YORK BY JOHNSON CONTROLS

CENTRIFUGAL LIQUID CHILLERS

OPERATIONS AND MAINTENANCE	Supersedes: 160.78-O1 (412)	Form 160.78-O1 (1112)

YMC² MODEL A
WITH OPTIVIEW™ CONTROL CENTER

LD14000

R-134a

Issue Date:
November 30, 2012

IMPORTANT!

READ BEFORE PROCEEDING!

GENERAL SAFETY GUIDELINES

This equipment is a relatively complicated apparatus. During installation, operation maintenance or service, individuals may be exposed to certain components or conditions including, but not limited to: refrigerants, materials under pressure, rotating components, and both high and low voltage. Each of these items has the potential, if misused or handled improperly, to cause bodily injury or death. It is the obligation and responsibility of operating/service personnel to identify and recognize these inherent hazards, protect themselves, and proceed safely in completing their tasks. Failure to comply with any of these requirements could result in serious damage to the equipment and the property in which it is situated, as well as severe personal injury or death to themselves and people at the site.

This document is intended for use by owner-authorized operating/service personnel. It is expected that these individuals possess independent training that will enable them to perform their assigned tasks properly and safely. It is essential that, prior to performing any task on this equipment, this individual shall have read and understood this document and any referenced materials. This individual shall also be familiar with and comply with all applicable governmental standards and regulations pertaining to the task in question.

SAFETY SYMBOLS

The following symbols are used in this document to alert the reader to specific situations:

DANGER

Indicates a possible hazardous situation which will result in death or serious injury if proper care is not taken.

CAUTION

Identifies a hazard which could lead to damage to the machine, damage to other equipment and/or environmental pollution if proper care is not taken or instructions and are not followed.

WARNING

Indicates a potentially hazardous situation which will result in possible injuries or damage to equipment if proper care is not taken.

NOTE

Highlights additional information useful to the technician in completing the work being performed properly.

WARNING

External wiring, unless specified as an optional connection in the manufacturer's product line, is not to be connected inside the OptiView cabinet. Devices such as relays, switches, transducers and controls and any external wiring must not be installed inside the micro panel. All wiring must be in accordance with Johnson Controls' published specifications and must be performed only by a qualified electrician. Johnson Controls will NOT be responsible for damage/problems resulting from improper connections to the controls or application of improper control signals. Failure to follow this warning will void the manufacturer's warranty and cause serious damage to property or personal injury.

WARNING

Ensure power is removed from the input side of the VSD at all times when the chiller is under vacuum (less than atmospheric pressure). The VSD maintains voltage to ground on the motor when the chiller is off while voltage is available to the VSD. Insulating properties in the motor are reduced in vacuum and may not insulate this voltage sufficiently.

CHANGEABILITY OF THIS DOCUMENT

In complying with Johnson Controls' policy for continuous product improvement, the information contained in this document is subject to change without notice. Johnson Controls makes no commitment to update or provide current information automatically to the manual owner. Updated manuals, if applicable, can be obtained by contacting the nearest Johnson Controls Service office.

Operating/service personnel maintain responsibility for the applicability of these documents to the equipment. If there is any question regarding the applicability of these documents, the technician should verify whether the equipment has been modified and if current literature is available from the owner of the equipment prior to performing any work on the chiller.

CHANGE BARS

Revisions made to this document are indicated with a line along the left or right hand column in the area the revision was made. These revisions are to technical information and any other changes in spelling, grammar or formatting are not included.

ASSOCIATED LITERATURE

MANUAL DESCRIPTION	FORM NUMBER
YMC² Installation	160.78-N1
YMC² Unit Re-assembly	160.78-N2
YMC² Centrifugal Chiller Long Term Storage	50.20-NM5
YMC² Field Connections	160.78-PW1
YMC² Unit Wiring and Field Control Modifications	160.78-PW2
YMC² Unit Renewal Parts	160.78-RP1
YMC² OptiView™ Contol Center Operation Manual	160.78-O2
OptiSpeed™ VSD Model HYP744 Renewal Parts	160.78-RP3

SYSTEM NOMENCLATURE

Y M C 2 - S 0756 A A

- Y: YORK
- M: Magnetic Bearing
- C 2: Centrifugal Chiller
- S: S = Single Stage; T = Two Stage
- 0756: Capacity in KW
- A: Refrigerant R-134a
- A: Mod Level

COMPRESSOR NOMENCLATURE

M1 B - 197 F A A

- M1: Motor
- B: Motor Design Level
- 197: Impeller Tip Diameter (mm)
- F: Rotation
  - F = Forward
  - R = Reverse
- A: Impeller Design Revision Level
- A: Gas Path Revision Level

VESSEL NOMENCLATURE

E A 25 14 271 B R 1 1 F C R

- E: Vessel
  - E = Evaporator
  - C = Condenser
- A: Heat Exchanger Mod Level
- 25: Nominal Inside Diameter (Inches)
- 14: Nominal Length (Feet)
- 271: Marketing Tube Number
- B: Tube Code
  - B = 3/4" Code 1
  - C = 3/4" Code 2
  - D = 3/4" Code 3
  - E = 3/4" Code 4
  - 2 = 1" Code 1
  - 3 = 1" Code 2
  - 4 = 1" Code 3
  - 5 = 1" Code 4
- R: Vessel Refrigerant Pressure Code
  - R = Code 180
  - S = Code 235
  - T = Code 300
  - U = Code 350
  - V = Code 400
- 1: Water Side Pressure Code
  - 1 = 150 psi
  - 3 = 300 psi
- 1: Number of Passes
- F: Water Connection Type
  - F = Flanges
  - G = Grooved Standard
  - A = Victaulic AGS
- C: Waterbox Type
  - C = Compact
  - M = Marine
- R: Inlet from Front View
  - R = Right
  - L = Left

VARIABLE SPEED DRIVE NOMENCLATURE

HYP 744 X H 15 D - 40

- HYP: Hyper
- 744: Amps
- X: X = Factory Mount; R = Retrofit Model
- H: H = YMC^2 Chiller
- 15: Liquid DWP
  - 15 = 150 psi
  - 30 = 300 psi
- D: D = Disconnect Switch; B = Circuit Breaker
- 40:
  - 40 = 380V 60Hz
  - 50 = 400V 50Hz
  - 46 = 460V 60Hz
  - 68 = 415V 50Hz

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SECTION 1 - SYSTEM FUNDAMENTALS

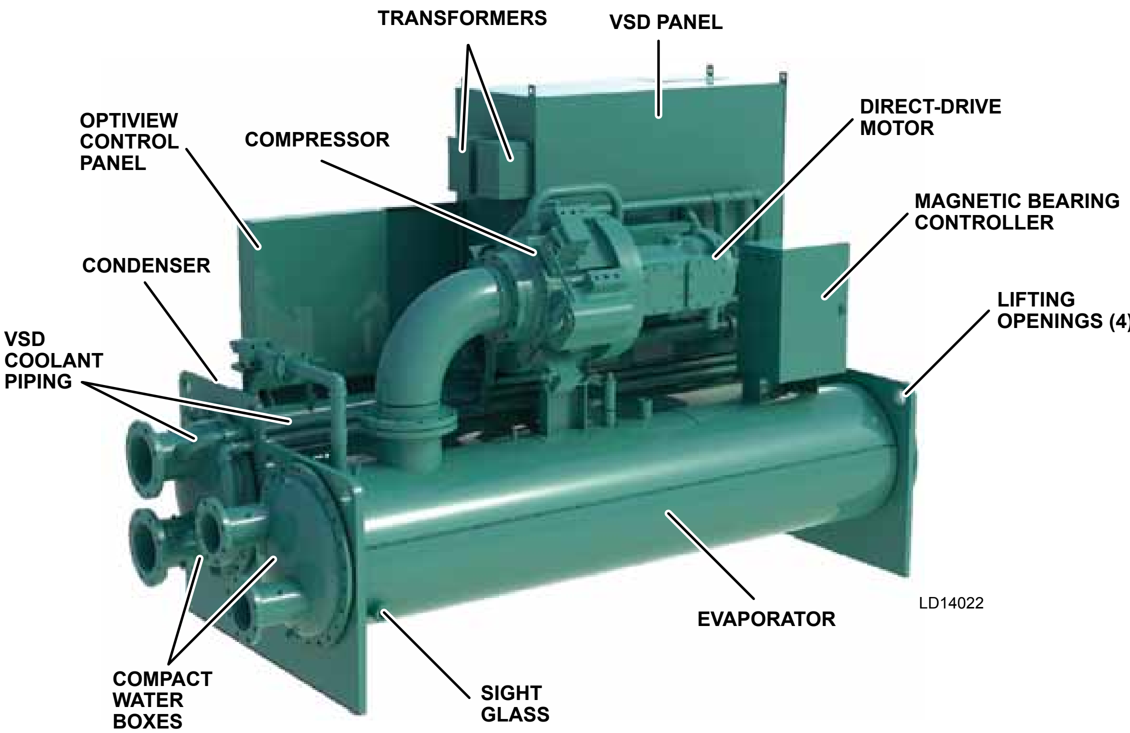

FIGURE 1 - YMC^2 CHILLER COMPONENTS

SYSTEM COMPONENTS

The YORK Model YMC^2 Centrifugal Liquid Chiller is completely factory-packaged including evaporator, condenser, compressor, motor, OptiView^{TM} Control Center, and all interconnecting unit piping and wiring (see *Figure 1*).

Compressor

The compressor is a single-stage centrifugal type powered by a hermetic electric motor, on a common shaft with a cast aluminum, fully shrouded impeller. The impeller is designed for balanced thrust and is dynamically balanced and over-speed tested. The compressor model number includes gas path revision level at the end of the model string. Gas path revision level A includes pre-rotation vanes. Gas path revisions B has fixed inlet vanes.

Motor

The compressor motor is a hermetic permanent magnet high speed design with magnetic bearings. The compressor impeller is overhung from the end of the motor shaft and has no bearings of it's own.

The motor includes angular contact ball bearings only for control of the rotor during shutdown after rotation is stopped or during shutdown due to loss of power to the magnetic bearings.

The bearing control center maintains proper shaft position in the magnetic bearings and counts events where the touchdown ball bearings may have been contacted during shaft rotation to alert the operation where a bearing check may be necessary. The condition of the touchdown bearings can be assessed by qualified service technicians electronically without opening the unit.

WARNING

Ensure power is removed from the input side of the VSD at all times when the chiller is under vacuum (less than atmospheric pressure). The VSD maintains voltage to ground on the motor when the chiller is off while voltage is available to the VSD. Insulating properties in the motor are reduced in vacuum and may not insulate this voltage sufficiently.

Heat Exchangers

Evaporator and condenser shells are fabricated from rolled carbon steel plates with fusion welded seams. Heat exchanger tubes are internally enhanced type.

Evaporator

The evaporator is a shell and tube, hybrid falling film, and flooded type heat exchanger. A distributor trough provides uniform distribution of refrigerant over tubes in the falling film section. Residual refrigerant floods the tubes in the lower section. Suction baffles are located above the tube bundle to prevent liquid refrigerant carryover into the compressor. A 2" liquid level sight glass is located on the side of the shell to aid in determining proper refrigerant charge. The evaporator shell contains dual refrigerant relief valves unless condenser isolation is installed.

Condenser

The condenser is a shell and tube type, with a discharge gas baffle to prevent direct high velocity impingement on the tubes. A separate subcooler is located in the condenser to enhance performance. Dual refrigerant relief valves are located on condenser shells and optional refrigerant isolation valves are available.

Water Boxes

The removable compact water boxes are fabricated of steel. The design working pressure is 150 PSIG (1034 kPa) and the boxes are tested at 225 PSIG (1551 kPa). Integral steel water baffles provide the required pass arrangements. Stub-out water nozzle connections with Victaulic grooves are welded to the water boxes. These nozzle connections are suitable for Victaulic couplings, welding or flanges, and are capped for shipment. Plugged 3/4" drain and vent connections are provided in each water box. Optional marine waterboxes are available.

Refrigerant Flow Control

Refrigerant flow to the evaporator is controlled by a variable orifice (refer to *Figure 3*).

A level sensor senses the refrigerant level in the condenser and outputs an analog voltage to the Microboard that represents this level (0% = empty; 100% = full). Under program control, the Microboard modulates a variable orifice to control the condenser refrigerant level to a programmed setpoint. Other setpoints affect the control sensitivity and response. These setpoints must be entered at chiller commissioning by a qualified service technician. Only a qualified service technician may modify these settings.

While the chiller is shut down, the orifice will be pre positioned to anticipate run. When the chiller is started, if actual level is less than the level setpoint, a linearly increasing ramp is applied to the level setpoint. This ramp causes the setpoint to go from the initial refrigerant level to the programmed setpoint over a programmable period of time. If the actual level is greater than the setpoint upon run, there is no pulldown period, it immediately begins to control to the programmed setpoint.

While the chiller is running, the refrigerant level is normally controlled to the level setpoint.

Optional Service Isolation Valves

If your chiller is equipped with optional service isolation valves on the discharge and liquid line, these valves must remain open during operation. These valves are used for isolating the refrigerant charge in either the evaporator or condenser to allow service access to the system. A refrigerant pump-out unit will be required to isolate the refrigerant.

CAUTION

Isolation of the refrigerant in this system must be performed by a qualified service technician.

Optional Hot Gas Bypass

Hot gas bypass is optional and is used to provide greater turndown than otherwise available for load and head conditions. The OptiView™ Control Center will automatically modulate the hot gas valve open and closed as required. Adjustment of the hot gas control valve must only be performed by a qualified service technician.

OptiView™ Control Center

The OptiView™ Control Center is factory-mounted, wired and tested. The electronic panel automatically controls the operation of the unit in meeting system cooling requirements while minimizing energy usage. For detailed information on the Control Center, refer to the *YMC² OptiView™ Control Center Operations Manual (Form 160.78-O2)*.

Variable Speed Drive

A Variable Speed Drive will be factory packaged with the chiller. It is designed to vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The drive also supplies DC power to the motor magnetic bearing controller for bearing operation. Operational information is contained in the *OptiSpeed VSD Operation Manual (Form 160.78-O3)*. The control logic automatically adjusts motor speed and compressor prerotation vane position for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.

SYSTEM OPERATION DESCRIPTION

The YORK Model YMC^2 Chiller is commonly applied to large air conditioning systems, but may be used on other applications. The chiller consists of a hermetic motor mounted to a compressor, condenser, evaporator and variable flow control.

The chiller is controlled by a modern state of the art Microcomputer Control Center that monitors its operation. The Control Center is programmed by the operator to suit job specifications. Automatic timed start-ups and shutdowns are also programmable to suit nighttime, weekends, and holidays. The operating status, temperatures, pressures, and other information pertinent to operation of the chiller are automatically displayed and read on a graphic display. Other displays can be observed by pressing the keys as labeled on the Control Center. The chiller with the OptiView™ Control Center is compatible with the Variable Speed Drive.

In operation, a liquid (water or brine to be chilled) flows through the evaporator, where boiling refrigerant absorbs heat from the liquid. The chilled liquid is then piped to fan coil units or other air conditioning terminal units, where it flows through finned coils, absorbing heat from the air. The warmed liquid is then returned to the chiller to complete the chilled liquid circuit.

The refrigerant vapor, which is produced by the boiling action in the evaporator, flows to the compressor where the rotating impeller increases its pressure and temperature and discharges it into the condenser. Water flowing through the condenser tubes absorbs heat from the refrigerant vapor, causing it to condense. The condenser water is supplied to the chiller from an external source, usually a cooling tower. The condensed refrigerant drains from the condenser into the liquid return line, where the variable orifice meters the flow of liquid refrigerant to the evaporator to complete the refrigerant circuit.

The major components of a chiller are selected to handle the required refrigerant flow at full load design conditions. However, most systems will be called upon to deliver full load capacity for only a relatively small part of the time the unit is in operation. A means exists to modulate capacity for other loads.

CAPACITY CONTROL

The speed at which the compressor rotates establishes the pressure differential that the chiller can operate against. As speed is reduced, the chiller power use is reduced. At reduced capacity requirements where condenser pressure is also reduced, the motor speed is reduced as much as possible while maintaining chilled water temperature and sufficient pressure differential. When the speed cannot be further reduced due to pressure difference required for the specified leaving chilled water temperature setting and available cooling to the condenser, other means to reduce refrigerant gas flow are used to manage capacity. Compressor models M1B-197FAA and M1B-205FAA use a device called prerotation vanes (PRV) at the entrance to the impeller to reduce capacity (See *Figure 2*). Regardless of chiller compressor model, the chiller also has a mechanism called Variable Geometry Diffuser (VGD) at the exit of the impeller that was designed to mitigate "stall". Stall is an effect caused by slow refrigerant gas

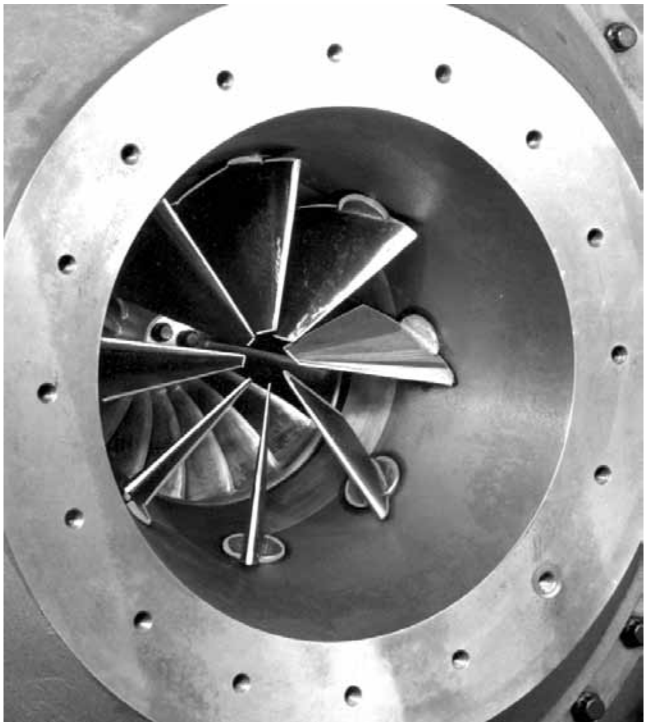

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FIGURE 2 - COMPRESSOR PREROTATION VANES

passing through the compressor at reduced flow rates needed for low capacity operation. Compressor models with gas path revision level "B" do not have operating prerotation vanes, but use the VGD also as a capacity control device instead.

A final optional means to reduce capacity called Hot Gas Bypass (HGBP) is available regardless of compressor model. When selected for an application, HGBP is used to re-circulate some refrigerant through the compressor without using it for cooling the chilled liquid. Although this does not reduce power consumption, it greatly reduces the capacity of the chiller for maximum turndown.

The YMC2 uses these mechanisms in a controlled order to maintain best efficiency.

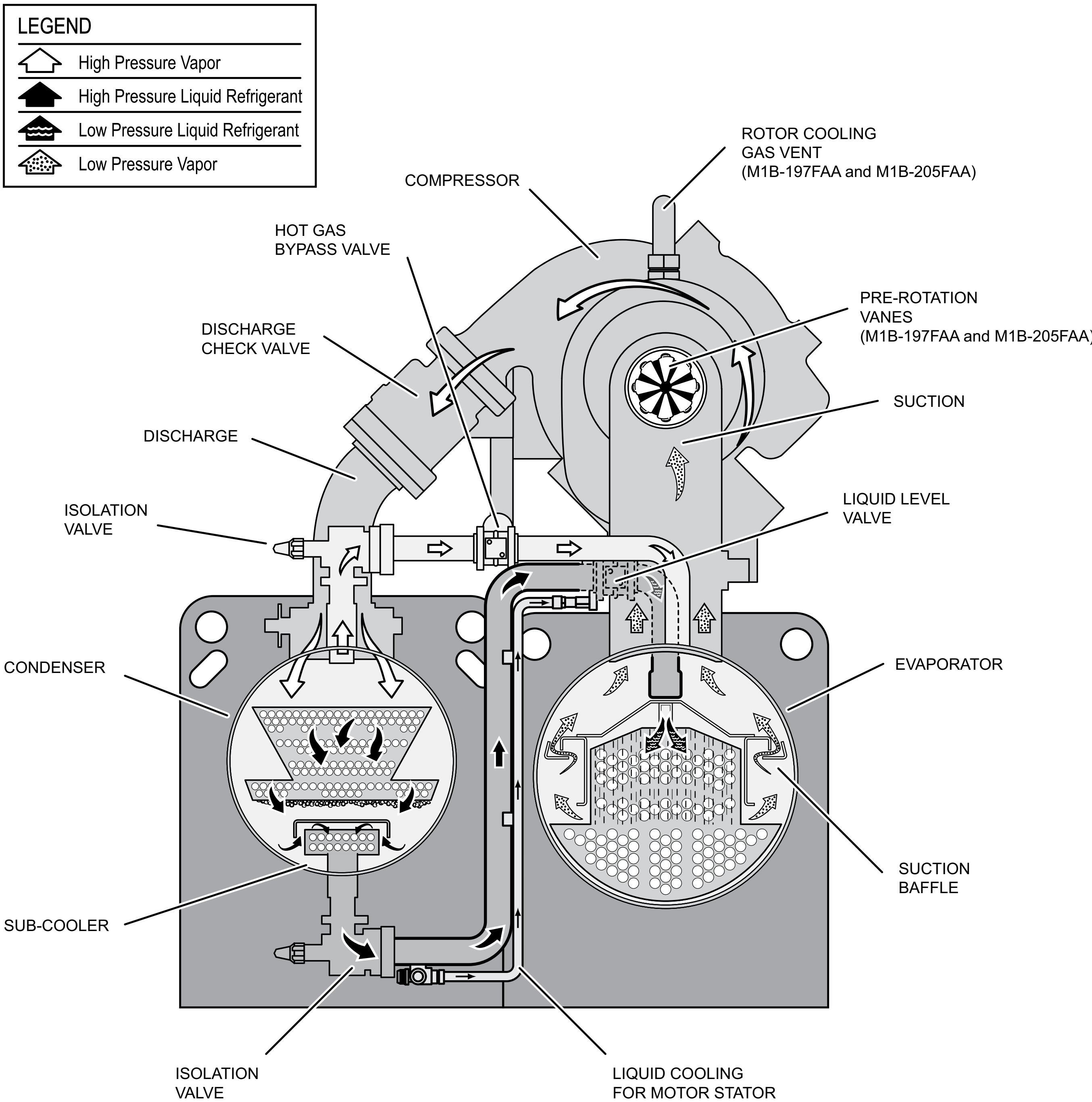


FIGURE 3 - REFRIGERANT FLOW-THRU CHILLER

SECTION 2 - SYSTEM OPERATING PROCEDURES

PRE-STARTING

Prior to starting the chiller, observe the OptiView™ Control Center (Refer to the *YMC² OptiView™ Control Center Operations Manual (Form 160.78-O2).* Make sure the display reads "SYSTEM READY TO START".

CAUTION

Vent any air from the chiller water boxes prior to starting the water pumps. Failure to do so will result in pass baffle damage.

START-UP

1. If the chilled water pump is manually operated, start the pump. The Control Center will not allow the chiller to start unless chilled liquid flow is established through the unit. If the chilled liquid pump is wired to the Microcomputer Control Center the pump will automatically start, therefore, this step is not necessary.
2. To start the chiller, press the RUN key on the Home Screen on the display panel.

   For display messages and information pertaining to the operation of the OptiView™ Control Center, refer to the *YMC² OptiView™ Control Center Operations Manual (Form 160.78-O2)*.

NOTE

Any malfunctions which occur during SHUTDOWN are also displayed.

The coolant temperature inside any JCI-supplied liquid-cooled motor starter must be maintained above the dewpoint temperature in the equipment room to prevent condensing water vapor inside the starter cabinet. Therefore, an additional temperature-controlled throttle valve is needed in the flow path for the starter heat exchanger to regulate cooling above the equipment room dewpoint for applications using cooling sources other than evaporative air-exchange methods, such as wells, bodies of water, and chilled water. The temperature control valve should be the type to open on increasing drive coolant temperature, fail-closed, and set for a temperature above dewpoint. It can be requested as factory-supplied on a chiller order by special quotation.

CHILLER OPERATION

The chiller will vary capacity to maintain the leaving chilled liquid temperature setpoint by a specific sequencing of optional hot gas bypass, pre-rotation vanes or variable geometry diffuser, and compressor speed.

Throughout capacity control, the compressor speed is maintained above the minimum required for the prevailing head condition, to avoid surge. Otherwise, the device maintaining capacity is controlled by a proportional-integral-derivative control based on leaving chiller liquid temperature. Pressure and motor current overrides also apply as necessary to maintain operating limits.

CONDENSER WATER TEMPERATURE CONTROL

The YORK YMC² chiller is designed to use less power by taking advantage of lower than design temperatures that are naturally produced by cooling towers throughout the operating year. Exact control of condenser water such as a cooling tower bypass, is not necessary for most installations. The minimum entering condenser water temperature for full and part load conditions is specified in the chiller engineering guide.

Where:

$$\text{Min. ECWT} = \text{LCWT} - \text{C RANGE} + 5^{\circ}\text{F} + 12\left(\frac{\%\ \text{Load}}{100}\right)$$

$$\text{Min. ECWT} = \text{LCWT} - \text{C RANGE} + 2.8^{\circ}\text{C} + 6.6\left(\frac{\%\ \text{Load}}{100}\right)$$

ECWT = Entering Condensing Water Temperature
LCWT = Leaving Chilled Water Temperature
C Range = Condensing water temperature range at the given load condition.

At start-up, the entering condenser water temperature may be as much as 25°F (14°C) colder than the standby return chilled water temperature. Cooling tower fan cycling will normally provide adequate control of the entering condenser water temperature on most installations.

OPERATING LOGS

A permanent daily record of system operating conditions (temperatures and pressures) recorded at regular intervals throughout each 24-hour operating period should be kept. Automatic data logging is possible by connecting the optional printer and programming the DATA LOGGER function. An optional status printer is available for this purpose. *Figure 4* shows an example log sheet used by Johnson Controls Personnel for recording test data on chiller systems. Log sheets are available in pads of 50 sheets and may be obtained through the nearest Johnson Controls office; request the *YMC² Centrifugal Liquid Chiller Log Sheets (Form 160.78-MR1)*.

An accurate record of readings serves as a valuable reference for operating the system. Readings taken when a system is newly installed will establish normal conditions with which to compare later readings.

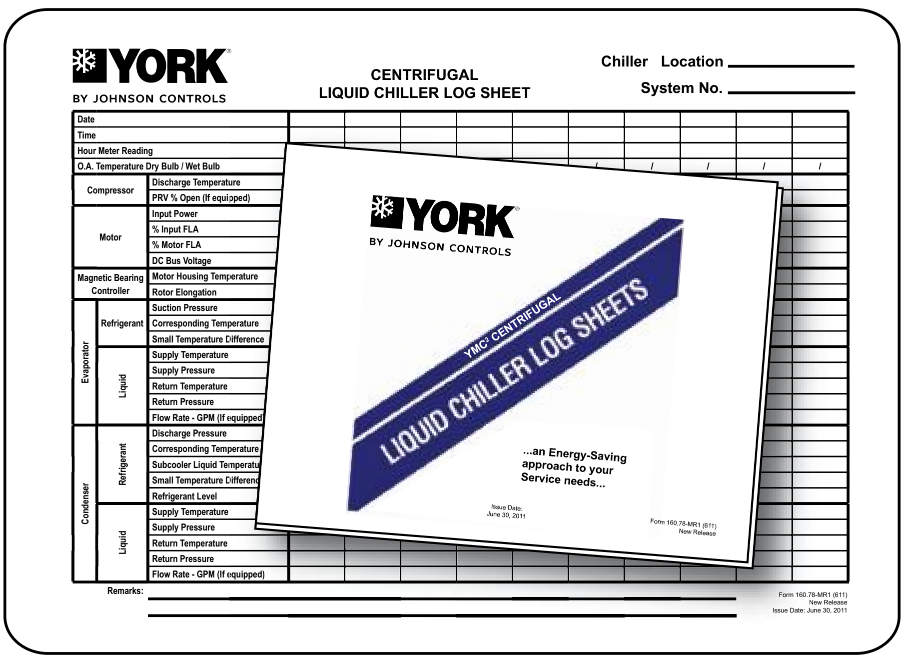
For example, an increase in condenser approach temperature (condenser temperature minus leaving condenser water temperature) may be an indication of dirty condenser tubes.

OPERATING INSPECTIONS

By following a regular inspection using the display readings of the OptiView™ Control Center, and maintenance procedure, the operator will avoid serious operating difficulty. The following list of inspections and procedures should be used as a guide.

Daily

1. Check OptiView™ Control Center displays.
2. Check entering and leaving condenser water pressure and temperatures for comparison with job design conditions. Condenser water temperatures can be checked on the SYSTEM Screen.
3. Check the entering and leaving chilled liquid temperatures and evaporator pressure for comparison with job design conditions on the SYSTEM Screen.
4. Check the condenser saturation temperature (based upon condenser pressure sensed by the condenser transducer) on the SYSTEM Screen.
5. Check the compressor discharge temperature on the SYSTEM Screen. During normal operation discharge temperature should not exceed 220°F (104°C).
6. Check the compressor motor current on the SYSTEM Screen.
7. Check for any signs of dirty or fouled condenser tubes. (The temperature difference between water



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*** NOTE:** A pad of 50 log sheets can be ordered from your local Johnson Controls branch by requesting Form 160.78-MR1.

FIGURE 4 - LIQUID CHILLER LOG SHEETS

leaving condenser and saturated condensing temperature should not exceed the difference recorded for a new unit by more than 4°F (2.2°C)).

Weekly

1. Check the refrigerant charge. Refer to *Checking The Refrigerant Charge During Unit Shutdown* in *SECTION 3 - MAINTENANCE*.

Monthly

1. Leak check the entire chiller.

Semi-Annually (Or More Often As Required)

1. Check controls.

Annually (More Often If Necessary)

1. Evaporator and Condenser.
    A. Inspect and clean water strainers.
    B. Inspect and clean tubes as required.
    C. Inspect end sheets.
2. Compressor Drive Motor.
    A. Meg motor windings.
3. Inspect and service electrical components as necessary.
4. Perform refrigerant analysis.

NEED FOR MAINTENANCE OR SERVICE

If the system is malfunctioning in any manner or the unit is stopped by one of the safety controls, refer to the Operation Analysis Chart shown in *Table 4* (*SECTION 4 - TROUBLESHOOTING*). After consulting this chart, if you are unable to make the proper repairs or adjustments to start the compressor or the particular trouble continues to hinder the performance of the unit, please call the nearest Johnson Controls District Office. Failure to report constant troubles could damage the unit and increase the cost of repairs.

STOPPING THE SYSTEM

The OptiView™ Control Center can be programmed to start and stop automatically (maximum - once each day) whenever desired. Refer to the YMC^2 *Optiview™ Control Center Operation Manual (Form 160.78-O1)*. To stop the chiller, proceed as follows:

1. Push the soft shutdown key on the homescreen of the OptiView™ panel. The compressor will stop automatically. In the event of an unusual circumstance requiring immediate stoppage, a safety stop switch is located on the side of the control panel. Normal stop eases the driveline to stop and should always be used instead of the safety stop during regular operation.
2. Stop the chilled water pump (if not wired into the Microcomputer Control Center, in which case it will shut off automatically. The actual water pump contact operation is dependent upon the selection on the SETUP screen.)
3. Open the switch to the cooling tower fan motors, if used.

PROLONGED SHUTDOWN

If the chiller is to be shut down for an extended period of time (for example, over the winter season), the following procedure should be followed.

1. Test all system joints for refrigerant leaks with a leak detector. If any leaks are found, they should be repaired before allowing the system to stand for a long period of time.

    During long idle periods, the tightness of the system should be checked periodically.
2. If freezing temperatures are encountered while the system is idle, carefully drain the cooling water from the cooling tower, condenser, condenser pump, and the chilled water system-chilled water pump and coils.

    Open the drains on the evaporator and condenser liquid heads to assure complete drainage. Drain the Variable Speed Drive cooling system.
3. If freezing temperatures are encountered for periods longer than a few days, the refrigerant should be recovered to containers to prevent leakage from O-ring joints.
4. On the SETUP Screen, disable the clock. This conserves the battery.
5. Open the main disconnect switches to the compressor motor, condenser water pump and the chilled water pump. Open the 115 volt circuit to the Control Center.

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SECTION 3 - MAINTENANCE

RENEWAL PARTS

For any required Renewal Parts, refer to the *YMC² Unit Renewal Parts Manual (Form 160.78-RP1).*

CHECKING SYSTEM FOR LEAKS

Leak Testing During Operation

The refrigerant side of the system is carefully pressure tested and evacuated at the factory.

After the system has been charged, the system should be carefully leak tested with a R-134a compatible leak detector to be sure all joints are tight.

If any leaks are indicated, they must be repaired immediately. Usually, leaks can be stopped by tightening flare nuts or flange bolts. However, for any major repair, the refrigerant charge must be removed. Refer to *Handling Refrigerant For Dismantling And Repairs* in this section.

CONDUCTING R-22 PRESSURE TEST

With the R-134a charge removed and all known leaks repaired, the system should be charged with a small amount of R-22 mixed with dry nitrogen so that a halide torch or electronic leak detector can be used to detect any leaks too small to be found by the soap test.

To test with R-22, proceed as follows:

1. With no pressure in the system, charge R-22 gas into the system through the charging valve to a pressure of 2 PSIG (14 kPa).
2. Build up the system pressure with dry nitrogen to approximately 75 to 100 PSIG (517 to 690 kPa). To be sure that the concentration of refrigerant has reached all parts of the system test for the presence of refrigerant with a leak detector at an appropriate service valve.
3. Test around each joint and factory weld. It is important that this test be thoroughly and carefully done, spending as much time as necessary and using a good leak detector.
4. To check for refrigerant leaks in the evaporator and condenser, open the vents in the evaporator and condenser heads and test for the presence of refrigerant. If no refrigerant is present, the tubes and tube sheets may be considered tight. If refrigerant is detected at the vents, the heads must be removed, the leak located (by means of soap test or leak detector) and repaired.

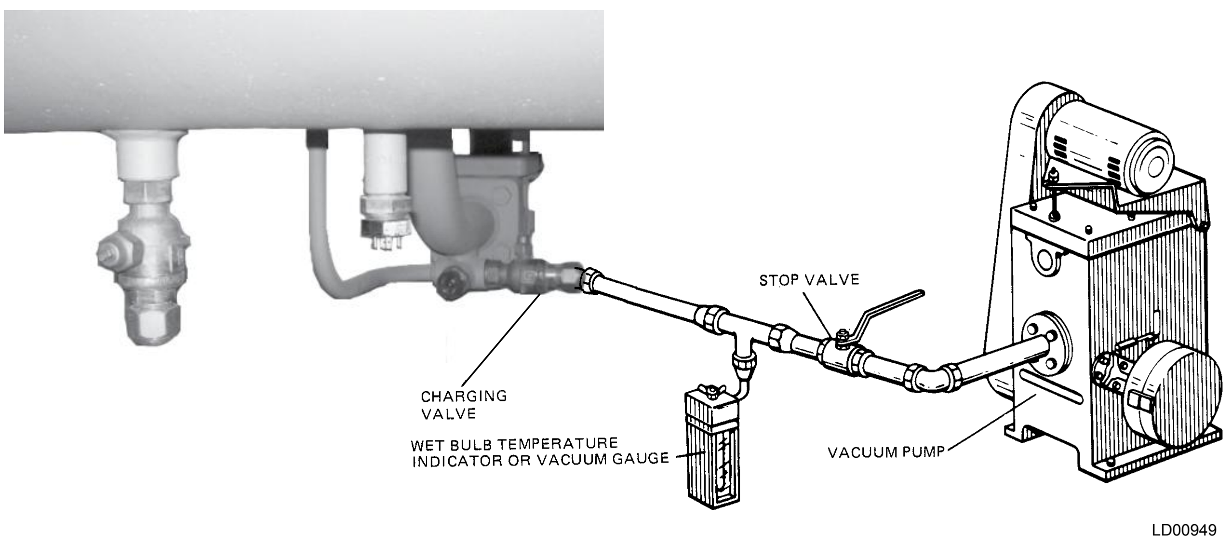

FIGURE 5 - EVACUATION OF CHILLER

TABLE 1 - SYSTEM PRESSURES

*GAUGE	ABSOLUTE			BOILING TEMPERATURES OF WATER °F
INCHES OF MERCURY (HG) BELOW ONE STANDARD ATMOSPHERE	PSIA	MILLIMETERS OF MERCURY (HG)	MICRONS	
0"	14.6960	760.00	760,000	212
10.240"	9.6290	500.00	500,000	192
22.050"	3.8650	200.00	200,000	151
25.980"	1.9350	100.00	100,000	124
27.950"	0.9680	50.00	50,000	101
28.940"	0.4810	25.00	25,000	78
29.530"	0.1920	10.00	10,000	52
29.670"	0.1220	6.30	6,300	40
29.720"	0.0990	5.00	5,000	35 ← Water Freezes
29.842"	0.0390	2.00	2,000	15
29.882"	0.0190	1.00	1,000	1
29.901"	0.0100	0.50	500	–11
29.917"	0.0020	0.10	100	–38
29.919"	0.0010	0.05	50	–50
29.9206"	0.0002	0.01	10	–70
29.921"	0	0	0	

*One standard atmosphere = 14.696 PSIA
= 760 mm Hg. absolute pressure at 32°F
= 29.921 inches Hg. absolute at 32°F

NOTES: PSIA = Lbs. per sq. in. gauge pressure
= Pressure above atmosphere
PSIA = Lbs. per sq. in. absolute pressure
= Sum of gauge plus atmospheric pressure

VACUUM TESTING

WARNING

Ensure power is removed from the input side of the VSD at all times when the chiller is under vacuum (less than atmospheric pressure). The VSD maintains voltage to ground on the motor when the chiller is off while voltage is available to the VSD. Insulating properties in the motor are reduced in vacuum and may not insulate this voltage sufficiently.

After the pressure test has been completed, the vacuum test should be conducted as follows:

1. Connect a high capacity vacuum pump, with indicator, to the system charging valve as shown in *Figure 5* and start the pump. Refer to *Vacuum Dehydration* in this section.
2. Open wide all system valves. Be sure all valves to the atmosphere are closed.
3. Operate the vacuum pump in accordance with *Vacuum Dehydration* in this section until a wet bulb temperature of +32°F (0°C) or a pressure of 5 mm Hg is reached. Refer to *Table 1* for corresponding pressure values.
4. To improve evacuation circulate hot water, not to exceed 125°F (51.7ºC) through the evaporator and condenser tubes to thoroughly dehydrate the shells. If a source of hot water is not readily available, a portable water heater should be employed.

DO NOT USE STEAM. A suggested method is to connect a hose between the source of hot water under pressure and the evaporator head drain connection, out the evaporator vent connection, into the condenser head drain and out the condenser vent. To avoid the possibility of causing leaks, the temperature should be brought up slowly so that the tubes and shell are heated evenly.

5. Close the system charging valve and the stop valve between the vacuum indicator and the vacuum pump. Then disconnect the vacuum pump leaving the vacuum indicator in place.
6. Hold the vacuum obtained in *Step 3* above in the system for 8 hours; the slightest rise in pressure indicates a leak or the presence of moisture, or both. If after 24 hours the wet bulb temperature in the vacuum indicator has not risen above 40°F (4.4°C) or a pressure of 6.3 mm Hg, the system may be considered tight.

NOTE

Be sure the vacuum indicator is valved off while holding the system vacuum and be sure to open the valve between the vacuum indicator and the system when checking the vacuum after the 8 hour period.

7. If the vacuum does not hold for 8 hours within the limits specified in *Step 6* above, the leak must be found and repaired.

VACUUM DEHYDRATION

To obtain a sufficiently dry system, the following instructions have been assembled to provide an effective method for evacuating and dehydrating a system in the field. Although there are several methods of dehydrating a system, we are recommending the following, as it produces one of the best results, and affords a means of obtaining accurate readings as to the extent of dehydration.

The equipment required to follow this method of dehydration consists of a wet bulb indicator or vacuum gauge, a chart showing the relation between dew point temperature and pressure in inches of mercury (vacuum), (refer to *Table 1*) and a vacuum pump capable of pumping a suitable vacuum on the system.

Operation

Dehydration of a refrigerant system can be obtained by this method because the water present in the system reacts much as a refrigerant would. By pulling down the pressure in the system to a point where its saturation temperature is considerably below that of room temperature, heat will flow from the room through the walls of the system and vaporize the water, allowing a large percentage of it to be removed by the vacuum pump. The length of time necessary for the dehydration of a system is dependent on the size or volume of the system, the capacity and efficiency of the vacuum pump, the room temperature and the quantity of water present in the system. By the use of the vacuum indicator as suggested, the test tube will be evacuated to the same pressure as the system, and the distilled water will be maintained at the same saturation temperature as any free water in the system, and this temperature can be observed on the thermometer.

If the system has been pressure tested and found to be tight prior to evacuation, then the saturation temperature recordings should follow a curve similar to the typical saturation curve shown as *Figure 6*.

The temperature of the water in the test tube will drop as the pressure decreases, until the boiling point is reached, at which point the temperature will level off and remain at this level until all of the water in the shell is vaporized. When this final vaporization has taken place the pressure and temperature will continue to drop until eventually a temperature of 35°F (1.6°C) or a pressure of 5 mm Hg. is reached.

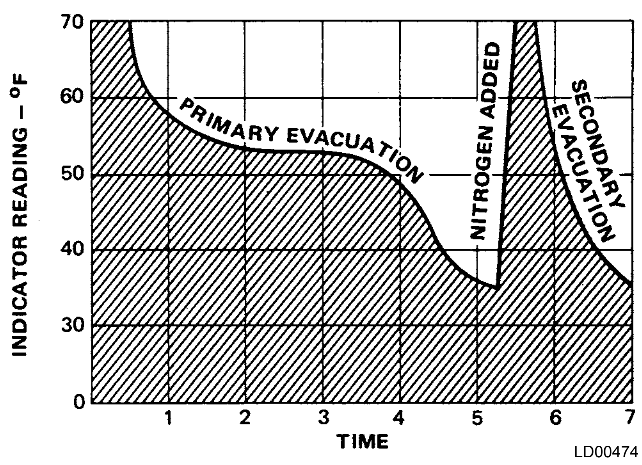

FIGURE 6 - SATURATION CURVE

When this point is reached, practically all of the air has been evacuated from the system, but there is still a small amount of moisture left. In order to provide a medium for carrying this residual moisture to the vacuum pump, nitrogen should be introduced into the system to bring it to atmospheric pressure and the indicator temperature will return to approximately ambient temperature. Close off the system again, and start the second evacuation.

The relatively small amount of moisture left will be carried out through the vacuum pump and the temperature or pressure shown by the indicator should drop uniformly until it reaches a temperature of 35°F (1.6°C) or a pressure of 5 mm Hg.

When the vacuum indicator registers this temperature or pressure, it is a positive sign that the system is evacuated and dehydrated to the recommended limit. If this level cannot be reached, it is evident that there is a leak somewhere in the system. Any leaks must be corrected before the indicator can be pulled down to 35°F (1.6°C) or 5 mm Hg. in the primary evacuation.

During the primary pulldown, keep a careful watch on the wet bulb indicator temperature, and do not let it fall below 35°F (1.6°C). If the temperature is allowed to fall to 32°F (0°C), the water in the test tube will freeze, and the result will be a faulty temperature reading.

REFRIGERANT CHARGING

To avoid the possibility of freezing liquid within the evaporator tubes when charging an evacuated system, only refrigerant vapor from the top of the drum or cylinder must be admitted to the system pressure until the system pressure is raised above the point corresponding to the freezing point of the evaporator liquid. For water, the pressure corresponding to the freezing point is 29 PSIG (200 kPa) for R-134a (at sea level).

While charging, every precaution must be taken to prevent moisture laden air from entering the system. Make up a suitable charging connection from new copper tubing to fit between the system charging valve and the fitting on the charging drum. This connection should be as short as possible but long enough to permit sufficient flexibility for changing drums. The charging connection should be purged each time a full container of refrigerant is connected and changing containers should be done as quickly as possible to minimize the loss of refrigerant.

Refrigerant may be furnished in cylinders containing either 30, 50, 125, 1,025 or 1750 lbs. (13.6, 22.6, 56.6, 464 or 794 kg) of refrigerant.

CHECKING THE REFRIGERANT CHARGE DURING UNIT SHUTDOWN

The refrigerant charge is specified for each chiller model in *Table 2*. Charge the correct amount of refrigerant and record the level in the evaporator sight glass.

The refrigerant charge should always be checked and trimmed when the system is shut down.

Charge the refrigerant in accordance with the method shown in *Refrigerant Charging* in this section. The weight of the refrigerant charged should be recorded after initial charging.

TABLE 2 - REFRIGERANT CHARGE

COMPRESSOR	EVAPORATOR	CONDENSER	EST. REFRIGERANT CHARGE LBS (KGS) [1]
M1-197FAA	EA2510	CA2110	570 (260)
	EA2510	CA2510	625 (285)
	EA2514	CA2514	860 (390)
M2-205FAA	EA2510	CA2110	555 (255)
	EA2510	CA2510	610 (280)
	EA2514	CA2514	860 (390)

1 Refrigerant charge quantity and weights will vary based on tube count.
* Refer to product drawings for detailed weight information.

HANDLING REFRIGERANT FOR DISMANTLING AND REPAIRS

If it becomes necessary to open any part of the refrigerant system for repairs, it will be necessary to remove the charge before opening any part of the unit. If the chiller is equipped with optional valves, the refrigerant can be isolated in either the condenser or evaporator / compressor while making any necessary repairs.

MEGGING THE MOTOR

Electrical test of motor winding resistance should be performed by a qualified service technician because it involves determination of power leads between the motor and the VSD. Results from these winding insulation resistance tests should be trended each interval to determine degradation in motor windings.

CONDENSERS AND EVAPORATORS

General

Maintenance of condenser and evaporator shells is important to provide trouble free operation of the chiller. The water side of the tubes in the shell must be kept clean and free from scale. Proper maintenance such as tube cleaning, and testing for leaks, is covered on the following pages.

Chemical Water Treatment

Since the mineral content of the water circulated through evaporators and condensers varies with almost every source of supply, it is possible that the water being used may corrode the tubes or deposit heat resistant scale in them. Reliable water treatment companies are available in most larger cities to supply a water treating process which will greatly reduce the corrosive and scale forming properties of almost any type of water.

As a preventive measure against scale and corrosion and to prolong the life of evaporator and condenser tubes, a chemical analysis of the water should be made preferably before the system is installed. A reliable water treatment company can be consulted to determine whether water treatment is necessary, and if so, to furnish the proper treatment for the particular water condition.

Cleaning Evaporator and Condenser Tubes

Evaporator

It is difficult to determine by any particular test whether possible lack of performance of the water evaporator is due to fouled tubes alone or due to a combination of troubles. Trouble which may be due to fouled tubes is indicated when, over a period of time, the cooling capacity decreases and the split (temperature difference between water leaving the evaporator and the refrigerant temperature in the evaporator) increases. A gradual drop-off in cooling capacity can also be caused by a gradual leak of refrigerant from the system or by a combination of fouled tubes and shortage of refrigerant charge.

Condenser

In a condenser, trouble due to fouled tubes is usually indicated by a steady rise in head pressure, over a period of time, accompanied by a steady rise in condensing temperature.

Tube Fouling

Fouling of the tubes can be due to deposits of two types as follows:

1. Rust or sludge – which finds its way into the tubes and accumulates there. This material usually does not build up on the inner tube surfaces as scale, but does interfere with the heat transfer. Rust or sludge can generally be removed from the tubes by a thorough brushing process.
2. Scale – due to mineral deposits. These deposits, even though very thin and scarcely detectable upon physical inspection, are highly resistant to heat transfer. They can be removed most effectively by circulating an acid solution through the tubes.

Tube Cleaning Procedures

Brush Cleaning of Tubes

If the tube consists of dirt and sludge, it can usually be removed by means of the brushing process. Drain the water sides of the circuit to be cleaned (cooling water or chilled water) remove the heads and thoroughly clean each tube with a soft bristle bronze or nylon brush. DO NOT USE A STEEL BRISTLE BRUSH. A steel brush may damage the tubes.

Improved results can be obtained by admitting water into the tube during the cleaning process. This can be done by mounting the brush on a suitable length of 1/8" pipe with a few small holes at the brush end and connecting the other end by means of a hose to the water supply.

The tubes should always be brush cleaned before acid cleaning.

Acid Cleaning of Tubes

If the tubes are fouled with a hard scale deposit, they may require acid cleaning. It is important that before acid cleaning, the tubes be cleaned by the brushing process described above. If the relatively loose foreign material is removed before the acid cleaning, the acid solution will have less material to dissolve and flush from the tubes with the result that a more satisfactory cleaning job will be accomplished with a probable saving of time.

WARNING

Acid cleaning should only be performed by an expert. Please consult your local water treatment representative for assistance in removing scale buildup and preventative maintenance programs to eliminate future problems.

Commercial Acid Cleaning

In many major cities, commercial organizations now offer a specialized service of acid cleaning evaporators and condensers. If acid cleaning is required, Johnson Controls recommends the use of this type of organization. The Dow Industries Service Division of the Dow Chemical Company, Tulsa, Oklahoma, with branches in principal cities is one of the most reliable of these companies.

Testing for Evaporator and Condenser Tube Leaks

Evaporator and condenser tube leaks in R-134a systems may result in refrigerant leaking into the water circuit, or water leaking into the shell depending on the pressure levels. If refrigerant is leaking into the water, it can be detected at the liquid head vents after a period of shutdown. If water is leaking into the refrigerant, system capacity and efficiency will drop off sharply. If a tube is leaking and water has entered the system, the evaporator and condenser should be valved off from the rest of the water circuit and drained immediately to prevent severe rusting and corrosion. The refrigerant system should then be drained and purged with dry nitrogen to prevent severe rusting and corrosion. If a tube leak is indicated, the exact location of the leak may be determined as follows:

1. Remove the heads and listen at each section of tubes for a hissing sound that would indicate gas leakage. This will assist in locating the section of tubes to be further investigated. If the probable location of the leaky tubes has been determined, treat that section in the following manner (if the location is not definite, all the tubes will require investigations).
2. Wash off both tube heads and the ends of all tubes with water.

NOTE

Do not use carbon tetrachloride for this purpose since its fumes give the same flame discoloration that the refrigerant does.

3. With nitrogen or dry air, blow out the tubes to clear them of traces of refrigerant laden moisture from the circulation water. As soon as the tubes are clear, a cork should be driven into each end of the tube. Pressurize the dry system with 50 to 100 PSIG (345 to 690 kPa) of nitrogen. Repeat this with all of the other tubes in the suspected section or, if necessary, with all the tubes in the evaporator or condenser. Allow the evaporator or condenser to remain corked up to 12 to 24 hours before proceeding. Depending upon the amount

of leakage, the corks may blow from the end of a tube, indicating the location of the leakage. If not, if will be necessary to make a very thorough test with the leak detector.

4. After the tubes have been corked for 12 to 24 hours, it is recommended that two men working at both ends of the evaporator carefully test each tube – one man removing corks at one end and the other at the opposite end to remove corks and handle the leak detector. Start with the top row of tubes in the section being investigated. Remove the corks at the ends of one tube simultaneously and insert the exploring tube for 5 seconds – this should be long enough to draw into the detector any refrigerant gas that might have leaked through the tube walls. A fan placed at the end of the evaporator opposite the detector will assure that any leakage will travel through the tube to the detector.
5. Mark any leaking tubes for later identification.
6. If any of the tube sheet joints are leaking, the leak should be indicated by the detector. If a tube sheet leak is suspected, its exact location may be found by using a soap solution. A continuous buildup of bubbles around a tube indicates a tube sheet leak.

COMPRESSOR

Maintenance for the compressor assembly consists of observing the operation of the compressor.

If the control panel warns of excessive landings of the magnetic bearing motor, notify the nearest Johnson Controls office to request the presence of a Johnson controls Service Technician. The technician can assess the condition of the touchdown bearings using electronic tools.

ELECTRICAL CONTROLS

For information covering the OptiView™ Control Center operation, refer to the *YMC² OptiView™ Control Center Operations Manual (Form 160.78-O2)*.

MAINTENANCE REQUIREMENTS FOR YORK YMC2 CHILLERS

TABLE 3 - MAINTENANCE REQUIREMENTS

YORK BY JOHNSON CONTROLS

MAINTENANCE REQUIREMENTS FOR YMC² CHILLERS

Procedure	Daily	Weekly	Monthly	Yearly	Other
Record operating conditions (on applicable Log Form)	X				
Check refrigerant levels		X			
Check three-phase voltage and current balance			X		
Verify proper operation/setting/calibration of safety controls [1]			X		
Verify condenser and evaporator water flows			X		
Leak check and repair leaks as needed [1]			X		
Check and tighten all electrical connections				X	
Megohm motor windings				X	
Clean or backflush VSD heat exchanger				X	
Replace VSD starter coolant				X	
Perform refrigeration analysis [1]				X	
Review operating data for trends which indicate increasing vibration or power consumption. The MBC data includes 1X rotational speed vibration in displacement				X	
Clean tubes				X[2]	
Perform Eddy current testing and inspect tubes					2-5 Years

For operating and maintenance requirements listed above, refer to appropriate service literature, or contact your local Johnson Controls Service Office.

[1] This procedure must be performed at the specified time interval by an Industry Certified Technician who has been trained and qualified to work on this type of YORK equipment. A record of this procedure being successfully carried out must be maintained on file by the equipment owner should proof of adequate maintenance be required at a later date for warranty validation purposes.

[2] More frequent service may be required depending on local operating conditions.

3

PREVENTATIVE MAINTENANCE

It is the responsibility of the owner to provide the necessary daily, monthly and yearly maintenance requirements of the system.

NOTE

IMPORTANT – If a unit failure occurs due to improper maintenance during the warranty period; Johnson Controls will not be liable for costs incurred to return the system to satisfactory operation.

In any operating system it is most important to provide a planned maintenance and inspection of its functioning parts to keep it operating at its peak efficiency. Therefore, the following maintenance should be performed when prescribed.

COMPRESSOR AND MOTOR

1. Check mounting screws and piping joint nuts frequently to insure tightness.
2. Meg motor windings annually to check for deterioration of windings.

LEAK TESTING

The unit should be leak tested monthly. Any leaks found must be repaired immediately.

EVAPORATOR AND CONDENSER

The major portion of maintenance on the condenser and evaporator will deal with the maintaining the water side of the condenser and evaporator in a clean condition.

The use of untreated water in cooling towers, closed water systems, etc. frequently results in one or more of the following:

1. Scale Formation.
2. Corrosion or Rusting.
3. Slime and Algae Formation.

It is therefore to the benefit of the user to provide for proper water treatment to provide for a longer and more economical life of the equipment. The following recommendation should be followed in determining the condition of the water side of the condenser and evaporator tubes.

1. The condenser tubes should be cleaned annually or earlier if conditions warrant. If the temperature difference between the water off the condenser and the condenser liquid temperature is more than 4°F (2°C) greater than the difference recorded on a new unit, it is a good indication that the condenser tubes require cleaning. Refer to *Cleaning Evaporator and Condenser Tubes* in this section for condenser tube cleaning instructions.
2. The evaporator tubes under normal circumstances will not require cleaning. If the temperature difference between the refrigerant and the chilled water increases slowly over the operating season, it is an indication that the evaporator tubes may be fouling or that there may be a water bypass in the water box requiring gasket replacement or refrigerant may have leaked from the chiller.

ELECTRICAL CONTROLS

1. All electrical controls should be inspected for obvious malfunctions.
2. It is important that the factory settings of controls (operation and safety) not be changed. If the settings are changed without Johnson Controls approval, the warranty will be jeopardized.

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SECTION 4 - TROUBLESHOOTING

TABLE 4 - OPERATION ANALYSIS CHART

RESULTS	POSSIBLE CAUSE	REMEDY
1. SYMPTOM: ABNORMALLY HIGH DISCHARGE PRESSURE		
Temperature difference between condensing temperature and water off condenser higher than normal.	Condenser tubes dirty or scaled.	Clean condenser tubes. Check water conditioning.
High discharge pressure.	Condenser tubes dirty or scaled.	Clean condenser tubes. Check water conditioning.
	High condenser water temperature.	Reduce condenser water inlet temperature. (Check cooling tower and water circulation.)
Temperature difference between condenser water on and water off higher than normal, with normal evaporator pressure.	Insufficient condensing water flow.	Increase the quantity of water through the condenser to proper value.
2. SYMPTOM: ABNORMALLY LOW SUCTION PRESSURE		
Temperature difference between leaving chilled water and refrigerant in the evaporator greater than normal with normal discharge temperature.	Insufficient charge of refrigerant.	Check for leaks and charge refrigerant into system.
	Variable orifice problem.	Remove obstruction.
Temperature difference between leaving chilled water and refrigerant in the evaporator greater than normal with normal discharge temperature.	Evaporator tubes dirty or restricted.	Clean evaporator tubes.
Temperature of chilled water too low with low motor amperes.	Insufficient load for system capacity.	Check capacity control operation and setting of low water temperature shutdown setpoint.
3. SYMPTOM: HIGH EVAPORATOR PRESSURE		
High chilled water temperature.	Capacity control failed to load.	Check the PRV (if applicable), VGD and Hot Gas Bypass (if applicable) positioning circuits.
	System overload.	Be sure the capacity control devices and speed increased (without overloading the motor) until the load decreases.

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The following factors can be used to convert from English to the most common SI Metric values.

TABLE 5 - SI METRIC CONVERSION

MEASUREMENT	MULTIPLY ENGLISH UNIT	BY FACTOR	TO OBTAIN METRIC UNIT
Capacity	Tons Refrigerant Effect (ton)	3.516	Kilowatts (kW)
Power	Horsepower	0.7457	Kilowatts (kW)
Flow Rate	Gallons / Minute (gpm)	0.0631	Liters / Second (l/s)
Length	Feet (ft)	0.3048	Meters (m)
	Inches (in)	25.4	Millimeters (mm)
Weight	Pounds (lbs)	0.4538	Kilograms (kg)
Velocity	Feet / Second (fps)	0.3048	Meters / Second (m/s)
Pressure Drop	Feet of Water (ft)	2.989	Kilopascals (kPa)
	Pounds / Square Inch (psi)	6.895	Kilopascals (kPa)

TEMPERATURE

To convert degrees Fahrenheit (°F) to degrees Celsius (°C), subtract 32° and multiply by 5/9 or 0.5556.

Example: (45.0°F - 32°) x 0.5556 = 27.2°C

To convert a temperature range (i.e., a range of 10°F) from Fahrenheit to Celsius, multiply by 5/9 or 0.5556.

Example: 10.0°F range x 0.5556 = 5.6 °C range

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