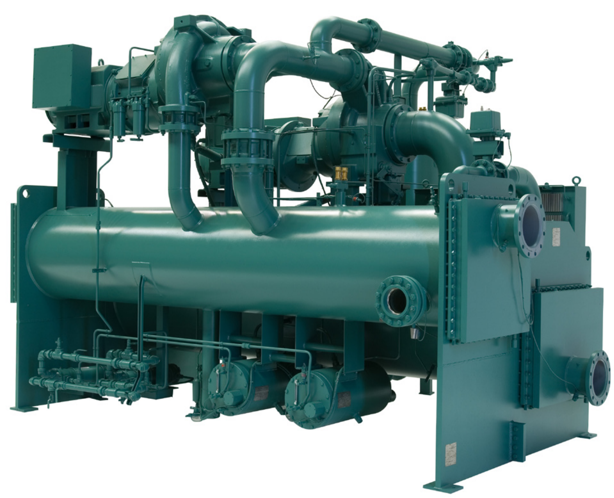
FORM 160.82-EG1 (1107)

YORK®

Model CYK Compound Centrifugal Liquid Chillers

Design Level G



700 Through 2400 TONS
(2500 Through 8440 kW)
Utilizing HFC-134a

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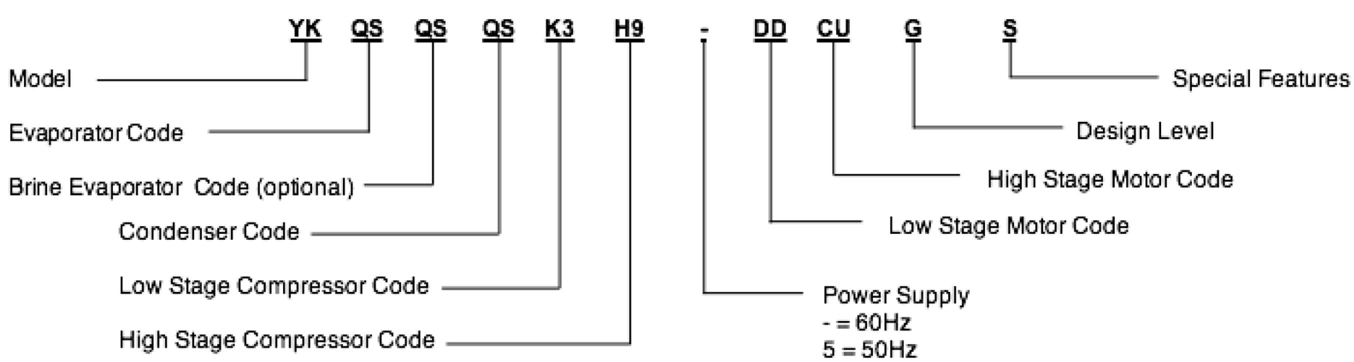
NOMENCLATURE



Introduction

The YORK Compound YK Chiller is a design using two centrifugal compressors arranged in series to handle radiator-cooled, brine-chilling, and heat-pump applications at conditions outside the range of typical centrifugal chillers. These custom units use HFC-134a refrigerant and are available in a wide range of capacities:

- For air-cooled applications, (air-cooled radiators) 700 to 2,400 tons at 45°F LWT and up to 155°F LCWT (2,500 to 8,440 kWR at 7°C LWT and up to 68.3°C LCWT).
- For brine chilling, 400 to 2,000 tons at 20°F LBT and 95°F LCWT (1,410 to 7,030 kWR at -7°C LBT and 35°C LCWT). Brine temperatures as low as 0°F (-17.8°C) can be achieved.
- For heat pump applications, 11,000 to 40,000 MBH (3,200 to 11,700 kWR) heat rejection.

STANDARD COMPONENTS

Each compound chiller employs common parts instead of a one-of-a-kind design. The compressors and heat exchangers use standard technology proven in the successful YORK packaged chiller line. Each compressor is driven by a standard, open-drive electric motor.

COMPACT FOOTPRINT

Compressors and motors are mounted above the shells to assure the smallest footprint for this type of chiller.

GREATER ADAPTABILITY

With the compound chiller, the impeller diameter, width and speed can be optimized for each stage of compression based on operating conditions.

SUPERIOR PART-LOAD PERFORMANCE

Using a compound arrangement allows the use of pre-rotation-vane (PRV) capacity control for the centrifugal impellers of both compressors. Pre-rotation vanes act like a throttle on the suction side of the compressor to control compressor load. With PRV control on both compressors, the result is better part-load performance than for typical multistage compressors.

HANDLES VARYING CONDENSING CONDITIONS

Since chillers most often operate at off-design conditions, off-design performance is a major factor in the energy saving equation. A compound chiller can operate with a wider range of condensing water temperatures than typical chillers. The compound unit allows one compressor to be shut off, so the chiller can run on just one compressor during low head conditions. This practice not only ensures system stability, it allows the chiller to run more efficiently and takes advantage of cooling water temperatures well below design.

LOWER INRUSH CURRENT

Instead of starting a single, large motor, the compound chiller stagger-starts the motors in sequence. Consequently, peak inrush current is reduced to about 58% compared to starting a motor for a single large compressor.

LOWER SOUND LEVELS

Acoustically, with compound compressors sharing the workload, compressor RPMs are lower than in standard centrifugal designs — and lower RPMs help lower sound levels.

GRAPHIC CONTROL

A powerful, graphic control panel makes chiller operation easy. Startup is handled by a push of the button; there is no need for manual intervention in the staggered-start sequence of the compressors. A color graphical operator interface means operating parameters, set-points and alarms are clearly visible, ensuring proper reading and response.

FLASH ECONOMIZER (INTERCOOLER)

The Compound YK Chiller includes a flash economizer (intercooler) that results in better efficiency during two stage operation. The Compound YK can be purchased without the economizer but the efficiency will be lower.

OPEN DRIVE DESIGN

Hermetic-motor burnout can cause catastrophic damage to a chiller. The entire chiller must be cleaned, and the refrigerant replaced. YORK centrifugal chillers eliminate this risk by using air-cooled motors. Refrigerant never comes in contact with the motor, preventing contamination of the rest of the chiller. Insurance companies that offer policies on large air conditioning equipment often consider air-cooled motors a significant advantage over hermetic refrigerant-cooled units.

HIGH-EFFICIENCY HEAT EXCHANGERS

The chiller heat exchangers offer the latest technology in heat transfer surface design to give you maximum efficiency and compact design. Waterside and refrigerant-side design enhancements minimize both energy consumption and tube fouling.

SINGLE-STAGE COMPRESSOR DESIGN AND EFFICIENCY PROVEN IN THE MOST DEMANDING APPLICATIONS

Designed to be the most reliable chillers we've ever made, YORK centrifugal chillers incorporate single-stage compressor design. With fewer moving parts and straightforward, efficient engineering, YORK single-stage compressors have proven durability records in hospitals, chemical plants, gas processing plants, the U.S. Navy, and in other applications where minimal downtime is a crucial concern.

In thousands of installations worldwide, YORK single stage compressors are working to reduce energy costs. High strength aluminum-alloy compressor impellers feature backward-curved vanes for high efficiency. Airfoil shaped pre-rotation vanes minimize flow disruption for the most efficient part load performance. Precisely positioned and tightly fitted, they allow the compressor to unload smoothly from 100% to minimum load for excellent operation in all applications.

PRECISION CONTROL OF COMPRESSOR OIL PRESSURE

Using our expertise in variable speed drive technology and applications, Johnson Controls has moved beyond the fixed head and bypass approach of oil pressure control. The old approach only assures oil pressure at the outlet of the pump rather than at the compressor, and allows no adjustment during chiller operation. The Compound chillers feature two variable speed drive oil pumps, monitoring and providing the right amount of oil flow to each compressor on a continuous basis. This design also provides sophisticated electronic monitoring and protection of the oil pump electrical supply, ensuring long life and reliable operation of the oil pump motor. Variable speed drive technology reduces oil pump power consumption, running only at the speed required, rather than at full head with a pressure regulating bypass valve.

FACTORY PACKAGING REDUCES FIELD LABOR COSTS

YORK centrifugal chillers are designed to keep installation costs low. Where installation access is not a problem, the unit can be shipped completely or partially packaged, requiring minimal piping and wiring to complete the installation.

The flash economizer (intercooler) ships separately for assembly to the chiller at time of installation. All piping between the economizer and the chiller is prefabricated so no welding is required for installation.

TAKE ADVANTAGE OF COLDER COOLING TOWER WATER TEMPERATURES

YORK centrifugal chillers have been designed to take full advantage of colder cooling tower water temperatures, which are naturally available during most operating hours. Considerable energy savings are available by letting tower water temperature drop, rather than artificially holding it above 75°F (23.9°C), Especially at low load, as some chillers require.

HEAT PUMP

The Compound YK is ideal for use in heat pump applications supplying up to 155°F (68.3°C) leaving condenser water temperature. In this application the CYK can provide Coefficients of performance over 4 times greater than water heaters. More information on heat pump applications can be found in Johnson Controls Form 160.00-PM31.

COMPUTERIZED PERFORMANCE RATINGS

Each chiller is custom-matched to meet the individual building load and energy requirements. Standard heat exchanger tube bundle sizes and pass arrangements, are available to provide the best possible match. It is not practical to provide tabulated performance for each combination, as the energy requirements at both full and part load vary significantly with each heat exchanger and pass arrangement. Computerized ratings are available through each Johnson Controls sales office. These ratings can be tailored to specific job requirements.

Mechanical Specifications

GENERAL

The YORK CYK Compound Centrifugal Liquid Chillers are factory-packaged including the evaporator, condenser, compressor, motor, lubrication system, control center, and interconnecting unit piping and wiring. The flash economizer (intercooler) ships loose for assembly to the chiller at time of installation. All piping between the economizer and the chillers is prefabricated in the factory so no welding is required in the field.

The initial charge of refrigerant and oil is supplied for each chiller. Actual shipping procedures will depend on a number of project-specific details.

The services of a Johnson Controls factory-trained, field service representative are incurred to supervise or perform the final leak testing, charging, the initial start-up, and concurrent operator instructions.

COMPRESSOR

Each compressor is a single-stage centrifugal type powered by an open-drive electric motor. The casing is fully accessible with vertical circular joints and fabricated of close-grain cast iron. The complete operating assembly is removable from the compressor and scroll housing.

The rotor assembly consists of a heat-treated alloy steel drive shaft and impeller shaft with a high strength, cast aluminum alloy, fully shrouded impeller. The impeller is designed for balanced thrust and is dynamically balanced and overspeed tested for smooth, vibration free operation.

The insert-type journal and thrust bearings are fabricated of aluminum alloy and are precision bored and axially grooved. The specially engineered, single helical gears with crowned teeth are designed so that more than one tooth is in contact at all times to provide even distribution of compressor load and quiet operation. Gears are integrally assembled in the compressor rotor support and are film lubricated. Each gear is individually mounted in its own journal and thrust bearings to isolate it from impeller and motor forces.

FLASH ECONOMIZER (INTERCOOLER)

Single stage type, consisting of a vertical pressure vessel with internally mounted mesh eliminators and liquid spray pipe, an externally mounted (field installed) level transmitter located with a liquid level pipe assembly and an external control valve mounted in the liquid outlet to the evaporator. Refrigerant from the condenser, after expanding through the condenser subcooler level control valve, enters through the internal spray pipe, where flash gas is removed and channeled through the mesh eliminator, out the top and on to the high stage compressor section. The remaining liquid feeds out of the economizer through a liquid level control valve to the evaporator. Eight sight glasses are provided, two above and two below the mesh eliminators, two at the liquid spray pipe, and two in the liquid line leaving the economizer. A thermometer well if furnished for checking the liquid temperature. Connections are provided for the Johnson Controls furnished, field installed pressure transmitter and relief valve assemblies. Three support legs of structural steel tubing are provided with mounting brackets for spring type isolators. Refrigerant connections are as follows: high pressure liquid inlet, interstage flash gas top outlet, and low pressure liquid bottom outlet.

CAPACITY CONTROL

Pre-rotation vanes (PRV) in each compressor modulate chiller capacity from 100% to 15% of design for normal air conditioning applications. Operation is by an external, electric PRV actuator which automatically controls the vane position to maintain a constant leaving chilled liquid temperature (or leaving condenser temperature for a heat pump application). Rugged airfoil shaped cast manganese bronze vanes are precisely positioned by solid vane linkages connected to the electric actuator.

Both compressors are normally operated to satisfy the evaporator load (or the condenser load in the case of a heat pump). Should the entering condensing water temperature drop below a preset temperature, a compressor will be taken off line. This allows the remaining compressor to continue operating more efficiently at low entering condensing water temperatures.

OPTISOUND™ CONTROL

The YORK® OptiSound™ Control is a patented combination of centrifugal-chiller hardware and software that reduces operational sound levels, expands the chiller operating range, and improves chiller performance. The OptiSound Control feature continuously monitors the characteristics of the compressor-discharge gas and optimizes the diffuser spacing to minimize gas-flow disruptions from the impeller. This innovative technology improves operating sound levels of the chiller an average of 7 dBA, and up to 13 dBA on the largest models. It can also reduce part-load sound levels below the full-load level.

In addition, the OptiSound Control provides the benefit of an expanded operating range. It improves performance and reliability by minimizing diffuser gas stall at off-design operation, particularly conditions of very low load combined with little or no condenser-water relief. The elimination of the gas-stall condition can also result in improved chiller efficiency at off design conditions.

Mechanical Specifications – *continued*

Johnson Controls includes the OptiSound Control for all CYK chillers when it is available on the compressors used. It is not available on all compressors.

LUBRICATION SYSTEM

Lubrication oil is force-fed to all bearings, gears and rotating surfaces by a variable speed drive pump; which operates prior to startup, and continuously during operation and during coast-down. A gravity-fed oil reservoir is built into the top of each compressor to provide lubrication during coast-down in the event of a power failure.

Dual oil reservoirs, separate from the compressors, contain the 2 HP submersible oil pumps and 1500 watt immersion-type oil heaters for each compressor. The oil heaters are thermostatically controlled to remove refrigerant from the oil.

A water-cooled oil cooler is provided after each oil pump, with factory installed water piping terminating at the center on the condenser side of the unit. A thermostatically controlled bypass valve maintains the required oil temperature supply from each oil cooler to its compressor. Oil is filtered by externally mounted, 1/2 micron, replaceable cartridge oil filters, equipped with service valves. An automatic oil return system recovers any oil that may have migrated to the evaporator. Oil piping is completely factory installed.

MOTOR DRIVELINE

The compressor motors are open drip-proof, squirrel cage, induction type constructed to YORK design specifications. 60 hertz motors operate at 3570 rpm. 50 hertz motors operate at 2975 rpm.

The open motor is provided with a D-flange, and is factory-mounted to a cast iron adapter mounted on the compressor. This unique design allows the motor to be rigidly coupled to the compressor to provide factory alignment of motor and compressor shafts.

Motor drive shaft is directly connected to the compressor shaft with a flexible disc coupling. Coupling has all metal construction with no wearing parts to assure long life, and no lubrication requirements to provide low maintenance.

A large, steel terminal box with gasketed front access cover is provided on each motor for field-connected conduit. There are six terminals (three for medium voltage) brought through the motor casing into the terminal box. Jumpers are furnished for three-lead types of starting. Motor terminal lugs are not furnished.

HEAT EXCHANGERS

Shells

Evaporator and condenser shells are fabricated from rolled carbon steel plates with fusion welded seams. Carbon steel tube sheets, drilled and reamed to accommodate the tubes, are welded to the end of each shell. Intermediate tube supports are fabricated from carbon steel plates, drilled and reamed to eliminate sharp edges, and spaced no more than four feet apart. The refrigerant side of each shell is designed, tested, and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII – Division I, or other pressure vessel codes as appropriate.

Tubes

Heat exchanger tubes are state-of-the-art, high-efficiency, externally and internally enhanced type to provide optimum performance. Tubes in both the evaporator and condenser are 3/4” or 1” O.D. copper alloy and utilize the “skip-fin” design, providing a smooth internal and external surface at each intermediate tube support. This provides extra wall thickness (up to twice as thick) and non-work hardened copper at the support location, extending the life of the heat exchangers. Each tube is roller expanded into the tube sheets providing a leak-proof seal, and is individually replaceable.

Evaporator

The evaporator is a shell and tube, flooded type heat exchanger. A distributor trough provides uniform distribution of refrigerant over the entire shell length to yield optimum heat transfer. Mesh eliminators or baffles are located above the tube bundle to prevent liquid refrigerant carryover into the compressor. A 1.5” (38mm) liquid level sight glass is conveniently located on the side of the shell to aid in determining proper refrigerant charge. The evaporator shell contains a dual refrigerant relief valve arrangement set to pressures up to 235 PSIG (1620 kPa). A 1” refrigerant charging valve is provided.

Condenser

The condenser is a shell and tube type, with discharge gas baffles to prevent direct high velocity impingement on the tubes. The baffles are also used to distribute the refrigerant gas flow properly for most efficient heat transfer. An integral sub-cooler is located at the bottom of the condenser shell providing highly effective liquid refrigerant sub-cooling to provide the highest cycle efficiency. The condenser contains dual refrigerant relief valves that can be set to pressures up to 350 PSIG (2413 kPa).

WATER BOXES

The removable 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 are located and welded within the water box to provide the required pass arrangements. Stub-out water nozzle connections with ANSI/AWWA C-606 grooves are welded to the water boxes. These nozzle connections are suitable for ANSI/AWWA C-606 couplings, welding or flanges, and are capped for shipment. Plugged 3/4" drain and vent connections are provided in each water box.

WATER FLOW SWITCHES

Thermal type water flow switches are factory mounted in the chilled and condenser water nozzles, and are factory wired to the control panel. These solid state flow sensors have a small internal heating element. They use the cooling effect of the flowing fluid to sense when an adequate flow rate has been established. The sealed sensor probe is 316 stainless steel, which is suited to very high working pressures.

ZERO LOAD HOT GAS BYPASS

Sized for operation to 0% evaporator load to prevent nuisance shutdowns due to low load conditions, and critical industrial and process applications.

LOW INLET CONDENSER WATER CAPABILITY

The CYK Compound chiller incorporates a control strategy that allows a compressor to shut down automatically when two-compressor operation is no longer required. This allows the chiller to take advantage of low-inlet condenser water temperatures to reduce energy consumption.

CONTROL CENTER

The chiller is controlled by a stand-alone PLC based control center. The chiller control center provides all the necessary controls and control logic to provide automatic start-up, automatic operation, capacity control and safety protection of the chiller.

Control Panel

The control panel includes a 10.4" color active matrix display with integral keypad for operator interface. The control panel is a factory wired, unit mounted, NEMA 12, gasketed enclosure. The panel is fabricated of 10 gauge steel and includes full height front access doors. The panel enclosure is painted to match the chiller color on the outside, and gloss white on interior surfaces. All controls are arranged for easy access and internally wired to clearly marked terminal strips or pre-wired PLC interface modules for external wiring connections. Wiring is color-coded black (control), white (neutral), and green (ground), with each wire numerically identified at both ends with heat shrinkable wire markers. Wiring enclosed in shielded cables and pre-wired cables are color coded per the wiring diagram.

The screen details all operations and parameters, using a graphical representation of the chiller and its components. Graphic screens are provided for:

a. Chiller Overview
b. Evaporator
c. Condenser
d. Low stage compressor
e. High stage compressor
f. Motors
g. Capacity control diagram
h. Manual/Auto stations for all control outputs

The operator interface is programmed to provide display of all major operating parameters in both graphical and list type screen displays. PID control loop set points, and Manual/Auto functions are also accomplished by the operator interface. Alarm indicators on the graphic display screen provide annunciation, and an alarm history screen is provided which shows the most recent alarms, with the time and date of occurrence. Trip status screens are provided which show the values of all analog inputs at the time of the last five chiller safety shutdowns. The time and date of the shutdown are also shown. Separate push buttons are provided on the face of the control panel for Chiller Start, Stop, Reset and Emergency Stop.

Capacity Controls System

The Capacity Control philosophy of the York CYK chiller control system allows efficient, fully automated control, without need for operator intervention. This control system also monitors and displays all safety aspects of the chiller and provides alarms and a shutdown if safety limits are exceeded. If operator intervention is required, manual controls are provided on the electronic operator interface, for all electric actuators.

Mechanical Specifications – *continued*

The capacity controls algorithm automatically seeks out the most efficient operation of the CYK chiller. The pre-rotation vanes are automated to obey the temperature controller to maintain chilled water production. In cases of low load, the pre-rotation vanes automatically throttle and are limited to a minimum anti-surge position. To provide light duty operation, the hot gas recycle valve is seamlessly throttled open according to temperature demands. This keeps the centrifugal compressor out of surge and maintains chilled water production.

In cases of high load, which exceeds the motor kilowatt (or current) usage, the capacity controls algorithm automatically unloads the system to maintain a restriction on power consumption. In the same way, conditions of high discharge pressure or low suction pressure override the production of chilled water in the interests of keeping the chiller system online.

In cases of light load and low head, the high compressor is dropped offline, the intercooler (if provided) bypassed, and the unit will be run with the low stage compressor like a normal single compressor chiller.

Analog Input List:

1. Low Stage Motor Current (% FLA)
2. High Stage Motor Current (% FLA)
3. Sub-cooler Refrigerant Liquid Level
4. Low Stage Oil Reservoir Oil Level (Brine Units)
5. High Stage Oil Reservoir Oil Level (Brine Units)
6. Evaporator Refrigerant Pressure
7. Condenser Refrigerant Pressure
8. Low Stage Compressor Low Oil Pressure
9. High Stage Compressor Low Oil Pressure
10. Low Stage Compressor High Oil Pressure
11. High Stage Compressor High Oil Pressure
12. Chilled Water-Out Temperature.
13. Chilled Water-In Temperature.
14. Condenser Water In Temperature
15. Condenser Water Out Temperature
16. Evaporator Refrigerant Liquid Temp.
17. Low Stage Compressor Refrigerant Discharge Temperature
18. High Stage Compressor Refrigerant Discharge Temperature
19. Sub-cooled Refrigerant Liquid Temperature
20. Low Stage Compressor Oil Temperature
21. High Stage Compressor Oil Temperature
22. Low Stage PRV Position
23. High Stage PRV Position
24. Low Stage Compressor high stage thrust Bearing Probe Gap
25. High Stage Compressor thrust bearing Probe gap
26. Flash Economizer Pressure

Digital Inputs:

1. Chilled Water Low Flow Switch
2. Condenser Water Low Flow Switch
3. Low Stage Motor Starter Full Voltage (Run) Auxiliary Contact
4. High Stage Motor Starter Full Voltage (Run) Auxiliary Contact
5. Low Stage Motor Starter Safety Fault Lockout Relay
6. High Stage Motor Starter Safety Fault Lockout Relay
7. Condenser Refrigerant High Pressure Cutout
8. Low Stage Compressor Oil Heater Thermostat
9. High Stage Compressor Oil Heater Thermostat
10. Low Stage PRV Closed Limit Switch
11. High Stage PRV Closed Limit Switch
12. Low Stage Compressor V.S. Oil Pump Drive Faulted Contact
13. High Stage Compressor V.S. Oil Pump Drive Faulted Contact
14. Chiller Start
15. Chiller Stop
16. System Reset
17. Emergency Stop

Analog Output List

1. Hot Gas Bypass Valve
2. Low Stage Compressor, V.S. Oil Pump Drive Control
3. High Stage Compressor, V.S. Oil Pump Drive Control
4. Variable Orifice Valve
5. Inter-stage Valve
6. Bypass Level Control valve output LCV-117

Digital Output List

1. Low Stage Liquid Line Solenoid Valve
2. High Stage Liquid Line Solenoid Valve
3. High Stage Oil Return Solenoid

Digital Output List - cont'd

4. Low Stage Oil Return Solenoid Valve
5. Low Stage Compressor Oil Heater Contactor
6. High Stage Compressor Oil Heater Contactor
7. Low Stage Compressor Motor Start/Stop Control Relay
8. High Stage Compressor Motor Start/Stop Control Relay
9. Low Stage Compressor Oil Pump Start/Stop Relay
10. High Stage Compressor Oil Pump Start/Stop Relay
11. Oil Level Control Pump Start/Stop Relay
12. Start-up Bypass Valve Open/Close Relay
13. Open Low Stage PRV
14. Open High Stage PRV
15. Close Low Stage PRV
16. Close High Stage PRV

Security

Security access to prevent unauthorized change of setpoints, to allow local or remote control of the chiller, and to allow manual operation of the pre-rotation vanes and oil pump. Access is through ID and password recognition, which is defined by three different levels of user competence: operator, service and programming.

Over-Current Protection

A fused connection through a transformer on the Variable Speed Oil Pump Panel to provide individual overcurrent protected power for all controls.

PLANT MANAGEMENT/CONTROL SYSTEM INTERFACE:

Ethernet I/P (Ethernet Industrial Protocol) is the preferred LAN (Local Area Network) between Local Chiller Control Panels. Ethernet I/P allows full management of the Allen-Bradley system from a central location.

All required analog and discrete data for communications will be arranged in blocks of IEEE Floating Point and 16-bit words within the Logix processor's data tables. All data is available remotely as read only values. The following write-able control signals are available. Remote Start, Remote Stop, Remote Leaving Chilled Water Setpoint, and Remote Demand Limit Setpoint.

Available Network Protocols

Media	Protocol
Cat-5 twisted pair	Ethernet Industrial Protocol www.ethernet-ip.org
RS-232	Allen-Bradley DF1 Full Duplex
RS-232	Modbus RTU Slave

Any protocol/media requirements not listed here must be called out on the factory order form.

Available protocols will be implemented with a Johnson Controls **eLink** module* or **Prolinx** gateway** where applicable:

- Modbus RTU over RS-485**
- Modbus over TCP/IP**
- BACnet MS/TP*
- BACnet/IP*
- LONworks*
- Profibus**
- ControlNet
- Allen-Bradley DH-485

Check appropriate protocol and include this document attached to the Factory Order Form.

All communication interface wiring and hardware, which is required external to the chiller control panel, will be supplied and installed by the electrical installation contractor under another contract.

CODES AND STANDARDS

- ASME Boiler and Pressure Vessel Code – Section VIII Division 1.
- ARI Standard 550/590 (When applicable)
- ASHRAE 15 – Safety Code for Mechanical Refrigeration
- ASHRAE Guideline 3 – Reducing Emission of Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems
- N.E.C. – National Electrical Code
- OSHA – Occupational Safety and Health Act

ISOLATION MOUNTING

The unit is provided with four vibration isolation mounts consisting of 1" (25.4 mm) thick neoprene isolation pads for field mounting under the steel mounting pads located on the tube sheets and three pads for the flash economizer (intercooler).

REFRIGERANT CONTAINMENT

The standard unit has been designed as a complete and compact factory-packaged chiller except for the flash economizer. The piping between the economizer and the main chiller is all prefabricated in the factory with strategically placed flanges. No field welding is necessary to attach the economizer. As such, it has minimum joints from which refrigerant can leak. The entire assembly has been thoroughly leak tested at the factory prior to shipment. The YORK chiller includes service valves, conveniently located to facilitate transfer of refrigerant to a remote refrigerant storage/recycling system.

PAINT

Exterior surfaces are protected with one coat of Caribbean blue, durable alkyd-modified, vinyl enamel, machinery paint.

SHIPMENT

Protective covering is furnished on the motor, Control Center and unit-mounted controls. Water nozzles are capped with fitted plastic enclosures. Entire unit is protected with industrial-grade, reinforced shrink-wrapped covering. The flash economizer (intercooler) is removed for shipment. Flanged joints are provided and all piping is prefabricated.

Accessories and Modifications

BAS REMOTE CONTROL

Alternate network mediums and protocols may be accomplished with the addition of a protocol translator gateway. These include: Modbus TCP/IP, Profibus, DNP, Remote I/0 and ASCII. Contact the factory for more information.

FACTORY INSULATION

Factory-applied thermal insulation of the flexible, closed-cell plastic type, 3/4” (19 mm) thick is attached with vapor-proof cement to the evaporator shell, tube sheets, suction connection, and (as necessary) to the auxiliary tubing. The flash economizer (intercooler) may require factory insulation for some operating conditions. For all other projects, optional factory insulation on the economizer is available upon request. Not included is the insulation of compact water boxes and nozzles. This insulation will normally prevent condensation in environments with relative humidities up to 75% and dry bulb temperatures ranging from 50° to 90°F (10° to 32.2°C). 1-1/2” (38 mm) thick insulation is also available for relative humidities up to 90% and dry bulb temperatures ranging from 50° to 90°F (10° to 32.2°C). For heat pump applications the condenser can be ordered with optional factory insulation to minimize heat loss to the atmosphere.

WATER FLANGES

Four 150 lb. ANSI raised-face flanges for condenser and evaporator water connections, are factory-welded to water nozzles. Companion flanges, bolts, nuts and gaskets are not included.

SPRING ISOLATION MOUNTING

Spring isolation mounting is available instead of standard isolation mounting pads when desired. Seven vertically restrained level-adjusting, spring-type vibration isolator assemblies with non-skid pads are provided for field-installation. Isolators are designed for one-inch (25 mm) deflection.

STARTER – FIELD-INSTALLED

Field installed, compressor motor starter assemblies are available, selected for proper size and type for job requirements and in accordance with Johnson Controls Engineering Standard (R-1151) for Starters. The starter assemblies have contactors and accessories for controlling the two compressor motors per chiller.

MARINE WATER BOXES

Marine water boxes allow service access for cleaning of the heat exchanger tubes without the need to break the water piping. Bolted-on covers are arranged for convenient access. ANSI/AWWA C-606 nozzle connections are standard; flanges are optional. Marine water boxes are available for condenser and/or evaporator.

Hinged water boxes are available upon request.

KNOCK-DOWN SHIPMENT

The chiller can be shipped knocked down into major subassemblies (evaporator, condenser, driveline, etc.) as required to rig into tight spaces. This is particularly convenient for existing buildings where equipment room access does not allow rigging a factory-packaged chiller.

REFRIGERANT STORAGE/RECYCLING SYSTEM

A refrigerant storage/recycling system is a self-contained package consisting of a refrigerant compressor with oil separator, storage receiver, water-cooled condenser, filter drier and necessary valves and hoses to remove, replace and distill refrigerant. All necessary controls and safety devices are a permanent part of the system.

HIGH VOLTAGE MOTORS

High voltage induction motors (11 kV to 13.8 kV), special motor enclosures such as TEWAC or WPII, may be substituted.

TUBE AND/OR TUBE SHEET MATERIALS AND/OR WATER BOX COATING

For condenser and/or evaporator for protection against aggressive water conditions. Alternate cupro-nickel or titanium tubes can be provided in lieu of standard copper. Tube sheets may be of the clad type. Epoxy coating may be applied to water boxes or to tubesheet and water boxes.

SACRIFICIAL ZINC ANODES

With mounting hardware for condenser and/or evaporator corrosion protection.

HIGHER WATER CIRCUIT DWP

Condenser and/or evaporator water circuit(s) DWP higher than the standard 150 PSIG (1034 kPa) DWP.

OUTDOOR AND/OR HAZARDOUS DUTY APPLICATIONS

Necessary unit, control and control center modifications for Outdoor (NEMA-3 & 4) application in lieu of standard NEMA-1 construction. Suitable alternate surface preparation and protective coating systems also available.

FIELD PERFORMANCE TEST

Services of a factory engineer or independent consultant to supervise a field performance test. Various levels of instrumentation can be offered by Johnson Controls.

Application Data

The following discussion is a user's guide in the application and installation of CYK chillers to ensure the reliable, trouble-free life for which this equipment was designed. While this guide is directed towards normal, water-chilling applications, the Johnson Controls sales representative can provide complete recommendations on other types of applications.

LOCATION

CYK chillers are virtually vibration free and may generally be located at any level in a building where the construction will support the total system operating weight.

The unit site must be a floor, mounting pad or foundation which is level within 1/4" (6.4 mm) and capable of supporting the operating weight of the unit.

Sufficient clearance to permit normal service and maintenance work should be provided all around and above the unit. Additional space should be provided at one end of the unit to permit cleaning of evaporator and condenser tubes as required. A doorway or other properly located opening may be used.

The chiller should be installed in an indoor location where temperatures range from 40°F to 104°F (4.4°C to 40°C).

WATER CIRCUITS

Flow Rate – For normal water chilling duty, evaporator and condenser flow rates are permitted at water velocity levels in the heat exchangers tubes of between 3.0 ft/sec (3.3 for condensers) and 12 ft/sec (0.91 m/s and 3.66 m/s). Variable flow applications are possible, and initial chiller selections should be made accordingly to allow proper range of flow while maintaining the minimum velocity noted above. Variable flow in the condenser is not recommended, as it generally raises the energy consumption of the system by keeping the condenser pressure high in the chiller. Additionally, the rate of fouling in the condenser will increase at lower water velocities associated with variable flow, raising system maintenance costs. Cooling towers typically have narrow ranges of operation with respect to flow rates, and will be more effective with full design flow. Contact Johnson Controls Sales for specific flow limits.

Water Quality – The practical and economical application of liquid chillers requires that the quality of the water supply for the condenser and evaporator be analyzed by a water treatment specialist. Water quality may affect the performance of any chiller through corrosion, deposition of heat-resistant scale, sedimentation or organic growth. These will degrade chiller performance and increase operating and maintenance costs. Normally, performance may be maintained by corrective water treatment and periodic cleaning of tubes. If water conditions exist which cannot be corrected by proper water treatment, it may be necessary to provide a larger allowance for fouling, and/or to specify special materials of construction.

General Piping – All chilled water and condenser water piping should be designed and installed in accordance with accepted piping practice. Chilled water and condenser water pumps should be located to discharge through the chiller to assure positive pressure and flow through the unit. Piping should include offsets to provide flexibility and should be arranged to prevent drainage of water from the evaporator and condenser when the pumps are shut off. Piping should be adequately supported and braced independently of the chiller to avoid the imposition of strain on chiller components. Hangers must allow for alignment of the pipe. Isolators in the piping and in the hangers are highly desirable in achieving sound and vibration control.

Convenience Considerations – To facilitate the performance of routine maintenance work, some or all of the following steps may be taken by the purchaser. Evaporator and condenser water boxes are equipped with plugged vent and drain connections. If desired, vent and drain valves may be installed with or without piping to an open drain. Pressure gauges with stop cocks and stop valves may be installed in the inlets and outlets of the condenser and chilled water line as close as possible to the chiller. An overhead monorail or beam may be used to facilitate servicing.

Connections – The standard chiller is designed for 150 PSIG (1034 kPA) design working pressure in both the chilled water and condenser water circuits. The connections (water nozzles) to these circuits are furnished with grooves for ANSI/AWWA C-606 couplings. Piping should be arranged for ease of disassembly at the unit for tube cleaning. All water piping should be thoroughly cleaned of all dirt and debris before final connections are made to the chiller.

Condenser Water Strainer – A water strainer of maximum 1/8" (3mm) perforated holes is recommended to be field installed in the refrigerant condenser water inlet line as close as possible to the chiller. If located close enough to the chiller, the condensate water pump may be protected by the same strainer. The loss or severe reduction of water flow due to blockage could seriously impair the chiller's performance.

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MULTIPLE UNITS

Selection – Many applications require multiple units to meet the total capacity requirements as well as to provide flexibility and some degree of protection against equipment shutdown. There are several common unit arrangements for this type of application. The *CYK* chiller has been designed to be readily adapted to the requirements of these various arrangements.

Parallel Arrangement (Refer to Fig. 1) **–** Chillers may be applied in multiples with chilled and condenser water circuits connected in parallel between the units. Fig. 1 represents a parallel arrangement with two chillers. Parallel chiller arrangements may consist of equally or unequally sized units. When multiple units are in operation, they will load and unload at equal percentages of design full load for the chiller.

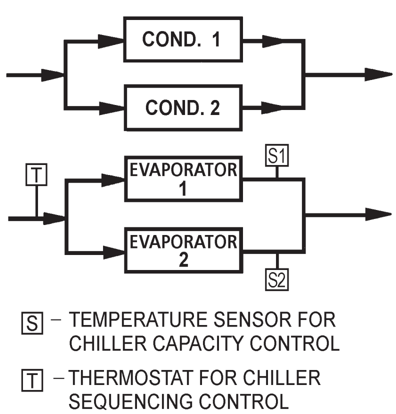
Depending on the number of units and operating characteristics of the units, loading and unloading schemes should be designed to optimize the overall efficiency of the chiller plant. It is recommended to use an evaporator by-pass piping arrangement to bypass fluid around evaporator of any unit which has cycled off at reduced load conditions. It is also recommended to alternate the chiller cycling order to equalize chiller starts and run hours.

Series Arrangement (Refer to Fig. 2) **–** Chillers may be applied in pairs with chilled water circuits connected in series and condenser water circuits connected in parallel. All of the chilled water flows through both evaporators with each unit handling approximately one-half of the total load. When the load decreases to a customer selected load value, one of the units will be shut down by a sequence control. Since all water is flowing through the operating unit, that unit will cool the water to the desired temperature.

REFRIGERANT RELIEF PIPING

Each chiller is equipped with dual pressure relief valves on the condenser, dual relief valves on the evaporator and dual relief valves on the flash economizer (intercooler). The dual relief valves are redundant and allow changing of either valve while the unit is fully charged. The purpose of the relief valves is to quickly relieve excess pressure of the refrigerant charge to the atmosphere, as a safety precaution in the event of an emergency such as fire. They are set to relieve at an internal pressure as noted on the pressure vessel data plate, and are provided in accordance with ASHRAE 15 safety code and ASME or applicable pressure vessel code.

Sized to the requirements of applicable codes, a vent line must run from the relief device to the outside of the building. This refrigerant relief piping must include a cleanable, vertical-leg dirt trap to catch vent-stack condensation. Vent piping must be arranged to avoid imposing a strain on the relief connection and should include one flexible connection.



S – Temperature Sensor for Chiller Capacity Control

T – Thermostat for Chiller Capacity Control

FIG. 1 – PARALLEL EVAPORATORS
PARALLEL CONDENSERS

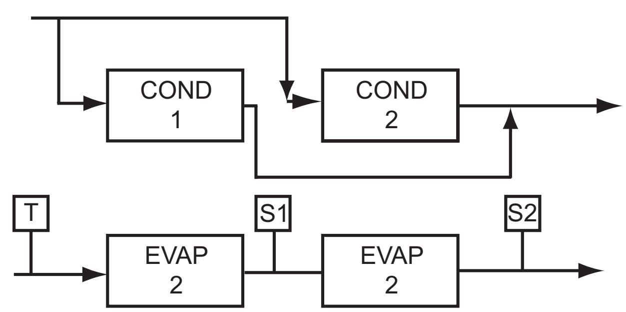


FIG. 2 – SERIES EVAPORATORS
PARALLEL CONDENSERS

SOUND AND VIBRATION CONSIDERATIONS

A YORK CYK chiller is not a source of objectionable sound and vibration in normal air conditioning applications. Neoprene isolation mounts are furnished as standard with each unit. Optional level-adjusting spring isolator assemblies designed for 1” (25 mm) static deflection are available from Johnson Controls.

YORK CYK chiller sound pressure level ratings will be furnished on request.

Control of sound and vibration transmission must be taken into account in the equipment room construction as well as in the selection and installation of the equipment.

THERMAL INSULATION

No appreciable operating economy can be achieved by thermally insulating the chiller. However, the chiller’s cold surfaces should be insulated with a vapor barrier insulation sufficient to prevent condensation. A chiller can be factory insulated with 3/4” (19 mm) or 1-1/2” (38 mm) thick insulation, as an option. This insulation will normally prevent condensation in environments with dry bulb temperatures of 50°F to 90°F (10°C to 32°C) and relative humidities up to 75% [3/4” (19 mm) thickness] or 90% [1-1/2” (38 mm) thickness]. The insulation is painted and the surface is flexible and reasonably resistant to wear. It is intended for a chiller installed indoors and, therefore, no protective covering of the insulation is usually required. If insulation is applied to the water boxes at the jobsite, it must be removable to permit access to the tubes for routine maintenance. For heat pump applications the condenser can be ordered with optional factory insulation to minimize heat loss to the atmosphere.

VENTILATION

The ASHRAE Standard 15 Safety Code for Mechanical Refrigeration requires that all machinery rooms be vented to the outdoors using mechanical ventilation by one or more power-driven fans. This standard, plus National Fire Protection Association Standard 90A, state, local and any other related codes should be reviewed for specific requirements. Since the CYK chiller motor is air-cooled, ventilation should allow for the removal of heat from the motor.

In addition, the ASHRAE Standard 15 requires a refrigerant vapor detector to be employed for all refrigerants. It is to be located in an area where refrigerant from a leak would be likely to concentrate. An alarm is to be activated and the mechanical ventilation started at a value no greater than the TLV (Threshold Limit Value) of the refrigerant.

ELECTRICAL CONSIDERATIONS

Motor Voltage – Low voltage motors (200 to 600 volts) are furnished with six leads. Medium voltage (2300 to 4160 volts) motors have three leads. Motor circuit conductor size must be in accordance with the National Electrical Code (NEC), or other applicable codes, for the motor full load amperes (FLA). Flexible conduit should be used for the last several feet to the chiller in order to provide vibration isolation. Table 2 lists the allowable variation in voltage supplied to the chiller motor. The unit name plate is stamped with the specific motor voltage, and frequency for the appropriate motor.

TABLE 2 – MOTOR VOLTAGE VARIATIONS

FREQ.	RATED VOLTAGE	NAMEPLATE VOLTAGE	OPERATING VOLTAGE	
			MIN.	MAX.
60 HZ	200	200/208	180	220
	230	220/240	208	254
	380	380	342	415
	416	416	375	457
	460	440/460/480	414	508
	575	575/600	520	635
	2300	2300	2,070	2,530
	3300	3300	2,970	3,630
	4000	4000/4160	3,600	4,576
50 HZ	346	346	311	381
	380	380/400	342	423
	415	415	374	440
	3300	3300	2,970	3,630

Starters – Electro-mechanical starters must be furnished in accordance with Johnson Controls Standard Specifications (R-1151). This will ensure that starter components, controls, circuits, and terminal markings will be suitable for required overall system performance.

Oil Pump Power Supply – A separate 3-phase power supply with a fused disconnect for the factory mounted oil pump variable speed drive is required. Power can also be supplied through an electro-mechanical starter. A 115 volt, single phase, control power transformer is provided in the oil pump drive panel to provide power to the Chiller Control Panel.

The variable speed drive oil pump can be selected for the following voltages:

AVAILABLE 3 PHASE VOLTAGES	
Frequency	**VOLTAGE**
60	200
	208
	220
	230
	240
	380
	416
	440
	460
	480
	550**
	575**
	600**
50	346
	220
	440
	380
	400
	415

**These voltages require a stepdown transformer to 480 Volts (by others).

Copper Conductors – *Only copper conductors should be connected to compressor motors and starters.* Aluminum conductors have proven to be unsatisfactory when connected to copper lugs. Aluminum oxide and the difference in thermal conductivity between copper and aluminum cannot guarantee the required tight connection over a long period of time.

Power Factor Correction Capacitors – Capacitors can be applied to a chiller for the purpose of power factor correction. For remote-mounted electro-mechanical starters, the capacitors should be located on the load-side of the starter. The capacitors must be sized and installed to meet the National Electrical Code and be verified by Johnson Controls.

Ampacity on Load Side of Starter – Electrical power wire size to the chiller is based on the minimum unit ampacity. For remote starters, the National Electrical Code defines the calculation of ampacity, as summarized below. More specific information on actual amperage ratings will be supplied with the submittal drawings.

- Six-lead type of starting (Star-Delta)

  Minimum circuit ampacity per conductor (1 of 6):

  Ampacity = .721 x compressor motor amps.

- Three-lead type of starting

  (Across-the-Line, Autotransformer and Primary Reactor)

  Minimum circuit ampacity per conductor (1 of 3):

  Ampacity = 1.25 x compressor motor amps.

Ampacity on Line-Side of Starter – The only additional load on the circuit for the chiller would be oil pump supply unless they are supplied by a separate source.

Minimum Circuit Ampacity = 125% of compressor motor amps + FLA of all other loads on the circuit.

Branch Circuit Overcurrent Protection – The branch circuit overcurrent protection device(s) should be a time-delay type, with a minimum rating equal to the next standard fuse/breaker rating above the calculated value. It is calculated taking into account the compressor motor amps and may also include control transformer and oil pump motor. Refer to submittal drawings for the specific calculations for each application.

MOTOR ELECTRICAL DATA

The smallest motor available which equals or exceeds the Input power (KW) from the chiller rating program is selected from Tables 3 and 4. The full load amperes (FLA) listed in the tables are maximum values and correspond to the maximum motor KW listed. When the input power (kW) is less than maximum motor KW, the FLA should be reduced per the following equation:

$$\text{FLA} = \frac{\text{Motor kW}}{\text{Max. Motor kW}} \times \text{Max. Motor FLA}$$

The benefit from the FLA correction is the possible use of smaller power wiring and/or starter size.

The locked rotor amperes (LRA) are read directly from Tables 3 and 4 for specific Motor Code and voltage. This is because the LRA is dependent only on motor size and voltage and is independent of input power (KW).

Inrush amperes (IRA) depend on LRA and the type of starter applied. The inrush can be calculated using a percentage of LRA shown in Table 5.

Application Data – *continued*

TABLE 3 – 60 Hz ELECTRICAL DATA

MOTOR CODE		CF	CG	CH	CJ	CK	CL	CM	CN	CP	CR	CS	CT	CU	CV	CW
KW (MAX)		125	144	161	190	214	240	257	276	302	333	368	395	435	478	514
SHAFT HPFL.		154	177	201	237	270	302	327	351	385	424	468	503	554	608	655
EFF. - %		92	92	93	93	94	94	95	95	95	95	95	95	95	95	95
VOLTS		AMPERES (MAX.)														
200	FLA	405	465	527	618	707	787	921	1,014	1,085	1,208	—	—	—	—	—
	LRA	2,598	3,111	3,810	4,550	4,900	5,470	5,780	7,350	7,794	—	—	—	—	—	
208	FLA	389	447	507	594	680	757	799	886	975	1,043	1,162	—	—	—	—
	LRA	2,702	3,235	3,235	3,962	4,732	5,096	5,689	6,011	6,011	7,644	8,106	—	—	—	—
230	FLA	352	404	464	540	610	685	749	804	882	944	1,050	1,130	—	—	—
	LRA	2,598	2,598	2,865	3,460	3,788	4,260	4,755	5,162	5,780	5,780	6,900	7,400	—	—	—
240	FLA	337	387	445	518	585	656	718	771	845	905	1,006	1,083	—	—	—
	LRA	2,711	2,711	3,120	3,610	3,953	4,445	4,962	5,386	6,031	6,031	7,200	7,722	—	—	—
380	FLA	217	249	285	336	378	421	453	487	534	571	636	684	756	817	879
	LRA	1,385	1,385	1,730	2,153	2,500	2,577	2,955	3,254	3,637	3,810	4,179	4,480	4,671	5,326	5,780
41 6	FLA	199	228	260	307	346	385	412	445	488	522	581	625	691	747	810
	LRA	1,385	1,385	1,638	1,967	2,190	2,356	2,700	2,976	3,536	3,637	3,810	3,810	4,270	4,869	5,640
440	FLA	184	211	238	281	319	358	392	397	461	493	549	591	646	706	579
	LRA	1,177	1,301	1,320	1,655	1,865	2,037	2,485	2,485	2,976	2,976	3,300	3,644	3,644	4,209	4,783
460	FLA	176	202	228	269	305	342	375	380	441	472	525	565	618	675	726
	LRA	1,230	1,360	1,380	1,730	1,950	2,130	2,598	2,598	3,111	3,111	3,450	3,810	3,810	4,400	5,000
480	FLA	169	194	219	258	292	328	359	364	423	452	503	541	592	647	696
	LRA	1,283	1,419	1,440	1,805	2,053	2,223	2,711	2,711	3,246	3,246	3,600	3,976	3,976	4,591	5,217
575	FLA	141	162	185	216	250	247	300	318	353	377	420	452	500	540	581
	LRA	909	909	1,100	1,384	1,556	1,700	1,900	2,066	2,078	2,413	2,760	2,960	3,089	3,550	4,039
600	FLA	135	155	177	207	240	263	288	305	338	361	403	433	479	518	557
	LRA	949	949	1,148	1,444	1,624	1,774	1,983	2,156	2,168	2,518	2,880	3,089	3,223	3,704	4,215
2300	FLA	36	41	46	55	63	70	74	80	87	95	106	113	124	135	146
	LRA	240	267	298	340	397	435	480	520	530	590	669	719	791	867	935
3300	FLA	25	29	33	39	44	49	52	55	61	67	73	79	86	94	102
	LRA	160	175	210	240	280	310	310	343	382	415	466	501	551	576	652
4000	FLA	21	24	27	32	36	40	43	46	50	55	60	65	71	78	84
	LRA	135	154	166	195	230	240	270	283	315	340	384	413	455	499	538
4160	FLA	20	23	26	30	34	38	41	44	48	52	58	63	68	75	81
	LRA	140	160	173	203	239	250	270	294	328	328	399	430	473	519	560

TABLE 4 – 50 Hz ELECTRICAL DATA[1]

MOTOR CODE		5CC	5CD	5CE	5CF	5CG	5CH	5CI	5CJ	5CK	5CL	5CM	5CN	5CO	5CP	5CQ	5CR	5CS
kW (MAX)		121	136	160	180	201	215	231	254	280	309	332	366	402	432	455	481	518
SHAFT HPFL		148	168	198	225	252	272	292	321	353	390	419	462	507	546	575	608	658
EFF.-%		91.1	92.4	92.4	93.4	93.4	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.7
FL PF		0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.88
VOLTS		AMPERES (MAX.)																
346	FLA	224	258	302	340	380	417	437	481	528	584	630	692	578	816	860	909	982
	LRA	1,385	1,721	1,790	2,208	2,467	2,598	2,840	3,081	3,350	3,706	3,810	4,177	4,830	4,944	5,373	5,780	5,780
380	FLA	204	235	275	309	346	379	398	438	481	532	572	630	690	743	783	841	895
	LRA	1,385	1,385	1,640	1,890	2,144	2,464	2,590	2,806	3,050	3,375	3,700	3,810	4,400	4,500	4,892	5,600	5,491
400	FLA	194	223	261	294	329	360	378	416	457	505	543	599	656	706	744	799	850
	LRA	1,458	1,458	1,726	1,990	2,257	2,594	2,726	2,954	3,211	3,553	3,895	4,011	4,632	4,737	5,149	5,895	5,780
415	FLA	187	215	252	284	317	347	364	401	441	487	526	577	632	680	717	764	819
	LRA	1,283	1,385	1,490	1,700	2,031	2,175	2,366	2,569	2,794	3,088	3,402	3,478	3,810	4,117	4,480	5,130	5,108
3300	FLA	24	27	32	36	41	44	47	50	56	62	66	73	80	87	91	96	103
	LRA	159	162	209	236	241	274	294	318	317	388	423	455	499	516	572	614	644

NOTE: 1. Chiller performance for 50 Hertz applications is outside the scope of the ARI Certification Program.

CX	CY	CZ	CA	CB	DA	DB	DC	DD	DE	DF	DH	DJ	DK	DL	MOTOR CODE	
542	578	617	660	703	781	859	937	1,015	1,093	1,171	1,359	1,554	1748	1942	kW (MAX.)	
690	740	790	845	900	1,000	1,100	1,200	1,300	1,400	1,500	1,750	2,000	2250	2500	SHAFT HPFL	
95	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	96	96	96	96	EFF.-%**	
AMPERES (MAX.)															VOLTS	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	FLA	200
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	LRA	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	FLA	208
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	LRA	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	FLA	230
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	LRA	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	FLA	240
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	LRA	
942	997	1065	1,126	1,200	1,364	1,500	1,636	—	—	—	—	—	—	—	FLA	380
6,782	5,780	6,644	7,106	7,513	7,794	8,491	9,431	—	—	—	—	—	—	—	LRA	
860	911	973	1,029	1,096	1,246	1,370	1,495	—	—	—	—	—	—	—	FLA	416
5,780	5,694	6,069	6,489	6,863	7,120	7,755	8,608	—	—	—	—	—	—	—	LRA	
813	861	920	973	1,036	1,178	1,295	1,413	—	—	—	—	—	—	—	FLA	440
5,357	4,783	5,249	5,529	5,529	6,160	6,709	7,455	—	—	—	—	—	—	—	LRA	
778	824	880	931	991	1,127	1,239	1,352	—	—	—	—	—	—	—	FLA	460
5,600	5,000	5,488	5,780	5,780	6,440	7,014	7,794	—	—	—	—	—	—	—	LRA	
746	790	843	892	950	1,080	1,187	1,296	—	—	—	—	—	—	—	FLA	480
5,843	5,217	5,727	6,031	6,031	6,720	7,319	8,133	—	—	—	—	—	—	—	LRA	
622	659	704	744	793	901	991	1,081	—	—	—	—	—	—	—	FLA	575
4,440	4,300	4,200	4,694	4,963	5,148	5,610	6,232	—	—	—	—	—	—	—	LRA	
596	632	675	713	760	863	950	1,036	—	—	—	—	—	—	—	FLA	600
4,633	4,484	4,383	4,898	5,179	5,372	5,854	6,503	—	—	—	—	—	—	—	LRA	
154	165	176	186	198	225	248	267	290	312	334	389	438	493	548	FLA	2,300
960	1,008	1,100	1,172	1,230	1,234	1,592	1,592	1,592	2,031	2,031	2,390	2,879	2908	3012	LRA	
108	115	123	130	138	157	173	186	202	217	233	271	306	344	382	FLA	3,300
682	719	744	744	858	861	1,110	1,110	1,110	1,416	1,416	1,661	2,011	2027	2100	LRA	
89	95	101	107	114	130	143	154	166	179	192	224	252	283	315	FLA	4,000
540	554	631	674	713	715	923	923	923	1,177	1,177	1,386	1,669	1672	1732	LRA	
85	91	97	103	110	125	137	149	160	172	185	215	242	273	303	FLA	4,160
562	576	656	701	742	744	960	960	960	1,224	1,224	1,441	1,736	1608	1666	LRA	

5CT	5CU	5CV	5CW	5CX	5DA	5DB	5DC	5DD	5DE	5DF	5DG	5DH	*5DJ	5DK	5DL	MOTOR code	
554	591	630	669	709	785	863	942	1,015	1,093	1,171	1,288	1,360	1,554	1,748	1,942	kW(MAX.)	
704	750	800	850	900	1,000	1,100	1,200	1,300	1,400	1,500	1,650	1,750	2,000	2,250	2,500	SHAFT HP	
94.7	94.7	94.7	94.7	94.7	95	95	95	95.5	95.5	95.5	95.5	96	96	96	96	FL EFF.-%**	
0.88	0.89	0.89	0.89	0.89	0.88	0.87	0.88	0.88	0.88	0.88	0.88	0.89	0.89	0.89	0.89	FL PF**	
AMPERES (MAX.)																VOLTS	
1,051	1,107	1,181	1,255	1,329	1,488	1,656	—	—	—	—	—	—	—	—	—	FLA	346
6,615	6,931	7,356	7,794	8,319	8,559	9,346	—	—	—	—	—	—	—	—	—	LRA	
957	1,008	1,075	1,143	1,210	1,355	1,508	—	—	—	—	—	—	—	—	—	FLA	380
5,491	6,313	6,694	7,113	7,404	7,794	8,511	—	—	—	—	—	—	—	—	—	LRA	
909	958	1,021	1,086	1,150	1,287	1,433	—	—	—	—	—	—	—	—	—	FLA	400
5,780	6,645	7,046	7,487	7,794	8,204	8,959	—	—	—	—	—	—	—	—	—	LRA	
876	923	985	1,046	1,108	1,241	1,381	—	—	—	—	—	—	—	—	—	FLA	415
5,512	5,780	6,131	6,513	6,938	7,138	7,794	—	—	—	—	—	—	—	—	—	LRA	
110	116	124	132	139	156	174	187	202	217	233	256	267	306	344	382	FLA	3,300
693	725	744	819	875	871	1,135	1,135	1,135	1,415	1,415	1,415	1,667	1,591	2,231	2,481	LRA	

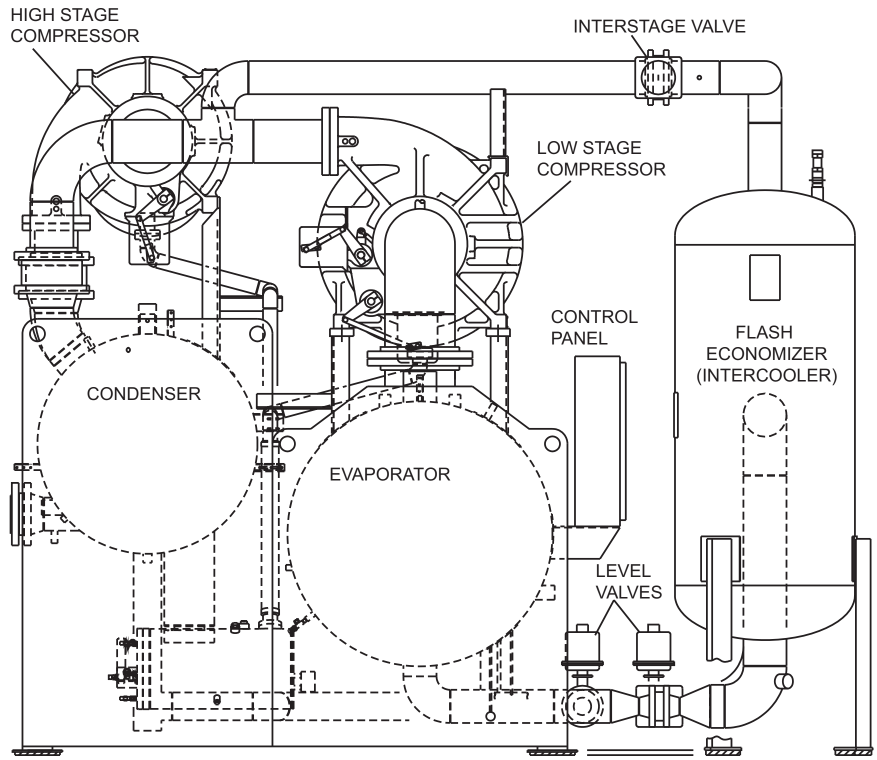
*Min. reduced voltage tap 80%.
** High voltage and special motor designs may not meet efficiency and P. F. shown for standard motors

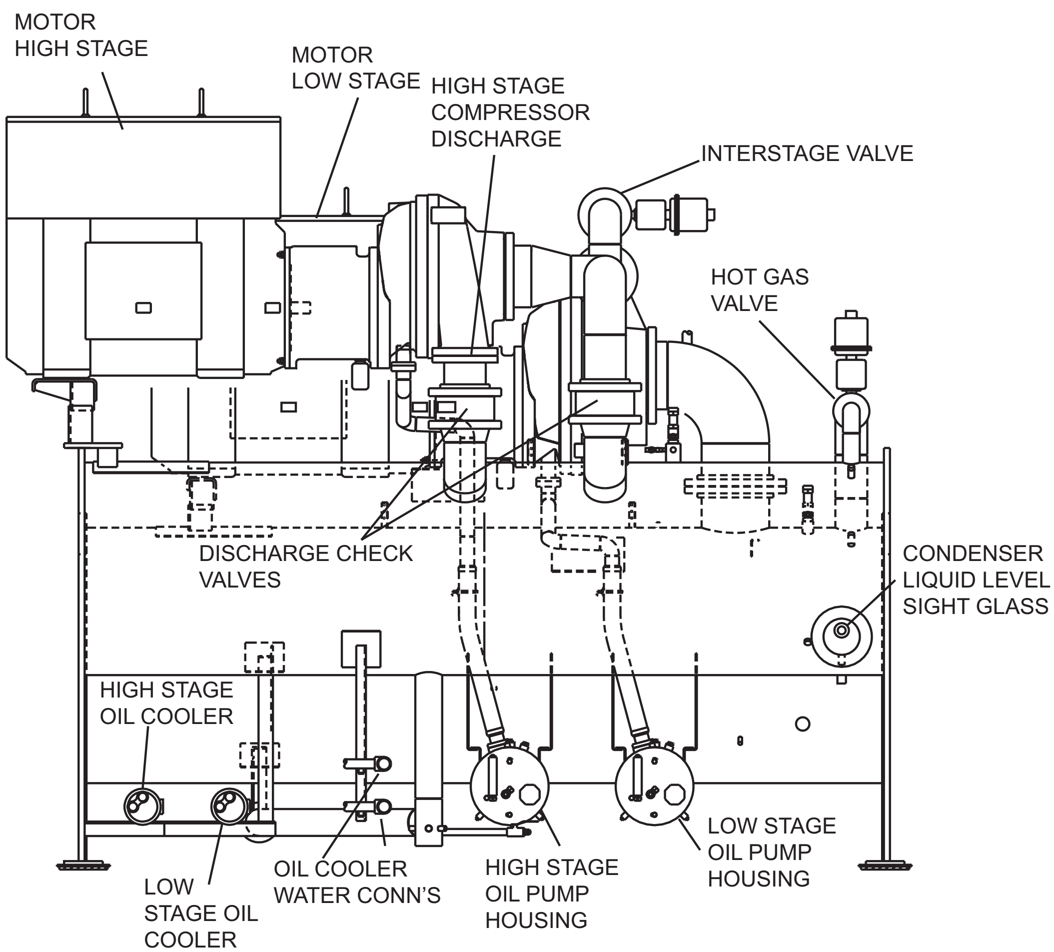
TABLE 5 – MOTOR STARTERS

TYPE STARTER	SOLID STATE STARTER	STAR DELTA	AUTO TRANSFORMER			ACROSS-THE-LINE	PRIMARY REACTOR	
VOLTAGE	LOW/MEDIUM	LOW	LOW	LOW/MEDIUM	LOW/MEDIUM	LOW/MEDIUM	MEDIUM	MEDIUM
60 HZ	200-4160	200-600	200-600	200-4160	200-4160	200-4160	2300-4160	2300-4160
50 HZ	380-3300	346-415	346-415	346-3300	346-3300	346-3300	2300-3300	2300-3300
TRANSITION	—	CLOSED	CLOSED	CLOSED	CLOSED	—	CLOSED	CLOSED
% TAP	—	—	57.7	65	80	—	65	80
INRUSH AS A % OF LRA	45	33	33	42.3	64	100	65	80

NOTE: Inrush less than 100% of full load amps (FLA).

Overall Chiller Arrangement





Note: See form 160.82-ES1 for chiller overall dimensioning.

Compact Nozzle Arrangements

EVAPORATOR COMPACT WATER BOXES

Shell Codes	1 Pass					2 Pass					3 Pass				
	Size	150LB		300LB		Size	150LB		300LB		Size	150LB		300LB	
		In / Out	Fig.	In / Out	Fig.		In / Out	Fig.	In / Out	Fig.		In / Out	Fig.	In / Out	Fig.
K	16	A / H	3A	A / H	3A	12	C / B	3B	C / B	3B	10	G / N	3D	G / N	3D
		H / A		H / A			K / J		K / J			P / F		P / F	
N, QQ, QR, QS, Q2, Q3, Q4	18	A / H	3E	A / H	3A	14	B / C	3F	C / B	3B	12	F / N	3G	G / N	3D
		H / A		H / A			C / B		K / J			N / F		P / F	
							J / K								
							K / J								
QT, QV	20	A / H	3E	A / H	3A	16	B / C	3F	C / B	3B	12	F / N	3G	G / N	3D
		H / A		H / A			C / B		K / J			N / F		P / F	
							J / K								
							K / J								
R, S, W, X, Z	20	A / H	3E	A / H	3A	18	B / C	3F	E / B	3C	14	F / N	3G	G / N	3D
		H / A		H / A			C / B		M / J			N / F		P / F	
							J / K		D / C						
							K / J		L / K						

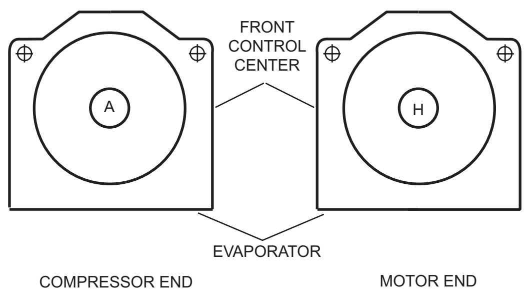


FIG. 3A – 1 PASS

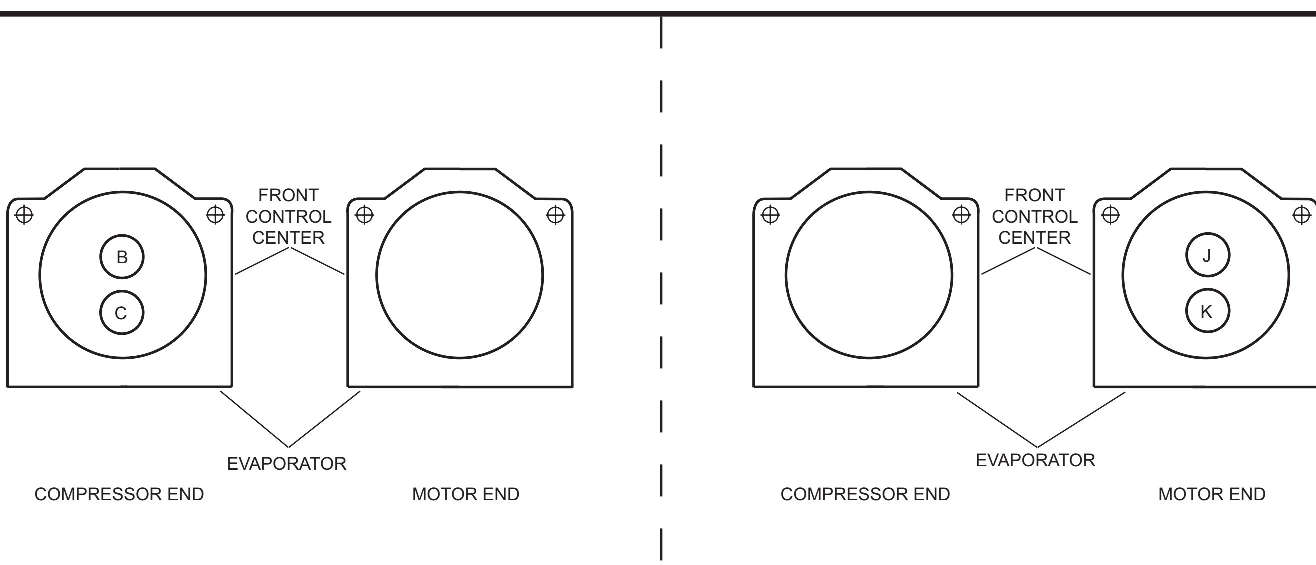


FIG. 3B – 2 PASS

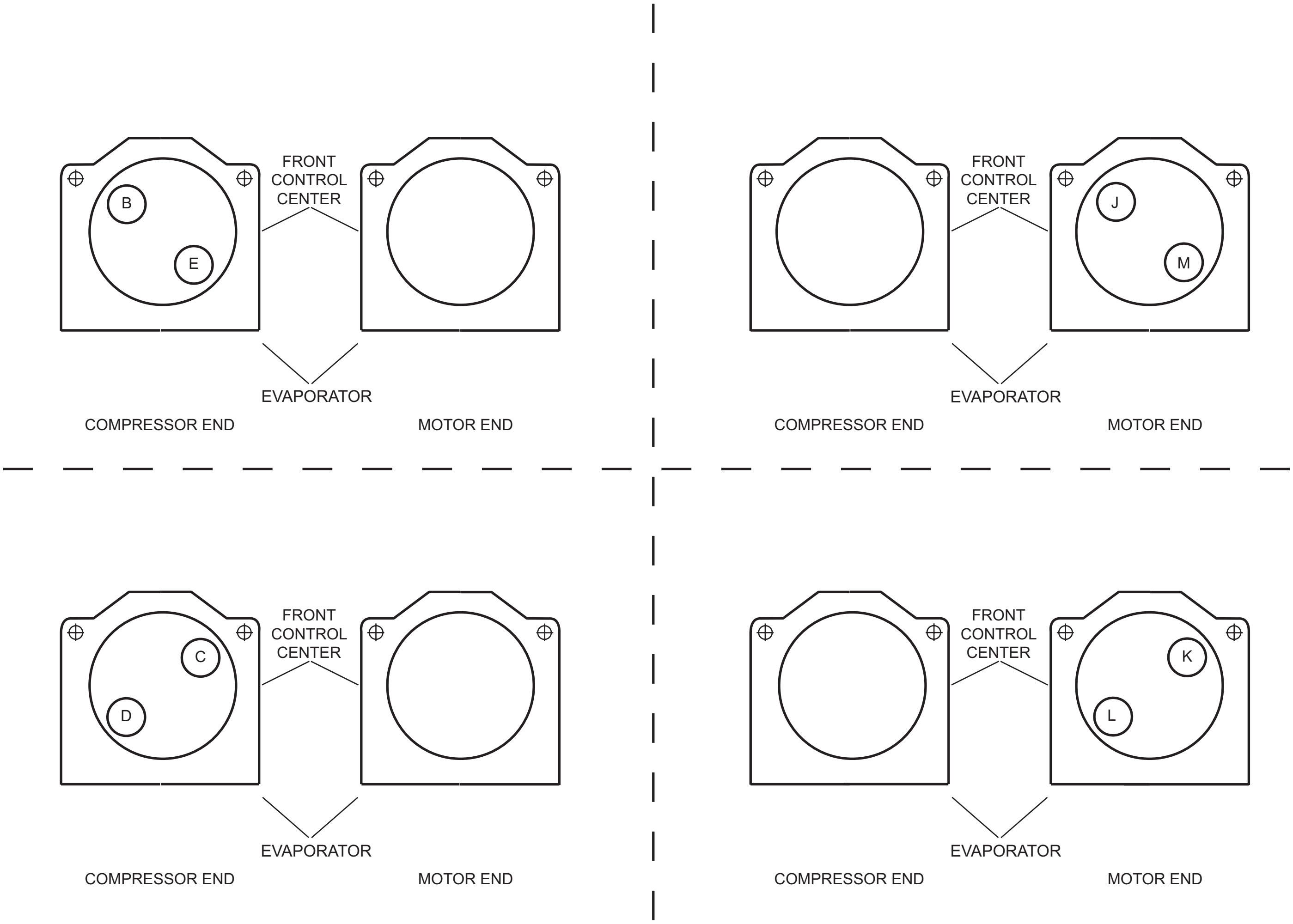


FIG. 3C – 2 PASS

Notes:

1. Standard water nozzles are Schedule 40 pipe size, furnished as welding stub-outs with ANSI/AWWA C-606 grooves, allowing the option of welding, flanges, or use of ANSI/AWWA C-606 couplings. Factory installed, Class 150 (ANSI B16.5, round slip-on, forged carbon steel with 1/16” raised face), water flanged nozzles are optional. Companion flanges, nuts, bolts and gaskets are not furnished.

2. One, two and three pass nozzle arrangements are available only in pairs shown. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles. Compact water boxes on one heat exchanger may be used with Marine water boxes on the other heat exchanger.

3. Water must enter the water box through the bottom connection to achieve rated performance.

4. Connected piping should allow for removal of compact water boxes for tube access and cleaning.

Compact Nozzle Arrangements – *continued*

EVAPORATOR COMPACT WATER BOXES

Shell Codes	1 Pass Size	1 Pass 150LB In / Out	1 Pass 150LB Fig.	1 Pass 300LB In / Out	1 Pass 300LB Fig.	2 Pass Size	2 Pass 150LB In / Out	2 Pass 150LB Fig.	2 Pass 300LB In / Out	2 Pass 300LB Fig.	3 Pass Size	3 Pass 150LB In / Out	3 Pass 150LB Fig.	3 Pass 300LB In / Out	3 Pass 300LB Fig.
K	16	A / H	3A	A / H	3A	12	C / B	3B	C / B	3B	10	G / N	3D	G / N	3D
		H / A		H / A			K / J		K / J			P / F		P / F	
N, QQ, QR, QS, Q2, Q3, Q4	18	A / H	3E	A / H	3A	14	B / C	3F	C / B	3B	12	F / N	3G	G / N	3D
		H / A		H / A			C / B		K / J			N / F		P / F	
							J / K								
							K / J								
QT, QV	20	A / H	3E	A / H	3A	16	B / C	3F	C / B	3B	12	F / N	3G	G / N	3D
		H / A		H / A			C / B		K / J			N / F		P / F	
							J / K								
							K / J								
R, S, W, X, Z	20	A / H	3E	A / H	3A	18	B / C	3F	E / B	3C	14	F / N	3G	G / N	3D
		H / A		H / A			C / B		M / J			N / F		P / F	
							J / K		D / C						
							K / J		L / K						

Note: This table is repeated from the previous page for convenience only.

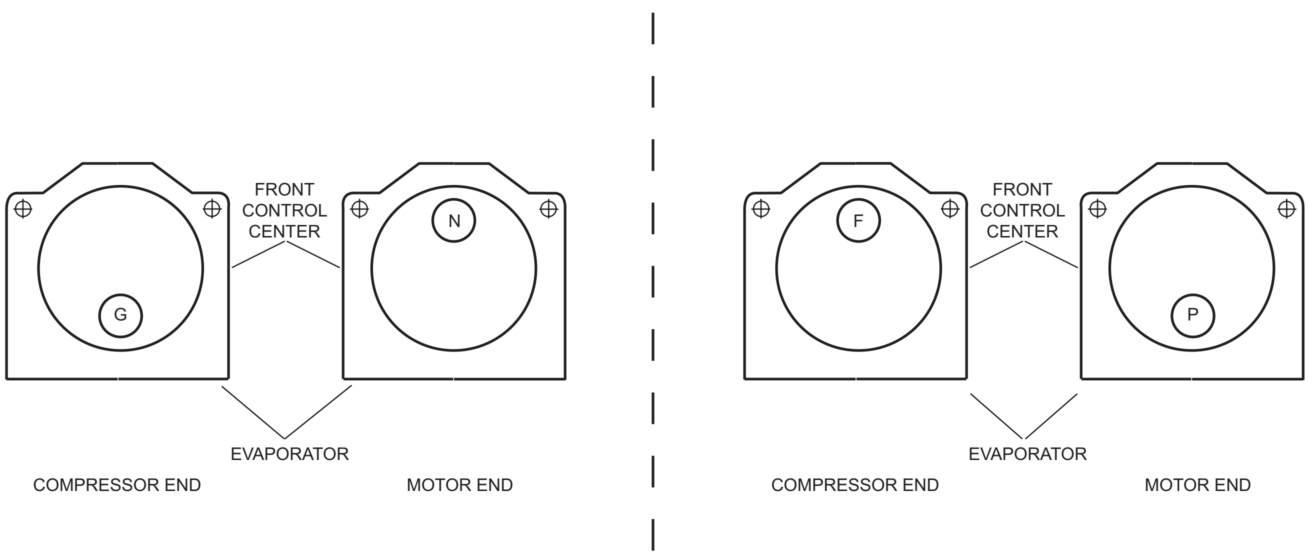


FIG. 3D – 3 PASS

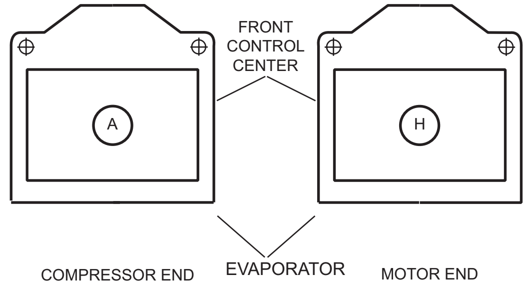


FIG. 3E – 1 PASS

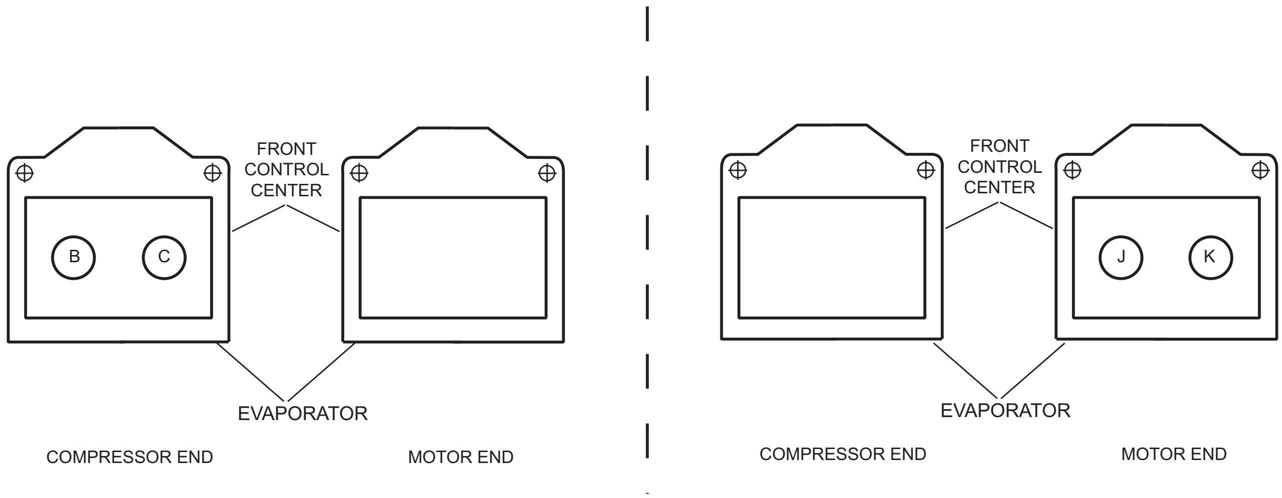


FIG. 3F – 2 PASS

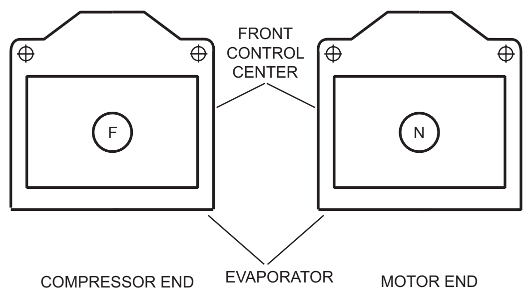


FIG. 3G – 3 PASS

Notes:

1. Standard water nozzles are Schedule 40 pipe size, furnished as welding stub-outs with ANSI/AWWA C-606 grooves, allowing the option of welding, flanges, or use of ANSI/AWWA C-606 couplings. Factory installed, Class 150 (ANSI B16.5, round slip-on, forged carbon steel with 1/16" raised face), water flanged nozzles are optional. Companion flanges, nuts, bolts and gaskets are not furnished.

2. One, two and three pass nozzle arrangements are available only in pairs shown. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles. Compact water boxes on one heat exchanger may be used with Marine water boxes on the other heat exchanger.

3. Water must enter the water box through the bottom connection to achieve rated performance.

4. Connected piping should allow for removal of compact water boxes for tube access and cleaning.

Compact Nozzle Arrangements – continued

CONDENSER COMPACT WATER BOXES

Shell Codes	1 Pass			2 Pass			3 Pass		
	Size	150LB / 300LB		Size	150LB / 300LB		Size	150LB / 300LB	
		In / Out	Figure		In / Out	Figure		In / Out	Figure
K	16			10			10		
N	20			14			10		
Q	20	P / Q or	3H	16	R / S or	3J	14	V / Y or	3K
R, S	20	Q / P		18	T / U		14	X / W	
W	24			18			16		
X, Z	24			20			16		

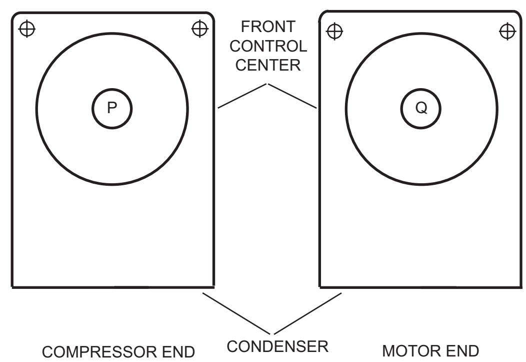


FIG. 3H – 1 PASS

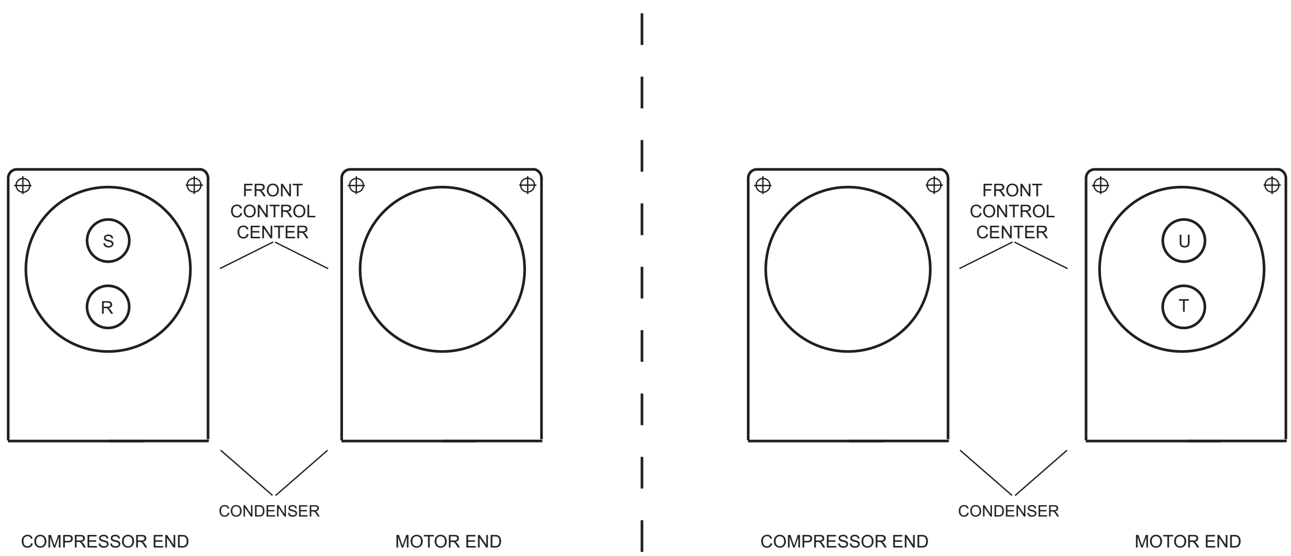


FIG. 3J – 2 PASS

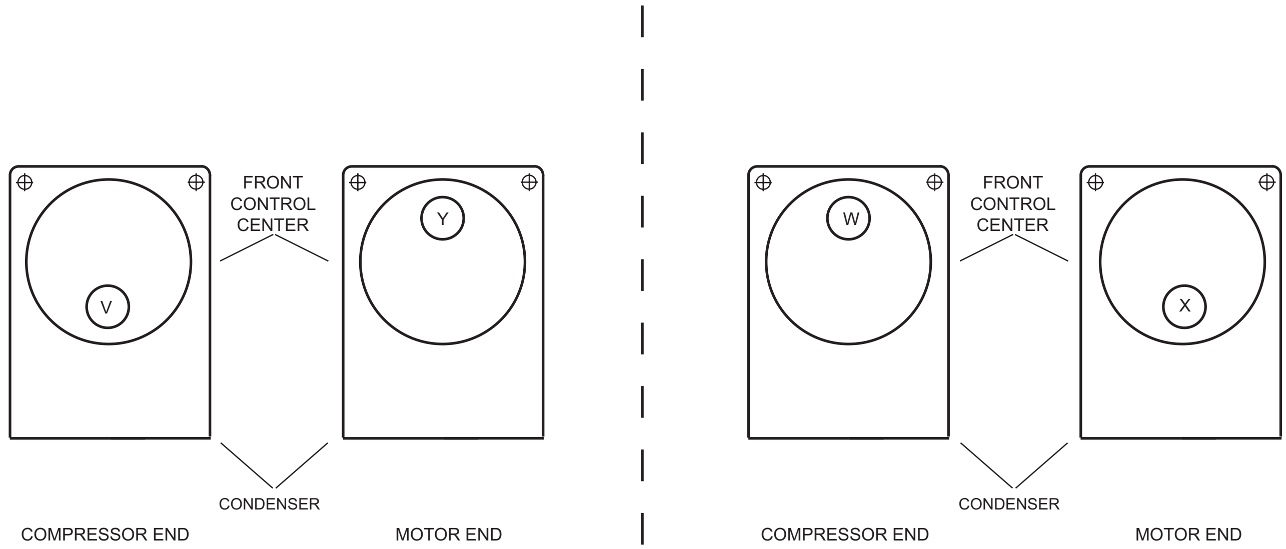


FIG. 3K – 3 PASS

Notes:

1. Standard water nozzles are Schedule 40 pipe size, furnished as welding stub-outs with ANSI/AWWA C-606 grooves, allowing the option of welding, flanges, or use of ANSI/AWWA C-606 couplings. Factory installed, Class 150 (ANSI B16.5, round slip-on, forged carbon steel with 1/16" raised face), water flanged nozzles are optional. Companion flanges, nuts, bolts and gaskets are not furnished.

2. One, two and three pass nozzle arrangements are available only in pairs shown. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles. Compact water boxes on one heat exchanger may be used with Marine water boxes on the other heat exchanger.

3. Water must enter the water box through the bottom connection to achieve rated performance.

4. Connected piping should allow for removal of compact water boxes for tube access and cleaning.

Marine Nozzle Arrangements

EVAPORATOR MARINE WATER BOXES									
Shell Codes	**1 Pass**			**2 Pass**			**3 Pass**		
	Size	**150 LB / 300 LB**		**Size**	**150 LB / 300 LB**		**Size**	**150 LB / 300 LB**	
		In / Out	**Figure**		**In / Out**	**Figure**		**In / Out**	**Figure**
K	16	1 / 6 or 6 / 1	4A	12	2 / 3 or 7 / 8	4B	10	5 / 10 or 9 / 4	4C
N, QQ, QR, QS, Q2, Q3, Q4	18			14			12		
QT, QV	20			16			12		
R, S, W, X, Z	20			18			14		

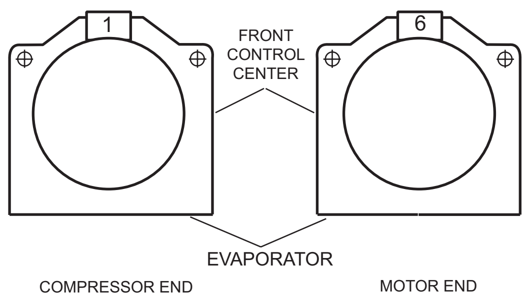


FIG. 4A – 1 PASS

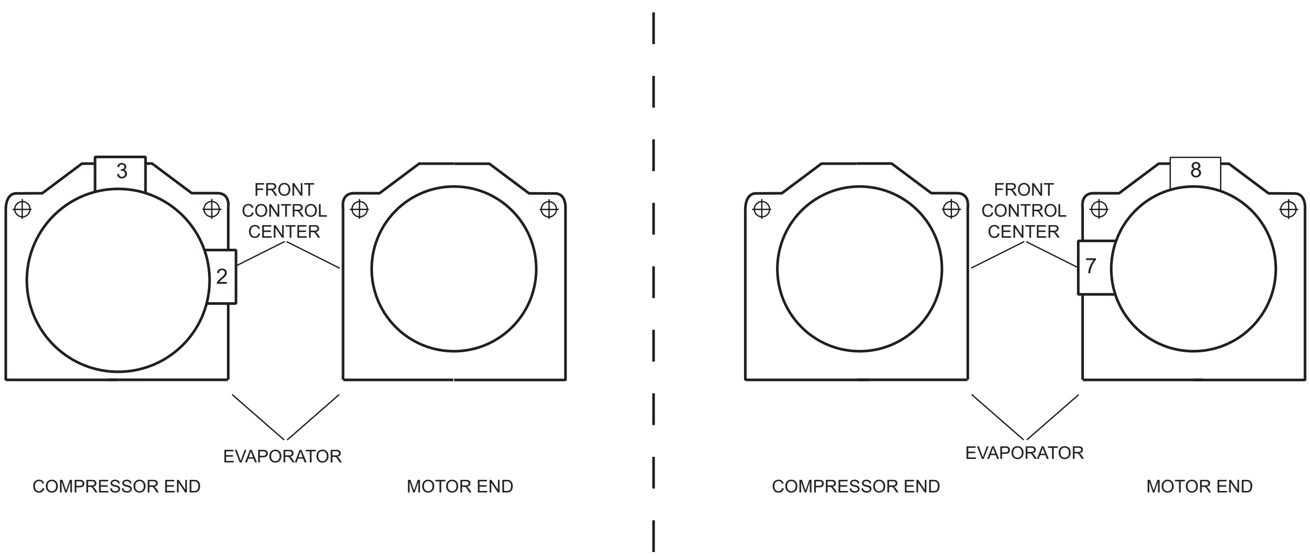


FIG. 4B – 2 PASS

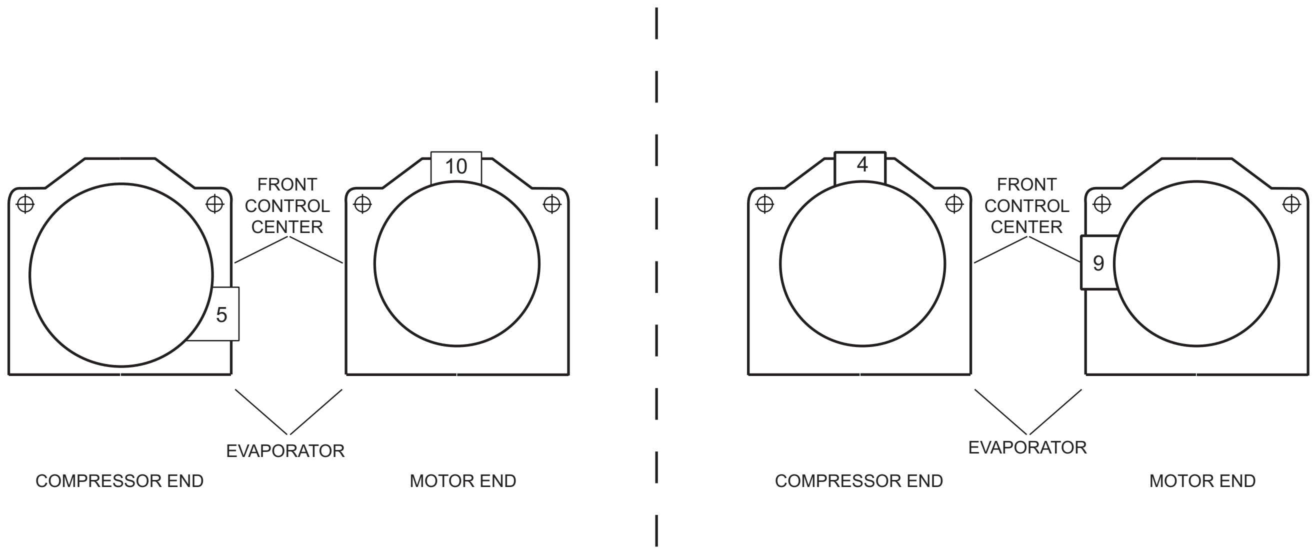


FIG. 4C – 3 PASS

Notes:

1. Standard water nozzles are Schedule 40 pipe size, furnished as welding stub-outs with ANSI/AWWA C-606 grooves, allowing the option of welding, flanges, or use of ANSI/AWWA C-606 couplings. Factory installed, Class 150 (ANSI B16.5, round slip-on, forged carbon steel with 1/16” raised face), water flanged nozzles are optional. Companion flanges, nuts, bolts and gaskets are not furnished.

2. One, two and three pass nozzle arrangements are available only in pairs shown. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles. Compact water boxes on one heat exchanger may be used with Marine water boxes on the other heat exchanger.

3. Water must enter the water box through the bottom connection to achieve rated performance.

4. Connected piping should allow for removal of compact water boxes for tube access and cleaning.

Marine Nozzle Arrangements – *continued*

CONDENSER MARINE WATER BOXES									
Shell Codes	1 Pass			2 Pass			3 Pass		
		150 LB / 300 LB		Size	150 LB / 300 LB		Size	150 LB / 300 LB	
	Size	In / Out	Figure		In / Out	Figure		In / Out	Figure
K	16	11 / 16 or 16 / 11	4D	10	12 / 13 or 17 / 18	4E	10	15 / 20 or 19 / 14	4F
N	20			14			10		
Q	20			16			14		
R, S	20			18			14		
W	24			18			16		
X, Z	24			20			16		

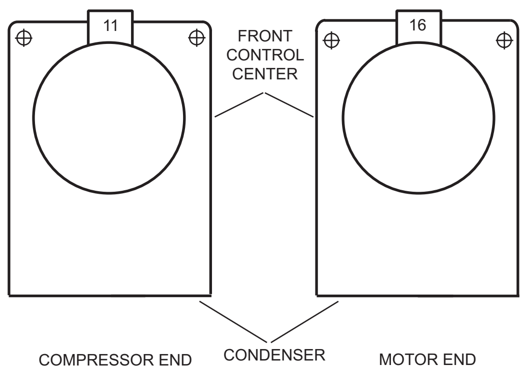


FIG. 4D – 1 PASS

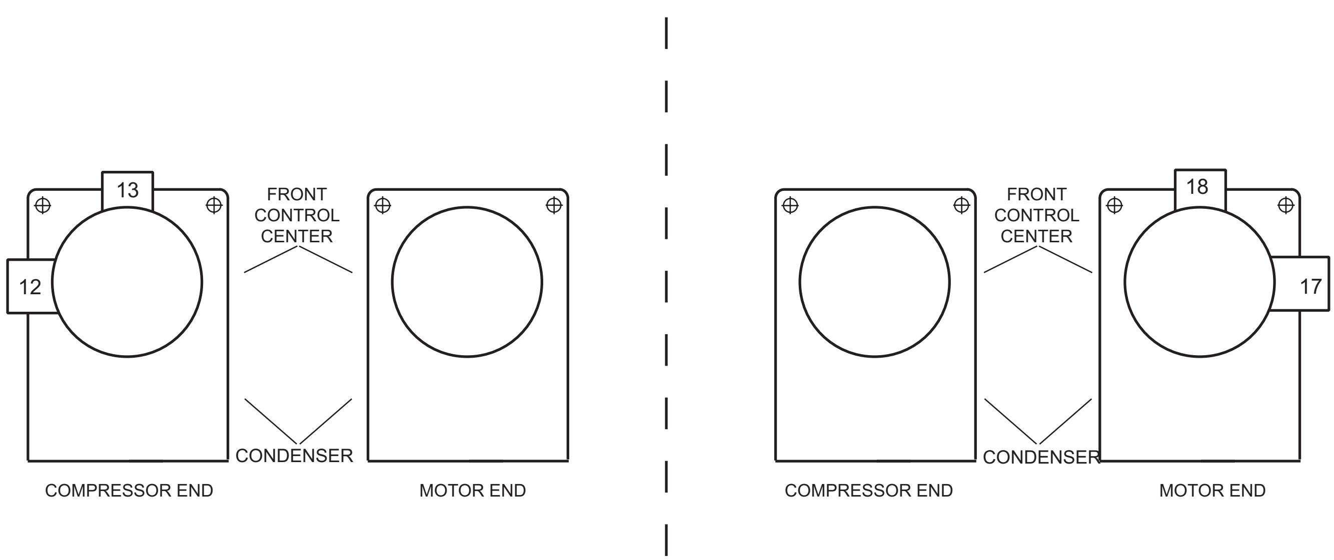


FIG. 4E – 2 PASS

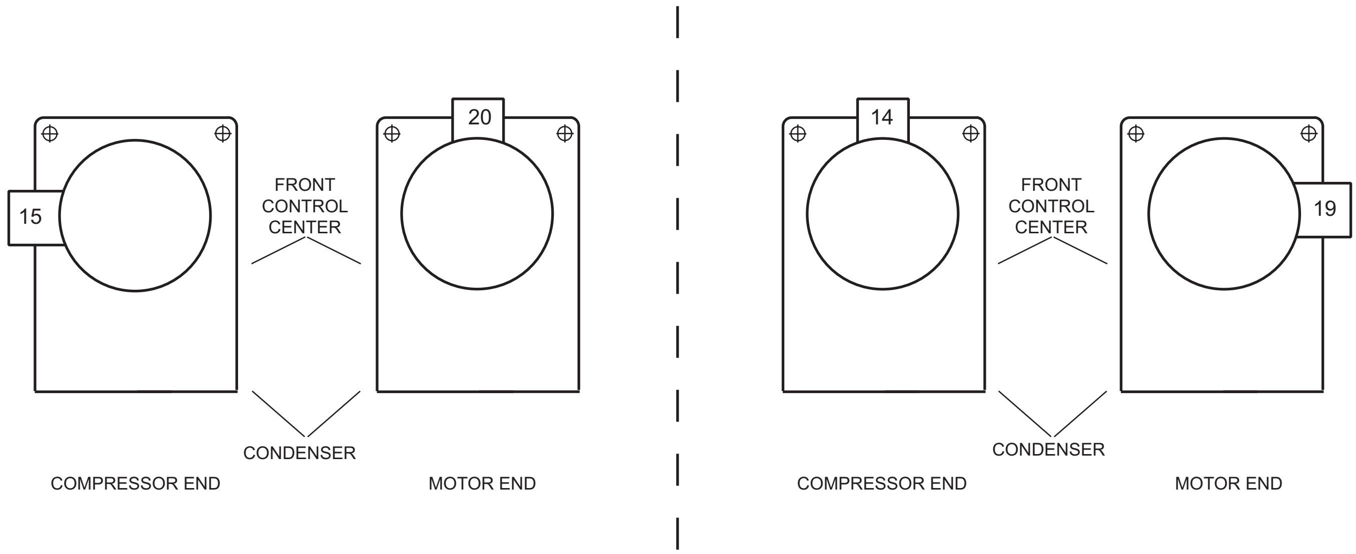


FIG. 4F – 3 PASS

Notes:

1. Standard water nozzles are Schedule 40 pipe size, furnished as welding stub-outs with ANSI/AWWA C-606 grooves, allowing the option of welding, flanges, or use of ANSI/AWWA C-606 couplings. Factory installed, Class 150 (ANSI B16.5, round slip-on, forged carbon steel with 1/16” raised face), water flanged nozzles are optional. Companion flanges, nuts, bolts and gaskets are not furnished.

2. One, two and three pass nozzle arrangements are available only in pairs shown. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles. Compact water boxes on one heat exchanger may be used with Marine water boxes on the other heat exchanger.

3. Water must enter the water box through the bottom connection to achieve rated performance.

4. Connected piping should allow for removal of compact water boxes for tube access and cleaning.

Guide Specifications

GENERAL

Furnish and install where indicated on the drawings____ YORK model CYK Compound Centrifugal Compressor Liquid Chilling Unit(s). Each unit shall produce a capacity of ____ tons, cooling ____ GPM of ____ from ____ °F to ____ °F when supplied with ____ GPM of condenser water at ____ °F. Total power input (two motors) shall not exceed ____ kW. The evaporator shall be selected for____ fouling factor and a maximum liquid pressure drop of ____ ft. Water side shall be designed for 150 PSIG working pressure. The condenser shall be selected for ____ fouling factor and maximum liquid pressure drop of ____ ft. Waterside shall be designed for 150 PSIG working pressure. Power shall be supplied to the compressor drive motors at ____ volts – 3-phase – (60)(50) Hertz. Auxiliary power to the oil pump motors and controls shall be supplied at___ volts – 3-phase – (60)(50) Hertz

(or)

Furnish and install where indicated on the drawings ___YORK model CYK Compound Centrifugal Compressor Liquid Chilling Unit(s). Each unit shall produce a capacity of ____ kW, cooling ____ L/S of ____ from ____ °C to ____ °C when supplied with ____ L/S of condenser water at ____°C. Total power input (two motors) shall not exceed ____ kW. The evaporator shall be selected for ____m^2°C/W fouling factor and maximum liquid pressure drop of ____kPa. Waterside shall be designed for 10.3 barg working pressure. The condenser shall be selected for ____ m^2°C/W fouling factor and maximum liquid pressure drop of ____ kPa. Waterside shall be designed for 10.3 barg working pressure.

Power shall be supplied to the compressor drive motors at ____ volts – 3-phase – (60)(50) Hertz. Auxiliary power to the oil pump motors and controls shall be supplied at ___ volts - 3-phase – (60)(50) Hertz.

Each unit shall be completely factory-packaged including evaporator, condenser, sub-cooler, compressors, flash economizer (intercooler), open motors, lubrication system, Control Center, and all interconnecting unit piping and wiring. The economizer is removed for shipment. Flanged joints are provided and all piping is prefabricated. The chiller shall be painted prior to shipment. The initial charge of oil and refrigerant shall be supplied, shipped in containers and cylinders for field installation or factory charged in the chiller when possible.

COMPRESSORS

Two centrifugal compressors shall be provided, operating in series and using a common refrigerant circuit on the chiller. Check valves will be supplied on the discharge of the low and high stage compressors to control refrigerant flow during single compressor low head operation and two compressor high head operation.

Each compressor shall be a single-stage centrifugal type, powered by an open-drive electric motor. The housing shall be fully accessible with vertical circular joints, with the complete operating assembly removable from the compressor and scroll housing. Compressor castings on the low stage shall be designed for a minimum 235 PSIG working pressure and hydrostatically pressure tested at a minimum of 352 PSIG. The high stage shall be designed for 235 or 350 PSIG as applicable, and hydrostatically pressure tested at a minimum of 1.3 times the design pressure. The rotor assembly shall consist of a heat-treated alloy steel drive shaft and impeller shaft with a cast aluminum, fully shrouded impeller. The impeller shall be designed for balanced thrust, dynamically balanced and over-speed tested for smooth, vibration-free operation. Insert-type journal and thrust bearings shall be fabricated of aluminum alloy, precision bored and axially grooved.

Internal single helical gears with crowned teeth shall be designed so that more than one tooth is in contact at all times to provide even load distribution and quiet operation. Each gear shall be individually mounted in its own journal and thrust bearings to isolate it from impeller and motor forces. Shaft seal shall be provided in double bellows, double-seal, cartridge type. A gravity-fed oil reservoir shall be built into the top of the compressor to provide lubrication during coast-down in the event of a power failure.

Capacity control shall be achieved by use of pre-rotation vanes to provide fully modulating control from full load to minimum load. Control shall automatically compensate for adverse operating conditions, such as fouled tubes, and adjust to prior operation after correction of these conditions. The unit shall be capable of continuous, reliable operation with low ECWT at all load conditions as outlined on the equipment schedule. An external electric actuator shall automatically control pre-rotation vane position for each compressor.

LUBRICATION SYSTEM

Lubrication oil shall be force-fed to all compressor bearings, gears, and rotating surfaces by variable speed oil pumps mounted in individual oil reservoirs. Each oil pump shall vary oil flow to its compressor based on operating and stand-by conditions, ensuring adequate lubrication at all times. The oil pump shall operate prior to start-up, during compressor operation and during coast-down.

Dual oil reservoirs, separate from the compressors, shall contain the 2 HP submersible oil pumps and 1500 watt immersion-type oil heaters for each compressor.

The oil heaters shall be thermostatically controlled to remove refrigerant from the oil. The oil reservoirs shall be designed and stamped in accordance with ASME or applicable pressure vessel code. A non-code reservoir is not acceptable.

Water-cooled oil coolers shall be provided after each oil pump, with factory installed water piping. A thermostatically controlled bypass valve shall maintain the required oil temperature supply from each oil cooler to its compressor.

Oil shall be filtered by externally mounted, 1/2 micron, replaceable cartridge oil filters, equipped with service valves. An automatic oil return system to recover any oil that may have migrated to the evaporator shall be provided. Oil piping shall be completely factory installed and tested.

MOTOR DRIVELINE

Each compressor motor shall be an open drip-proof, squirrel cage, induction type operating at 3570 rpm (2975 rpm for 50 Hz operation).

Each open motor shall be provided with a D-flange, bolted to a cast iron adaptor mounted on the compressor to allow the motor to be rigidly coupled to the compressor to provide factory alignment of motor and compressor shafts.
Each motor drive shaft shall be directly connected to its compressor shaft with a flexible disc coupling.The coupling shall have all metal construction with no wearing parts to assure long life, and no lubrication requirements to provide low maintenance. A large steel terminal box with gasketed front access cover shall be provided for field-connected conduit.

EVAPORATOR

Evaporator shall be of the shell-and-tube, flooded type designed for a minimum of 180 PSIG (1241 kPa) working pressure on the refrigerant side. Shell shall be fabricated from rolled carbon steel plates with fusion welded seams, carbon steel tube sheets, drilled and reamed to accommodate the tubes, and intermediate tube supports spaced no more than four feet apart. The refrigerant side of each shell is designed, tested and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII – Division I, or other pressure vessel code as appropriate.

Heat exchanger tubes shall be high-efficiency, externally and internally enhanced type. Tubes shall utilize the “skip-fin” design, providing a smooth internal and external surface at each intermediate tube support. This provides extra wall thickness and non-work hardened copper at the support location, extending the life of the heat exchangers. If skip-fin tubes are not used, minimum tube wall thickness shall be 0.035” (0.889 mm). Each tube shall be roller expanded into the tube sheets providing a leak-proof seal, and be individually replaceable. Water velocity through the tubes shall not exceed 12 ft./sec. (3.65 m/sec). A liquid level sight glass shall be provided on the side of the shell to aid in determining proper refrigerant charge and to check condition of the refrigerant charge. Aluminum mesh eliminators or baffles shall be located above the tube bundle to prevent liquid refrigerant carryover to the compressor. The evaporator shall have a refrigerant relief device sized to meet the requirements of the ASHRAE 15 Safety Code for Mechanical Refrigeration.

Water boxes shall be removable to permit tube cleaning and replacement. Stub-out water connections having ANSI/AWWA C-606 grooves shall be provided. Water boxes shall be designed for 150 PSIG (1034 kPa) design working pressure and be tested at 225 PSIG (1551 kPa). Vent and drain connections with plugs shall be provided on each water box. Low flow protection shall be provided by a thermal-type flow sensor, factory mounted in the water nozzle connection and wired to the chiller panel.

CONDENSER

Condenser shall be of the shell-and-tube type, designed for a minimum of 235 PSIG (1620 kPa) working pressure on the refrigerant side. Shell shall be fabricated from rolled carbon steel plates with fusion welded seams. Carbon steel tube sheets, drilled and reamed to accommodate the tubes, are welded to the end of each shell. Intermediate tube supports are drilled and reamed to eliminate sharp edges, fabricated from carbon steel plates. The refrigerant side of each shell is designed, tested and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII – Division I, or other pressure vessel code as appropriate.

Heat exchanger tubes shall be high efficiency, externally and internally enhanced type. Tubes shall utilize the “skip-fin” design, providing a smooth internal and external surface at each intermediate tube support. This provides extra wall thickness and non-work hardened copper at the support location, extending the life of the heat exchangers. If skip-fin tubes are not used, minimum tube wall thickness shall be 0.035” (0.889 mm). Each tube shall be roller expanded into the tube sheets providing a leak-proof seal, and be individually replaceable. Water velocity through the tubes shall not exceed 12 ft./sec. (3.65 m/sec.). A liquid level sight glass shall be provided on the side of the shell to aid in determining proper refrigerant charge and to check condition of the refrigerant charge. The condenser shall have dual refrigerant relief devices; each sized to meet the requirements of the ASHRAE 15

Safety Code for Mechanical Refrigeration. Arrangement shall allow either valve to be isolated and replaced without removing the unit refrigerant charge.

Water boxes shall be removable to permit tube cleaning and replacement. Stub-out water connections having ANSI/AWWA C-606 grooves shall be provided. Water boxes shall be designed for 150 PSIG (1034 kPa) design working pressure and be tested at 225 PSIG (1551 kPa). Vent and drain connections with plugs shall be provided on each water box. A thermal-type water flow sensor shall provide low flow protection, factory mounted in the water nozzle connection and wired to the chiller control panel.

FLASH ECONOMIZER (INTERCOOLER)

A single stage, vertical type, flash economizer (intercooler) shall be provided with internally mounted mesh eliminators, liquid spray pipe, an externally mounted (field installed) level transmitter and an external control valve. Economizer shall include eight sight glasses, two above and two below the mesh eliminators, two at the liquid spray pipe and two in liquid line leaving the economizer. A thermometer well shall be furnished for checking liquid temperature. Connections and field installed pressure transmitter and relief valve assemblies shall be provided for field installation. Support legs of structural steel tubing shall be provided with mounting brackets for optional spring type isolators.

CONTROL CENTER

General – The chiller is controlled by a stand-alone PLC based control center. The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays and switches. The chiller panel shall provide capacity control operation of the two series compressors in reponse to low entering condenser water and start-up requirements. The panel shall also allow the chiller to operate down to 0% evaporator load.

Control Panel – The control panel shall include a 10.4” color active matrix display with integral keypad for operator interface. The control panel shall be factory wired, unit mounted, Nema 12, gasketed enclosure. The panel shall be fabricated of 10 gauge steel and include full height front access doors. The panel enclosure shall be painted to match the chiller color on the outside, and gloss white on interior surfaces. All controls are arranged for easy access and internally wired to clearly marked terminal strips or pre-wired PLC interface modules for external wiring connections. Wiring shall be color-coded black (control), white (neutral), and green (ground), with each wire numerically identified at both ends with heat shrinkable wire markers. Wiring enclosed in shielded cables and pre-wired cables shall be color coded per the wiring diagram.

The screen shall detail all operations and parameters, using a graphical representation of the chiller and its components. Graphic screens shall provide for:

a. Chiller Overview
b. Evaporator
c. Condenser
d. Low stage compressor
e. High stage compressor
f. Motors
g. Capacity control diagram
h. Manual/Auto stations for all control outputs

The operator interface shall be programmed to provide display of all major operating parameters in both graphical and list type screen displays. PID control loop set points, and Manual/Auto functions shall be accomplished by the operator interface. Alarm indicators on the graphic display screen shall provide annunciation, and an alarm history screen to which show the most recent alarms, with the time and date of occurrence. Trip status screens shall be provided which show the values of all analog inputs at the time of the last five chiller safety shutdowns. The time and date of the shutdown should also be shown. Separate pushbuttons shall be provided on the face of the control panel for Chiller Start, Stop, Reset and Emergency Stop.

CAPACITY CONTROLS SYSTEM

The Capacity Control philosophy of the chiller control system shall allow efficient fully automated control, without need for operator intervention. This control system shall monitor and display all safety aspects of the chiller and provide alarms and a shutdown if safety limits are exceeded. If operator intervention is required, manual controls shall be provided on the electronic operator interface, for all electric actuators.

The capacity controls algorithm shall automatically seek out the most efficient operation of the chiller. The pre-rotation vanes are automated to obey the temperature controller to maintain chilled water production. In cases of low load, the pre-rotation vanes shall automatically throttle and be limited to a minimum anti-surge position. To provide light duty operation, the hot gas recycle valve shall be seamlessly throttled open according to temperature demands. This keeps the centrifugal compressor out of surge and maintains chilled water production.

In cases of high load, which exceeds the motor kilowatt (or current) usage, the capacity controls algorithm shall automatically unload the system to maintain a restriction on power consumption. In the same way, conditions of high discharge pressure or low suction pressure shall override the production of chilled water in the interests of keeping the chiller system online.

In cases of light load and low head, the high stage compressor shall be dropped offline, the flash economizer bypassed, and the unit will be run with the low stage compressor like a normal single-compressor chiller.

Analog Input List:

1. Low Stage Motor Current (% FLA)
2. High Stage Motor Current (% FLA)
3. Sub-cooler Refrigerant Liquid Level
4. Low Stage Oil Reservoir Oil Level
5. High Stage Oil Reservoir Oil Level
6. Evaporator Refrigerant Pressure
7. Condenser Refrigerant Pressure
8. Low Stage Compressor Low Oil Pressure
9. High Stage Compressor Low Oil Pressure
10. Low Stage Compressor High Oil Pressure
11. High Stage Compressor High Oil Pressure
12. Chilled Water-Out Temperature.
13. Chilled Water-In Temperature.
14. Condenser Water In Temperature
15. Condenser Water Out Temperature
16. Evaporator Refrigerant Liquid Temp.
17. Low Stage Compressor Refrigerant Discharge Temperature
18. High Stage Compressor Refrigerant Discharge Temperature
19. Sub-cooled Refrigerant Liquid Temperature
20. Low Stage Compressor Oil Temperature
21. High Stage Compressor Oil Temperature
22. Low Stage PRV Position
23. High Stage PRV Position
24. Low Stage Compressor high stage thrust Bearing Probe Gap
25. High Stage Compressor thrust bearing Probe gap
26. Flash Economizer (Intercooler) Pressure

Digital Inputs:

1. Chilled Water Low Flow Switch
2. Condenser Water Low Flow Switch
3. Low Stage Motor Starter Full Voltage (Run) Auxiliary Contact
4. High Stage Motor Starter Full Voltage (Run) Auxiliary Contact
5. Low Stage Motor Starter Safety Fault Lockout Relay
6. High Stage Motor Starter Safety Fault Lockout Relay
7. Condenser Refrigerant High Pressure Cutout
8. Low Stage Compressor Oil Heater Thermostat
9. HIGH STAGE Compressor Oil Heater Thermostat
10. LOW STAGE PRV Closed Limit Switch
11. HIGH STAGE PRV Closed Limit Switch
12. LOW STAGE Compressor V.S. Oil Pump Drive Faulted Contact
13. HIGH STAGE Compressor V.S. Oil Pump Drive Faulted Contact
14. Chiller Start
15. Chiller Stop
16. System Reset
17. Emergency Stop

Analog Output List

1. Hot Gas Bypass Valve
2. Low Stage Compressor, V.S. Oil Pump Drive Control
3. High Stage Compressor, V.S. Oil Pump Drive Control
4. Variable Orifice Valve
5. Inter-stage Valve
6. Bypass Level Control valve output LCV-117

Digital Output List

1. Low Stage Liquid Line Solenoid Valve
2. High Stage Liquid Line Solenoid Valve
3. High Stage Oil Return Solenoid
4. Low Stage Oil Return Solenoid Valve
5. Low Stage Compressor Oil Heater Contactor
6. High Stage Compressor Oil Heater Contactor
7. Low Stage Compressor Motor Start/Stop Control Relay
8. High Stage Compressor Motor Start/Stop Control Relay
9. Low Stage Compressor Oil Pump Start/Stop Relay
10. High Stage Compressor Oil Pump Start/Stop Relay
11. Oil Level Control Pump Start/Stop Relay
12. Start-up Bypass Valve Open/Close Relay
13. Open Low Stage PRV
14. Open High Stage PRV
15. Close Low Stage PRV
16. Close High Stage PRV

Security

Security access to prevent unauthorized change of setpoints, to allow local or remote control of the chiller, and to allow manual operation of the pre-rotation vanes and oil pump shall be provided. Access shall be through ID and password recognition, which is defined by three different levels of user experience: operator, service and programming.

OVER-CURRENT PROTECTION

The Variable Speed Oil Pump Panel shall include a fused connection through a transformer to provide individual over-current protected power for all controls.

PLANT MANAGEMENT/CONTROL SYSTEM INTERFACE:

Ethernet I/P (Ethernet Industrial Protocol) is the preferred LAN (Local Area Network) between Local Chiller Control Panels. Ethernet I/P allows full management of the Allen-Bradley system from a central location.

All required analog and discrete data for communications will be arranged in blocks of IEEE Floating Point and 16-bit words within the Logix processor's data tables. All data is available remotely as read only values. The following write-able control signals are available. Remote Start, Remote Stop, Remote Leaving Chilled Water Setpoint, and Remote Demand Limit Setpoint.

Available Network Protocols

Media	Protocol
Cat-5 twisted pair	Ethernet Industrial Protocol www.ethernet-ip.org
RS-232	Allen-Bradley DF1 Full Duplex
RS-232	Modbus RTU Slave

Any protocol/media requirements not listed here must be called out on the factory order form.

Available protocols will be implemented with a Johnson Controls **eLink** module* or **Prolinx** gateway** where applicable:

- Modbus RTU over RS-485**
- Modbus over TCP/IP**
- BACnet MS/TP*
- BACnet/IP*
- LONworks*
- Profibus**
- ControlNet
- Allen-Bradley DH-485

Check appropriate protocol and include this document attached to the Factory Order Form.

All communication interface wiring and hardware, which is required external to the chiller control panel, will be supplied and installed by the electrical installation contractor under another contract.

REMOTELY MOUNTED COMPRESSOR MOTOR-STARTER (OPTION)

A remotely mounted starter shall be furnished for each compressor motor. The starter shall be furnished in accordance with the chiller manufacturer's starter specifications R-1151, and as specified elsewhere in these specifications.

PORTABLE REFRIGERANT STORAGE / RECYCLING SYSTEM (OPTION)

A portable, self-contained refrigerant storage/recycling system shall be provided consisting of a refrigerant compressor with oil separator, storage receiver, water-cooled condenser, filter drier and necessary valves and hoses to remove, replace and distill refrigerant. All necessary controls and safety devices shall be a permanent part of the system.

SI Metric Conversion

Values provided in this manual are in the English inch-pound (I-P) system.
The following factors can be used to convert from English to the most common SI Metric values.

MEASUREMENT	MULTIPLY THIS *ENGLISH* VALUE	BY	TO OBTAIN THIS *METRIC* VALUE
CAPACITY	TONS REFRIGERANT EFFECT (ton)	3.516	KILOWATTS (kW)
POWER	KILOWATTS (kW)	NO CHANGE	KILOWATTS (kW)
	HORSEPOWER (hp)	0.7457	KILOWATTS (kW)
FLOW RATE	GALLONS / MINUTE (gpm)	0.0631	LITERS / SECOND (L/s)
LENGTH	FEET (ft)	304.8	MILLIMETERS (mm)
	INCHES (in)	25.4	MILLIMETERS (mm)
WEIGHT	POUNDS (lb)	0.4536	KILOGRAMS (kg)
VELOCITY	FEET / SECOND (fps)	0.3048	METERS / SECOND (m/s)
PRESSURE DROP	FEET OF WATER (ft)	2.989	KILOPASCALS (k Pa)
	POUNDS / SQ. INCH (psi)	6.895	KILOPASCALS (k Pa)

TEMPERATURE

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

To convert a temperature range (i.e., 10°F or 12°F chilled water range) from Fahrenheit to Celsius, multiply by 5/9 or 0.5556.

EFFICIENCY

In the English I-P system, chiller efficiency is measured in kW / ton:

$$\text{kW / ton} = \frac{\text{kW input}}{\text{tons refrigerant effect}}$$

In the SI Metric system, chiller efficiency is measured in Coefficient of Performance (COP).

$$\text{COP} = \frac{\text{kW refrigeration effect}}{\text{kW input}}$$

kW / ton and COP are related as follows:

$$\text{kW/ton} = \frac{3.516}{\text{COP}}$$

$$\text{COP} = \frac{3.516}{\text{kW/ton}}$$

FOULING FACTOR

ENGLISH I-P (fl^2 °F hr/Btu)	EQUIVALENT SI METRIC (m^2 k/kW)
0.0001	.018
0.00025	.044
0.0005	.088
0.00075	.132

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