not all of which may be applicable to your workplace. Please read the instructions carefully and act on those which apply.

## 2) SPECIAL NOTES

Safe working practice in the furnace area is generally the same as the existing safety regulation for industries concerning machinery and molten metal.

- 1. Before working on electrical units make sure that the power is isolated and cannot be switched on by other persons. Check that capacitors are discharged.
- 2. Before working on air or hydraulic components make sure that pressure does not exist in the system and that no part of the furnace can move to create pressure.
- 3. Do not attempt to stop an air or hydraulic leak with the hands. High pressure leaks can cause physical damage.
- 4. Do not override electrical interlocks or remove guards.

Warning:

The power control units and operating panels contain dangerous mains voltages. Electrical maintenance should only be undertaken by suitably trained and qualified personnel and only after reading and understanding the maintenance instructions

Cabinets should only be opened after opening the main circuit breaker and, for internal maintenance, locking the handle in the OFF position.

## 3) INSTALLING AND DISMANTLING MACHINERY

- 1. All installation and dismantling work to be carried by suitably trained persons. (Similarly, electrical work to be carried out by a suitable trained electrician).
- 2. Seek the co-operation of local management and discuss the program of work and its implications with regard to Health and Safety, before starting work.
- 3. Persons designated to assist with the installation or dismantling work (e.g.: laborers) must be given adequate information and instruction regarding their duties and safe working practices and they should wear appropriate personal protection equipment (see paragraph 4).

 Author: RCO
 Revised:

 Approver: TEB
 SU-22-0100

 10/25/02
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- 4. Personal protection equipment, as deemed necessary for the task, should be worn (The equipment may include safety boots, helmet, gloves and hearing defenders).
- 5. Ensure safe access to working area. Use suitable ladder, proprietary working platform fitted to forklift truck or fixed platform with safety rail and toeboard when working more than 2M above floor level, (see also paragraph 6).
- 6. Wear a safety belt or harness when working above floor level where other safe standing system (e.g.: platforms and ladders are inappropriate. (See Paragraph 5).
- 7. Keep work area free of obstructions and from any substance likely to cause persons to slip.
- 8. Prevent unauthorized persons entering the work area. Erect a barrier and display warning notices/signs where appropriate and reasonable practicable.
- 9. Where machinery is being installed or being dismantled alongside or adjacent to existing equipment use a suitable barrier/screen to create a safe working area.
- 10. Lifting and handling machinery (see Section IV).
- 11. Ladders and platforms shall be placed on a level base and securely fixed or lashed.
- 12. Erect a fence around, or cover, floor openings to prevent persons falling into them.
- 13. Do not install or leave an item where it is likely to cause a person injury by tripping (e.g. cables and pipe work on floor level).
- 14. Keep clear of winch ropes.
- 15. If the presence of a dangerous substance is suspected (e.g.: asbestos, lead paint etc.) seek qualified advice before proceeding.
- 16. When using welding or acetylene cutting equipment keep working area clear of waste material and ensure a fire blanket is readily available. Oxyacetylene welding/burning equipment should be fitted with suitable flashback arresters.
- 17. Portable tools and equipment must be regularly checked and maintained in good working condition.

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- 18. Grinding wheels/discs to be changed by suitably trained persons, as required.
- 19. Maintain constant vigilance against the risk of injury by impact, trapping, crushing, abrasion, cutting etc., caused by movement of machinery or machine parts and the use of tools during the installation and dismantling of machinery.
- 20. Switch off tools and power sockets before plugging in.
- 21. Avoid using electrical tools and equipment in damp or corrosive conditions.
- 22. Use 110 volt power tools when possible.
- 23. Protect trailing cables from passing vehicles.
- 24. Be aware of transport moving in the work area (e.g.: cranes, forklift trucks etc.).
- 25. Exercise extreme caution during the installation and commissioning of machinery before bridges, catwalks, and designated pedestrian areas have been provided.
- 26. Ensure work area is safe and secure before leaving site.

## 4) LIFTING AND HANDLING

- 1. Work to be carried out by suitably trained persons.
- 2. Suitable protective clothing as appropriate to be worn.
- 3. Floor, in the area of lifting, moving, and settling down, to be free of defects and clear of obstructions.
- 4. Remove all unsecured parts from item to be lifted.
- 5. Assess weight of item to be lifted. If too heavy to be lifted safely and without risks to health by one person get help or decide the best method of lifting by mechanical means.
- 6. Only use certified lifting equipment (marked with the safe working load) which is not overdue for examination.
- 7. Never use makeshift, damaged or badly worn equipment.

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- 8. Use suitable packing to protect slings from damage by sharp edges of load and do not allow lifting tackle to be damaged by being dropped or dragged from under the load.
- 9. Attach slings/chains to the lifting points specified by the equipment supplier.
- 10. Check that load is in balance before lifting fully. Raise slightly off ground and pause. Re-positioning lifting tackle if necessary.
- 11. When using lifting jacks keep clear of un-propped machinery.
- 12. Keep clear of moving machinery.
- 13. Do not walk under any item suspended from a crane or hoist.
- 14. Set down on a flat floor or suitably prepared base.
- 15. Do not remove slings/chains until item is in a stable and safe condition.

NOTE: Lifting equipment is to be taken to include cranes, hoists, fork lift trucks, lifting chains, slings, jacks, winches, lever lifts or any other device used to transport, raise, lower or move an article or piece of machinery.

## 5) MAINTENANCE

## **Definition:**

Maintenance is deemed to include examination, setting, adjustment, cleaning, lubrication, refueling, recharging, fault finding and repair.

#### General:

- 1. Work to be carried out by suitably trained persons.
- 2. Personal protection equipment, appropriate for the maintenance task, should be worn (e.g.: close fitting overalls, industrial gloves, protective boots, safety helmet, eye protection, face mask, hearing defenders etc.).
- 3. Ensure safe access to working area. Use suitable ladder, proprietary working platform fitted to a forklift truck or fixed platform with safety rail and toeboard when working more than 2M above floor level.

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- 4. Working area to be free of obstructions and from any substance likely to cause a person to slip.
- 5. Prevent unauthorized persons entering the work area. Erect a barrier and display warning notices/signs where appropriate and reasonably practicable.
- 6. Isolate <u>all</u> electrical supplies before work commences and lock off with a personal padlock where necessary.
- 7. Organize tasks to minimize risk of injury. Check for absence of hazards (e.g.: live electricity, pressurized pneumatic and hydraulic pipes, asbestos, lead etc.).
- 8. Ensure firm footholds and handholds and avoid obstructions or any material likely to cause slipping.
- 9. Provide safe means for the removal of metal chips and trade waste to prevent accumulation on the floor of the work area.
- 10. Ladders and platforms shall be placed on a level base and securely fixed or lashed.
- 11. Where two or more people are at risk in the work area each person should use a personal lock on a multi-padlockable hasp at each control station, thus ensuring the isolation of dangerous machinery until all locks have been removed on completion of the maintenance task.
- 12. Replace and secure all guards before switching on the machine for test purposes.

### 6) ELECTRICAL SAFETY

## General:

- 1. The following instructions give guidance to those involved with the operation, maintenance, testing, and repair of electrical systems and equipment.
- 2. In certain circumstances, where conditions demand, special written procedures may be issued. These appear in the applicable sections of the manual.

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## **Training:**

3. Work to be carried out by suitably trained persons who are competent for the particular class of work.

## **Protective Equipment:**

4. Protective equipment, as deemed necessary for the task, must be provided, property used and maintained in a condition suitable for its use.

Protective equipment may include - protective clothing, insulating helmets, insulating gloves, floor mats, insulating screening materials, suitable tools and test probes.

Use safe voltages where possible (e.g.: 110 volt power tools).

## Safety Requirements (applicable to all electrical work):

- 5. Before starting work assess the risks, organize tasks to minimize the risk of injury and check for absence of hazards (e.g.: live conductors).
- 6. No person shall work on or near live conductors for any purpose whatsoever unless, having regard to all relevant factors, the task cannot be carried out with the equipment dead (see "Working Dead" paragraphs 16 to 18 and "Working Live" paragraphs 19 to 25).
- 7. Ensure safe access to work area, sufficient working space and adequate lighting.
- 8. Prevent unauthorized persons entering the work area. Erect a barrier and display warning notices/signs where appropriate and reasonably practicable.
- 9. Protect electrical installations which are exposed to adverse conditions (e.g.: wet, dirty, dusty or corrosive conditions, flammable or explosive substances including dusts, vapors, and gasses and mechanical damage).
- 10. Ensure all conductors are suitably covered with insulating material.
- 11. Use steel trunking, conduit or steel armoured cable to protect insulation where possible.
- 12. All connections, plugs and sockets should be suitable for the purpose for which they are used. (Special attention should be given to joints and connections in flexible cables for portable equipment).

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- 13. Unused conductors, metal enclosures and components which may become charged as a result of a fault in a system, must be suitably earthed.
- 14. Provide protection against excess current. Use fuses or circuit breakers to prevent overload, short circuit and earth fault current.
- 15. Disused equipment should be disconnected and isolated so that it cannot be re-energized.

## **Working Dead:**

- 16. Isolate all points of supply
  - a) Remove fuses or links (and keep in safe storage under the supervision of a person in authority). Or,
  - b) Lock off isolator switch to prevent unauthorized, improper or unintentional energization.
  - c) Where two or more people are at risk in the work area each person should use a personal padlock on a hasp with sufficient capacity to accept three locks at each control station
- 17. Prove system is dead at point of work using a suitable test instrument or voltage indicator, (N.B.: Test instrument or voltage indicator should itself be proved immediately before work starts).
- 18. Follow checking procedure, Section VII.

## Working Live (for test purposes only):

- 19. Work to be carried out by persons properly trained and competent to work on live equipment safely.
- 20. Under no circumstances must a person work on or near live equipment as an expedient to 'cut corners' or save time.
- 21. Ensure adequate information is available and understood with regard to the live conductors involved.
- 22. Use suitable insulated tools, equipment and protective clothing (see paragraph 4).

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- 23. Use suitable insulated barriers/screens (e.g.: safety mats and insulating material capable of providing safe and adequate separation of adjacent live conductors).
- 24. Use suitable insulated instruments and test probes.
- 25. Work accompanied by another trained person who can recognize danger and render assistance in an emergency.
- 26. Prevent unauthorized persons entering the work area (e.g.: keep constant surveillance, use lockable enclosures or barriers and display warning notices/signs).

## Vacating the Area:

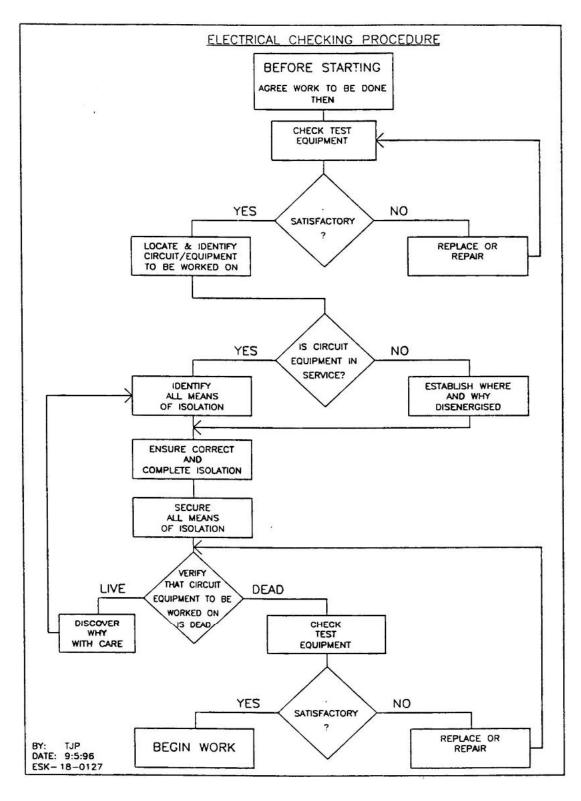
27. Leave all systems and equipment in a safe condition. Under no circumstances resort to makeshift methods or temporary solutions.

**REMEMBER** – "It shall be the duty of every employee at work to take care for the health and safety of himself and of other persons who may be effected by his acts or omissions".

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## Ajax Tocco Magnethermic Corporation

NORRIS CYLINDER 76-1031 SECTION NO. 13 SHEET NO. 1

## **DRAWING LIST**

I.D.	REV.	DESCRIPTION	BOM STATUS
G-01-10625-01	00	BRIDGE/REACTOR TUBE ASSEMBLY	
G-01-10625-A	00	BRIDGE/REACTOR TUBE ASSEMBLY	MK-A
G-01-10626-01	00	PACER ZONE HEATER OUTPUT ASSEMBLY	
G-01-10626-A	00	PACER ZONE HEATER OUTPUT ASSEMBLY	MK-A
G-01-10627-01	00	PACER ZONE HEATER OUTPUT ASSEMBLY	
G-01-10627-A	00	PACER ZONE HEATER OUTPUT ASSEMBLY	MK-A
G-01-10628-01	00	PACER ZONE HEATER DC BUS INPUT ASSEMBLY	
G-01-10628-A	00	PACER ZONE HEATER DC BUS INPUT ASSEMBLY	MK-A
G-01-10631-01	00	PACER ZONE HEATER ASSEMBLY	
G-01-10631-A	00	PACER ZONE HEATER ASSEMBLY	MK-A
G-03-10501-01	01	PACER ZONE HEATER INPUT WATER ASSEMBLY	
G-03-10501-A	02	PACER ZONE HEATER INPUT WATER ASSEMBLY	MK-A
G-03-10502-01	01	PACER ZONE HEATER WATER SCHEMATIC	
G-03-10502-02	01	PACER ZONE HEATER WATER SCHEMATIC	
G-03-10502-03	01	PACER ZONE HEATER WATER SCHEMATIC	
G-03-10502-04	01	PACER ZONE HEATER WATER SCHEMATIC	
G-03-10502-A	00	PACER ZONE HEATER WATER SCHEMATIC	MK-A
G-03-10502-B	00	PACER ZONE HEATER WATER SCHEMATIC	MK-B
G-03-10502-C	00	PACER ZONE HEATER WATER SCHEMATIC	MK-C
G-03-10502-D	00	PACER ZONE HEATER WATER SCHEMATIC	MK-D
G-22-10550-A	01	POWER ZONE RECTIFIER PARTS LAYOUT BOM	MK-A
H-01-11862-01	01	HYDRAULIC PUSHER ASSEMBLY	
H-01-11862-A	00	HYDRAULIC PUSHER ASSEMBLY	MK-A
H-01-11869-01	03	HEATING SYSTEM ASSEMBLY	
H-01-11869-A	03	HEATING SYSTEM ASSEMBLY	MK-A
H-01-11888-01	02	EXIT CONVEYOR ASSEMBLY	
H-01-11888-02	01	EXIT CONVEYOR ASSEMBLY	
H-01-11888-A	07	EXIT CONVEYOR ASSEMBLY	MK-A
H-01-11908-01	04	BILLET LOADER ASSEMBLY	
H-01-11908-A	04	BILLET LOADER ASSEMBLY	MK-A
H-02-12405-01	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-02	02	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-03	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-04	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-05	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-06	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-07	01	POWER & CONTROL SCHEMATIC	NO BOM

## Ajax Tocco Magnethermic Corporation

NORRIS CYLINDER 76-1031 SECTION NO. 13 SHEET NO. 2

## **DRAWING LIST**

I.D.	REV.	DESCRIPTION	BOM STATUS
H-02-12405-08	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-09	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-10	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-11	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-12	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-13	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-14	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-15	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12405-16	01	POWER & CONTROL SCHEMATIC	NO BOM
H-02-12409-01	00	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12409-02	03	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12409-03	02	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12409-04	00	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12409-05	01	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12409-06	03	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12409-07	05	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12409-08	04	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12409-09	03	CONTROL SYSTEM SCHEMATIC	NO BOM
H-02-12411-01	02	CONTROL PANEL ASSEMBLY	
H-02-12411-02	04	CONTROL PANEL ASSEMBLY	
H-02-12411-03	05	CONTROL PANEL ASSEMBLY	
H-02-12411-04	03	CONTROL PANEL ASSEMBLY	
H-02-12411-A	01	CONTROLS ASSEMBLY - EXTERIOR	MK-A
H-02-12411-B	02	CONTROLS ASSEMBLY - INTERIOR	MK-B
H-02-12411-C	00	CONTROLS ASSEMBLY - TERMINAL BOXES	MK-C
H-02-12414-01	01	WATER SYSTEM CONTROL PANEL	
H-02-12414-02	01	WATER SYSTEM CONTROL PANEL	
H-02-12414-A	01	WATER SYSTEM CONTROL PANEL	MK-A
H-02-12414-B	01	WATER SYSTEM CONTROL PANEL	MK-B
H-02-12415-01	01	WATER SYSTEM CONTROL PANEL SCHEMATIC	NO BOM
H-02-12417-01	00	WATER SYSTEM ELECTRICAL INTERCONNECTION WIRING	NO BOM
H-02-12424-01	02	ELECTRICAL INTERCONNECTION DIAGRAM	
H-02-12424-02	03	ELECTRICAL INTERCONNECTION DIAGRAM	
H-03-10897-01	01	WATER SYSTEM SCHEMATIC	NO BOM
H-03-10897-02	00	WATER SYSTEM SCHEMATIC	NO BOM
H-03-10900-01	05	CPX WATER SYSTEM, 208 GPM @ 165 FT. HEAD	
H-03-10900-02	03	CPX WATER SYSTEM, 208 GPM @ 165 FT. HEAD	
H-03-10900-A	08	CPX WATER SYSTEM, 208 GPM @ 165 FT. HEAD	MK-A

## Ajax Tocco Magnethermic Corporation

NORRIS CYLINDER 76-1031 SECTION NO. 13 SHEET NO. 3

## **DRAWING LIST**

I.D.	REV.	DESCRIPTION	BOM STATUS
H-03-10904-01	00	WATER PUMP STATION 375-500 GPM DUAL PUMP	
H-03-10904-02	00	WATER PUMP STATION 375-500 GPM DUAL PUMP	
H-03-10904-03	00	WATER PUMP STATION 375-500 GPM DUAL PUMP	
H-03-10904-F	00	WATER PUMP STATION 375-500 GPM	MK-F
H-04-10234-01	00	HYDRAULIC SCHEMATIC	
H-04-10234-A	00	HYDRAULIC POWER UNIT	MK-A
H-04-10234-B	00	HYDRAULIC CYLINDER	MK-B
H-04-10234-C	00	HYDRAULIC CYLINDER, 2.00" X 15.00" STROKE	MK-C
H-04-10234-D	00	HYDRAULIC CYLINDER, 2.00" X 3.50" STROKE	MK-D
H-04-10234-E	00	HYDRAULIC CYLINDER ACCESORIES	MK-E
H-13-10390-01	01	SYSTEM ARRANGEMENT	NO BOM
H-13-10390-02	01	SYSTEM ARRANGEMENT	NO BOM
H-13-10392-01	01	PLANT EQUIPMENT ARRANGEMENT	NO BOM
H-22-10003-00	00	FILLING THE SEALED WATER SYSTEM FOR	
		NORRIS CYLINDER	
SH-32-10527-01	01	POWER TRAIN ASSEMBLY	
SH-32-10527-02	01	POWER TRAIN ASSEMBLY	
SH-32-10527-03	01	POWER TRAIN ASSEMBLY	
SH-32-10527-A	00	POWER TRAIN ASSEMBLY	MK-A
SH-32-10527-B	00	POWER TRAIN ASSEMBLY	MK-B

## **June 2016**



# Ajax Tocco Magnethermic

1745 Overland Ave NE Warren, OH 44483 1-800-321-0153 1-330-372-8511

# **Revision Status Sheet**

Release Date	Rev.	I.D.	Comment	Author/Approver
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## 1 Introduction

## 1.1 Manuals

The Ajax Tocco Magnethermic Power Zone is a static AC-DC-AC frequency converter, using a nominal 480 VAC, 3 phase, 50/60 HZ line as its power source. The output is single phase, nominal frequency of 500-3 kHz. This model is compatible with induction heating and melting requirements and is designed with a fault-protected power section and FPGA control logic with the necessary status indicators to reduce and simplify operation and troubleshooting. This manual describes the theory of operation, startup procedure and troubleshooting techniques. These sections are subdivided into convenient sub-topics that are listed in the Table of Contents.

It is recommended that this manual be reviewed prior to operating, servicing or troubleshooting the Power Zone. To address questions or request any assistance, contact the Ajax Tocco Service Department at 1-800-321-0153.

## 1.2 Definitions and Trademarks

**Table 1-1: Defines Some Terms Used In This Manual** 

Term	Definition	
AC	Alternating Current	
CT	Current Transformer	
С	Capacitor	
Curie Temperature	The temperature at which ferrous materials lose their magnetic properties.	
_		
DC	Direct Current	
Dpsi	Differential Pressure	
Dout	Digital output signal from the Power Zone Logic Board	
F	Frequency	
Finv	Inverter Operating Frequency	
FTank	Tank Resonant Frequency	
FPGA	Field-Programmable Gate Array	
Hz	Hertz, a measure of frequency as cycles per second	
	• • • • • • • • • • • • • • • • • • • •	
Inv.	Inverter	
G	Conductance	

Gate Drive	Control Logic Board for the gating of the IGBTS
т	Inductor
L	
Load Coil	The induction heating or melting coil to which induction power is applied
IGBT	Insulated gate bipolar transistor
PF	Power Factor
PCB	Printed Circuit Board
PT	Potential Transformer
R	Resistance
V <sub>Tank</sub>	Tank Voltage
UVR	Under Voltage Relay and Under Voltage Release, depending on context
***	Walta A.C.
VAC	Volts AC
V <sub>DC</sub>	Volts DC
Z	Impedance

**Table 1- 2: Preprogrammed Units of Measure** 

<b>Description/Parameter</b>	Units of Measure
Impedance	Ohms
Conductance	Mhos or Siemens
Power	Kilowatts
Line Voltage	Volts AC 3-Phase
Rectifier Voltage	Volts DC
Inverter Voltage	Volts AC Single-Phase

## 1.2.1 Trademarks and Product Names

Trademarks and Trade names are used throughout this manual. An effort has been made to include the ® symbol wherever they are used. The origins of these products are as follows:

Power Zone® Is a registered trademark of Ajax Tocco Magnethermic.

## 1.2.2 Conventions

Certain conventions have been used for clarity and highlighting in this document as explained below:

## 1.2.2.1 Leading Capital Letters

Capital letters are used when sub systems are mentioned throughout. Capitals are also used when specific hardware is referred to as the subject of the paragraph.

## 1.2.2.2 Capital Letters

All caps are used such as: DO NOT where not reading the wording would result in certain equipment failure and must be heeded.

### **1.2.2.3 Italics**

Italics are used for document titles such as *Vendor Literature* and bold italics emphasis as deemed necessary for such as *CAUTION and WARNING*.

## 1.2.2.4 Quotation Marks

These marks are used to delineate a specific pushbutton or other device from the regular text flow. e.g. "Close", "Open".

## 1.2.3 Audience

Operators must be trained and have thorough knowledge of this manual and safe practices around induction power supplies. New operators must be trained with experience personnel and supervised with "hands-on" operation.

## **WARNING**

HIGH VOLTAGES ARE ACCESSIBLE WITHIN THE CABINET. NO ATTEMPTS SHOULD BE MADE TO TROUBLESHOOT THIS EQUIPMENT UNLESS THE PERSONNEL HAVE BEEN TRAINED BY AJAX TOCCO MAGNETHERMIC AND ARE QUALIFIED!!!

## 2 Safety

### 2.1 Personnel

This section identifies and explains special risks associated with an Induction Power Supply. Topics include materials whose handling requires special precautions, as well as techniques and practices to observe while operating and/or servicing the furnace.

Personal safety equipment should be used as specified by local safety codes. Emergency supplies such as first-aid equipment should be readily available as specified by local safety standards.

Safety notices have also been placed in numerous other sections of this manual.

#### NOTICE

As mentioned frequently in this manual, is the necessity to apply common sense, follow plant procedures and heed the warnings in this manual and the *vendor literature*.

## 2.1.1 Personnel Training and Qualifications

The skills and training of personnel maintaining the Power Supply must be appropriate to the tasks being performed. Consult local plant procedures for details. As examples, personnel disassembling mechanical components or equipment should possess appropriate tools and be highly experienced handling heavy and sometimes awkward equipment. Personnel disassembling or troubleshooting electrical equipment must possess appropriate training and experience with the types of components being serviced.

### 2.1.2 Induction Fields

A magnetic field exists around the power cables and bus bar. Personnel should keep clear of these devices when the Power Supply is not locked out. Jewelry, and especially watches, earrings, and finger (and toe) rings should not be worn, as metallic objects will couple to the electromagnetic field and cause serious burns. The steel toes in safety shoes also present a burn hazard.

## CAUTION!

Personnel with heart pacemakers or metallic medical device or implants are at particular risk and should stay clear of all cables and bus bar.

## 2.1.3 High Voltages and Currents

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The Power Supply delivers /uses high current, voltage and frequency to achieve induction melting or heating. Warning signs are affixed and should never be removed. Where power cables connect, preventive maintenance should include keeping insulators from accumulating dirt that attracts moisture and could cause short-circuiting and heat.

CAUTION!
Always observe lock and tag out procedures before touching current carrying components

## 2.1.4 Mechanical Motion/Heavy Equipment

Consult plant standards for rigging and lifting the Power Supply before handling heavy objects. Also check rigging points in the Installation Chapter of this manual. Always "size up" the object to be moved or removed and use common sense when handling heavy objects.

## 2.1.5 Carcinogens

Materials that are believed to be carcinogens (or have caused cancer in laboratory animals) are used in the normal operation of the Power Supply. These materials may include the materials within components as well as solvents that are, or will, become part of the plant's inventory. The plant must maintain ready access to MSDS sheets on all materials and personnel must consult MSDS before performing work with any of these materials

### 2.1.6 Flammable Materials

Flammable liquids and pastes are used during maintenance of the Power Supply. These include various types of sealants, adhesives and solvents. A list of these materials is provided in the Preventive Maintenance Chapter and *Vendor Literature*.

Provide proper ventilation in the facility and follow applicable plant safety precautions at all times.

### 2.1.7 Media Under Pressure

The Closed Water System or water source that cools the Power Supply should operate with pressurized water from 30 to 45 psi differential. Observe pressure and temperature gauges to evaluate pressurized water risk of injury and take appropriate precautions consistent with plant safety rules. If water and/or other liquids or dirt enter the skin, medical personnel must remove them immediately to avoid tissue damage such as gangrene.

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## 2.2 Locks and Lock Out Tags

Locks and Tags are designed to prevent operation of equipment while personnel are performing maintenance. Each tag should be filled out and affixed by the person who will perform the maintenance. Locks and tags are typically affixed to:

Utility line supply valves (gas and water, etc.)

Power Supply disconnect

A lock is used to prevent a switch, disconnect or valve from being physically moved while the equipment is being serviced.

### **CAUTION!**

Electrical interlocks and in some cases mechanical limits are built into the Power Supply to protect personnel and equipment. Always use lock out and tag out procedures when maintaining electrical equipment. Bypassing interlocks must be avoided to protect personnel and safeguard equipment.

## 2.3 Forcing PLC Circuits and Defeating Safety Interlocks

All interlocks should remain as delivered and should NEVER BE FORCED or defeated. If there are occasions in system maintenance (with system off) where it is absolutely necessary, it is recommended that personnel consider the following points:

Interlock defeating should be undertaken only by or under the direction of experienced personnel.

A log should be kept of the actions and notices posted on the system that such is the case.

Interlocks should be tested for function after they have been restored.

Interlocks logged along with the time and date after testing is completed.

## 2.4 Cabinet Ground

The Power Supply cabinet must be grounded per National Electric Code specifications. Refer to the Power Supply nameplate for the input current rating and the ground plane diagram.

### 2.5 Acoustic Noise

Noise levels from the power supply are within the audio range of human hearing. These sound pressure levels can be quite high. Appropriate hearing protection shall be worn when working in the vicinity, especially for extended periods of time.

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## 3 Theory of Operation

## 3.1 Fundamentals of Operation

The Power Supply input power is typically 3-phase 480 VAC, 50/60hz. This is converted to approximately 680 VDC by the Power Supply front end. The DC is then converted back to AC at the desired frequency. The nominal output frequency is 0.5 to 3 kHz depending on tank capacitors.

## 3.2 Power Circuit

The circuit consists of four sections; Rectifier and Inverter sections, which are located inside the Power Supply, Tank Circuit, which includes the tap-able tank capacitors (inside the Power Supply) and the Load Coil (outside the Power Supply).

The input power to the rectifier section is a nominal 480 VAC, 3 phase, 50/60 Hz with the output at approximately 680 VDC. This 680 VDC feeds the inverter section, which is a variable frequency switching network that converts DC power to a single phase nominal 0.5 to 3 KHZ sinusoidal power. This single-phase output then drives the series Tank Circuit, consisting of a Load Coil (inductor).

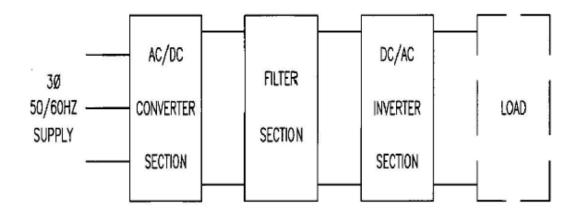
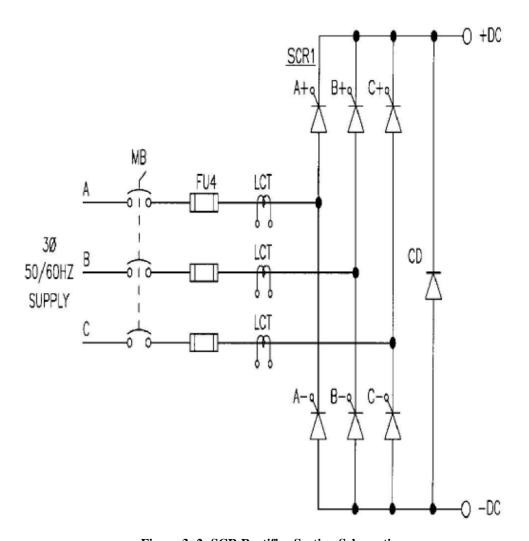


Figure 3-1: Power Zone Basic Circuit

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## 3.3 DC Bridge Section

The rectifier section consists of a SCR bridge and a Clamp Diode (CD) (figure 3-2) or just a Diode Bridge (figure 3-3). Actual reference designators for these components will be found on the schematic drawings and do not necessarily match the nomenclature used in this manual.



**Figure 3-2: SCR Rectifier Section Schematic** 

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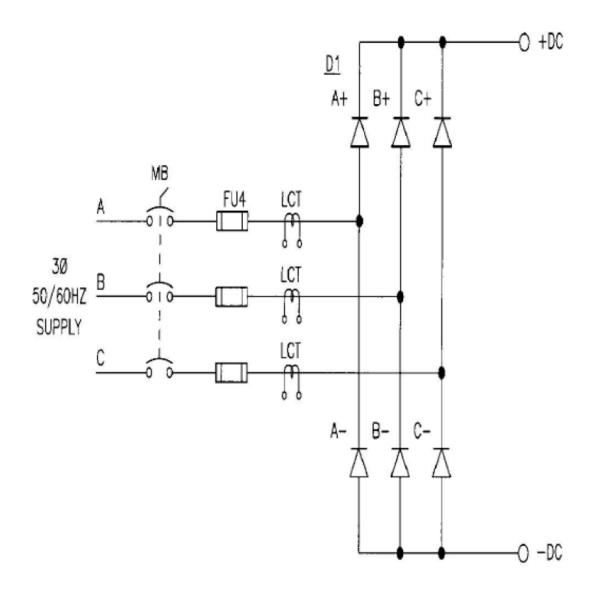


Figure 3- 3: Diode Rectifier Section Schematic



Figure 3- 4: Rectifier Panel



Figure 3- 5: Rectifier Logic Section

## 3.4 Inverter Section

The inverter is a half bridge. Figure 3-4 is the inverter section schematic. This section transforms the DC voltage into a single phase, high frequency output.

IGBT These are the Inverter IGBTs whose firing is controlled by the

logic to produce the 0.5 to 3 kHz output.

CF These are the filter capacitors used to block any AC

Voltage from entering the inverter section.

CTO This the Output Current Transformer which monitors the

Inverter output current and provides the Logic with a current

signal for metering, regulation and protection purposes.

Ls Series Output Inductance

Cs, Rs Capacitor-resistor snubber network to protect the IGBT gating.

PV Primary voltage on the inverter bridge

HF2, HF3 High frequency output terminals

The basic operational concept of the AC/DC inverter section consists of alternatively firing the positive (P+ & P-) and negative (N+ & N-) IGBTs at the frequency of the tuned load circuit. These firings occur prior to the zero crossing of the output current at a time sufficient to allow for complete recovery of the IGBT that is turning off.

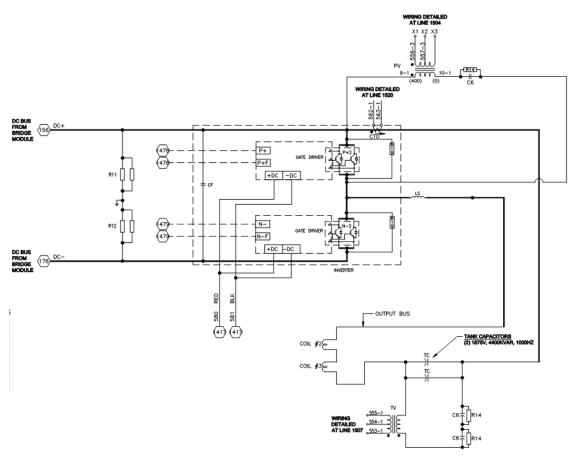


Figure 3- 6: Inverter Section Schematic



Figure 3-7: Inverter Section

# 3.5 Logic Section

The Power Zone control implementation uses one highly advanced embedded Field Programmable Gate Array (FPGA) integrated with two virtual microprocessor cores (NIOS II). All control is purely digital and is handled inside the FPGA and NIOS cores and leaves all hardware components on the circuit board to feedback conditioning and gate driving. With the single Power Zone Programmable logic board, all feedback, start, stop and potentiometer signals are hard wired to the Power Zone logic board through two ELCO connection points. Gating, fault, and reset signals controlling IGBT firing are connected with fiber optics.



Figure 3- 8: Logic Section

## Power Zone Limits are:

Inverter Voltage Limit (100% or 110%) Inverter Current Limit (100% or 110%) Tank Voltage Limit (100% or 110%) Power Limit (100% or 110%) KVAR Limit (133%)

## Power Forge Faults are:

Inverter Over Voltage High Frequency Fault
Inverter Over Current Low Frequency Fault
Line Over Current Line Sync Fault

Tank Over Voltage

KVAR Fault

Phase Fault

Lack of Feedback Fault

Test Mode Feedback Fault

Negative Phase Fault

Module Fault

Protection functions are implemented with 15 relay-isolated inputs on the termination board along with LED indicators. All protection functions with the exception of the water conductivity warning will perform a controlled shutdown and turn off high frequency power. In addition to removing high frequency power, the Power Circuit Door contacts and Heat Station Door contacts will also dump the main breaker UVR. All protection contacts are normally closed so that loss of a connection contact will trip the fault. All protection and fault functions, with the exception of the water conductivity warning, are latched and require a reset to clear.

The HMI display's the power supply faults. This is the primary level of diagnostic information **but** "flash codes" are implemented to give a secondary level of information. The flash codes also pull out each individual fault, protection or limit which directly tells the operator what the problem is. For example: The A/KVAR/KW Limit FAULT is lit on the HMI display, there are three possible reasons for it to light but the description on the mylar only says A/KVAR/KW. The communication protocol decodes these individually so that the operator knows exactly what the indicator is trying to show.

#### The Power Forge flash codes are:

## CAP/XFMR/V Limit and A/KVAR/KW Limit together:

# **Heartbeat:** (thump/thump)

This indicates a "Ready" condition. This should occur whenever there is no fault/protection and high frequency power is off.

#### Railroad: (alternate flash)

Indicates that no synchronization occurred with line frequency during start. Most likely not connected to the 60 Hz line voltage.

#### **Protection Indicator:**

#### Flashing: (2 per second)

Indicates that for some reason the breaker did not dump in test mode and that the power circuit actually energized.

## Solid by itself:

Indicates that a stop was made from a source other than the selected control source. (IE: In remote control, a stop is initiated from the local panel).

## **Flashing with solid Fault Indicator:**

Indicates that no feedback was sensed after two seconds of initiating a start. Most likely to occur when the start button is pressed without engaging the main breaker.

#### **Phase Fault Indicator:**

#### **Solid with Solid Fault Indicator:**

Indicates controller lost phase lock for more than 30mS and inverter phase angle is too low.

#### **Flashing with Solid Fault Indicator:**

Indicates a "Negative Phase Angle" Condition. This happens when inverter current leads inverter voltage. This can happen with too much 360 Hz ripple on the DC bus, or when getting incorrect feedback from the inverter voltage PT and inverter current CT.

#### **Over Current Indicator:**

#### **Solid with Solid Fault Indicator:**

Indicates an Inverter Over Current Trip has occurred.

#### Flashing with Solid Fault Indicator:

Indicates a Line Over Current Trip has occurred.

#### **Tank Over Volts Indicator:**

#### **Solid with Solid Fault Indicator:**

Indicates a Tank Over Voltage Trip has occurred.

#### **Flashing with Solid Fault Indicator:**

Indicates an Inverter Over Voltage Trip has occurred.

#### **CAP/XFMR/V** Limit:

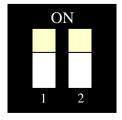
#### **Solid in Test Mode:**

Indicates the Local Potentiometer is wired correctly.

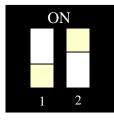
# 3.6 Regulation Modes

The Power Zone can control on 4 different operating parameters, Coil Voltage, Tank Voltage, Power and Inverter Current. SW2 on the logic board can be changed to regulate on the corresponding variable. Please see the diagram below:

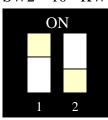
SW2 - 11 - CTO



SW2 - 01 - TV



SW2 - 10 - KW



SW2 - 00 - XP

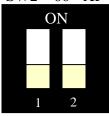


Table 3- 1:SW2 Regulation

CTO (Inverter Current)	11
TV (Tank Voltage)	01
KW (Power)	10
XP (Coil Voltage)	00

Figure 3-9: Switch 2 Regulation Modes

# 4 Power Supply Component Identification

#### POWER ZONE ASSEMBLY DRAWING H-02-XXXXX-01

sheet 01 Power schematic & Bridge rectifier

sheet 02 DC bus sensing crowbar, Water System Temp sensors, AC Ground

Detector, Bridge Pulse Amplifier, and Bridge Ethernet Card

sheet 03 Bridge Fault Section

sheet 04 Bridge Feedback Section

sheet 05 Controls Motor Starters and VFDs

sheet 06 PLCs, HMI, and Ethernet Switch

sheet 07 Safety Relays

sheet 08 PLC Racks

sheet 09 Inverter section 1 schematic

sheet 10 inverter section 1 Gate Drive Boards and Fault Section

sheet 11 Inverter section 1 Feedbacks

sheet 12 Exit conveyor control box

sheet 13 Inverter section 2 schematic

sheet 14 inverter section 2 Gate Drive Boards and Fault Section

sheet 15 Inverter section 2 Feedbacks

#### sheet 1 Power Zone major component layouts G-21-XXXXX

#### reference

SH-32-XXXXX Power Zone outline drawing G-03-XXXXX Power Zone water schematics

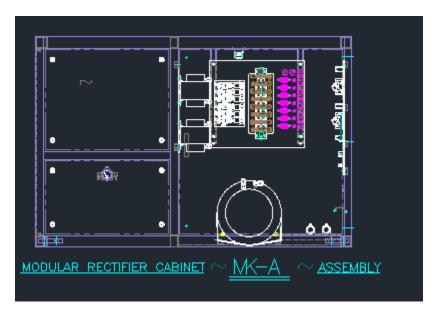


Figure 4-1: Bridge Section Layout

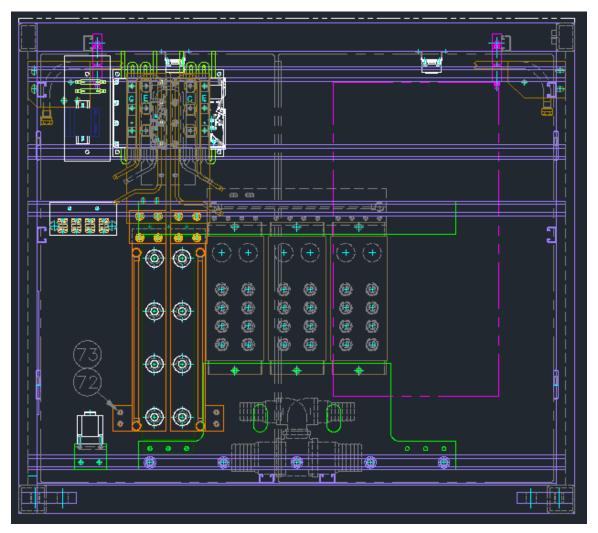


Figure 4- 2: Inverter Section Layout

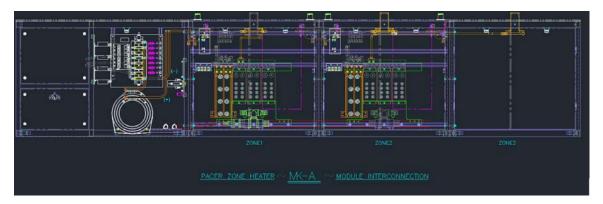


Figure 4- 3: Power Zone Layout

# 5 Start Up Procedures

When starting the Power Zone, follow the startup checklist. The first section of this list is "POWER OFF CHECKS".

#### 5.1 Power Off Checks

#### 5.1.1 Checks at Installation

These steps may not be necessary after installation and startup unless the Power Supply is being moved or replaced.

- 1. Remove all shipping braces and packing material.
- 2. Check for loose parts and shipping damage
- 3. Verify that all internal bus bars and terminal strips are tight.
- 4. Make sure that the customer terminal strips are connected as per print.
- 5. Visually inspect control boards for any damage and make sure that all logic board cables are properly installed. This may also mean unwrapping printed circuit boards and plugging them in place.
- 6. Turn on water and inspect for leaks.
- 7. Verify all control fuses are functional using a volt-ohm meter. Consult assembly drawings for fuse location on fuse block.

# 5.1.2 Checks and Operation

Perform these checks each time the Power Supply is started from an inoperative condition and/or after maintenance.

- 1. Check grounding strap (cable) from the cabinet or base is connected to facility earth ground.
- 2. Turn on water and inspect for leaks.
- 3. Connect input power cables (480V, 3-phase, VAC) sized as per the Power Supply's requirements, to the top of the Main Disconnect.

#### 5.2 Breaker Closed Checks

The following checks require "BREAKERS CLOSED" and therefore, extreme care should be taken due to high voltages inside the cabinet.

- 1. Close the Control Breaker
- 2. Turn the water system on from both the Power Supply and the Tower Water System Control Panels. Reduce the water flow to the Power Supply using the valves at the power supply connection point and check the water pressure switch operation. Then return pressure to the normal 30 to 40 psi (2 to 2.75 bar) differential, inlet to outlet.
- 3. Close the Main Circuit Breaker and check the door interlock switch to make sure it trips the Main Circuit Breaker if the door is opened.
- 4. Reset and verify that all faults are cleared and that there is a flashing/alternating "heartbeat" between the "A/KVAR/KW LIMIT" and the

- "CAP/XFMR LIMIT" display indicators, which show that the power supply is ready to be started.
- 5. CHECK TO MAKE SURE THAT THERE IS NO ONE WORKING ON, OR NEAR THE COIL OR LEADS BEFORE ENERGIZING/STARTING THE EQUIPMENT. The power supply may now be started with the "START" button and power may be adjusted.

## CAUTION

DO NOT OVERRIDE ANY PRESSURE OR THERMAL SWITCHES. OPERATING WITH INADEQUATE WATER FLOW, OR EXCESSIVELY WARM WATER WILL DAMAGE THE POWER SUPPLY

#### WARNING

OPERATING THE POWER SUPPLY WITH THE DOORS OPEN SHOULD ONLY BE DONE BY TRAINED, QUALIFIED PERSONNEL, BECAUSE OF THE HIGH VOLTAGES THAT ARE ACCESSIBLE WITHIN THE POWER SUPPLY!!!

# 5.3 Load Analysis

## WARNING

DURING THIS TEST, THE LINE AND CONTROL VOLTAGE ARE OFF AND YOU HAVE FOLLOWED YOUR COMPANY'S PREDETERMINED "LOCK/OUT-TAG/OUT" PROCEDURES. THIS TEST DOES NOT REQUIRE ANY LINE OR CONTROL VOLTAGE.

#### Tank Frequency Test (this test is only used if the load changes)

1. **Setup**: Disconnect the inverters from the tank circuit. Connect an oscillator to

the output leads coming from the power supply or at the buss bar going into the capacitor station. The oscillator used must have an output impedance of 50 ohms or less and be capable of providing a sine wave at frequencies of 500 Hz to 3 kHz and 1 to 5 volts in magnitude. Connect an oscilloscope to the same connection as the oscillator. The oscilloscope must also be capable of reading 500 Hz-3 kHz sine

- 2. <u>Pre-tuning</u>: Turn on the oscillator and the oscilloscope. Sweep the frequency range with oscillator in the vicinity of the estimated resonant frequency. Adjust the oscillator's frequency slowly enough that a rise in the tank voltage can be detected on the oscilloscope. The resonant frequency is found when the oscilloscope voltage trace rises to a peak and further adjustment of the frequency reduces the magnitude of the trace.
- 3. Add or remove capacitor taps and re-test to reach desired frequency.

## **WARNING**

ALWAYS REMOVE HIGH VOLTAGE FROM THE POWER ZONE BY DE-ENERGIZING THE MAIN DISCONNECT PRIOR TO ENTERING THE LOAD STATION TO CHANGE MATCHING COMPONENTS!!!

# 6 Basic Trouble Shooting

## WARNING

HIGH VOLTAGES ARE ACCESSIBLE WITHIN THE CABINET. NO ATTEMPTS SHOULD BE MADE TO TROUBLESHOOT THIS EQUIPMENT UNLESS THE PERSONNEL HAVE BEEN TRAINED BY AJAX TOCCO MAGNETHERMIC AND ARE QUALIFIED!!!

# 6.1 Fault Troubleshooting

Circuits that protect the power supply are broken down into three categories, faults, protections and limits. Faults occur when a limit of the dynamic operating range of the power supply is exceeded such as an over current condition. Protections occur when an event happens that prevents the power supply from running such as an open power section door. Limits occur when the logic is limiting the power supply from supplying more voltage, current or power.

# 6.1.1 Fault Explanations

Low Frequency Fault: A Low Frequency Fault will occur when the power supply operates at 40 % frequency for longer than .5 seconds. This condition will usually happen when the logic does not have enough current and voltage feedback signals to determine phase lock. If this is not the circumstance, then the resonant frequency of the output circuit is too low. This condition can be remedied by removing capacitors in the tank circuit.

<u>High Frequency Fault:</u> A High Frequency Fault will occur when the unit operates at high frequency and high current. Operating the power supply in a ratio of 120% Frequency to 110% current for more than .5 seconds will trigger a High Frequency Fault condition. This condition can be corrected by lowering the operating frequency of the power supply by adding capacitance in the tank circuit.

#### WARNING

When adding or removing capacitance, capacitor nuts must be properly tightened and insulated if not being used! The Tank Voltage feedback transformer PCB connections must be installed in the exact locations they were removed from!

Module Fault: A Module Fault is detected by the Gate Drive PCB. The presence of the fault may indicate a failure of an IGBT. If the fault can be reset and is not reoccurring, run the power supply in test mode. If the fault does not reoccur, restart the power supply. A resettable Module Fault can occur from noise generated by an arc in the capacitor station. With the power supply off and locked out, check for signs of arcing in the capacitor station. Make sure all capacitor connections are tight. If the fault cannot be reset, there is a problem with a component in the power section of the power supply. Check Fault fiber optic cables for kinks or tears. Check the IGBTs (Section 6.2 Basic Checks).

<u>Inverter Over Current:</u> An Inverter Over Current fault is measured by the output current transducer (CTO). This fault occurs when the inverter current at the output of an inverter peaks higher than the acceptable level for continued safe operation.

Possible Corrective Actions:

- 1. Check the tank capacitors
- 2.Check all IGBTs
- 3.Place logic in the Test Mode and check for pulses (See Test Mode).

**Phase Fault:** A Phase Fault indicates the power supply logic controller lost phase lock for more than 30 mS and inverter phase angle is too low. This problem would most likely be a feedback signal problem. Check all connections to the inverter voltage PT and the inverter current CTOs all the way back to the logic board.

Negative Phase Fault: A Negative Phase Fault Indicates a "Negative Phase Angle" Condition. This happens when inverter current leads inverter voltage. This can happen with too much 360 Hz ripple on the DC bus or when getting incorrect feedback from the inverter voltage PT and inverter current CT. Check that the inverter voltage PT and the inverter current CTOs connections were not accidentally reversed. Check the inverter voltage PT and inverter current CTOs connections all the way back to the logic board. Inverter Over Voltage: An Inverter Over Voltage fault is measured by the inverter voltage PT. This fault occurs when inverter voltage present across the output of an inverter peaks higher than the acceptable level for continued safe operation. Check the inverter voltage PT connections to the inverter and to the control logic.

<u>Tank Over Voltage:</u> This fault is detected when the voltage present across the Tank Capacitors peaks higher than the acceptable level for continued safe operation. This is a tuning problem and one can tune the tank circuit as to reduce the voltage present across the capacitor.

Possible corrective actions:

- 1. Check Coil connections or clamps. Make sure there is a good tight connection.
- 2. Add more capacitance to the Tank Circuit.

# WARNING

When adding or removing capacitance, capacitor nuts must be properly tightened and insulated if not being used! The Tank Voltage feedback transformer PCB connections must be installed in the exact locations they were removed from!

<u>Line Over Current</u>: This fault occurs when a current peak is detected by the line current transformers that is higher than the acceptable level for continued safe operation. Check the line current CT's and their respective connections back to the logic compartment. Check for loose ground wires in the logic compartment. Check all connections in the DC Bridge section.

**KVAR Fault:** This fault occurs when the reactive power in the system is higher than the acceptable level for safe operation. The red "FAULT" Indicator along with the yellow "A/KVAR/KW LIMIT" Indicator, indicate this fault. An active "BIT 4" in the register "30013" of the communication table will also indicate the KVAR Fault. This fault can be corrected by reducing frequency by adding capacitor sections to the tank circuit.

## **6.1.2 Protection Explanations**

Temp (Temperature) Fault: When lit, indicates allowable temperature limits have been exceeded at any of the outlet water monitored locations within the converter. If a Temperature Monitor Board is used, visual inspection will be required to the independently located temperature monitor display which will indicate, by bar segment readout, a "frozen" display. The display will show a location # (0-15), a location ID description legend relating to all monitored locations, and a reference temperature for each location relating the "trip" temperature for that area. Look for the "Hi-temp" indicator also to be lit at this time. Watch for the "fault" indicator to possibly be lit at this time indicating an open circuit sensor condition (bad thermistor wiring) of same problem. When the Temperature Monitor Board is not used the temperature of the water paths is monitored via thermo discs located on the water outlet header. All thermo discs are electrically connected in series. If a thermo disc has tripped, press the red button on the thermo disc to reset it and check the water path for any blockage.

<u>Ground Fault:</u> When lit, indicates a ground condition has occurred between the power circuit and earth ground in excess of allowable limits. To correct or satisfy this protection condition, first inspect for excessive lining wear or damage. Generally, if the Ground Detector can be reset without immediate re-tripping, it is safe to attempt a system restart. However, it is the responsibility of the operator to first at least attempt to evaluate why a ground trip occurred at all.

<u>AUX (Water Conductivity):</u> When first lit, indicates a de-ionized water circuit (WATER CONDUCTIVITY) conductivity condition as a warning to inspect the de-

ionized water circuit quality, while still allowing normal converter operation. If not corrected, a heat disabling protection shutdown will occur at a time when the de-ionized water reaches a fault level. This disabling shutdown is indicated by the combination of the "AUX" and "PROTECT" Indicator. Please refer to the Conductivity Board section for further information on alarm and fault levels. To correct this protection condition, complete replacement of the de-ionized water in the system with fresh is recommended.

<u>Switch Interlk(optional)</u>: When lit, it indicates furnace selector switch isn't in a proper position or the furnace selector switch has been switched after the controls were last reset. Refer to the Power and Control Schematic for further information. To correct this protection condition, re-evaluate and reassure correct furnace switch positioning, and then reset the controls.

<u>Test Mode:</u> When lit, indicates the power supply is in "Test Mode". This mode is a method for determining whether pulses are delivered to the IGBTs, and bridge SCRs (if used), without the presence of high voltage in the converter. See the section on "Gate Pulse Test" for more information.

<u>Water Pressure:</u> When lit, indicates unacceptably low water flow in any of the possible water circuits:

- 1) Bridge Section de-ionized water system circuit- must have a minimum 30 psi differential reading on the associated gauge located on the front of the rectifier cabinet.
- 2) Coil Section de-ionized water system circuit- must have a minimum 30 psi differential reading on the associated gauge located on the front of the capacitor stations cabinet.

To correct this protection condition, inspect for adequate water pressure and flow throughout the associated water circuit as required.

<u>UVR Aux (Under Voltage Release Auxiliary)</u>: When lit, indicates loss of UVR voltage to the main circuit breaker as supplied by customer designated switch(es) with normally open contacts. This provision allows for additional personnel safety by allowing the customer to "customize" safety interlocks at the plant, which may not have been considered by original system engineering. This condition will result in loss of UVR voltage to the main circuit breaker thereby either "dumping" it if previously energized, or not allowing it to be energized. This condition will most likely occur when an Emergency Stop button is pressed. To correct this protection, check that a closed electrical circuit condition exists when a safe operating condition exists.

<u>Power Sec Door (Power Section Door):</u> When lit, indicates that a door in the section is open. This fault will result in loss of UVR voltage to the main circuit breaker thereby either "dumping" the main breaker it if previously energized, or not allowing it to be energized. To correct this protection condition, ensure that this door is fully closed, then press reset to clear the indication.

<u>Heat Sta Door (Heat Station Door):</u> When lit, it indicates a tripped door switch, (partially or fully open door), at the door accessing the tank circuit capacitors, or output isolation transformer, (when they are separate from the converter). This condition will

result in loss of UVR voltage to the main circuit breaker thereby either "dumping" the main breaker it if previously energized, or not allowing it to be energized. To correct this protection condition, ensure that this door is fully closed, then press reset to clear the indication.

<u>Control Door:</u> When lit, it indicates a tripped door switch, (partially or fully open door), at the control section of the system This condition will result in loss of UVR voltage to the main circuit breaker thereby either "dumping" the main breaker it if previously energized, or not allowing it to be energized. To correct this protection condition, ensure that this door is fully closed, then press reset to clear the indication.

<u>AUX 1 – AUX 4:</u> When lit indicates a "tripped" protection circuit. These are spare; user designated, indicators, whose purpose of protection should be documented on pages 3, 10, or 14 of the Power and Control Schematic; (They all require a closed contact to satisfy protection logic.) To correct these protection conditions, refer to the Power and Control Schematic, to determine the function of the suspect circuit.

# 6.1.3 Limit Explanations

<u>Inverter Current Limit:</u> This will occur when the power supply is delivering the maximum allowable output current, thus limiting any further attempt to increase current so as not to exceed the rated output current of the power supply. To identify the inverter current limit, the yellow "A/KVAR/KW LIMIT" Indicator will be lit along with "110" being shown in the %AMPS Indicator. An active "BIT 0" in the register "30013" of the communication table will also recognize the inverter current limit.

Inverter Power Limit: This will occur when the power supply is delivering the maximum allowable output power, thus limiting any further attempt to increase power so as not to exceed the rated output power of the power supply. To identify the inverter power limit, the yellow "A/KVAR/KW LIMIT" Indicator will be lit along with "110" being shown in the %kW Indicator. An active "BIT 3" in the register "30013" of the communication table will also recognize the inverter power limit.

<u>Capacitor Voltage Limit:</u> This will occur when the power supply is delivering the maximum allowable voltage across the tank capacitors in the heat station, thus limiting any further attempt to increase voltage so as not to exceed the rated capacitor voltage of the power supply. To identify the capacitor voltage limit, the yellow "CAP/XFMR LIMIT" Indicator will be lit along with "110" being shown in the %VOLTS Indicator. An active "BIT 2" in the register "30013" of the communication table will also recognize the capacitor voltage limit.

<u>Inverter Voltage Limit:</u> This will occur when the power supply is delivering the maximum allowable voltage across the high frequency output of the power supply, thus limiting any further attempt to increase voltage so as not to exceed the rated inverter voltage of the power supply. To identify the inverter voltage limit, the yellow "CAP/XFMR LIMIT" Indicator will be lit. An active "BIT 1" in the register "30013" of the communication table will also recognize the inverter voltage limit.

## 6.2 Basic Checks

#### 6.2.1 IGBT Self-Test

When the Main Breaker is closed (and every time the unit goes into Ready mode) the logic will check the status of the inverter IGBTs. If any of them check bad, the logic will indicate a Module Fault on the Front Panel. To determine which IGBT is bad, inspect the Fault Feedback Fiber Optics. The failed IGBT or gate drive will be the one without the red light coming from the fiber optic

#### **Diode Forward Biased:**

#### (+) PROBE ON ANODE (-) PROBE ON CATHODE

When forward biased, the ohmmeter reading will be low"; less than 20 ohms.

#### **Diode Reverse Biased:**

#### (-) PROBE ON ANODE (+) PROBE ON CATHODE

When reverse biased, the ohmmeter reading will be high; greater than 500 ohms. If a zero ohm reading is indicated in both directions, the diode or its associated snubber network is shorted.

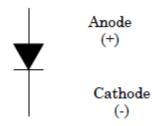


Figure 6-1: Typical Diode Schematic

#### 6.2.2 Inverter IGBT Ohmmeter Test

To check the IGBTs (insulated Gate Bi-Polar Transistor), obtain an Ohmmeter; check the emitter to collector, the gate-o-emitter, and the gate-to-collector junctions. Make to check both isolated connections on each device.

To check the emitter-to-collector junction, place the positive lead on the emitter connection and the negative lead on the collector connection. Observe the meter to read a resistance of 2K Ohms- 5K Ohms or more. Reverse the positions, of the meter leads, so that, the positive lead is on the collector and the negative lead is on the emitter. Observe the meter to read approximately the same, (note: this is due to the snubber components in parallel with each device). This value will vary depending on how strong a signal is produced by the meter to turn the diode junction, internal to the IGBT on. Use the meter's

diode test function to read approximately 0.3 V diode drop. A bad device will read close to zero Ohms in both directions, indicating a bad emitter-to-collector junction.

To check the gate-to-emitter junction, place the positive lead on the gate connection and the negative lead on the emitter connection. Observe the meter to read a high resistance of 50K ohms o more when the IGBT is in circuit. This resistance will increase towards an open reading when the IGBT is out of the circuit, due to the gate capacitance. A bad device will read zero Ohms, (or close to zero), indicating a bad gate-to-emitter junction.

**Table 6-1:IGBT Meter Readings** 

## **IGBT READINGS (OUT OF CIRCUIT)**

(+) (-)	DIGITAL METER (DMM)
E-C =	25K – 75K
C-E =	120K – "OVERLIMIT"
E - C =	.301 vdc
G - E =	STARTED AT 2M THEN GOES OVERRANGE (> 4M)
C - G =	STARTS AT 2M THEN GOES OVERRANGE (> 4M)

## IGBT READINGS (IN CIRCUIT)

+) (-)	DIGITAL METER (DMM)
E-C =	2K – 7K
C-E =	2K – 7K
E - C =	.301 vdc
G - E =	STARTS AT 1 OR 2M THEN GOES OVERRANGE (> 4M)
C - G =	STARTS AT 1 OR 2M THEN GOES OVERRANGE (> 4M)

To check the gate to collector junction, place the positive lead on the gate connection and the negative lead on the collector connection. Observe the meter to indicate an open reading. A bad device will read zero Ohms indicating a bad gate-to-collector junction.

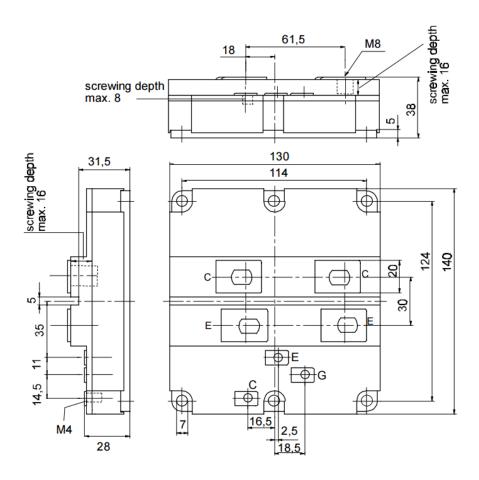


Figure 6-2: IGBT Module Outline

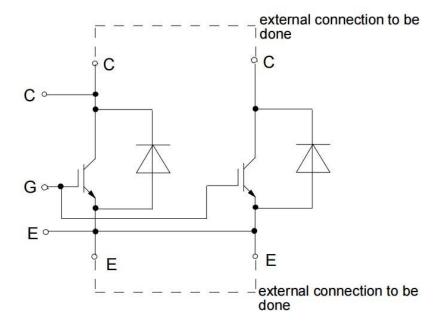


Figure 6-3: IGBT Schematic

#### 6.3 Fuse Failures

The Power Zone is designed to recover from SCR commutation fault and load faults without component failure. This self-protection eliminates casual fuse failure. Therefore, if a fuse fails, there is a problem that must be corrected.

#### 6.3.1 Control Fuse Failures

The control fuses protect the control transformer and control circuitry from excessive current. If these fuses failed, check the following:

- 1. Short circuit on door switch wiring.
- 2. Under voltage release on Main Breaker is bad.
- 3. Logic power supply, system power supply or main power supply is bad.
- 4. Bad fan in logic enclosure.

#### 6.4 Tests

#### 6.4.1 Gate Pulse Test

This test mode is a method for determining whether pulses are delivered to the IGBTs, and bridge SCRs (if present), without the presence of high voltage in the converter. In Test Mode, as in Run Mode, the gate pulses are generated at the Logic Board and are transmitted to the Gate Drive Boards. If an SCR bridge is used, the Logic Board also sends gate-pulse signals via fiber optic cables, to the 6-channel Pulse-Amp board.

To use this test method, follow these steps:

1. Turn on the Control Breaker. The HMI Display should turn on indicating control power is present.

- 2. **Do not turn the Main Circuit Breaker on**. If the Main Circuit Breaker is on, then **turn it off**, **(open it)**, before proceeding, and perform your company's predetermined "Lock/Out-Tag/Out" procedure. (NOTE: Lock-Out is an OSHA requirement).
- 3. At the Logic Board, flip the switch labeled SW3 switch 1, to the upper, or "TEST" position. (It should have been in Run-Mode before this) Observe the red "TEST MODE" indication light on the diagnostic display, on the front panel, to be lit at this time. Also observe that the green "Main Breaker Enable" light will go off on the front of the unit.
- 4. While in "Test Mode", the logic will ignore protection indications, such as water conductivity, door open, etc. The only protection that will need to be satisfied is water pressure. This protects the gate drives from overheating during gating. However, if the fault Indicator is lit, press the "Stop/Reset" button to clear the fault(s). If there are no faults the A/KVAR/KW LIMIT and CAP/XFMR V LIMIT Indicators, known as the "heartbeat", will be flashing. If the "heartbeat" cannot be obtained, turn off control power for 3 or 4 seconds, then back on. If there are no faults showing, and the "heartbeat" still cannot be obtained, change the Logic Board.
- 5. Press the "Power On" button on the front panel and you should be able to observe three things:
  - The green "Power On" Indicator should light.
  - The frequency display should show some value other than 0.
- 6. Use an oscilloscope with a voltage probe to view the gate drive signals to the IGBTs.
- 7. Rotate the control potentiometer to "sweep" the firing pulses through the frequency range of the power supply and advance the bridge pulses through the normal firing range.

Once you have verified that all pulses are present, and replaced any component necessary, you should prepare the unit to go back into production by performing the following steps:

- 1. Press the Stop/Reset Button.
- 2. Return SW1 switch 1 on the Logic Board to the Run position.
- 3. Be sure that the all protection circuits are satisfied, then, Press the Stop/Reset button again to clear any faults showing. If the fault and protection Indicators are not lit, and if the "heartbeat" is flashing, then continue to step 4.
- 4. Remove your lock/Out, and turn the Main Circuit Breaker on.
- 5. Check the area around the power supply, furnace or heating coil, and all External buss work, to make sure that everything is safe for operation.

6. Try to start the unit. The unit should now be ready for production.

## 6.4.2 'Burp' Test

"Burp tests" are tests used primarily at start-up, but they can also be of some benefit in troubleshooting. One usage of these tests for troubleshooting would be if the PV, or output CT, (CTO), or their wiring had been damaged, or replaced, and the unit will not start afterwards. The "burp" test can also be used to detect arcing in the output, without the worry of damaging components that would be present if you tried to actually run the power supply.

### How to perform the Burp Test:

- 1. Close the main circuit breaker and record the peak DC bus voltage on the voltmeter.
- 2. Connect a 10x probe to TP 14 "PV" on the logic board. Set the volts/div to 1v/div. This is the inverter voltage signal the logic actually "sees".
- 3. Connect a 10x probe to TP 12 "CTO". Set the volts/div to 1v/div. This is the inverter current signal the logic actually "sees".
- 4. Set the oscilloscope up to 5 uSec/div. Set for a single acquisition. Set to trigger on the rising edge of the channel that TP 14 "PV" is hooked up to.
- 5. Open the main breaker and **immediately** press the START button.
- 6. Observe a square wave on TP 14 "PV" and a sinusoidal wave on TP 12 "CTO". PV must go positive first and the CTO will peak positive 90 degrees later. This indicates correct polarity on the feedback signals as the logic sees them. IF they appear incorrectly or are absent, troubleshoot and then repeat the test.

# 7 Communications

## 7.1 Power Zone Remote Controls

The Power Zone logic board has integrated the Modbus protocol into the logic for fast and reliable monitoring and remote control. Modbus protocol was developed by Modicon in 1979 and has become an industry standard for supervisory control and data acquisition systems. Modbus was chosen because of open source and royalty free publishing along with the most common means of networking programmable logic controllers.

The Power Zone logic board supports only the following Modbus function codes:

- 04 Read Input Registers
- 06 Preset Single Register
- 16 Preset Multiple Registers
- Port: 502

#### **Meter Monitoring:**

Monitoring of the meter values on the Power Zone logic board can be done at any time the logic board is powered. Monitoring can be done in either local or remote control and does not require a watchdog in order to operate. Meter Monitoring can be achieved by using Modbus Function 04 Read Input Registers. See Register Revision spreadsheet for variable names and locations.

#### **Remote Controls:**

The Power Zone logic board safely integrates Remote Start, Remote Stop and Remote Demand control through Modbus protocol. In order to achieve Remote Control functionality, a Modbus Master must be connected and communicating with the Power Zone logic board. The Local/Remote (2) switch on SW1 must be closed by placing the switch in the up position. In order to maintain a Remote Control connection, the Modbus Master must continually write a "0x01" to Address "40003" using Modbus Function 06 Preset Single Register or Modbus Function 16 Preset Multiple Registers. This must be written in sub 2-second intervals or the Power Zone logic will do a normal shutdown of the power supply. This is a safety precaution and is meant to deter lack of communication or cable connection problems.

Sending a START signal to the Power Zone logic board can be achieved by writing a "1" to address "40011" using Modbus Function 06 Preset Single Register or Modbus Function 16 Preset Multiple Registers. This is a "pulsed" command and will be written back to "0x0" by the Power Zone logic. This function will provide a normal "On Sequence" of the power supply.

Sending a STOP signal to the Power Zone logic board can be achieved by writing a "1" to address "40012" using Modbus Function 06 Preset Single Register. This is a "pulsed" command and will be written back to "0x0" by the Power Zone logic. This function will provide a normal "Shutdown" of the power supply followed by a normal "Reset" of the power supply. In the event of a fault condition, this function will provide a normal "Reset" of the power supply.

Sending a DEMAND signal to the Power Zone logic board can be achieved by writing 0-4096 to address "40002" using Modbus Function 06 Preset Single Register or Modbus Function 16 Preset Multiple Registers. The Demand signal needs to be scaled to 100%=3412.

**Table 7- 1:Modbus Functions** 

Meter/Read Only Registers			
Modbus Function Code	Register	Name	Scale
04 Read Input Registers	30001	Inverter Voltage	100% = 3412
04 Read Input Registers	30003	Inverter Current	100% = 3412
04 Read Input Registers	30005	Power	100% = 3412
04 Read Input Registers	30007	Frequency	In Hertz 1000Hz = 1000
04 Read Input Registers	30009	TV	100% = 3412
04 Read Input Registers	30011	KVAR	0-133%
04 Read Input Registers	30013	Flt4 Variable	*
04 Read Input Registers	30015	Pot Control	100% = 3412 = 4.165 VDC
04 Read Input Registers	30017	Flt1 Variable	*
04 Read Input Registers	30019	Flt2 Variable	*
04 Read Input Registers	30021	Flt3 Variable	*
04 Read Input Registers	30027	Regulation Mode	•

Remote Registers			
Modbus Function Code Register Name Scale		Scale	
06 Preset Single Register	40011	Remote Start	1 = Start
06 Preset Single Register	40012	Remote Stop	1 = Stop
06 Preset Single Register	reset Single Register 40002 Remote Pot Control 100% = 3412		
06 Preset Single Register	40003	Remote Watch Dog	1 = Online

	*Regulation Mode		
Code	Bit Mask		
0	CTO Regulation		
4	kW Regulation		
8	TV Regulation		

*Fit1 Variable		
Active Bit	Bit Mask	
Bit 0	Module Fault: Protects unit from running into a failed device	
Bit 1	Over Current Fault: Active when current = 120%	
Bit 2	Tank Over Voltage Fault: Active when voltage = 120%	
Bit 3	Phase Fault: Active when loss of phase lock	
Bit 4 CAP / XFMR / V Limit: See Flt4 Variable below		
Bit 5 A / KVAR / KW Limit: See Flt4 Variable below		
Bit 6 General Fault: Active along with a specific fault		
Bit 7	Bit 7 General Protection: Active along with a specific protection	

*FIt2 Variable		
Active Bit	Bit Mask	
Bit 0	Frequency: Active along with a low or high frequency fault	
Bit 1	Test Mode: Active when power supply is in Test Mode	
Bit 2	Power On: Active when power supply is delivering high frequency output power	
Bit 3	Temperature Fault: See Water Trip Table below	
Bit 4	Water Pressure Fault: See Water Trip Table below	
Bit 5	Bit 5 Auxiliary Fault: See Water Trip Table below	
Bit 6	Auxiliary 1	
Bit 7	Ground Fault: Active when AC Ground Detector Trips	

	*Flt3 Variable		
Active Bit	Bit Mask		
Bit 0	Switch Interlock Fault		
Bit 1	Control Door		
Bit 2	Auxiliary 3		
Bit 3	Auxiliary 4		
Bit 4	4 Auxiliary 2		
Bit 5	Bit 5 Power Section Door – Active when any power section door is opened		
Bit 6	Heat Station Door – Active when any heat station door is opened		
Bit 7	UVR Auxiliary – Active when auxiliary under voltage release is de-energized		

	*FIt4 Variable		
Active Bit	Bit Mask		
0	Current Limit: Active in current limiting condition = 110%		
1	Inverter Voltage Limit: Active in inverter voltage limiting condition = 110%		
2	Tank Voltage/Coil Voltage Limit: Active in tank/coil voltage limiting condition = 110%		
3	kW Limit: Active in power limiting condition = 110%		
4	kVAR Fault: Active when in a volt-ampere reactive fault condition = 133%		
5	Low Frequency Fault: Active when below 40% of nominal rating		
6	Line Sync Fault: Active when line frequency signal is removed		
7	Lack of FB Fault: Active when Feedback is below minimum level = 2%		
8	8 Test Mode FB Fault: Active when Feedback is sensed while in Test Mode		
9	Low Phase Fault: Active when loss of phase lock		
10	Negative Phase Fault: Active when inverter current leads inverter voltage		
11	Line Current Fault: Active when line current exceeds rating		
12	Hi Freq Fault: Active when exceeding frequency to current ratio = 120%/110%		
13	Inverter Voltage Fault: Active when voltage = 120%		

Water Trip Variables	Trip Value
Water Inlet Temperature Trip	105 F
Control Section Air Temp Trip	125F
Power Section Air Temp Trip	125 F
Reactor Temperature Trip	NA
Filter Choke TemperatureTrip	NA
Water Pressure Trip	29 psi
Water Conductivity Trip	NA
Water Conductivity Warning	NA

# 8 Installation

#### 8.1 Installation

## 8.1.1 Unpacking

If facilities for shelter of equipment are not available, do not unpack until ready to use. If this equipment is to be stored for any period of time prior to installation, the storage area should be a dry and protected, which is not subject to severe humidity changes, freezing temperatures, extreme oily or dry atmosphere, etc.

## 8.1.2 Extended Storage

Power Zone systems stored for extended periods of time should be handled as follows:

- 1. Purge all water from the Power Supply using low-pressure air.
- 2. To minimize rubber hose aging and general corrosion, the Power Supply cabinet should be stored with doors and panels closed under the conditions described in section 8.1.1.

Before placing the stored Power Supply into service, open all electrical connections, clean and retighten. A general inspection for damaged or missing components is also recommended.

# 8.1.3 Nameplate Markings

The nameplate on the side of the Power Supply lists the model number, serial number, voltage, current, frequency and kilowatt ratings of the system. When ordering spare parts, please have these numbers available.

#### 8.2 Location

Although the Power Supply is enclosed in a NEMA 12 type cabinet, good practice, especially concerning working conditions for the maintenance personnel, requires that installation be in a dry atmosphere, not subject to dripping moisture or steam and minimal exposure to dirt from coal, ashes, metallic dust, or chemical contaminants. Hazardous areas containing flammable gases or extremes in temperatures of over 125°F (52°C) and below 32°F (0°C) must be avoided.

#### 8.2.1 Foundation

The Power Supply is designed for floor or balcony mounting. Access is from the front and the back therefore mounting against a wall is not permissible. Care should be taken to provide adequate clearance for door swings, input power and water connections. In addition, leveling should be done to minimize cabinet warping, which may prevent doors from proper sealing. In vibration areas, shock mounting is recommended.

#### 8.2.2 Additional Electrical Loads

No additional electrical loads are to be connected to the Power Supply control transformer. In addition, timers, relays or lights should not be mounted in the Power Supply cabinet or control/display panel without prior approval by Ajax Tocco engineering. These restrictions are for the Power Supply protection., since miscellaneous component additions can interfere with proper Power Supply operation and can therefore cause control system failures.

#### 8.2.3 Water Connections

The water strainer provided with the Power Supply should be connected into the incoming water lines and should be kept clean. The Power Supply requires a minimum of 30 psi differential between inlet and outlet manifolds. For specific gpm requirements at 30 psi, consult your Ajax Tocco engineering representative. The maximum water system pressure is not to exceed 90 psi. The water supply quality must be in accordance with Ajax Tocco Engineering Bulletin 370B24.

In general, the water should be clear, without sediments or floating particles. The minimum water resistivity is 3.333 ohm-cm or a conductivity of 300 micromhos/cm. For best operation, a resistivity of 5,000 ohm-cm or 200 micromhos/cm is recommended. For specific information, contact your Ajax Tocco engineering representative and request a copy of the Ajax Tocco Bulletin 370B24.

## 8.2.4 Water Specifications

Maximum inlet temperature 105°F (37.8°C)

Minimum inlet temperature High enough to prevent condensation

Minimum inlet pressure 30 psi (2bar) differential inlet to outlet

Maximum system pressure 90 psi (6bar)

Maximum outlet water temperature Individual lines or combination 130°F (54°C)

Maximum resistivity 75 micromhos/cm

# 8.2.5 Air Specifications

Maximum ambient air temperature 125°F (52°C).

#### 8.2.6 Corrosion Concerns

Since the Power Supply contains cooled copper bus, brass fittings and internal DC components, galvanic corrosion can occur at accelerated rates if improper plumbing materials are used, or the water quality is allowed to drop below minimum specifications. A water system using the following material is recommended:

- 1. Plastic or Copper Pipe
- 2. Plastic, Brass or Stainless Steel Pump
- 3. Stainless Steel or Fiberglass Tank

When the Power Supply is not in use for extended time periods (more than a few hours), open the Main Breaker. DC power is normally present within the Power Supply with the breaker closed when the Power Supply is shut off. This DC voltage will cause galvanic

corrosion of the water fittings and will lead to unscheduled water failure. For further information concerning Ajax Tocco manufactured water systems, or other water questions, consult your Ajax Tocco engineering representative.

# 8.3 High Frequency Inverter Output

All output cables should be interposed to reduce impedance and power losses. All output HF cables should be routed in non-ferrous, non-magnetic conduit or tray to prevent induction heating of conduit or tray.

#### 8.3.1 Maximum altitude

The maximum altitude is 6,000 feet (1,828 meters). Contact Ajax Tocco engineering if requirements exceed this value.

# 8.3.2 Grounding

The Power Supply should be grounded to a true earth ground. A cable size of not less than No. 6 cable is recommended, from the Power Supply base to earth ground. This grounding connection should conform to local or national codes that apply.

# 8.3.3 Plumbing

The various components that make up the induction heating system should always be plumbed in parallel. An example of a typical plumbing diagram is as follows:

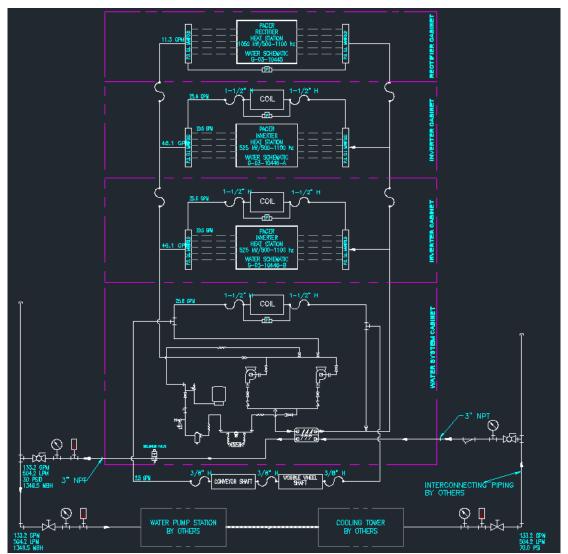


Figure 8- 1: Water System Block Diagram

# 9 Preventive Maintenance

Timely preventive maintenance will ensure the longevity of the converter and will minimize down-time.

Preventive maintenance includes:

1) Regularly checking the conductivity of the water in the converter to ensure it is within the set guidelines for normal operation. The water conductivity in the converter must be maintained between 20 and 75 micro-mhos-cm to prevent erosion of hose barbs and volatile water-cooled parts, such as, SCR and diode heat sinks. A periodic check of the water conductivity should be established, either through the maintenance department or an outside agent, for every converter, to prevent lengthy shutdown delays due to eroded hose fittings, as a result of high water conductivity.

If the converter is supplied with a Conductivity Monitor Board, please refer to that section in the manual for further explanation.

- 2) Regularly checking the snubber networks on the thyristor devices to ensure the integrity of the individual components and wire connections. These snubber networks consist of water-cooled and air-cooled resistors and capacitors. These components and the interconnecting wiring should be checked periodically to ensure their integrity; an open resistor as a result of overheating or a loose wire connection may cause SCR or diode failure and disrupt the normal operation of the converter.
- 3) Regularly checking hose connections, the tightness of the stainless-steel hose clamps, and the integrity of the hose barbs. It is important that the hose barbs are checked periodically as to prevent water leaks due to hose barb erosion from high water conductivity. In addition, drastic fluctuations in the water temperature inside the converter may result in loose hose clamps and eventually to water leaks.
- 4) The torque of the clamps holding components, such as the thyristors on the bridge panel, the isolation diodes, and the IGBTs, should be checked periodically to ensure correct tightness. Refer to the following sections describing the checking and changing of these components for specific torque guidelines.

Performing these preventive maintenance suggestions will help achieve trouble free operation.

5) Regular inspection of buswork, power leads, power connections, bolted connections.

6) Look for early warning signs of possible component failure e.g. capacitor case swelling, signs of arcing, burning, oil leaking from capacitors, water leaks, wire harnesses and cable trays coming apart.

The following sections describe and illustrate the checking and replacing of thyristor devices, the IGBTs, the tank capacitors, and the output transformer.

CAUTION: When attempting any change of parts in the converter, just opening the Control and Main Circuit Breakers does not totally isolate the power into the converter. Voltage would still be present at the line side of both of these breakers. For added safety, opening a switch or a disconnect upstream from the converter is strongly recommended.

Always check for voltage on individual parts, especially capacitors, inside the converter before handling or coming in touch with them. See the Tank Capacitor Checking and Changing procedure on how to discharge a capacitor before handling it.

NOTE:

The Main Circuit Breaker is supplied with an under-voltage release (UVR) unit for the purpose of personnel safety only. Under normal circumstances, do not "dump" the main breaker by removing UVR voltage. The Main Breaker is to be manually opened only after the high frequency power is shut down.

# 9.1 Checking and Replacing the Bridge Devices

The AC/DC Bridge may consist of Diodes or SCRs; the choice is application specific and varies from converter to converter.

# 9.1.1 Diode Bridge

The Diode devices may be a block-type diodes or puck-type depending on the power level of the converter. Typically, lower kilowatt units (15-300 kW) use block-type diodes, while higher kilowatt units (350 and above) use puck-type diodes.

The Bridge devices are on the AC/DC converter panel, and they are identified by the designation D1.

## 9.1.1.1 Checking the Block-Type Diodes

The Diode Bridge consists of three dual diode blocks, three positive and three negative diodes. On the positive diodes, the Top Connection is the cathode and on the negative diodes the Top connection is the anode. See Fig. 9-1.

To check the diodes, obtain an Ohmmeter and place the positive lead on the Top connection (the cathode for the negative diode) and the negative lead on the bottom connection (anode for negative diode). Observe the meter to read a high resistance, 15K Ohms to 30K Ohms. Reverse the positions of the meter leads so that the positive lead is on the anode and the negative lead is on the cathode. Observe the meter to read a low resistance, less than 5K Ohms. This value will vary depending on how strong a signal is produced by the meter to turn the diode on. A bad device will read zero Ohms in both lead directions. Next place the positive lead on the middle connection (the cathode for the positive diode) and the negative lead on the top connection (the anode for the positive diode). Observe the meter to read a high resistance, 15K Ohms to 30K Ohms. Reverse the positions of the meter leads so that the positive lead is on the anode and the negative lead is on the cathode. Observe the meter to

read a low resistance, less than 5K Ohms. This value will vary depending on how strong a signal is produced by the meter to turn the diode on. A bad device will read zero Ohms in both lead directions.

If the diode is judged to be bad, see section 9.1.1.2 for replacing a bad block resistor.

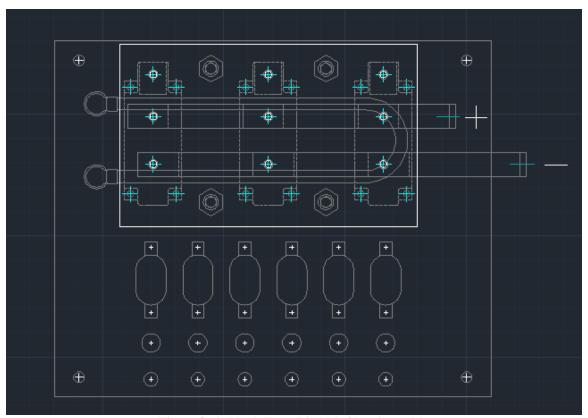


Figure 9-1: Block Type Diode Bridge Assembly

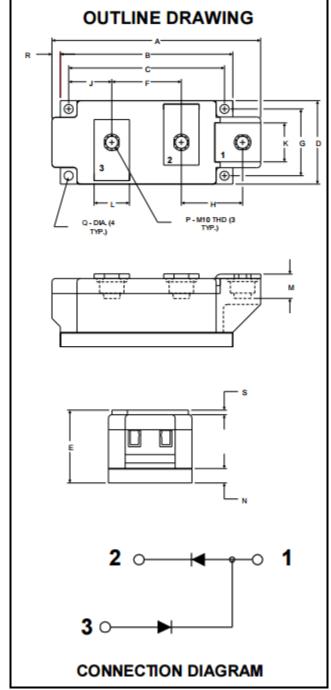


Figure 9-1: Block-Type Diode Bridge Assembly

Figure 9- 2: Block Type Diode

## 9.1.1.2 Replacing the Block-Type Diodes

When a bridge diode is to be changed, first make sure that a replacement is available. Each device is marked with an Ajax Stock Control number. This number should be matched with the replacement, although alternate authorized sources may be used.

To remove the block-type diode, perform the following steps:

- 1) Remove the buss work from the positive leg of the diode.
- 2) Remove the buss work from the negative leg of the diode.
- 3) Remove lead on the top of the block.
- 4) Remove the mounting screws.

Follow the above steps in reverse order to install the replacement diode. Apply a minute amount of silicone oil, Ajax Stock Control number 82300A01, supplied with the converter, to the diode's surface that comes into contact with the heat sink.

## 9.1.1.3 Checking the Puck-Type Diodes

The Bridge Diodes are located in the stack assembly on the AC/DC Converter panel, as shown in Fig. 9-3. They are identified by the letters A+, A-, B+, B-, C+, and C-on the label next to the stack.

To check the diodes, obtain an Ohmmeter and place the positive lead on the heat sink of the cathode end and the negative lead on the heat sink of the anode end. See Fig. 9-4. Observe the meter to read a high resistance, 15K Ohms to 30K Ohms. Reverse the positions of the meter leads so that the positive lead is on the anode and the negative lead is on the cathode. Observe the meter to read a low resistance, less than 5K Ohms. This value will vary depending on how strong a signal is produced by the meter to turn the diode on. A bad device will read zero Ohms in both lead directions.

If the diode is judged to be bad, see the replacement procedure to properly change the device.

# 9.1.1.4 Replacing the Puck-Type Diodes

When a bridge diode is to be changed, first make sure that a replacement is available. Each device is marked with an Ajax Stock Control number, as shown in Fig. 9-4. This number should be matched with the replacement, although alternate authorized sources may be used.

To remove the puck-type diode, refer to Fig. 9-3 and perform the following steps:

- 1) Remove the 3/8-24 hex nuts on the metal brace (bottom) end of the clamp.
- 2) Remove the metal brace and the copper centering tab next to it from the bottom of the assembly.
- 3) Slide the insulating sleeve off the front bolt. The sleeve on the back will probably drop down.
- 4) Rotate the front end of the plastic end and copper centering tab next to

#### Power Zone Instruction Manual

it counter-clock-wise to move the bolt out of the way. The assembly is now in a position to replace the diodes. To do this, follow all these steps:

- 1) Locate the device to be replaced and spread the heat sinks apart until the centering pins in the heat sink have cleared the diode. This will be approximately 3/16 to 1/4 inch.
- 2) With the heat sinks spread apart, pull the semiconductor device forward out of the assembly.
- 3) Release the pressure on the two heat sinks.
- 4) Apply a minute amount of silicone oil, Ajax Stock Control number 82300A01, supplied with the converter, to both the anode and cathode surfaces of the replacement device. Wipe off the excess. This silicone oil is needed to fill the gaps and nicks in the contact surfaces.
- 5) Spread the heat sinks on either side of the device position apart.
- 6) Orientate the diode like the pictorial view on the label next to the position in which the device is being placed.
- 7) Place the diode between the two heat sinks and align the centering pins on the heat sinks with the centering holes on the device.
- 8) Release the pressure on the heat sinks and observe them to snap together on the diode. There should be no gaps between the surfaces and the diode should be free to rotate. If a gap exists, spread the heat sinks apart and align the pins again.
- 9) Repeat steps 5 through 9 moving from bottom to top until all the devices have been replaced.

At this point, check to make sure that all devices are centered properly. To install the clamp and adjust it, follow these steps:

- 1) Rotate the plastic end and the copper centering tab next to it clockwise and align the centering pin up with the hole in the tab. This will leave the plastic end perpendicular to the panel surface.
- 2) Place the insulating sleeve over the front bolt and slide it up into the plastic end of the clamp.
- 3) Repeat step 2 for the back bolt.
- 4) Place the copper centering tab first and then the metal brace over the bolts at the bottom of the stack assembly.
- 5) Place both 3/8-24 nuts on their bolts and snug them up equally.
- 6) Check again to make sure that all the diodes are centered properly.
- 7) Symmetrically tighten the bolts 1/4 turn at a time until the metal spring between the bolt heads in the plastic end deflect properly. This deflection is measured by the force gauge, Ajax Stock Control number 52760A00, supplied with the converter. Place the force gauge across the spring, as shown in Fig. 9-5, and tighten the bolts until the gauge reads the force level specified on the Force Calibration Instruction Label on the Bridge Panel. See Fig. 9-6 for gauge readings.
- 8) Check to see that no gaps exist between the heat sinks and the diodes.

This procedure must be followed to its entirety to insure the best possible operating conditions.

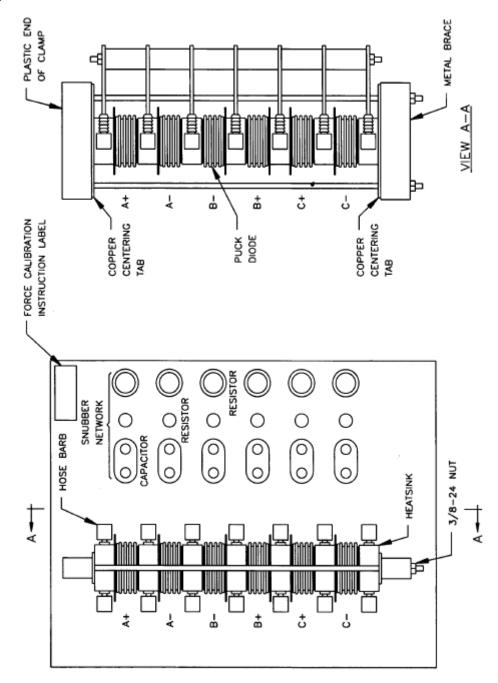


Figure 9- 3: Puck-Type Diode Bridge Assembly

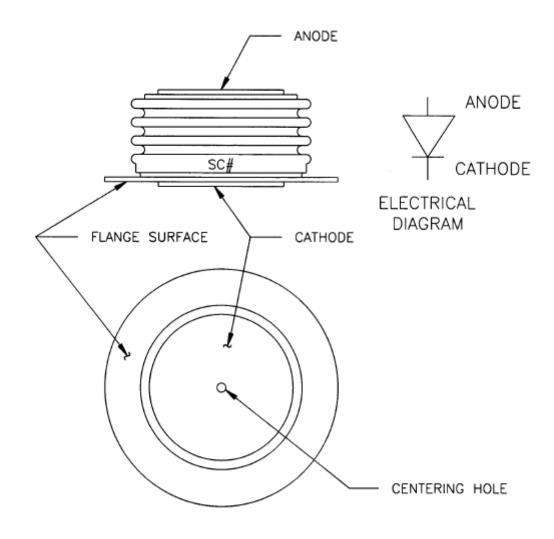


Figure 9- 4: Puck Diode

NOTE: TO USE PLACE ALL THREE POINTS OF GAUGE ON SPRING SURFACE AS SHOWN.

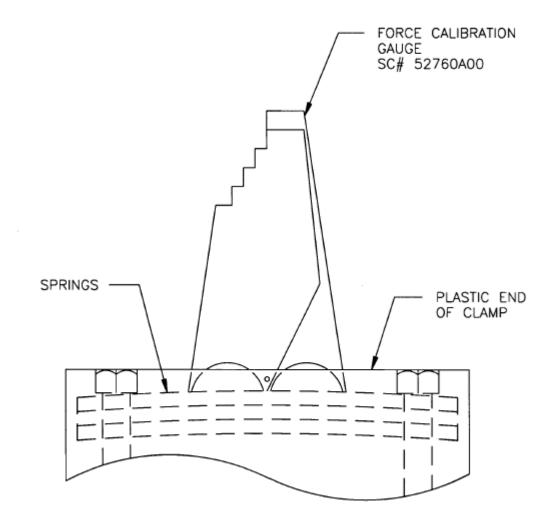


Figure 9- 5: Force Calibration of SCR Stack

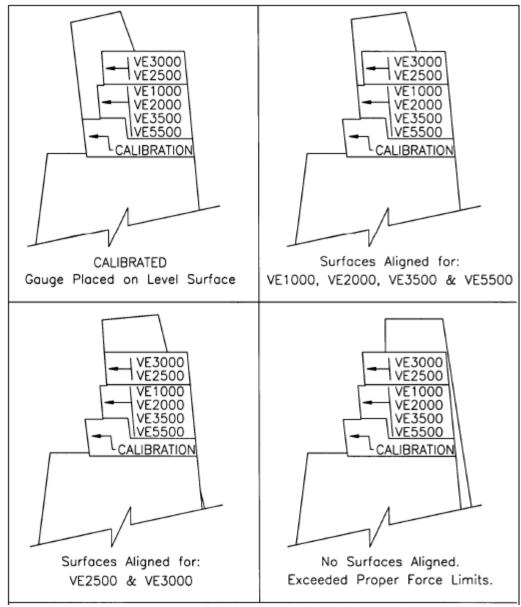


Figure 9-6: Force Gauge Readings

# 9.1.2 SCR Bridge

# 9.1.2.1 Checking the Bridge SCRs and Clamping Diode

The Bridge SCRs and the Clamping Diode are located in the stack assembly on the AC/DC Converter panel, as shown in Fig. 9-7. The SCRs are identified by the letters A+, A-, B+, B-, C+, and C- and the Clamping Diode by the letters CD on the label next to the stack.

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To check the SCRs or the Clamping Diode, obtain an Ohmmeter and place the positive lead on the heat sink of the cathode end and the negative lead on the heat sink of the anode end. See Fig 9-8 and Fig. 9-9. Observe the meter to read a high resistance, 15K Ohms to 30K Ohms. Reverse the positions of the meter leads such that the positive lead is on the anode and the negative lead is on the cathode. Observe the meter to read a low resistance, less than 5K Ohms. This value will vary depending on how strong a signal is produced by the meter to turn the diode on. A bad device will read zero Ohms in both lead directions.

If the device is judged to be bad, see the replacement procedure to properly change the device.

# 9.1.2.2 Replacing the Bridge SCRs and Clamping Diode

When a bridge SCR or the Clamping Diode is to be changed, first make sure that a replacement is available. Each device is marked with an Ajax Stock Control number, as shown on Fig. 9-8 and Fig. 9-9. This number should be matched with the replacement, although alternate authorized sources may be used.

To remove the device, refer to Fig 9-7 and perform the following steps:

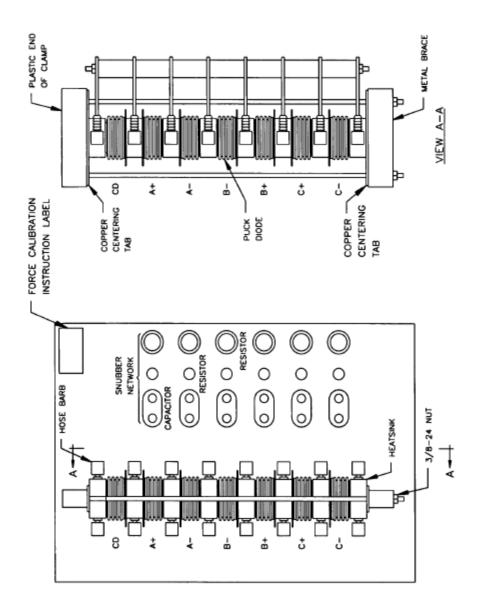


Figure 9-7: SCR Bridge Assembly

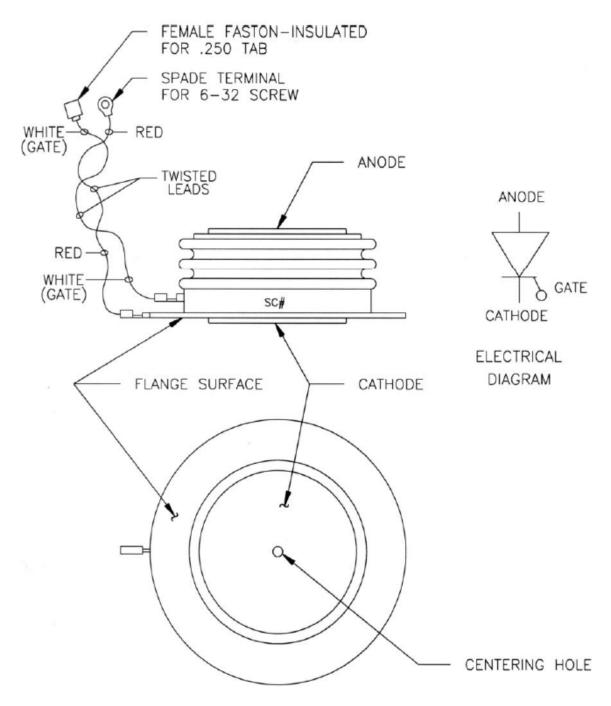


Figure 9- 8: SCR (Silicone Controlled Rectifier)

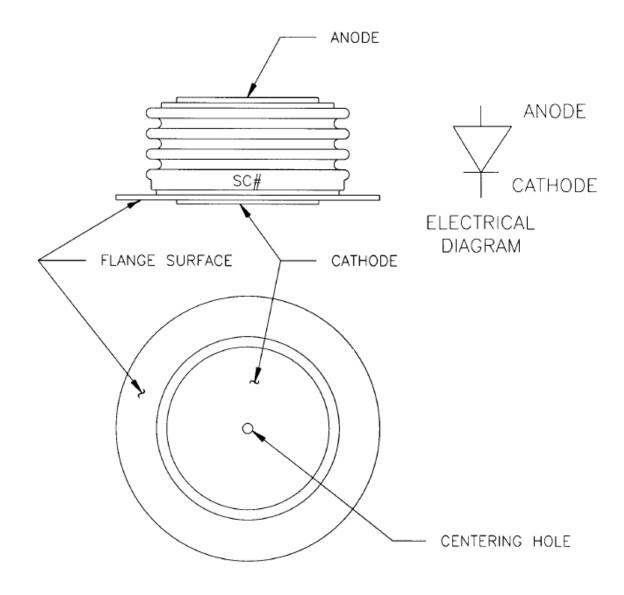


Figure 9-9: Clamp Diode

- 1) Remove the 3/8-24 hex nuts on the metal brace (bottom) end of the clamp.
- 2) Remove the metal brace and the copper centering tab next to it from the bottom of the assembly.
- 3) Slide the insulating sleeve off the front bolt. The sleeve on the back will probably drop down.
- 4) Rotate the front end of the plastic end and copper centering tab next to it counter-clock-wise to move the bolt out of the way.

The assembly is now in a position to replace the SCRs. To do this, follow all these steps:

1) Locate the device to be changed and spread the two heat sinks apart

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- until the centering pins in the heat sink have cleared the device. This will be approximately 3/16 to 1/4 inch.
- 2) With the heat sinks spread apart, pull the semiconductor device forward out of the assembly.
- 3) Release the pressure on the two heat sinks.
- 4) Apply a minute amount of silicone oil, Ajax Stock Control number 82300A01, supplied with the converter, to both the anode and cathode surfaces of the replacement device. Wipe off the excess. This silicone oil is needed to fill the gaps and nicks in the contact surfaces.
- 5) Spread the heat sinks on either side of the device position apart.
- 6) Orientate the device like the pictorial view on the label next to the position in which the device is being placed.
- 7) Place the device between the two heat sinks and align the centering pins on the heat sinks with the centering holes on the device.
- 8) Release the pressure on the heat sinks and observe them to snap together on the device. There should be no gaps between the surfaces and the SCR should be free to rotate. If a gap exists, spread the heat sinks apart and align the pins again.

At this point, check to make sure that all devices are centered properly. To install the clamp and adjust it, follow these steps:

- 1) Rotate the plastic end and the copper centering tab next to it clockwise and align the centering pin up with the hole in the tab. This will leave the plastic end perpendicular to the panel surface.
- 2) Place the insulating sleeve over the front bolt and slide it up into the plastic end of the clamp.
- 3) Repeat step 2 for the back bolt.
- 4) Place the copper centering tab first and then the metal brace over the bolts at the bottom of the stack assembly.
- 5) Place both 3/8-24 nuts on their bolts and snug them up equally.
- 6) Check again to make sure that all the devices are centered properly.
- 7) Symmetrically tighten the bolts 1/4 turn at a time until the metal spring between the bolt heads in the plastic end deflect properly. This deflection is measured by the force gauge, Ajax Stock Control number 52760A00, supplied with the converter. Place the force gauge across the spring, as shown in Fig. 9-5, and tighten the bolts until the gauge reads the force level specified on the Force Calibration Instruction Label on the Bridge Panel. See Fig. 9-6 for gauge readings.
- 8) Check to see that no gaps exist between the heat sinks and the devices.

This procedure must be followed to its entirety to insure the best possible operating conditions.

# 9.2 Replacing an IGBT

## **Important! MAKE SURE POWER IS OFF**

When an IGBT (Insulated Gate Bi-polar Transistor) has to be changed, first make sure that an EXACT replacement is available. To remove the IGBT, the bus assembly on each module must be removed/suspended completely to gain access to the devices. See Fig. 9-10. Perform the following steps to remove the bus assembly:

- 1) Remove the Bolts from the Filter Capacitors.
- 2) Remove the M8 hex cap screws and washers from all the IGBTs then remove the following:
  - the Feedback Wiring on Inverter Module #1 (exists only on Module #1 on multiple Inverter Units), make sure to mark their corresponding locations for re-connecting.
- Remove/Suspend the DC Bus and the Output Bus away from the IGBTs with the hoses still intact (if possible). See Fig. 9-10.
  - Remove Teflon and Spacers
- 4) Remove the Six #1/4-20 socket head cap screws holding the Defective IGBT to the heat sink.
- 5) Notice the orientation of the IGBT with regards to the location of the control connections in relationship to the heat sink.
- 6) Handling the replacement IGBT with care apply 1.5cc of heat sink compound, Ajax Stock Control number 82300A01, supplied with converter, to the back surface of the IGBT. Distribute the compound evenly though out the entire surface.
- 7) Use the six #1/4-20 socket head cap screws to fasten the IGBT to the heat sink. Using a torque wrench tighten to 3 Nm (2.2 ft-lb). Make sure to follow the torque sequence pattern shown in Fig. 9-11.
- 8) Re-connect and re-assemble per previous Steps 1-5.
- 9) The unit should be ready to be return to production.

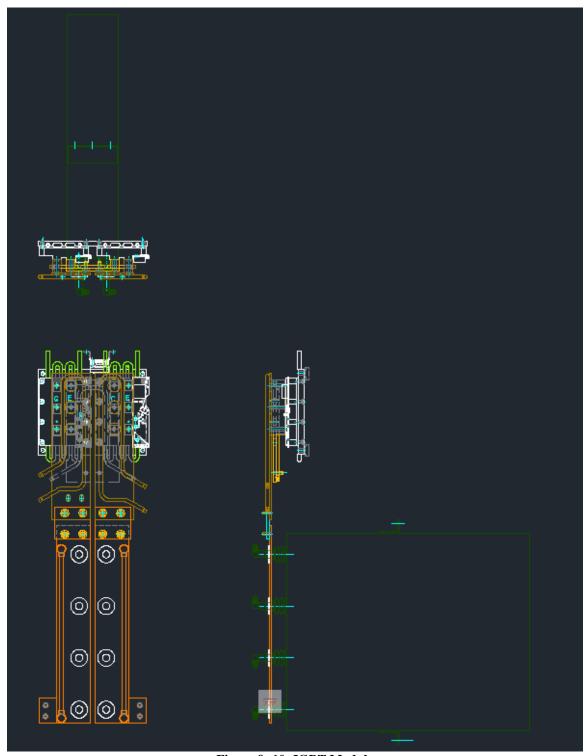


Figure 9- 10: IGBT Module

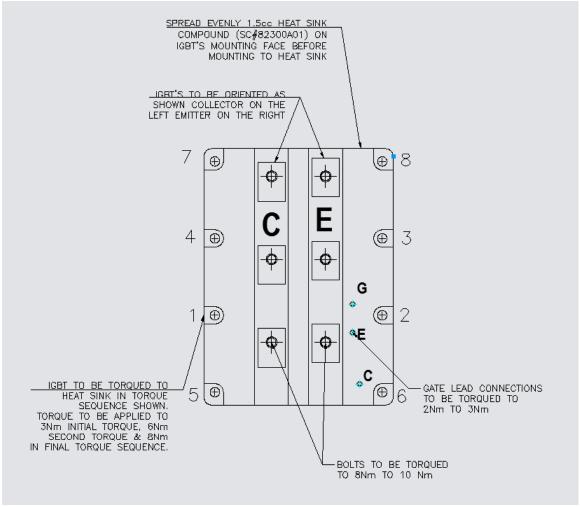


Figure 9-11: IGBT Installation Specifications

# 9.3 Checking and Changing a Vernier (Tapped) Tank Capacitor

A Vernier or tapped tank capacitor is shown in Figures 9-12A and 9-13A as viewed looking down at the top of the capacitor. Note that each of the taps is numbered corresponding to the outline drawing supplied in the drawing folder on the inside of the cabinet door. Use this drawing to determine the amount of KVAR connected when running. To insulate or connect a tap, refer to the procedure in Part IV of the Normal Operation section.

To determine if a section or the entire capacitor is bad, the following steps need to be taken:

- 1. Turn off the main circuit breaker and the control breaker. (See CAUTION at the beginning of the maintenance section).
- 2. Make sure that any unused taps are discharged by the shorting

- them out to the tap collector bus with an insulated rod.
- 3. Short the tap collector bus and the common collector bus together through a 15 Ohm, 100 Watt or larger resistor to discharge any potential remaining in the tank circuit. See Fig. 9-12 or Fig. 9-13 depending on the style of tank capacitor present in the converter. Isolate each of the taps from the tap collector bus by removing the 1/2-13 nut and washer from each tap.

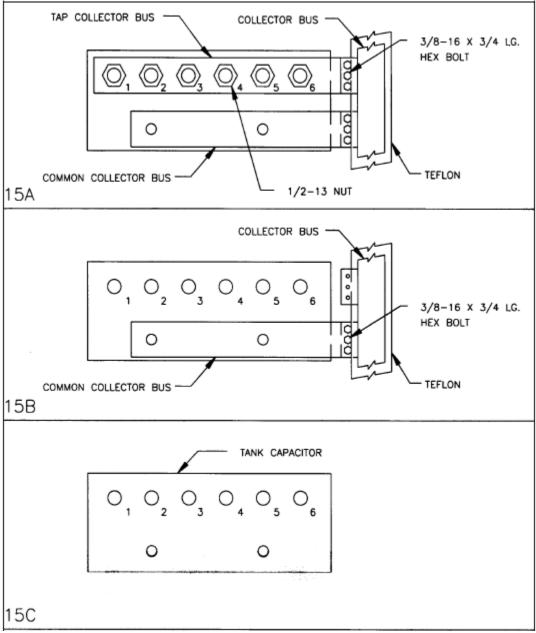


Figure 9-12: Vernier Tank Capacitor

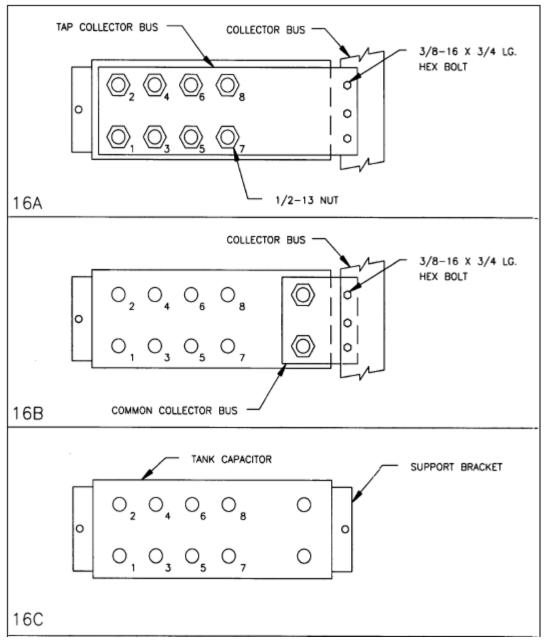


Figure 9-13: Vernier Tank Capacitor

- 4. Obtain Ohmmeter and place the leads between the stud of the capacitor and the common collector bus, and observe the meter to read infinity for a good section and 0 (short), for a bad section.
  - 5. Repeat this for all taps.

If suspicion still exists, a DC hi-pot can be used to check the capacitor. Follow these steps very cautiously:

- 1. Place the hi-pot leads between the stud of the capacitor and the common collector bus.
- 2. Try to apply voltage to the section and watch for a steady minimum

leakage once maximum voltage is obtained. This maximum VDC voltage level should not exceed two times the nominal rating of the capacitor. If no voltage can be applied or the current rises and trips the hi-pot, the section is bad. If the leakage current is steady for a period of 15 seconds, the section is good. NOTE: Please discharge the tap to the common collector bus with an insulated rod before handling the stud. Also, a capacitor is deemed bad if there is any physical damage or leaking of oil from the capacitor.

If a capacitor is determined to be bad and needs to be changed, follow these steps to remove the capacitor:

- 1. Remove the 1/2-13 nut and washer from all the taps.
- 2. Remove the three, or four, 1/8-16 x 3/4 lg. hex bolts attaching the
- 3. Remove the tap collector bus from the capacitor.
- 4. Remove the top hat insulator from the taps. The capacitor should now look like Figures 9-12B or 9-13B.
- 5. Turn off the water pressure to the unit and relieve the pressure in the unit before removing the hose from the hose barb fitting on the common collector side of the capacitor.
  - NOTE: The capacitors in Figure 9-11 have 1/2" tube extensions instead of fittings.
- 6. Remove the 3/4-16 hex nut from each of the common connections.
- 7. Remove the three, or four, 3/8-16 x 3/4 lg. hex bolts attaching the common collector bus on the capacitor to the main common collector bus.
- 8. Remove the common collector bus from the capacitor. The capacitor should now look like Figures 9-12C or 9-13C.
- 9. Remove the 3/8-16 x 1" lg. hex bolt and nut from the mounting tab on either side of the capacitor.
  - NOTE: The capacitors in Figure 9-13 do not have support brackets and they are resting in an insulated carrier box.
- 10. Remove the bad capacitor from the rack.

Before proceeding with the installation of a new capacitor, check to make sure the Ajax Magnethermic Stock Control number marked on the bad capacitor agrees with the number on the new capacitor. To install the new capacitor, follow these steps:

- 1. Remove the 3/4-16 hex nut from each of the common connections.
- 2. Remove the 1/2-13 hex nut from each of the taps.
- 3. Place the tank capacitor in the rack with the common connections nearest to the main common collector bus and secure the capacitor to the rack with the 3/8-16 x 1" lg. hex bolt and nut on the mounting tab.
- 4. Place the common collector bus on the capacitor and secure it to the main collector bus with the three, or four 3/8-16 x 3/4" lg. hex bolts.
- 5. Place the 3/4-16 hex nut on the common collector connections and tighten to 15 ft-lbs (20 N-m).
- 6. Install the hose barb fittings on the common connections using a piping compound to prevent leaks, and connect the hose onto the

- hose barbs. Tighten the hose clamps.
- 7. Turn the water pressure on and check for leaks.
- 8. Place a top hat insulator (Ajax Magnethermic Stock Control number 74700A04) on each tap with the flat or large diameter surface toward the capacitor.
- 9. Place the tap collector bus on the capacitor and secure it to the main collector bus with the three (3) 3/8-16 x 3/4" lg. hex bolts.
- 10. Connect or insulate the desired taps by referring to the procedure described in Part IV of the Normal Operation Section. Tighten the 1/2 13 nuts to 15 ft-lbs (20 N-m).

# 9.4 Checking the Line Fuses

To check the line fuses, follow these steps:

- 1. Make sure the main circuit breaker is off.
- 2. Using an Ohmmeter measure the resistance of each fuse.
- 3. An open or infinite resistance reading indicates a bad fuse.
- 4 Zero resistance indicates a good fuse.

#### 9.5 Preventive Maintenance Schedule

**Table 9-1:Preventive Maintenance Schedule** 

Interval	Maintenance Task	Ref Data
Daily	Inspect doors with handles are closed and	
	access doors latched; door interlock	
	switches functional.	
Weekly	Check cabinets for tools and debris left	
	inside.	
Weekly	Test water system for resistivity	
	/conductivity, pH between 7.0-9.0 and	
	visual cleanliness.	
Weekly	Maintain water quality	Ajax Tocco Engineering
		Bulletin 370B24
Weekly	Inspect for water leaks	
Weekly	General visual for overhead components,	
	arc marks, etc.	
Monthly	Test System water for resistivity value:	
	Absolute minimum: 3,333 ohm-cm or 300	
	micromhos/cm	
	Suggested: 5,000 – 10,000 ohm-cm or 200	
	- 100 micromhos/cm	
Monthly	Tighten Bus Bar connections	
Monthly	Record display readings and input line	
	voltage using a typical load and compare	

Interval	Maintenance Task	Ref Data
	previous readings with the same standard load.	
Monthly	Check all power connections for tightness Open and clean any that show signs of overheating.	Copper oxide colors reveal overheating
Monthly	Tighten Earth Ground connections	Do not over tighten
Monthly	Tighten door earth ground jumpers.	Do not over tighten
Monthly	Clean fan blades as needed- Check door seals if fan(s) are dirty.	Denatured alcohol
Monthly	Check water-cooled power lead for water leaks and discoloration from overheating.	
Monthly	Perform weekly preventive maintenance recommendations	
Quarterly	Clean printed circuit boards if needed. Check door seals if dirty.	Use vacuum with fine bristle upholstery brush. No compressed air, water or oily solvents.
Quarterly	Check door interlock switch function and adjust/replace as needed.	
Semi-annually	Check each fan for operation. Fans will remain on with doors open (if present).	
Semi Annually	Perform ohm test on Bleeder Resistors.	2.5k Ohm
Semi Annually	Perform ohm test on Balance Resistors.	50k Ohm
Annually	Inspect door and access door sealed, replace as needed	
Annually	Flush water system and make sure individual water paths are unrestricted.	
Annually	Check all power connections for tightness; open and clean any that show signs of overheating	
Annually	Check all terminal strips for tightness.	
Annually	Check all fans are operational (if present).	
Annually	Check door interlocks and master Stop button, if provided, make sure they operate the under voltage release on DS.	
Annually	Inspect rubber hose for cracking or conductivity and replace as needed with exact lengths of nonconductive hose.	
Annually	If so equipped, check ground monitor conductivity data (to ground) over time and check paths to ground if the trend is upward or current readings crowd	
	acceptable limits.	

Interval	Maintenance Task	Ref Data
Annually	Use a clean cloth to wipe dirt off and	
	visually inspect the Power Supply for arc	
	marks, damaged components, etc.	
Annually	Perform weekly and monthly preventive	
	maintenance recommendations.	

#### 9.6 Preventive Maintenance Procedures

## 9.6.1 Placing Equipment Back in Service After Maintenance

Before placing equipment back in service after rebuilding or disassembly, operate off-line several times before placing it back in active service.

#### 9.7 Generic Maintenance

Always use lock washers when installing components. The Power Supply is prone to vibration when in use and requires lock washers to prevent loosening of fasteners. If any lock washers, nuts or other fasteners are dropped inside the Power Supply, they must be found before starting the Power Supply.

Compressed air must not be used in maintenance of the Power Supply. Moist compressed air lines are contaminated with oil or water and neither is welcome inside the Power Supply. Oil attracts dust and water is an electrical conductor. Remove dust inside the Power Supply, vacuum using a light nonmetallic brush

In the unlikely event that fire or smoke are evident, extinguish and cool components using a CO2 fire extinguisher. While dry powder is effective for smothering fires, the cleanup of electrical equipment afterwards is costly. Carbon Dioxide leaves no film or deposit for cleanup.

Overheating will be evident by looking at surfaces for oxide discoloration on bus bars, water leaks, paint blistering, burn marks on leads or physical distortion (swelling or shrinking).

Testing of fuses and diodes are best accomplished using a volt-ohm meter with power off, locked and tagged out.

# **10 Typical Waveforms for system Components**

# 10.1 Power Zone Logic Signals

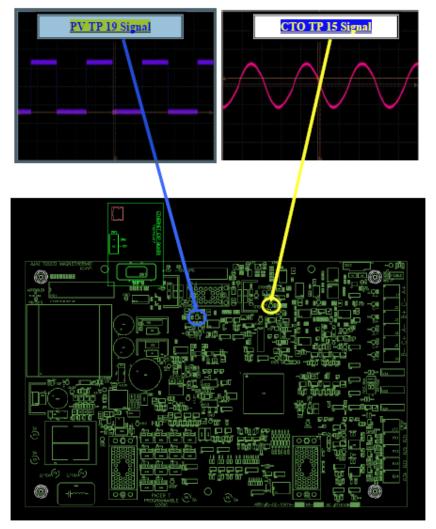


Figure 10-1: CTO and PV Signals

# 10.2 IGBT Gate Drive Signals

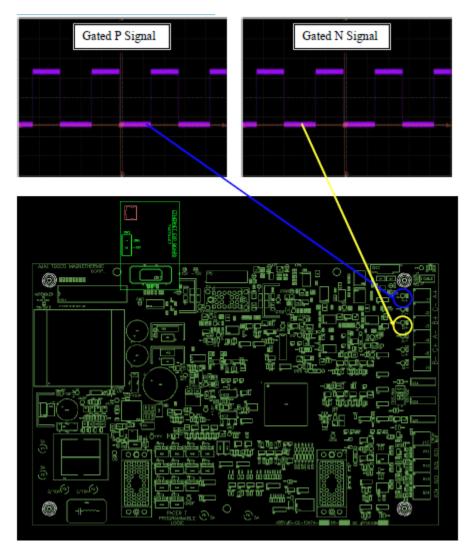


Figure 10-2: Gate Drive Signals

# 11 Pre-Outage Testing

Pre-outage testing can be accomplished by opening the Main Breaker, following lock out/tag out procedures, and energizing the control disconnect only. All control logic; including gate drive boards will now be powered. Control functions such as remote start, remote stop; demand and metering can now be debugged without applying high frequency output power.

# **12 HMI**

#### 12.1 Main Menu Screen

This is the main menu screen of the HMI that is displayed upon power-up. From this screen the operator may select any of the screens available and to log on by entering the correct password. Log on is required to make any recipe changes.



Figure 12- 1: Main Menu Screen

The machine mode and cycle status are displayed on the Main Screen.

#### **Machine Fault**

Machine Fault will illuminate red when there is a machine fault. An alarm banner will also appear on the screen displaying the machine fault.

#### **Auto Cycle**

Auto Cycle will illuminate green when the machine in running in automatic mode.

#### Creep Mode

Creep Mode will illuminate yellow when the selector switch for creep mode on is.

#### **Automatic Mode**

Automatic Mode will illuminate green when the machine is in Automatic mode.

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#### Manual Mode

Manual Mode will illuminate yellow when the machine is in Manual mode.

#### **Static Hold**

Static Hold selector switch places the machine in and out of static hold. When Static hold is on, Zone 2 will run at a reduced power level for a specific amount of time. These values are parameters in the recipe. Zone 1 will not be active and the line will not move. After the set time, Static Hold will turn off and the line will run with its Run or Creep Mode parameters.

#### **Cold Start**

Cold Start selector switch places the machine in and out of cold start. When Cold Start is on, Zone 2 will run at a specific amount of time. This timer value is a parameter in the recipe. After the Zone 2 time is complete, Zone 1 will run at a specific amount of time. This timer value is a parameter in the recipe. The line will not move until both Zone 2 and Zone 1 times are complete. The ATM Power supply indicators show the status of the power supply for the bridge section and the two zones. The include the following:

Power Supply Fault Power Supply Ready Power Supply Heat On Power Supply % kW

#### **Billet Exit Temperature**

Billet Exit Temperature is the value from the temperature sensor. This sensor only reads temperatures between 1112  $^{\circ}$  and 2552  $^{\circ}$  F.

#### **Billets per Hour**

Billets per Hour represents the production rate from the recipe.

#### **Line Speed**

Line Speed displays the line speed of the system.

#### **Screen Selection**

Screen Selection allows you to switch to another screen.

# 12.2 Login Screen

The **Login** screen allows for the operator to put in a password.

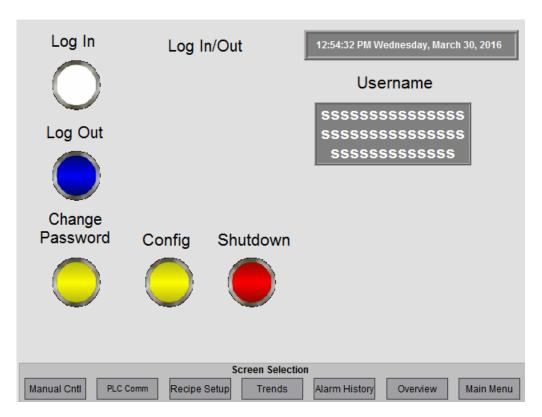


Figure 12-2: Login Screen

#### PASSWORD LOG IN/OUT

Entering the correct password will "Login" the operator. The operator must be logged in to modify and save recipes. There also may be some screens that will not be displayed and other devices not usable without a logged in status.

#### **SHUTDOWN**

The Shutdown button closes the runtime application.

#### **CONFIG**

The configuration button closes the application and allows for access to the Panelview drives.

#### **SCREENS**

Pressing any of the buttons in the Overview, Alarm History, I/O Status, Trends, or Recipe Setup boxes will display the associated screens.

### 12.3 Manual Screen

### **MANUAL SCREEN**

This is the manual screen of the HMI that allows the operator to perform some manual functions. From this screen the operator can view the mode (Auto/Mode) of the machine as well as other status indicators.

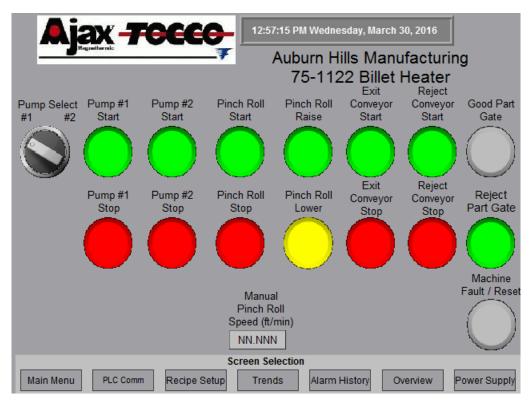


Figure 12-3: Manual Screen

#### **FAULT RESET**

Displays the fault status of the system. Pressing the button will reset the alarms.

#### REJECT CONVEYOR PB START/STOP

Allows for the pushbutton operation of the reject conveyor in "Manual" mode only.

### PINCH ROLLS PB START/STOP

Allows for the pushbutton operation of the pinch rolls in "Manual" mode only.

#### PINCH ROLLS PB RAISE/LOWER

Allows for the pushbutton operation of the pinch roll position in "Manual" mode only.

#### EXIT CONVEYOR PB START/STOP

Allows for the pushbutton operation of the exit conveyor in "Manual" mode only.

#### GOOD PART/REJECT PART GATE PB EXTEND/RETRACT

Allows for the pushbutton operation of the good part gate in "Manual" mode only.

## 12.4 Process Overview Screen

The Process Overview Screen displays some of the most pertinent data to the heating process.

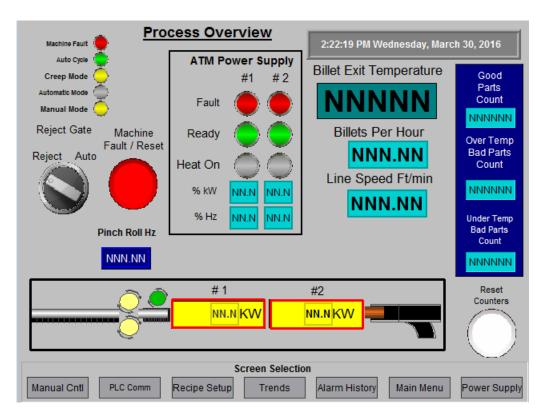


Figure 12-4: Process Overview Screen

The parts counters can be reset with the **Reset Counters** button.

# 12.5 Recipe Setup Screen - Recipe Parameters

The recipe screen displays and allows the entry of the parameter variables that comprise a recipe. After logging on the operator may make changes to any of the recipes. Changes are saved, then downloaded to the PLC and become the active recipe. There are areas to display both "Display" and "Active" recipes. The "Display" variables are for viewing and changing while the "Active" variables are the ones currently controlling the process.

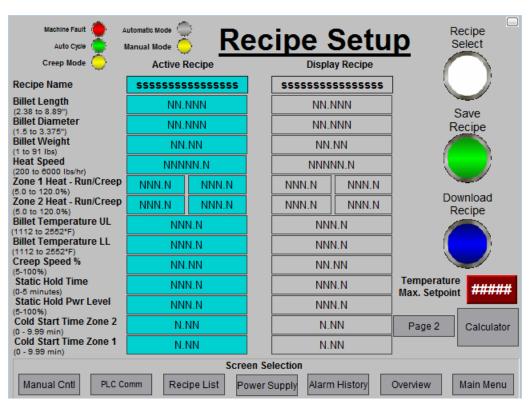


Figure 12-5: Recipe Setup Screen

Billet Length - range is from 2.38" to 8.89".

**Billet Diameter** - range is from 1.5" to 3.375"

**Billet Weight** - range is from 1 to 91 lbs

Heat Speed - 200 to 6000 lbs/hr

Zone 1 Power Level Run/Creep - 5 to 120% power

**Zone 2 Power Level Run/Creep** - 5 to 120% power

Billet Temperature Upper and Lower Limit - sets up the machine for acceptable parts.

**Creep Speed %** - is the percentage of Heat Speed required.

**Static Hold Time** - range is from 0 to 5 minutes.

**Static Hold Power Level (Zone 2)** - range is from 5 to 100%.

**Cold Start Time Zone 2** - range is from 0 to 9.99 minutes.

**Cold Start Time Zone 1** - range is from 0 to 9.99 minutes.

Pushing the Recipe Select button will pull up a keyboard that will be used to type in the Recipe Name. If the Recipe exists, the parameters will display in the gray Recipe Display boxes. Each parameter may be modified. The Save button will save the Display recipe to the Panelview computer. The Download Recipe button must be used to transfer the recipe to the plc. It plc Active Recipe parameters show up in the blue boxes. The Save and Download buttons only appear if the correct password is used at Log in.

## 12.5.1 Recipe Setup Loader

The Recipe Setup Loader screen is used to set up the parameters for the Loader.

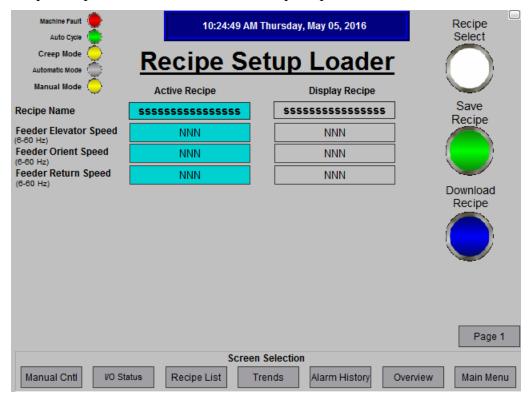


Figure 12-6: Recipe Setup Loader

# 12.5.2 Recipe List

This screen displays all the stored recipes by name. For viewing only. No other actions are performed on this screen.

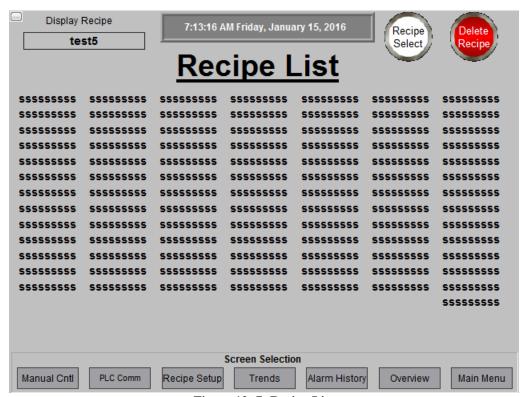


Figure 12-7: Recipe List

# 12.5.3 Recipe Screen – Production Calculator

This screen is a tool on the recipe screen that calculates a production variable based on values entered into two of the three variables. There are three separate calculators, although some variables are common. To use, enter a value for any two of the variables, say "Pounds/Hour" and "Billet Weight", then press "Billets/Min" to reveal that variables calculated value.

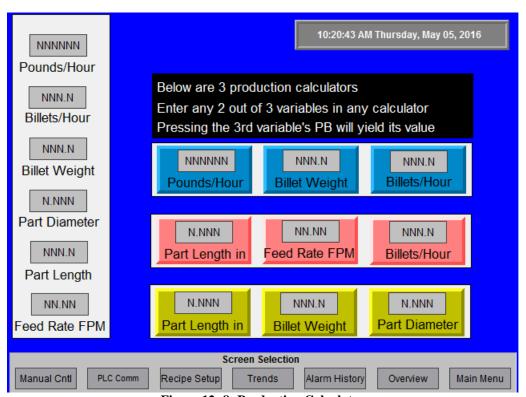


Figure 12-8: Production Calculator

# 12.6 Power Supply Screen

This screen controls the power supplies in manual mode.



Figure 12-9: Power Supply Screen

#### **ZONE 1 HEAT ON/OFF**

Pressing this pushbutton turns on Zone 1 section of the power supply. Zone 1 remains on until the "Stop Reset" pushbutton is pressed. The manual power level is setup on the numeric entry below the buttons.

#### ZONE 1 POWER SUPPLY ON/OFF

This selector switch enables the Zone 1 Power supply in Auto and Manual mode.

#### **ZONE 2 HEAT ON/OFF**

Pressing this pushbutton turns on Zone 2 section of the power supply. Zone 1 remains on until the "Stop Reset" pushbutton is pressed. The manual power level is setup on the numeric entry below the buttons.

#### **ZONE 2 POWER SUPPLY ON/OFF**

This selector switch enables the Zone 2 Power supply in Auto and Manual mode.

There are Heat Level numeric input displays for running the system in Manual Mode.

## 12.7 Machine I/O Status Screen

This screen displays the communications status of the Exit Conveyor I/O rack and the power supply zones.

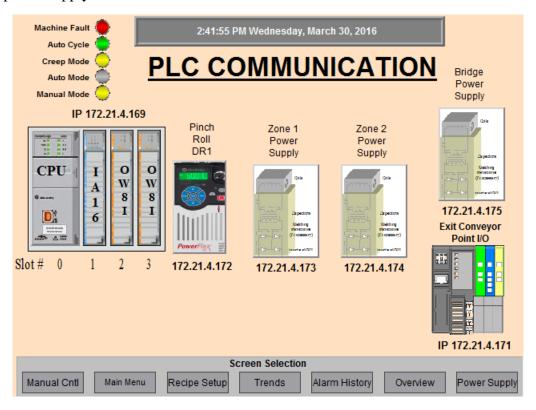


Figure 12- 10: PLC Communication Screen

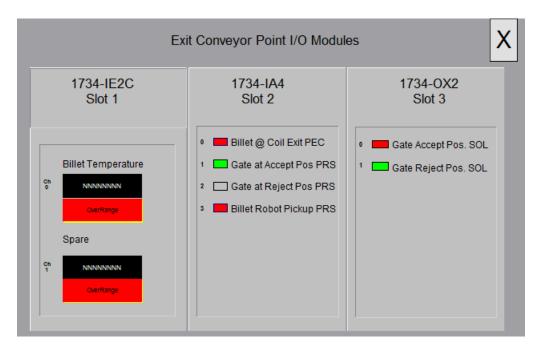


Figure 12-11: Exit Conveyor Status Screen

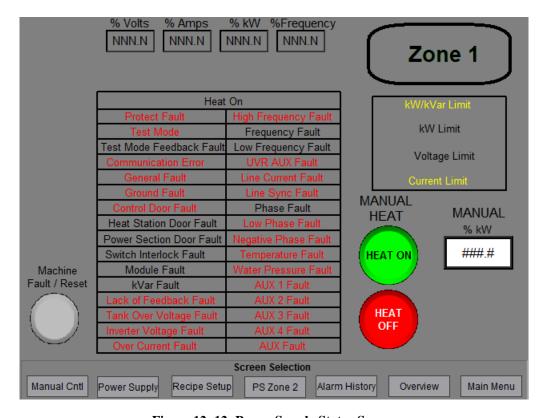


Figure 12- 12: Power Supply Status Screen

Rev. 0, June 2016

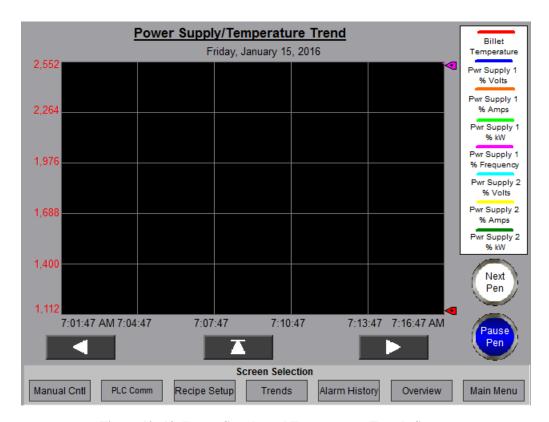


Figure 12-13: Power Supply and Temperature Trends Screen

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# 12.8 Alarm History Screen

This is the screen that keeps track of the inactive and acknowledged alarms and warnings. Once an alarm gets acknowledged, its condition is cleared, and fault reset, it causes the alarm to get moved from Alarm screen to the Alarm History screen.

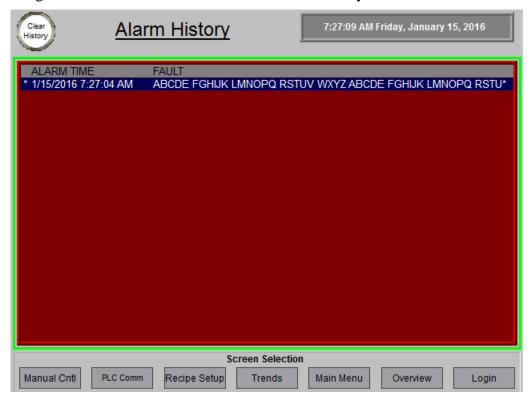


Figure 12-14: Alarm History Screen

# 12.8.1 List of Alarms

This is a list of all the alarms:

- 1. Exit Conveyor Drive Fault
- 2. Pinch Roll Drive Fault
- 3. Zero Speed Detected Billets are not Moving
- 4. Air Pressure Low Fault
- 5. Gate not at Good Position Fault
- 6. Gate not at Reject Position Fault
- 7. Pinch Roll Overload Fault
- 8. Zone 1 Power Supply Fault
- 9. Zone 2 Power Supply Fault
- 10. Billet Recipe Temperature Limits Equal Zero
- 11. Recipe Parameters Set to Zero Fault
- 12. Control Power Off
- 13. Recirculating Pump 1 Fault
- 14. Recirculating Pump 2 Fault
- 15. Pump Filter Fault

Rev. 0, June 2016

# Power Zone Instruction Manual

- 16. Bridge Power Supply Fault17. Reject Conveyor Fault

- 18. Sensor in Exit Conveyor Fault19. Billet Temperature Too Hot Fault

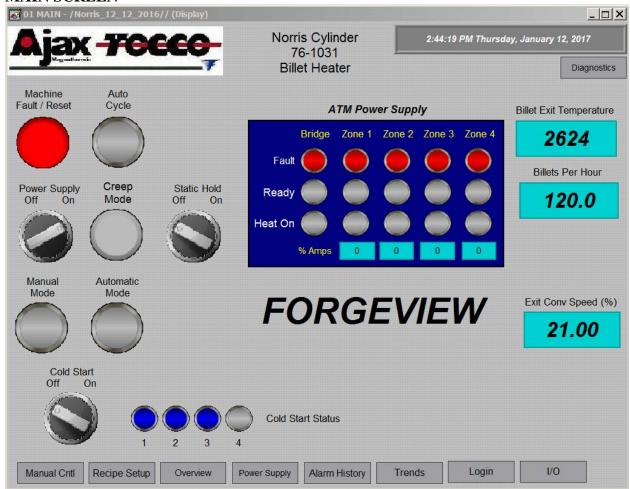
12-15 Rev. 0, June 2016

# Ajax-TOCCO Magnethermic Norris Cylinder 76-1031 Billet Heater

# OPERATORS MANUAL Jan 2017

This manual provides a description of the controls included with your ATM heating system. This manual focuses on the PLC panel HMI, HMI screens, and their associated functions. The PLC panel contains a HMI terminal along with pushbuttons, selector switches, and indicating lights to provide complete control of the power supply. The pushbuttons and other devices provide basic operations that are generally self-explained by their labels. Interaction between these devices and the HMI will be discussed as needed throughout this document.

# **MAIN SCREEN**



This is the main screen of the HMI that is displayed upon power-up. From this screen the operator may select any of the other screens available. Some screens may require the user to log in to gain access

#### MACHINE FAULT RESET - PB

Pressing this button resets all faults that are not currently active

# **AUTO CYCLE - PL**

Illuminates when system is operating automatically

# POWER SUPPLY OFF/ON - SS

Allows for cycling parts through the machine with/without heat. Power supply requirements and faults are ignored with the power supply off to allow cycling

# **CREEP MODE - PB**

Places system in creep mode. Line speed and power are reduced to levels set in the recipe

#### STATIC HOLD - SS

When on, the line speed goes to zero, heat is shut off in zone 1, and is reduced in zones 2, 3, & 4 to the level set by the "Static Hold Power Level" recipe parameter. After the preset time dictated by the "Static Hold Time" recipe parameter, the line resumes normal operation

# MANUAL MODE - PL

Indicates the system is in manual mode

# **AUTO MODE - PL**

Indicates the system is in automatic mode. Once in auto mode the auto cycling is initiated by the cycle start button

# **COLD START - SS**

When on, it allows the start of the line with cold parts. When auto cycling is initiated the heat will come on in the zones specified by the "Cold Start Enable" parameter. The feeder is disabled during this time with no new parts being fed in. Initially, because of the cold parts, the actual power supply output in each zone will be lower than the commanded levels. As the parts heat the actual power level will increase. When the actual power reaches the commanded level the appropriate cold start status light will illuminate and the zone will turn off. When all lights are illuminated the message "Cold Start Complete, Press Cycle Start to Continue" will appear. If the "Cold Start Time Limit" is exceeded before the levels reach their targets, the cold start will be aborted and the message "!!Cold Start Failed!! will appear

# ATM POWER SUPPLY

Under this banner there are several self-explanatory pilot lights and data displays to indicate faults, readiness, heat application, and actual heat (amps) levels

# BILLET EXIT TEMPERATURE/ BILLET PER HOUR

Displays actual billet information

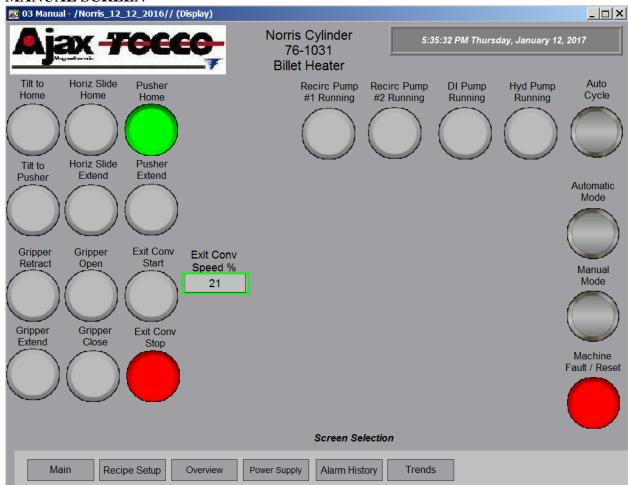
### LINE SPEED

Displays production rate in feet per minute

# BILLET EXIT TEMPERATURE/BILLETS PER HOUR/EXIT CONV SPEED (%)

Displays of the current actual named values

# **MANUAL SCREEN**



This screen allows the operator to move individual machine components

# TILT TO HOME/TILT TO PUSHER – PB/PL

These pushbuttons/indicators operate the billet tilt mechanism, and indicate its position

# HORIZ SLIDE HOME/HORIZ SLIDE EXTEND - PB/PL

These pushbuttons/indicators operate the horizontal slide mechanism, and indicate its position

# PUSHER HOME/PUSHER EXTEND - PB/PL

These pushbuttons/indicators operate the billet pusher mechanism, and indicate its position

#### GRIPPER RETRACT/GRIPPER EXTEND – PB/PL

These pushbuttons/indicators operate the gripper positioning mechanism, and indicate its position

# GRIPPER OPEN/CLOSE - PB/PL

These pushbuttons/indicators operate the gripper jaw mechanism, and indicate its position

#### EXIT CONVEYOR START/STOP – PB/PL

These pushbuttons/indicators operate the exit conveyor and indicate its running state

# EXIT CONV SPEED % - NUMERIC DATA ENTRY

This display indicates and allows the entry of the exit conveyor speed command in terms of percentage of nameplate speed

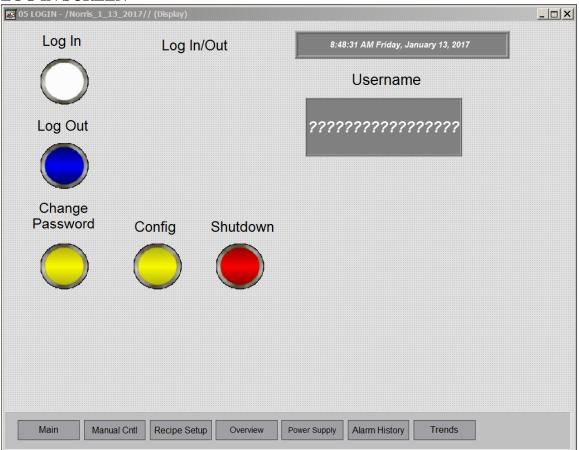
# RECIRC PUMP #1/#2 RUNNING - PL

These indicators display the running status of the recirculating pumps at the cooling station

#### DI/HYD PUMP RUNNING - PL

These indicators display the running status of the DI water cooling pump and the hydraulic pump

# LOG IN SCREEN



This screen allows the operator to enter a log in to access some of the restricted screens and activities such as recipe editing

# LOG IN/OUT - PB

Pressing these buttons allow the operator to enter the log in password

# **CHANGE PASSWORD - PB**

This button allows the password to be changed

# CONFIG - PB

This button allows access to the HMI terminal settings

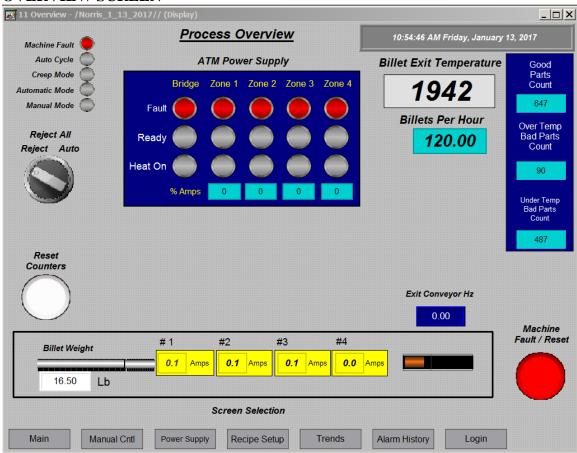
#### SHUTDOWN - PB

Closes the HMI application and returns the screen to Windows

#### USERNAME – TEXT DISPLAY

Displays the name of the current log on

#### **OVERVIEW SCREEN**



This screen provides an overview of the heating process. Many of the indicators have been on previously explained displays, but a few new items exist

### **REJECT ALL - SS**

When in the "Reject" position all billets will be evaluated as a "Bad Part" and this information will be passed to the unloading system. In the "Auto" position the billets will be evaluated using the pyrometer readings and the recipe parameters

# PARTS COUNTERS – GOOD, OVER & UNDER TEMP – NUMERIC DISPLAYS

Displays the accumulated counts of all the evaluated billets. A "Counter Reset" pushbutton is provided at the lower left to reset the counters to zero

### BILLET EXIT TEMPERATURE - NUMERIC DISPLAY

Displays the current temperature of the billet in the sensing range of the pyrometer. The pyrometer has a valid range of 1112 to 2552 degrees F

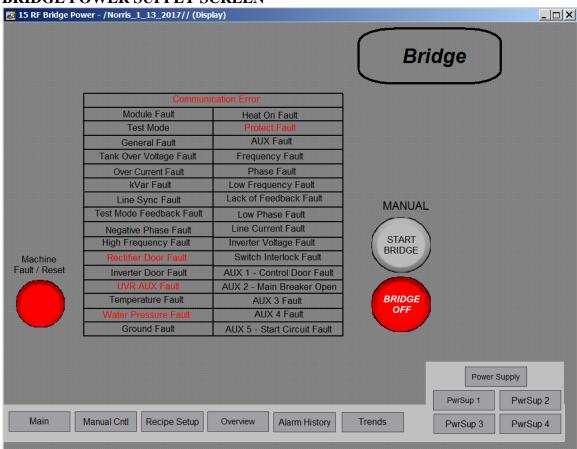
# BILLETS PER HOUR - NUMERIC DISPLAY

Displays the calculated billets per hour rate based on the recipe, and line mode (Norm/Creep)

# BILLET WEIGHT - NUMERIC DISPLAY

Displays the billet weight as entered into the recipe

# **BRIDGE POWER SUPPLY SCREEN**



This screen displays the faults and status of the bridge section of the power supply. It also allows for the manual initiation of the bridge section. See the power supply manual for an explanation of the individual indicators

#### POWER SUPPLY SCREEN (ALL) \_ | \_ | × | 11:00:28 AM Friday, January 13, 2017 **ATM Power Supply** 7one2 7one3 7one4 Power Supply Bridge Z1 **Z**3 **Z4** PS Enable PS Enable PS Enable PS Enable Off Off Fault Ready Heat On Amps % 80.0 0.0 **ATM Power Supply** % Volts 0.0 0.0 % Amps 0.2 0.4 0.4 0.5 Heat On % kW 0.1 0.1 0.1 0.0 Total kW % Hz 111 78.4 93.0 89.4 Machine Fault / Reset

This screen provides the status of all the power supplies. It also provides for the manual operation of each supply

Alarm History

Trends

PwrSup 2

PwrSup 4

PwrSup 1

PwrSup 3

# ZONE 1(2,3,4) PS ENABLE - SS

Manual Cntl

When enabled, allows the manual operation of each power supply

Overview

Screen Selection

Recipe Setup

#### AMPS % - NUMERIC DATA ENTRY

Allows the operator to manually enter a heat command. Note that this value is only used for operation in the "Manual Mode"

# HEAT ON/OFF - PB

This button initiates the power output of any power supply that is enabled. Note that these buttons only work in the "Manual Mode"

# %VOLTS/AMPS/kW/Hz - NUMERIC DISPLAY

These indicators display the actual values of the feedbacks from the power supply. Each value is represented as a percentage of the rated value of the power supply

#### **ZONE 1 (2,3,4) POWER SUPPLY SCREENS 17 RF PS Zone1 - /Norris\_1\_13\_2017// (Display)** % TV % Amps % kW %Frequency Regulation Mode 0.0 0.0 0.0 0.0 Zone 1 Command KW 0.0 XP Current Limit Heartbeat Module Fault Heat On Fault Inverter Voltage Limit Tank Voltage Limit Test Mode Protect Fault kW Limit General Fault Aux Fault Tank Over Voltage Fault Frequency Fault PS Not Ready Over Current Fault Phase Fault Low Frequency Fault kVar Fault MANUAL Lack of Feedback Fault Line Sync Fault MANUAL **HEAT** Test Mode Feedback Fault Low Phase Fault % Amps Negative Phase Fault Line Current Fault High Frequency Fault Inverter Voltage Fault 80.0 **START** Power Section Door Fault Switch Interlock Fault Machine Fault / Reset Heat Station Door Fault Coil Water Pressure Fault **UVR AUX Fault** AUX 1 Fault Temperature Fault AUX 2 Fault HEAT OFF Inlet Temp Fault AUX 3 Fault **Ground Fault** AUX 4 Fault Power Supply Bridge PwrSup 2 Main Manual Cntl Recipe Setup Overview Alarm History Trends PwrSup 3 PwrSup 4

These screens display the faults and status of each zone section of the power supply. It also allows for the manual initiation of each section. See the power supply manual for an explanation of the individual indicators

# **REGULATION MODE - PL**

This indicator displays the regulator mode of the power supply. This mode is fixed via PLC code.

# HEARTBEAT - PL

These pilot lights indicate the status of the communication between the PLC and the power supply. When communication is active they will flash

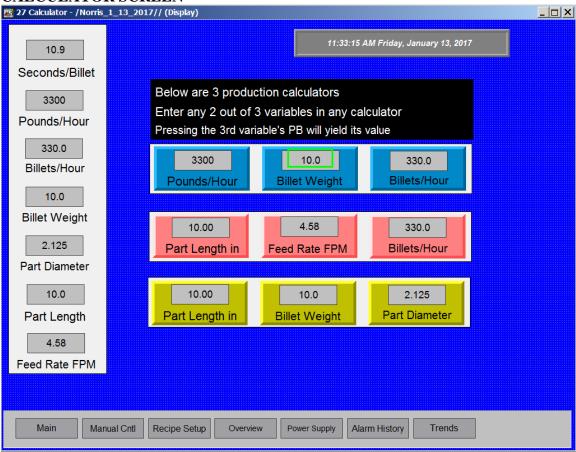
# PS READY/NOT READY - PL

These indicator displays the status of the power supply. The power supply must be ready before heat can be initiated

# COMMAND - NUMERIC DISPLAY

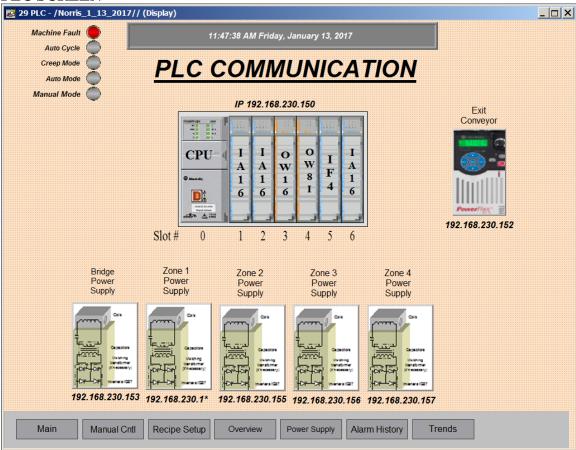
Displays the current value of the commanded power to the power supply

# **CALCULATOR SCREEN**



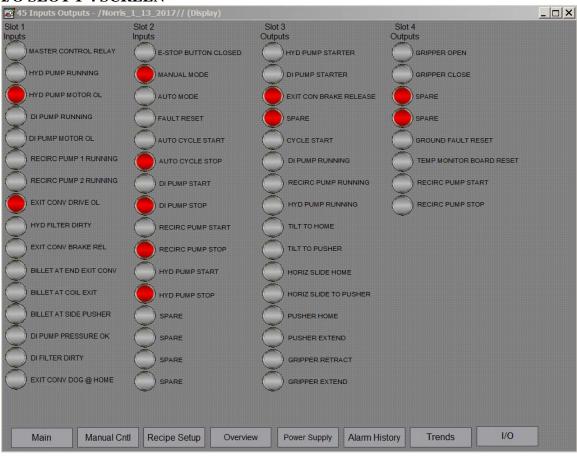
This screen allows an operator to perform production calculations based on known factors. There are three separate calculators, represented by their color schemes. Within each calculator the operator can enter any two out of the three values and then by pressing the button of the third, the calculated value will be displayed. All the calculated values are displayed in the column at left as well

# **PLC SCREEN**

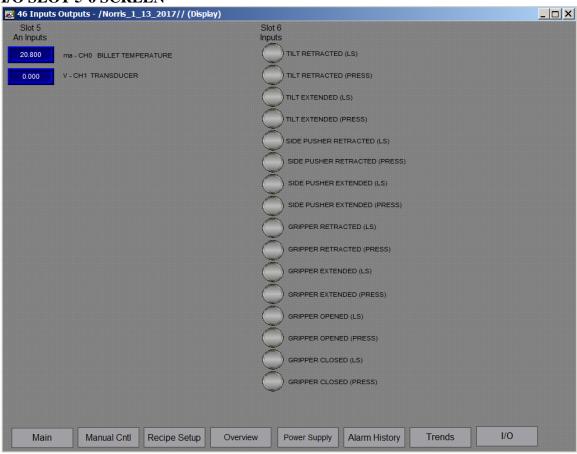


This screen displays the individual components of the heating system and provides a way to look at the individual I/O involved. Pressing the icon of any one device will pop up a screen displaying the I/O for that group of devices. See screens below

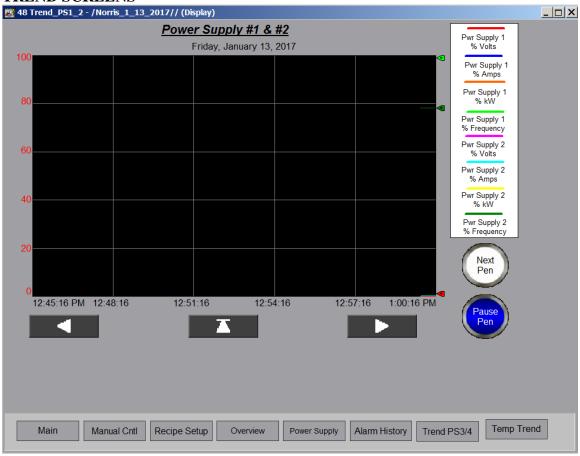
# **I/O SLOT 1-4 SCREEN**



# **I/O SLOT 5-6 SCREEN**

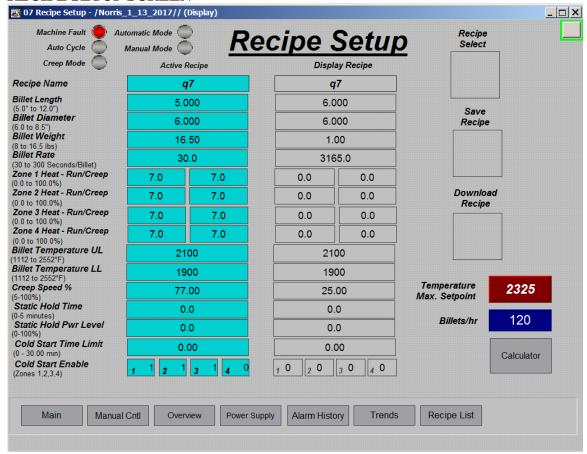


# TREND SCREENS



These screens allow the operator to view the power supply feedbacks and temperature readings in a graphical manner

# RECIPE SETUP SCREEN



This screen allows an operator to select, view, and download recipes

#### **RECIPE NAME**

Recipes are saved and operated on based on their recipe name. The recipe name can be alphanumeric characters

#### BILLET LENGTH

Billet length is entered in inches and must be between 5 and 12 inches. This value is used in production calculations

### **BILLET DIAMETER**

Billet diameter is entered in inches and must be between 6 and 8.5 inches. This value is used in production calculations

# **BILLET WEIGHT**

Billet weight is entered in pounds and must be between 8 and 16.5 pounds. This value is used in production calculations

# **BILLET RATE**

Billet weight is entered in seconds per billet and must be between 30 and 300 seconds. This value is used in controlling the rate of the entry end billet feeding system

# ZONE 1 (2,3,4) RUN/CREEP HEAT %

This is the power command that will sent to each power supply. There are two entries, one for the run rate and the other is used when the system is placed in the "Creep Mode".

# BILLET TEMPERATURE UL/LL

These upper and lower limits are used to determine if the heated billet is a "Good, Over-temp, or Under-temp" part. This information is passed to the billet unloading equipment

# **CREEP SPEED %**

This value determines the speed of the system when it is placed in the "Creep Mode". The speed is a percentage of the billet rate. For example, if the run speed was 30 seconds per billet, and 25% is the "Creep Speed", the line speed would now be 120 seconds

#### STATIC HOLD TIME

This is the amount of time that the line will remain in "Static Hold Mode"

# STATIC HOLD POWER LEVEL

This is the power level commanded to zones 2, 3, & 4 while the system is in "Static Hold Mode"

#### COLD START TIME LIMIT

This is the maximum amount of time that the system will stay in the "Cold Start Mode". If the power supplies do not reach the programmed power levels within this time the "Cold Start Mode" will be aborted

#### **COLD START ENABLE**

This recipe parameter gives the operator to select the zones that will be affected during a cold start. Entering a zero disables the mode, while entering a one enables it

# RECIPE SELECT

Pressing this button allows the operator to enter a recipe name in this field. The recipe values saved to this recipe will be displayed in the right hand section of the screen under the "Display Recipe" banner. Recipes can be edited from this section. Note – To create a new recipe enter a unique name in this field and then save the recipe

# SAVE RECIPE

Pressing this button will save all the displayed recipe values to the named recipe in a file in the HMI

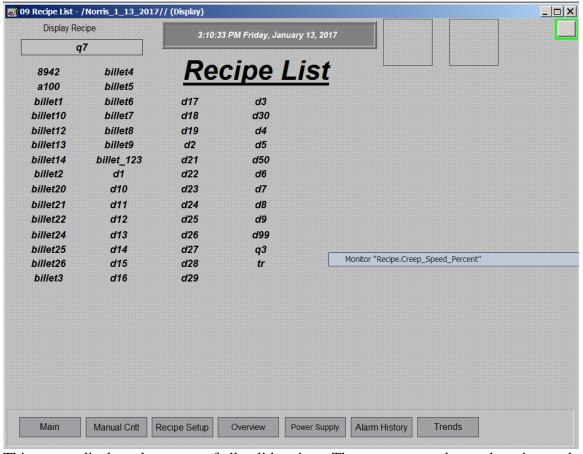
# DOWNLOAD RECIPE

Pressing this button downloads the displayed recipe values to the PLC. When the download is complete the data from the right side will appear on the left side under the banner "Active Recipe"

# TEMPERATURE MAX SETPOINT – NUMERIC DATA ENTRY

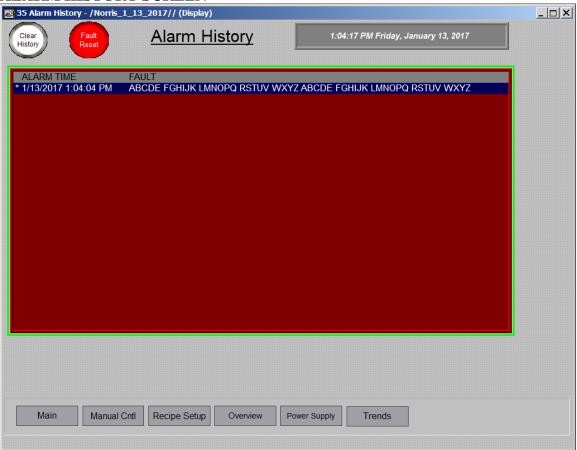
Allows the operator to change the value at which the "MAX BILLET TEMPERATURE" fault will occur. This is not to be confused with the "Billet Temperature UL" stored in the recipe, which only rejects the billet. The max temperature fault stops the machine and shuts off the heat. The use of this button is password protected and the value is not stored in the recipe

# RECIPE LIST SCREEN



This screen displays the names of all valid recipes. These names can be used to view and download recipes to the PLC

# **ALARM HISTORY SCREEN**



This screen keeps track of inactive alarms and warnings. Once an alarm is cleared and fault reset, the alarm is removed from the active alarm banner but remains on the Alarm History screen

#### TUNING OF HIGH FREQUENCY EQUIPMENT

Some power components of the induction heating system are adjustable, and can be used to tune the system for optimum performance. The components which can be adjusted are 1) most capacitors, and 2) variable ratio transformers. In general, a transformer (if necessary) is used to match the load to the power supply, and conventional bulk and vernier capacitors are used for fine tuning of frequency. Note: The amount of capacitance in a flatpack capacitor station is fixed and therefore the frequency cannot be altered by varying the capacitance. Refer to SU-22-0001 HF Capacitors for additional information.

Keep in mind that the system will operate over a range of frequencies, and it is usually not necessary to have the equipment tuned to the exact design frequency. Tuning becomes more important as power levels approach the available nameplate power. For consistency of heated parts, the system should be tuned so that the power supply is not running in any limits.

All components in the load circuit, e.g. bus, leads, induction coils, and even the workpiece itself, will have some effect on the resonant frequency. These other items are not, however, used to tune the system to the desired tuning for frequency is done with capacitors All transformer. The frequency should be rechecked and re-adjusted necessary, after any changes are made to any of these other components. Normally, the equipment is tuned to run at or slightly below its nominal (nameplate) frequency under steady state conditions.

Typically, at initial startup, the Ajax Service Engineer will determine the best settings for the equipment. The following guidelines can be followed when the user wants to set up different parts. It is suggested that settings and meter readings be recorded as a quide when running similar parts in the future. Attached is a sample data sheet which can be copied and used to record this information.

# Capacitors

Your induction heating system was designed to run at a given frequency. desired frequency is obtained by including power factor correction capacitors in the system. These capacitors and the heating inductors form a resonant circuit, which is tuned by changing the amount of capacitance in the circuit.

Adding capacitors lowers the frequency, and removing capacitors raises the frequency.

(See the capacitor section of this manual, SU-22-0001, for instructions on how to add or remove capacitors.)

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If the power unit is running in a current limit, move away from the limit by raising the frequency (removing capacitors).

If the unit is running in a (capacitor) volt limit, move away from the limit by lowering the frequency (adding capacitors).

#### <u>Transformers</u>

Many induction systems will include matching transformers between the power supply and the load. These will be one of two types, either fixed ratio or variable ratio (i.e. tapped). The effect of the transformer on frequency depends upon its position in the circuit. Transformers which are on the power supply side of the capacitors will have a minor effect on frequency. Transformers which are located between the capacitors and the induction heating load will have a large effect on frequency.

When changing transformer ratios, pay attention to the vendor's data plate on the transformer, and use the taps shown to get the desired ratios. The reason for this is to try to keep the ampere turns in the transformer as balanced as possible. For example, on a 5/3 - 11/3 transformer there are taps at 0, 1, 3, 8, 9, 11. You could get an 8/3 ratio by using primary taps 0 and 8. But the better, proper, way to get an 8/3 ratio is by using taps 1 and 9 as shown on the vendor's data plate.

# Tuning

If previous data exists on similar parts, that data should be used as a starting point.

For unknown loads, start with all the capacitors connected. If there is no matching transformer, or there is a fixed ratio transformer, turn the unit on and observe the frequency. Remove capacitors to achieve the design frequency.

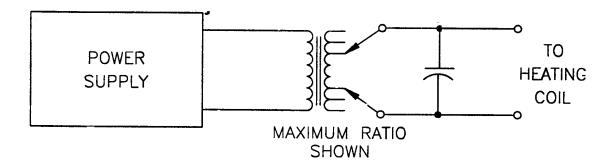
If there is a tapped transformer, for unknown loads start with the transformer set to deliver the lowest voltage to the load. This is the safest place to start if tuning is unknown, and the best place to leave it if it runs properly; it results in the lowest converter current (lowest losses).

(Note: Variable ratio transformers can be tapped on either the primary or the secondary. Obtaining the lowest output voltage means having the highest ratio of primary turns to secondary turns. Thus, if the secondary is tapped, it should be set up for the fewest turns. If the primary is tapped, which is the case for systems using low voltage heat treat inductors, it should be set up to have the maximum number of primary turns.)

If your system has a tapped transformer, it will probably have one of the following configurations. (Note: Capacitors and transformers are shown schematically; actual physical location may be inside the power unit. Limits referred to below may be indicated by an indicating light on the power supply or by flashing dots in the meter. In some cases, frequency limit is indicated when the frequency meter reads 100% of maximum frequency.)

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# Conditions

- 1. Parallel resonant circuit.
- 2. Transformer tapped on secondary.
- 3. Capacitors on load side of transformer.

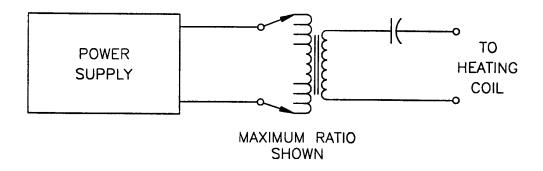
#### Procedure.

- a. Start at lowest tap, with all capacitors connected.
- b. Remove capacitors to obtain design frequency.
- c. If KW obtained is too low, raise the transformer tap, one step at a time.
- d. Check operating frequency and re-adjust capacitors if necessary.

<u>IF LIMIT IS REACHED</u>	DO THIS
Volt Limit	Lower Frequency Or Change Load
Current Limit	Reduce Transformer Tap,
	i.e. Go To Higher Ratio
High Freq	Add Capacitors

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# <u>Conditions</u>

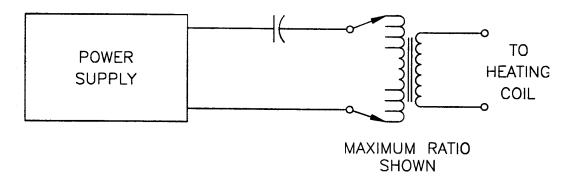
- 1. Series resonant circuit.
- 2. Transformer tapped on primary.
- 3. Capacitors on load side of transformer.

#### Procedure.

- a. Start with all primary turns in circuit, i.e. maximum ratio, with all capacitors connected.
- b. Remove capacitors to obtain design frequency.
- c. If KW obtained is too low, or volt limit is encountered, reduce the number of primary turns, i.e. go to a lower ratio.
- d. Check operating frequency and re-adjust capacitors if necessary.

(Note the distinction below between `volt limit' and `cap volt limit'. `Volt limit' is an inverter volt limit, and refers to a condition where the inverter output current is too low to deliver power. `Cap volt limit' means the voltage across the capacitors has reached the maximum value, 110%)

<u>IF LIMIT IS REACHED</u>	DO THIS			
Volt Limit	Take Out Primary Turns, i.e. Go To A Lower Ratio			
Current Limit	Add Primary Turns, i.e. Go To A Higher Ratio			
Freq Limit	Add Capacitors			
Cap Volt Limit	Lower Frequency Or Change Load Or Change Capacitors To Higher Voltage Capacitors			



# Conditions

- 1. Series resonant circuit.
- 2. Transformer tapped on primary.
- 3. Capacitors on line side of transformer.

#### Procedure.

- a. Start with all primary turns in circuit, i.e. maximum ratio, with all capacitors connected.
- b. Remove capacitors to obtain design frequency.
- c. If KW obtained is too low, or volt limit is encountered, reduce the number of primary turns, i.e. go to a lower ratio.
- d. Check operating frequency and add capacitors to obtain design frequency again.

(Note the distinction below between `volt limit' and `cap volt limit'. `Volt limit' is an inverter volt limit, and refers to a condition where the inverter output current is too low to deliver power. `Cap volt limit' means the voltage across the capacitors has reached the maximum value, 110%. In some cases, there is an additional voltage limit sensed across the transformer, to protect it from overvoltage. When this sensing is used, and a transformer voltage limit is reached, the `cap volt limit' light will be lit.)

<u>IF LIMIT IS REACHED</u>	DO THIS
Volt Limit	Take Out Primary Turns, i.e. Go To A Lower Ratio
Current Limit	Add Primary Turns, i.e. Go To A Higher Ratio
Freq Limit	Add Capacitors

5/18/94 RRI

REVISED: 8/03/01

# Summary

Optimum tuning is often not necessary unless full power is required. There are many reasons for deviating from the above tuning guidelines, such as a desire to run several different parts without having to make setup changes. This is not only acceptable but highly desirable, and will not cause any damage to the equipment. The above guidelines for tuning are suggested to allow operation at the desired power levels without running into voltage or current limits when running unknown parts.

5/18/94 RRL

REVISED: 8/03/01

XFMR RATIO							
KVAR							
FREQUENCY							
KILOWATIS							
AMPS							
VOLTS							
CYCLE TIME							
PART IDENTIFICATION							

SKU-22-0008-03 SHEET 7 OF 7

# **HF CAPACITORS**

Capacitors are used to correct the inherently lagging power factor of induction coils. In parallel tuned systems, currents between the inductor and capacitors are higher than in the rest of the system. Because of this, the capacitors are located as close to the coil as possible.

# **RATINGS**

The capacitor's nominal ratings are on the capacitor nameplate and repeated in this instruction manual. The capacitor can be run continuously at 110% nameplate voltage, and in most instances, 110% of the rated frequency.

# SAFETY

Capacitors are energy storage devices. They can retain a charge after power is shut off. Capacitors which are used to correct the coil power factor are shorted through the coil when power is off. Nevertheless, it is good practice to short the capacitor before working in the cubicle. This is especially true of unused capacitor taps which may become charged internally through the capacitor but which have no external discharge path.

To discharge a capacitor, first ensure that the main breaker or disconnect is open. Then short the front and back pieces of bus with a short loop of insulated wire and a resistor to limit the current. Recommended resistor size is 15 ohms, 100 watts, or larger. Then short any unused taps to the opposite polarity bus. When discharging capacitors, care should be taken to guard against getting shocked.

After all of the unused capacitor taps have been discharged, measure the voltage between the discharged taps and the opposite polarity bus to ensure that they have been fully discharged.

The capacitors used by Ajax are of live case design. This means that the case of the capacitor is connected to one side of the circuit, and is electrically hot during operation. In some cases, capacitors are mounted in metal racks which are, therefore, also "hot."

The insulating (dielectric) fluid used in most capacitors is classified as a combustible fluid. This normally presents no problems to the user, but in the event of a rupture of the capacitor case, the capacitor should be removed and any spilled fluid cleaned up. Flatpack capacitors are dry and do not contain a dielectric fluid.

The capacitor cabinet should be grounded in accordance with Article 250-110 of the 1999 NEC.

Author: RRL Approver: TMK

8/29/90

Revised: 9/24/13 SU-22-0001-11 Sheet 1 of 7

# WATER FLOW

See the capacitor station water schematic drawing for specific design flows and differential pressure requirements. Maximum pressure should be held to 70 psig. (480 kpa). See also the water requirements section of this manual. Most capacitors are directly cooled by flowing water through the case of the capacitor. Flatpack capacitors are indirectly cooled by sandwiching them between water cooled bus bars or water cooled heat sinks.

# **CAPACITOR ADJUSTMENTS**

See also the "Tuning of High Frequency Equipment" section of this instruction manual.

Three types of capacitors are used; vernier, bulk, and flatpack. In general, vernier capacitors are used where there is a need for fine tuning; bulk capacitors are used where there is a need for large amounts of capacitance. The total capacitance of a flatpack capacitor station is fixed and cannot be adjusted.

# Vernier

On a vernier capacitor, the amount of capacitance in the tank circuit can be varied by independently disconnecting or connecting each of the insulated studs. The electrical circuit is completed from the capacitor stud, through the brass nut, through the brass washer, to the bus bar.

Refer to the left hand view of sketch SU-22-0073 Sheet 1 for 1/4" thick capacitor bus. To remove a section of a vernier capacitor from the circuit, discharge the capacitor as described on Sheet 1 of this section, remove the brass nut and washer, install a second .343" high nylon top hat insulator over the stud, and reinstall the hex nut. Do not reinstall the brass washer because this will reduce the creepage distance between the live hex nut and the bus. The right hand view of SU-22-0073 Sheet 1 depicts how to properly connect a capacitor section using a brass washer and hex nut.

Sheet 2 of SU-22-0073 shows similar information for 1/8" thick capacitor bus which is typically used at frequencies greater than 10 KHZ. Note in the left hand view that two different nylon top hat insulators are used to disconnect a section. The lower top hat is .218" high whereas the upper one is .343". Do **not** try to isolate a stud using two .218" high insulators because the resulting air gap is insufficient to prevent arcing in the presence of moisture and conductive contaminants.

Author: RRL Revised: 9/24/13 Approver: TMK SU-22-0001-11 8/29/90

Sheet 2 of 7

Each stud of a vernier capacitor must either be connected to the circuit or insulated as described above. Do <u>not</u> energize the capacitor unless all isolated studs have an upper top hat held securely in place with a hex nut because of the possibility of arcing from the stud to the bus bar. If arcing does occur between a <u>properly isolated</u> stud and the bus due to the presence of moisture and conductive contaminants, apply a layer of high voltage silicon non-hardening putty between the mating surfaces of the two top hats and between the capacitor stud and the top hats.

# <u>Bulk</u>

Bulk capacitors have two or four insulated studs. These studs are connected internally, therefore, it is not possible to disconnect part of the capacitor from the circuit. Bulk capacitors must be either totally connected to the circuit or totally disconnected. Bulk capacitors are disconnected by removing a bus link between the capacitor studs and the main collector bus. No nylon insulators are used over studs on bulk capacitors. The electrical path is both through the nut and washer, and directly to the capacitor case.

# <u>Flatpack</u>

Flatpack capacitors may be used at frequencies greater than 10 KHz. These capacitors have ratings up to 500 volts and do not have insulated studs for electrical connections. A 1500 Volt system will utilize multiple parallel groups of three 500 volt capacitors connected in series. Likewise, a 3000 volt system will consist of groups of six 500 volt capacitors in series. The series connections are achieved by clamping each capacitor between a water cooled bus bar or a water cooled heat sink to form a multi layered sandwich. The amount of capacitance in a flatpack capacitor bank is fixed and cannot be adjusted.

Nuts on capacitor studs should be tightened to 15 lb-ft (2 m-kg) of torque. This is sufficient for good electrical contact. Overtightening may pull the stud out of the capacitor or strip the threads on the stud. Likewise, nuts on the clamp bolts for flatpack capacitors should be tightened to 15 lb-ft.

If capacitor sections are removed for tuning, always remove those capacitor sections farthest from the induction coil first. For frequencies greater than 10 kHz, always remove the capacitor sections closest to the collector bus to minimize the possibility of arcing.

Occasionally capacitor banks are supplied with parallel groups of two vernier capacitors connected in series. For example the connection schemes depicted in Diagram A and Diagram B on sketch SU-22-0072 allow two series-connected 1250 volt capacitors to operate at 2500 volts. In Diagram A capacitors #1 and #2 (#3 and #4) are connected in series by individual bus clips. In Diagram B a third collector bus (rear) is used to achieve the series connection. **Regardless of the method used, the two series-connected 1250 volt capacitors must have the same amount of microfarads (or kvar) connected in order to equally share the 2500 volt system voltage.** 

Author: RRL Revised: 9/24/13
Approver: TMK SU-22-0001-11
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If the two capacitors have unlike amounts of microfarads, the one with the least will be overvoltaged and will consequently fail prematurely. Likewise, capacitor #3 must have the same microfarads connected into the circuit as capacitor #4. However, it is not necessary that capacitors #1 and #2 have the same amount of connected capacitance as capacitors #3 and #4.

# TROUBLESHOOTING

With proper cooling water, capacitors should provide years of reliable service. If a fault condition indicates the capacitors should be checked, it is an easy procedure. A capacitor failure will normally occur as a short circuit, causing an overcurrent device to operate, or a logic overcurrent fault in the case of a solid state converter.

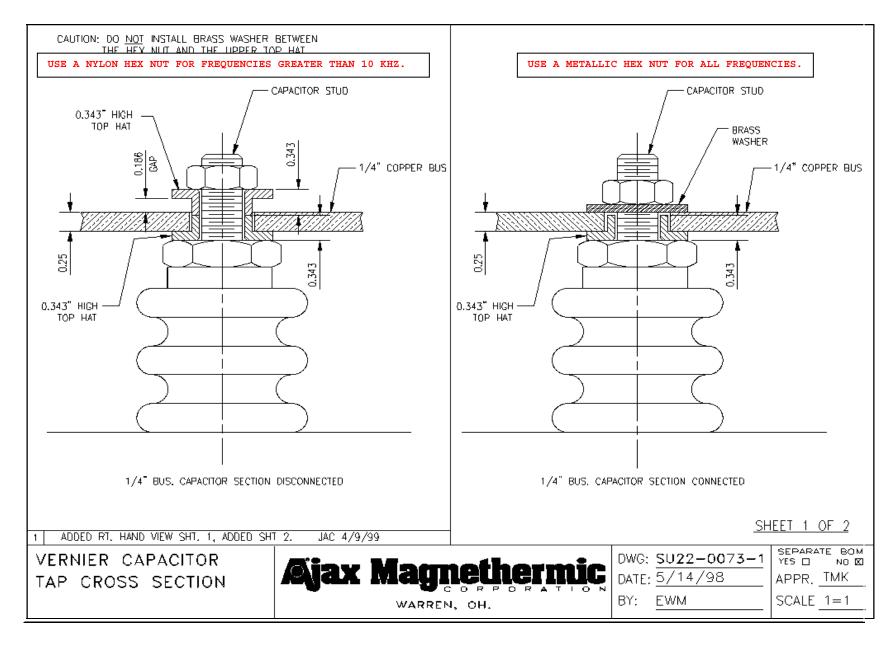
A megger should be used to check capacitors, although shorted capacitors can generally be found with an ohmmeter (meter reads a dead short).

Do not use a megger which is of a higher voltage rating than the voltage rating of the capacitor. Isolate the capacitor section to be checked from the rest of the circuit. Megger from the capacitor stud to the common (rear) bus bar. The megger reading should initially show a short circuit, but resistance should increase as the megger is cranked. The length of time required to see this charging action depends on the size of the capacitor, but it is no more than a few seconds in any case. If the megger does not indicate that the capacitor is charging up, the capacitor section is defective. (It is possible for one or more sections of a vernier capacitor to be shorted, with the remainder of the capacitor still useable.)

After megger testing, the capacitor stud should be discharged. The small arc when discharging is further proof that the capacitor is accepting a charge and doing its job.

Author: RRL Revised: 9/24/13 Approver: TMK SU-22-0001-11 8/29/90

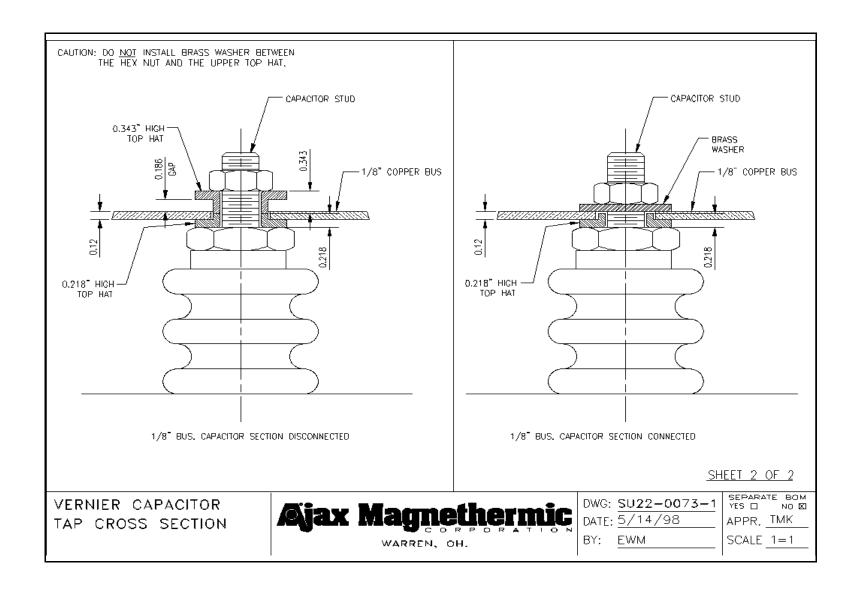
Sheet 4 of 7



Author: RRL Approver: TMK

8/29/90

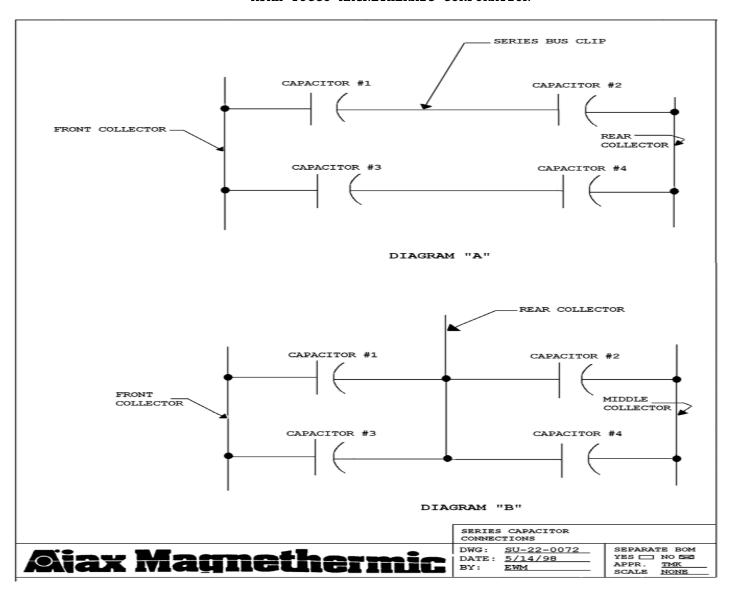
Revised: 9/24/13 SU-22-0001-11 Sheet 5 of 7



Author: RRL Approver: TMK

8/29/90

Revised: 9/24/13 SU-22-0001-11 Sheet 6 of 7

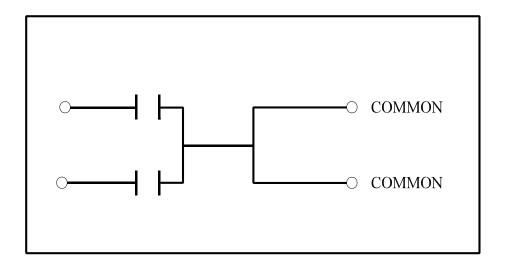


Author: RRL Approver: TMK

8/29/90

Revised: 9/24/13 SU-22-0001-11 Sheet 7 of 7

# **BULK CAPACITORS**



NOTE: BOTH STUDS MUST BE EITHER ELECTRICALLY IN OR OUT OF THE CIRCUIT.

STEP	1
MICROFARAD	305.6
KVAR	3000

SC# <u>31187A50</u>

FREQUENCY 1000 HZ

VOLTAGE 1250 V

DIELECTRIC <u>DIELECTROL VII</u>

# PREVENTIVE MAINTENANCE CHECKLIST

UNIT I.D. #:	BY:
DATE PERFORMED:	AJAX ORDER NO.:
COMPANY:	POWER UNIT HOUR METER READING:

			6			ACTION		
DAILY	WEEKLY	MONTHLY	-	YEARLY	ок		FIXED	
								HEATING COILS
								I. VISUAL
	Х							A. Check for water leaks or cracked hoses. <sup>1</sup>
	Х							B. Look for overheated electrical connections.
	Х							C. Inspect refractory for cracks.
								II. Other
Х								D. Remove scale.
		Х						E. Tighten connections. <sup>2</sup>
			Х					F. Megger winding to frame.
				Х				G. Check water flows - each path.
								HEAT STATION
								I. Visual
	Х							A. Check for water leaks or cracked hoses. <sup>1</sup>
	Х							B. Look for overheated electrical connection.
		Х						C. Look for bulged or leaking capacitors.
		X						Check for missing or worn top hat insulators.
				Х				Check condition of door latches and gaskets.
								II. Other
			Х					F. Check operation of ground detector.
			Х					G. Check operation of pressure switch.
		Х						H. Check operation of door switch.
				Х				I. Check cabinet ground.
				Х				J. Check water flows - each path.
		Χ						K. Tighten connections. <sup>2</sup>

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DAILY	WEEKLY	MONTHLY	6 MONTHS	YEARLY	ок	ACTION REQ'D	FIXED	
								BUS AND CABLES
								I. Visual
	Χ							A. Check for water leaks or cracked hoses. <sup>1</sup>
	Χ							B. Look for overheated electrical connections.
								II. Other
				Х				C. Check water flows each path.
		Х						D. Tighten connections. <sup>2</sup>
								<u>SYSTEM</u>
		Х						A. Compare meter readings to original.
		Х						B. Record and plot water conductivity.

# NOTES:

- 1. Hose and tubing must be nonconductive. Rubber hose should be Gates 19B, Gates Premo Flex, or equivalent. Hose clamps must be nonmagnetic. (Contact Ajax for assistance).
- 2. Maximum Bolt Torques (slightly less than the yield point, no lubrication)
  - a) Capacitor studs 15 lb-ft (20.3 Newton-Meters)

b)

BOLT <u>SIZE</u>	316 STAINLESS STEEL LB-FT (NEWTON-METERS)	SILICON BRONZE FASTENERS LB-FT (NEWTON-METERS)	BRASS FASTENERS LB-FT (NEWTON-METERS)
1/4-20	6.5 (8.8)	5.7 (7.7)	5.1 (6.9)
1/4-28	8.2 (11.1)	7.3 (9.9)	6.4 (8.7)
3/8-16	20.5 (27.8)	18.3 (24.8)	16.0 (21.7)
3/8-24	22.5 (30.5)	20.0 (27.1)	17.7 (24.0)
1/2-13	45.1 (61.2)	40.0 (54.2)	35.2 (47.7)
1/2-20	47.0 (63.7)	41.8 (56.7)	36.9 (50.0)



# PACER-HF PREVENTIVE MAINTENANCE CHECKLIST

DAILY_			30 DAYS_		_	90 DAYS		_ YEARLY (CHECK ONE
								AJAX ORDER NO:
UNIT I.I	D. #							CONVERTER HRS:
DATE PERFORMED								CYCLE COUNTER:
								BY:
	<u> </u>	T	ı	1	T		1	
DAILY	30 DAYS	90 DAYS	YEARLY	OK	ACTION REQ'D	FIXED		WATER SYSTEM COMPONENTS
Х							1. C	check for Leaks
Х							2. C	Check Water Level
	Х						3. C	Check H <sub>2</sub> 0 Conductivity (>5/<50 μmho/cm)
	Х						4. C	Check PH of Water (Must be between 7 & 9)
			Х				5. C	Check for Build-up of Deposits on I.D., Flush if Necessary
			Х				6. C	Check Water Flow in Each Path, Flush if Necessary
			Х				7. V	Vater Pressure Switch Operation
			Х				8. V	Vater Temperature Switch Operation
		Х					9. C	Check Solenoid Operated Valves
			<u> </u>		<u> </u>		1	
DAILY	30 DAYS	90 DAYS	YEARLY	ОК	ACTION REQ'D	FIXED		ELECTRICAL POWER CONNECTIONS:
	Х						1. Ir	nput Cable Connections
	Х						2. F	use Connections
		Х					3. C	Output Connections
		Х					4. P	ower Capacitor Nuts (If Applicable)
		Х					5. H	ligh Current Switch Contactors (If Applicable)
	Х						6. C	Output Transformer Connections (If Applicable)
Х							7. C	Check for Discoloration on Bus & Power Connections
							1	
DAILY	30 DAYS	90 DAYS	YEARLY	OK	ACTION REQ'D	FIXED		SMALL ELECTRICAL POWER CONNECTIONS:
							A. 6	60 Hz Bridge(s):
	Х						1. S	Snubber Connections
		Х					2. 8	Snubber Resistor (Ohmage)
	Х						3. 8	Snubber Capacitors (Visual)
			Х				4. 8	Snubber Capacitors (Stressed to 2.5 X Rating)
	Х						5. S	SCR or Diode Devices

Author: JPM Approver: RJP 10/05/2012



# PACER-HF PREVENTIVE MAINTENANCE CHECKLIST

DAILY	30 DAYS	90 DAYS	YEARLY	OK	ACTION REQ'D	FIXED		SMALL ELECTRICAL POWER CONNECTIONS:
							В.	Choke Firing Panel
	Х						1.	Wiring Connection
	Х						2.	SCR Device

DAILY	30 DAYS	90 DAYS	YEARLY	ОК	ACTION REQ'D	FIXED		SMALL ELECTRICAL POWER CONNECTIONS
							C.	DC Reactor (if applicable)
		Х					1.	Tube Bus Connections
		Х					2.	Inspect the Epoxy for Signs of Overheating
			Х				3.	Flush and Check Water-Flow Rate

DAILY	30 DAYS	90 DAYS	YEARLY	ОК	ACTION REQ'D	FIXED	SMALL ELECTRICAL POWER CONNECTIONS:
							D. Inverter Sections:
	Х						All Bolted Connections (Correct Torque on IGBTS)
	Х						2. Snubber Connections
		Х					3. Snubber Resistors (Ohmage)
	Х						4. IGBT Devices
	Х						5. Filter Capacitor Bolts
		Х					6. DC Blocking Capacitor Nuts (IF Applicable)

DAILY	30 DAYS	90 DAYS	YEARLY	ОК	ACTION REQ'D	FIXED	CONTROL SYSTEM
							A. Logic Section
	Χ						Inspect Boards (Visual)
			Х				Replace Boards and Return to Factory for Inspection and Update
							3. Check Connectors:
		Х					a. Logic Board
		Х					b. Gate Drive Interface
		Х					c. Gate Drive Expansion (If Applicable)
		Х					d. Gate Drive Boards
		Х					e. Temp. Monitor Board
		Х					f. Expansion Board
		Х					g. Front Panel Board(s)
			Х				4. Door Gasket
			Х				5. Door Latch
	Х						6. Read Operating Time Meter and Cycle Counter and Record

Author: JPM Approver: RJP 10/05/2012



# PACER-HF PREVENTIVE MAINTENANCE CHECKLIST

DAILY	30 DAYS	90 DAYS	YEARLY	OK	ACTION REQ'D	FIXED	CONTROL SYSTEM
							B. Wiring Harness
	Х						Bending Points (Visual)
		Х					2. Supports (Tie Down Straps Repair)
	Х						3. Contact With High Voltage
							C. Inverter Section
	Х						IGBT Devices Gate Connections (Tighten)
							D. Bridge Panel
	Х						Pulse Amplifier Connections (Tighten)
							E. Component Panel
	Х						Board Connections (Tighten)
							F. Feedback Transformer (PV, TV, XP)
	Х						1. Connections
	Х						2. Stress Winding to Ground
							G. Power Supply
	Х						Run In Test Mode Per Instruction Manual
	Х						Safety Interlock - Door Switches

DAILY	30 DAYS	90 DAYS	YEARLY	OK	ACTION REQ'D	FIXED	GENERAL MAINTENANCE
			Х				Door Gaskets (Repair as Necessary)
			Х				2. Door Latches (Repair as Necessary)
		Х					3. Fans & Filters (Repair & Clean as Necessary)
	Х						4. Safety Interlock - Door Switches
			Х				5. Cabinet Ground

- A Daily Inspection Includes All Checks X'd Under Daily
  A 30 Day Inspection Includes All Checks X'd Under Daily and 30 Day
  A 90 Day Inspection Includes All Checks X'd Under Daily, 30 Day, and 90 Day.
  A Yearly Inspection Includes All Checks X'd Under Daily, 30 Day, 90 Day, and Yearly. 1) 2) 3) 4)

# **NOTES**

#### SPARE PARTS, SERVICE, WARRANTY PARTS

#### I. GENERAL

Ajax Tocco Magnethermic Corporation, in an effort to give accurate and faster service would like to request that the induction heater or furnace serial number be shown on purchase orders, in addition to the following items.

# a) PARTS

- i. Ajax Tocco SC# of part if available.
- ii. If fabricated part, part drawing number, MK letter, and item number.

(The part number or drawing number, MK letter and item number, can be found either on a bill of material, Ajax Tocco spare parts list, or on the part itself).

# b) REPAIRS

- i. Brief explanation and location of failure.
- ii. Ajax Tocco SC# of part, or drawing number, MK letter, and item number.
- iii. For coils and inductors, serial number of coil or inductor.
  - iv. Whether overtime is authorized.

NOTE: Any water-cooled devices being shipped must be drained and flushed with antifreeze prior to return shipment.

This information is quite valuable in expediting the processing of purchase orders.

#### II. SPARE PARTS

To assure continued performance of your induction system to original specifications, all replacement parts must be supplied by Ajax Tocco Magnethermic.

For repair and spare part orders Ajax Tocco toll free number is 800-547-1527. Ask for extension 660. The Ajax Tocco Magnethermic Spare Parts Department facsimile number is 330-372-8659.

Ajax Tocco carries a large inventory of components used in your induction system and in some cases can offer re-manufactured parts at reduced prices.

Author: MRG Revised: 8/7/03 Approver: RRL SU-22-0011-9

Approver: RRL SU-22-0011-9 9/15/87 Sheet 1 of 2

#### III. SERVICE

Ajax Tocco also repairs customer equipment and has a Service Department ready and able to assist you. The Service Department number is area code (330) 372-8633 and the Service Department facsimile number is (330) 372-8623. The Service Department e-mail address is Service@ajaxtoccomag.com

#### IV. WARRANTY PARTS AND REPAIRS

For repairs or replacement of parts under warranty, contact the Ajax Tocco Service Department at the above numbers for authorization. Ajax Tocco will issue a return authorization number, which must be shown on the packing list and address label. For repairs, please also supply the information requested in I.b above. The Service Department will tell you which location to send the part back to.

# WARREN

Ajax Tocco Magnethermic Corp. Return # 1745 Overland Avenue N.E. Warren, OH 44482

Defective items replaced under warranty are on a bill-and-credit basis. New components are sent and invoiced, with credit being applied after the old parts are returned for evaluation and determined to be defective. Any items returned for credit under warranty **must** be returned within 30 days of the invoice, and **must** be accompanied by the return number, or credit will not be issued.

Author: MRG Revised: 8/7/03 Approver: RRL SU-22-0011-9 9/15/87 Sheet 2 of 2



# **CUSTOMER CARE PROGRAM**

Ajax Tocco's Customer Care Program is designed to help customers who want to work with a service provider that can support a broad range of needs. Ajax Tocco's world class service department, in coordination with the district service engineers and district repair centers, provide the maintenance support services.

The Customer Care Program meets the needs of all customers, small or large.



# Design a Maintenance Plan That Fits Your Needs:

- Per Diem Rates
- Basic Plan
  - On Site Maintenance
  - Assigned Account Manager
  - Escalation Management
  - 24/7 Service Department
  - Toll Free Number
  - Support Web Site Access
  - On-Line Training
  - Technical Workshop

# Options

- Additional On-Site Maintenance Visits
- Infrared Imaging
- \*IPSMTS School
- Engineering Support
- \* IPSMTS- Induction Power Supply Maintenance and Troubleshooting School
- \*\* Includes 33% discount on additional service and engineering support.

The Ajax Tocco Service Department offers a full line of services to our customers. These services include our Customer Care Program, Infrared Imaging, Induction Power Supply Maintenance and Troubleshooting Schools, and much more!

# Or Choose Our Cost Saving Premium Customer Care Package\*\*:

- Two Scheduled On-Site Maintenance Visits
- One Infrared Imaging (plus Orientation)
- One On Site \*IPSMTS School
- Critical Problem Alert
- Continuous Trend Monitoring
- Orientation and Planning
- Escalation Management
- Technical Workshop
- Assigned Account Manager
- 24/7 Service Department
- Toll Free Number
- Support Web Site Access
- On-Line Training





800-547-1527





# REQUEST FOR WARRANTY REPAIR OR REPLACEMENT

AJAX TOCCO MAGNETHERMIC CORPORATION 1745 OVERLAND AVENUE N.E. WARREN, OH 44483

**PHONE (330) 372-8633** FAX (330) 372-8623

EMAIL: SERVICE@AJAX TOCCO.COM

An RMA number is needed before any defective parts can be returned to Ajax Tocco Magnethermic and processed. Please complete this form and return it to the Service Department at the facsimile number or email address listed above. Please keep a copy of this form for future use. Use one form per unit. When received by Ajax Tocco, your RMA will be faxed or emailed to you as soon as possible.

(ALL NON-WARRANTY REPAIRS REQUIRE A PURCHASE ORDER BEFORE SHIPMENT)

COMPANY NAME:	COMPANY ADDRESS:
SC/PI#:	Serial Number:
Contact:	(Job Number) Located on the Name Plate of PS Phone Number:
Position:	Fax Number:
E-mail:	Date unit was installed:
Date started:	Date of Failure:
The RMA for this unit:SHOULD CLEARLY BE MARKE	, Ajax Tocco will issue THIS NUMBER, which D ON THE SHIPPING CONTAINER (and all related
part or parts. The warranty obligations of Ajax Toc limited to the warranty actually extended to Ajax To fifteen (15) days after purchaser learns of defect. TE FREIGHT PREPAID, UNLESS OTHERWISE DIRE TOCCO MAGNETHERMIC CORPORATION MAKIND, EXPRESS OR IMPLIED WHICH EXTEND FOR ANY AND ALL LOSSES AND DAMAGES TO NO EVENT EXCEED THE COST OF REPAIR OR EQUIPMENT. IN NO EVENT SHALL AJAX TOCO OR NATURE WHATSOEVER.  AJAX TOCCO USE ONLY (do not mark	Y: Ajax Tocco shall at its option, repair or replace F.O.B. shipping point, such defective co with respect to equipment not manufactured by Ajax Tocco shall conform to and be cco by its suppliers. Notice of a claim for alleged defective equipment must be given within the Defective Part or Parts Shall be returned to Ajax Tocco, ected by Ajax Tocco. This warranty shall be exclusive and Ajax akes no warranty of merchantability or warranties of any other beyond the warranty as set forth above. Ajax Tocco 's liability of purchaser resulting from defective parts or equipment shall in replacement, f.o.b. shipping points of defective parts or co be liable for incidental or consequential damages of any kind below this area):
AJAX TOCCO STANDARD WARRANT part or parts. The warranty obligations of Ajax Toc limited to the warranty actually extended to Ajax To fifteen (15) days after purchaser learns of defect. THE FREIGHT PREPAID, UNLESS OTHERWISE DIRECTOCCO MAGNETHERMIC CORPORATION MAKIND, EXPRESS OR IMPLIED WHICH EXTEND FOR ANY AND ALL LOSSES AND DAMAGES TO NO EVENT EXCEED THE COST OF REPAIR OR EQUIPMENT. IN NO EVENT SHALL AJAX TOCCOR NATURE WHATSOEVER.  AJAX TOCCO USE ONLY (do not mark	Y: Ajax Tocco shall at its option, repair or replace F.O.B. shipping point, such defective co with respect to equipment not manufactured by Ajax Tocco shall conform to and be cco by its suppliers. Notice of a claim for alleged defective equipment must be given within the Defective Part or Parts Shall be returned to Ajax Tocco, ECTED BY AJAX TOCCO. THIS WARRANTY SHALL BE EXCLUSIVE AND AJAX LKES NO WARRANTY OF MERCHANTABILITY OR WARRANTIES OF ANY OTHER BEYOND THE WARRANTY AS SET FORTH ABOVE. AJAX TOCCO'S LIABILITY OP PURCHASER RESULTING FROM DEFECTIVE PARTS OR EQUIPMENT SHALL IN REPLACEMENT, F.O.B. SHIPPING POINTS OF DEFECTIVE PARTS OR CO BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND
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