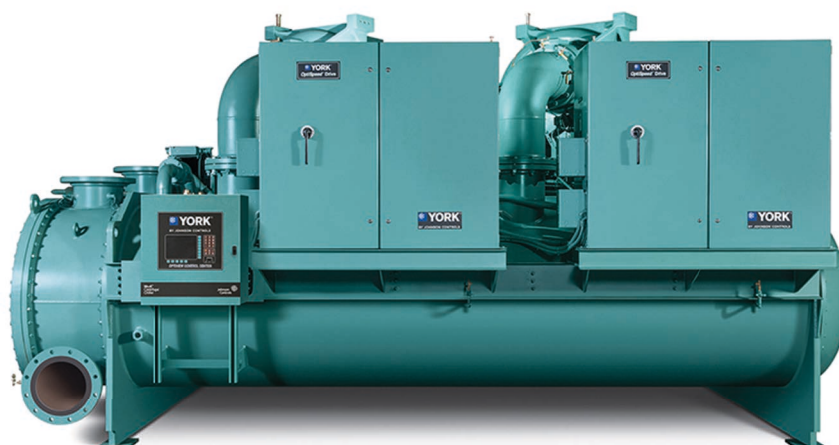




Model YD Style D Dual Centrifugal Liquid Chillers

1,500 ton to 6,000 ton (5,000 kW to 21,000 kW), with R-134a, R-513A, R-515B, and R-1234ze Refrigerant



Engineering Guide

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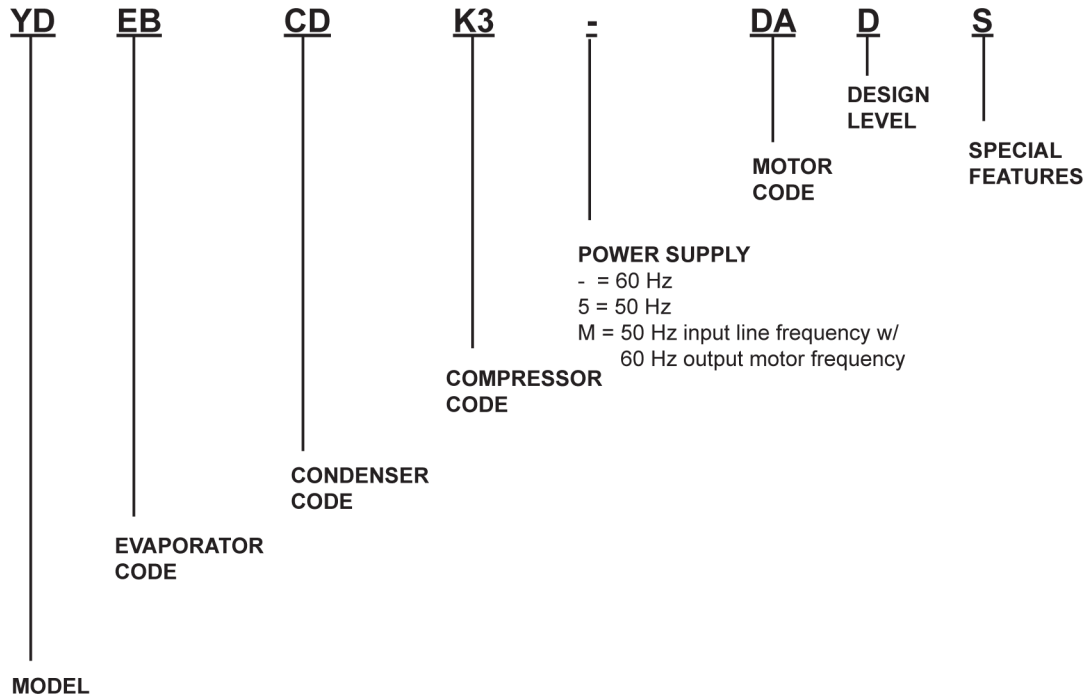
Supersedes: 160.79-EG1 (124)



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Nomenclature



Approvals

- ASME Boiler and Pressure Vessel Code – Section VIII Division 1.
- AHRI Standard 550/590 (up to 3,000 tons or 10,500 kW).
- c/UL: Underwriters Laboratory
- ASHRAE 15 – Safety Code for Mechanical Refrigeration.
- ASHRAE Guideline 3 – Reducing Emission of Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems.
- NEC – National Electrical Code.
- OSHA – Occupational Safety and Health Act.

Due to the configurability of this product, images contained in this document are illustrations and may represent the standard product with available options.

Introduction

YORK® YD™ chillers offer a complete combination of features for total owner satisfaction. The YD line of chillers uses two YORK centrifugal compressors operating in parallel on a common set of heat exchanger shells to obtain large chiller capacities and efficient part load operation.

Matched components maximize efficiency

Actual chiller efficiency cannot be determined by analyzing the theoretical efficiency of any one chiller component. It requires a specific combination of heat exchanger, compressor, and motor performance to achieve the lowest system kW/ton. YORK YD chiller technology matches chiller system components to provide maximum chiller efficiency under actual – not just theoretical – operating conditions.

Real-world energy performance

Johnson Controls® pioneered the term Real World Energy to illustrate the energy saving potential of focusing on chiller performance during off-design conditions. Off-design is not only part load, but full load operation as well, with reduced entering condenser water temperatures (ECWTs). Where chillers operate 99% of the time, operating costs add up.

YORK YD chillers are designed to operate on a continuous basis with cold ECWTs and full condenser flow at all load points, taking full advantage of real-world conditions. This type of operation benefits the cooling tower as well by reducing cycling of the fan motor and ensuring sufficient coverage of the cooling tower fill.

The YD dual compressor chiller provides further energy savings by running in single compressor mode to achieve the optimal operational performance. At part loads below 40%, only one compressor runs, as the chiller operates more efficiently by running a single more fully loaded compressor. Between 40% and 60% part load, the second compressor may be on or off depending on best performance. Part loads above 60% require both compressors to share the load. The two compressors share a common refrigerant circuit, thereby utilizing the full heat transfer surface available for part load single compressor operation.

YORK YD chillers offer the most efficient real-world operation of any chiller, meaning lower operating costs and an excellent return on your chiller investment.

Open drive design

Hermetic- motor burnout can cause catastrophic damage to a chiller. The entire chiller must be cleaned and the refrigerant replaced. YORK YD centrifugal chillers eliminate this risk by using air cooled motors. The refrigerant never comes in contact with the motor, which prevents 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.

The YD chiller uses two motors, each approximately half the size of a motor used on an equivalently-sized single compressor chiller. By staggering the start of these motors, the starting in-rush current of each smaller motor is less, for electromechanical and solid state starters only. This provides a lower burden on the building electrical system. Using two smaller motors also allows low voltage compressor drive motors to be applied on larger chillers. This can be an advantage for applications where medium voltage power sources are not available.

High-efficiency heat exchangers

YD chiller heat exchangers use the latest technology in heat transfer surface design, resulting in maximum efficiency and a 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 made by Johnson Controls, YORK YD centrifugal chillers incorporate single-stage compressor design. With fewer moving parts and straightforward, efficient engineering, YORK single-stage compressors have proven durability records in the U.S. Navy, hospitals, chemical plants, gas processing plants, 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. The vanes are precisely positioned and tightly fitted, allowing the compressor to unload smoothly from 100% to minimum load for excellent operation in air-conditioning 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 ensures oil pressure at the outlet of the pump rather than at the compressor, and allows no adjustment during chiller operation. YD chillers feature two variable speed oil pumps (VSOP), one for each compressor, to monitor and provide the correct 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 at the speed required, rather than at full head with a pressure regulating bypass valve.

Factory packaging reduces field labor costs

YORK YD centrifugal chillers are designed to keep installation costs low. Installation access might be a problem, so the H9, K1, and K2 compressor size YD dual compressor chillers may be shipped using Form 2, Form 3, or Form 7 methods.

- Form 2 shipment: Allows the chiller to be shipped completely packaged as one assembly.
- Form 3 shipment: Requires the two drivelines to be shipped separately from the shells as three major assemblies.
- Form 7 shipment: When installation requirements are non-trivial and to ensure that the evaporator and condenser shells are split apart, separated from the two drivelines into four major assemblies

① **Note:** To save on shipping and rigging costs, larger K3, K4, and K7 compressor size units mandate the use of Form 7 shipment.

The following occurs in all three shipping methods:

- The refrigerant and oil charges are shipped separately
- The connections are closed or flanged
- The wiring connections are simple plug-type to ensure a simple chiller commissioning using a starter

- The heat exchanger refrigerant sides are charged with nitrogen

Take advantage of colder cooling tower water temperatures

YORK YD 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 full load and full condenser flow, as some chillers require. 50°F (10°C) is used as the rule of thumb in many scenarios depending on the conditions, but this minimum ECWT should be validated using the formula in [Water circuits](#).

Off-design performance

Because the vast majority of its operating hours are spent at off-design conditions, a chiller should be chosen not to meet the full load design, but also for its ability to perform efficiently at lower loads and lower tower water temperatures. It is common for chillers with the same full load kW/ton to have an operating cost difference of over 10% due to part-load operation.

Part load information can be easily and accurately generated by use of the computer. Because it is so important to an owner's operating budget, this information has now been standardized in the AHRI Certification Program in the form of an Integrated Part Load Value (IPLV), and Non Standard Part Load Value (NPLV).

The IPLV/NPLV formulas from AHRI Standard 550/590 more closely track actual chiller operations. A more detailed analysis must take into account actual building load profiles, and local weather data. Obtain part load performance data for each job using its own design criteria.

AHRI certification program

YORK YD chillers have been tested and certified by Air Conditioning, Heating and Refrigeration Institute (AHRI) in accordance with the latest edition of AHRI Standard 550/590 (I-P) and 551/591 (up to 3,000 ton or 10,550 kW). Under this Certification Program, chillers are regularly tested in strict compliance with this Standard. This provides an independent, third-party verification of chiller performance. Refer to the AHRI site at <http://www.ahrinet.org/WCCCL> for complete program scope, inclusions, and exclusions, because some options listed in this document fall outside the scope of the AHRI certification program. For verification of certification, go to the AHRI Directory at <http://www.ahridirectory.org>.

UL compliance: Your assurance of reliability

YORK YD centrifugal chillers conform to UL standards for listing by a qualified nationally recognized testing laboratory for the United States and Canada. Recognition of safety and reliability is your assurance of trouble free performance in day-to-day building operation. Some chiller options or modifications may affect the UL compliance of the chiller. Some examples include:

- Special motor enclosures, such as TEFC, TEWAC, or TEAAC
- Special panels, such as NEMA 4X
- Special unit wiring options, anything other than NEMA 1

For further clarification, contact your local Johnson Controls Sales Office.

Computerized performance ratings

Each chiller is custom matched to meet the individual building load and energy requirements. Several 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.

Sustainability

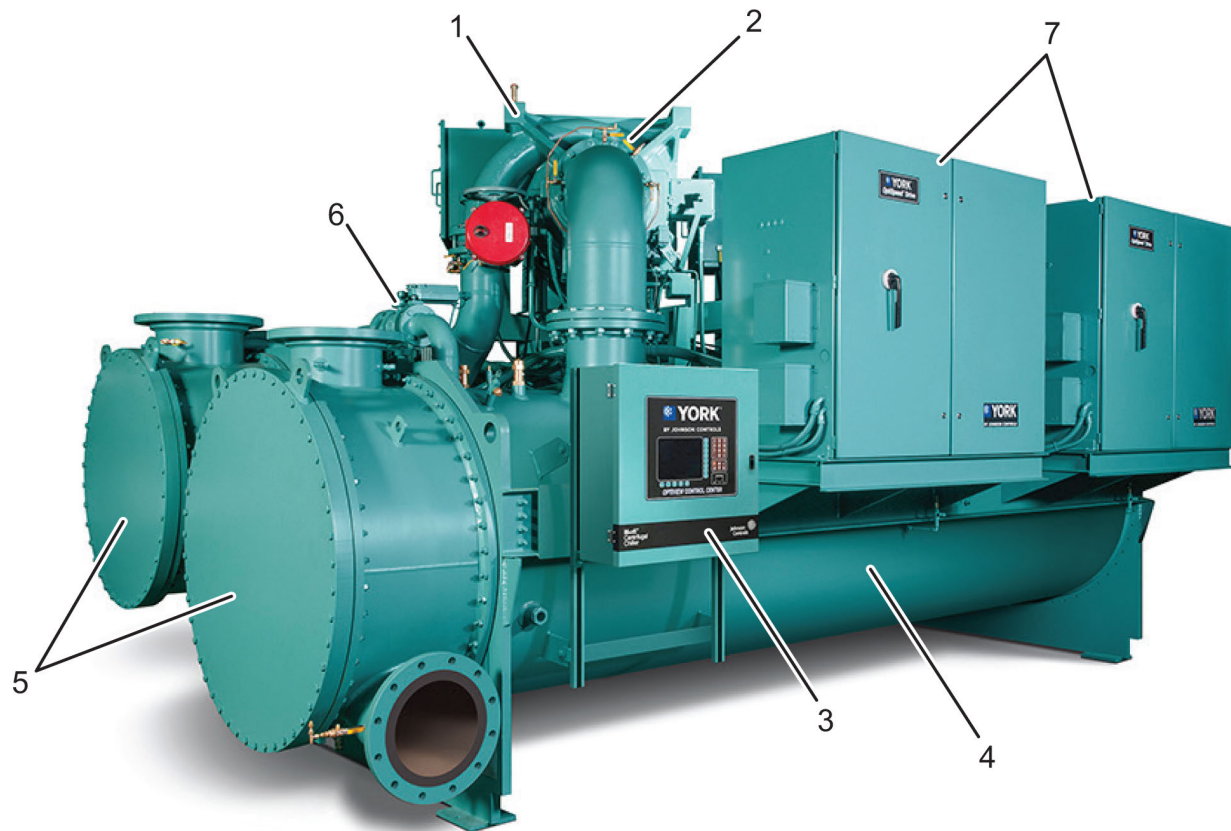
Over 95% of the global-warming potential (GWP) of a centrifugal chiller comes from the indirect effect or the greenhouse gases generated in the production of electricity to run the chiller. Less than 5% of the GWP is from the direct effect or release of the refrigerant gases into the atmosphere.

To combat the direct effect, the YD chiller employs the most environmentally friendly medium pressure refrigerants available, R-134a, R-513A, R-515B, and R-1234ze, in accordance with the Montreal Protocol. Using R-134a, R-513A, R-515B, and R-1234ze provides options to achieve better results based on customer and local regulatory requirements when using the US Green Building Council's (USGBC) Template EAc4 (Enhanced Refrigerant Management) to calculate the refrigerant impact of your project.

The YD chiller is also designed for efficient performance to reduce the indirect effect. The YD chiller uses less energy, which reduces the greenhouse gases generated in the production of electricity to run the chiller. This can help qualify your project for up to two more LEED points using the advanced refrigerant-management credit.

Unit components

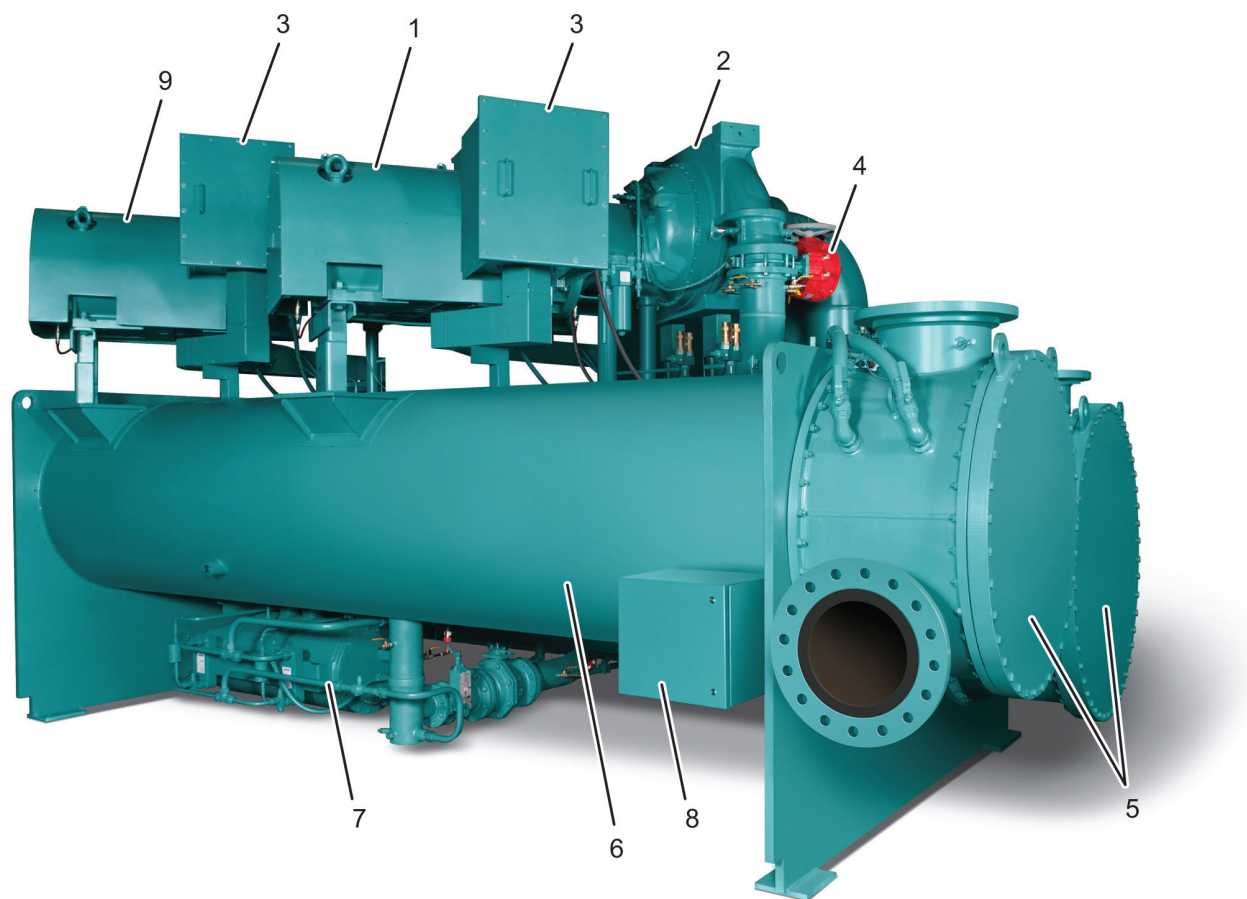
Figure 1: Chiller front view



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Component	Description
1	System 1 motor
2	System 1 compressor
3	OptiView control panel
4	Evaporator
5	Marine waterboxes, optional
6	Hot gas bypass, optional
7	Unit mounted starters and drives, optional

Figure 2: Chiller back view



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Component	Description
1	System 1 motor
2	System 1 compressor
3	Terminal box
4	Discharge isolation valve
5	Marine waterbox
6	Condenser
7	Oil sump housing
8	Variable speed oil pump control panel
9	System 2 motor

Equipment overview

YORK YD Centrifugal Liquid Chillers are completely factory packaged including the evaporator, condenser, compressor, motor, lubrication system, and all interconnecting unit piping and wiring. Larger YD chillers, such as K3, K4, and K7 compressors, are disassembled for shipment.

The initial charge of refrigerant and oil is supplied for each chiller, and is shipped separately from the unit. Actual shipping procedures depends on a number of project specific details.

A Johnson Controls factory-trained or field service representative must supervise or perform the following:

- Final leak testing
- Charging
- Initial start up
- 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. The 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.

Compressor discharge valves

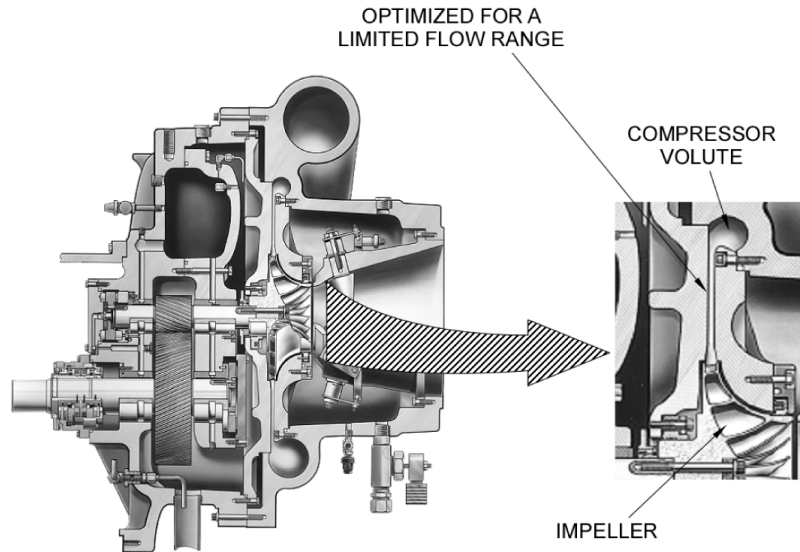
Automated valves are provided in the discharge of each compressor. The discharge valve ensures that there is no backspin of the non running compressor when the chiller is in single compressor operating mode. These valves are cycled by the control panel during the start and stop sequence of the lag (second) compressor.

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 by an average of 7 dBA, and up to 13 dBA on the largest models, far superior to competitors' sound levels. It can also reduce part load sound levels below the full load level.

In addition, the OptiSound Control provides 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.

Figure 3: Typical optimized centrifugal compressor



Capacity control

Pre-rotation vanes (PRV) in each compressor modulate chiller capacity from 100% to 10% of design for normal air conditioning applications. An electric PRV actuator automatically controls the vane position to maintain a constant leaving chilled liquid temperature. Rugged airfoil shaped cast manganese bronze vanes are precisely positioned by solid vane linkages connected to the electric actuator.

Both compressors are operated when needed to satisfy building load, for part loads above 60%. At loads below 40%, a single compressor is able to handle the load more efficiently. Between 40% and 60%, one or two compressors operate, depending on operational performance.

For units equipped with variable speed drives, the capacity control is achieved by the combined use of variable speed control and PRVs to provide fully modulating control from maximum to minimum load. For each condition, the speed and the PRV position is automatically optimized to maintain a constant leaving chilled liquid temperature.

Lubrication system

Lubrication oil is force-fed to all bearings, gears and rotating surfaces by a variable speed oil pump (VSOP), which operates before start-up, continuously during operation and during coastdown. 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.

A common oil reservoir, which is separate from the compressor, contains a submersible oil pump, a 2 hp (1.5 kW) pump motor and immersion type oil heater for each compressor. Two 2.7 hp (2 kW) immersion oil heaters are provided, and a thermostatically controlled expansion valve maintains the required oil temperature supply from each oil cooler to its compressor. The heaters are thermostatically controlled from the sump oil temperature sensor. Oil is filtered by an externally mounted, 1/2 μ m, replaceable cartridge oil filter equipped with service valves. Oil is cooled by a refrigerant-cooled oil cooler, eliminating the requirement for field water piping. The oil side of the oil cooler is provided 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. Motors rated at 60 Hz operate at 3,570 rpm. Motors rated at 50 Hz operate at 2,975 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. Overload and over current transformers are furnished with remote mounted electromechanical starters only. For chillers supplied with solid state starters or variable speed drives, the current transformers are supplied inside the starter and drive panels.

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 4 ft (1.2 m) 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.

Tubes: Heat exchanger tubes are state-of-the-art, high-efficiency, internally and externally enhanced type to provide optimum performance. Tubes in both the evaporator and condenser are 3/4 in. (19 mm) O.D. standard or 1 in. (25.4 mm) O.D. copper alloy. The tubes use the skip-fin design, providing a smooth internal and external surface at each intermediate tube support. This provides extra wall thickness (nearly 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 leakproof 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 are located above the tube bundle to prevent liquid refrigerant carryover into the compressor. A 2 1/4 in. (57 mm) diameter 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 relief valve or valves set at 180 psig (1.34 MPa). A 1 in. (25 mm) refrigerant charging valve is provided.

Condenser: The condenser is a shell-and-tube type, with discharge gas diffuser to prevent direct high velocity impingement on the tubes. The diffusers provide dynamic pressure recovery and enhanced chiller efficiency. An integral sub-cooler is located at the bottom of the condenser shell providing highly effective liquid refrigerant subcooling for the highest cycle efficiency. The condenser contains redundant refrigerant relief valves set at 235 psig (1.72 MPa).

Waterboxes: Standard waterboxes are compact type and fabricated of steel. The design working pressure is 150 psig (1.14 MPa) and the boxes are tested at 225 psig (1.65 MPa). Integral steel water baffles are located and welded within the waterbox to provide the required pass arrangements. Stub-out water nozzle connections with ANSI/AWWA C-606 couplings grooves are welded to the waterboxes. These nozzle connections are suitable for ANSI/AWWA C-606 couplings, welding or flanges, and are capped for shipment. Plugged 3/4 in. (19 mm) drain and vent connections are provided in each waterbox, except for marine waterboxes with vertical nozzles where there are

drain connections only. Although compact waterboxes are installed on standard units, marine waterboxes are available. See [Accessories and modifications](#) for details.

Isolation mounting

The unit is provided with vibration isolation mounts of nominal 1 in. (25 mm) operating height. The pads have a neoprene pad to contact the foundation, bonded to a steel plate. The vibration isolation pad assemblies are mounted under steel plates fixed to the chiller tube sheets.

Refrigerant flow control

Refrigerant flow to the evaporator is controlled by the YORK variable orifice control system. Liquid refrigerant level is continuously monitored to provide optimum subcooler, condenser and evaporator performance. The variable orifice electronically adjusts to all real-world operating conditions, providing the most efficient and reliable operation of refrigerant flow control.

Refrigerant isolation valves

Factory-installed isolation valves in the compressor discharge line and refrigerant liquid line are available for the chiller. This allows isolation and storage of the refrigerant charge in the chiller condenser during servicing, eliminating time-consuming transfers to remote storage vessels. Both valves are positive shut-off, ensuring integrity of the storage system.

Refrigerant containment

The standard unit is a complete and compact factory-packaged chiller. It has minimum joints from which refrigerant can leak. The entire assembly has been thoroughly leak tested at the factory before shipment. The YORK chiller includes service valves conveniently located to facilitate transfer of refrigerant to a remote refrigerant storage and recycling system.

Paint

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

Shipment

YORK YD centrifugal chillers are designed to keep installation costs low. Installation access might be a problem, so the H9, K1, and K2 compressor size YD dual compressor chillers can be shipped using Form 2, Form 3, or Form 7 methods.

- Form 2: The chiller is shipped completely packaged as one assembly
- Form 3: The two drive lines are shipped separately from the shells as three major assemblies
- Form 7: The evaporator and condenser shells are split apart, shipped separately from the two drive lines in four major assemblies

① **Note:** To save on shipping and rigging costs, larger K3, K4, and K7 compressor size units mandate the use of Form 7 shipment.

The following occurs in all three shipping methods:

- Refrigerant and oil charges are shipped separately
- Connections are closed or flanged
- Wiring connections are simple plug-type to ensure a simple chiller commissioning using a starter
- Heat exchanger refrigerant sides are charged with nitrogen

Water flow switches

Thermal-type water flow switches are factory-mounted in the chilled and condenser water nozzles, and are factory-wired to the OptiView 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.

System flow diagram

Figure 4: Refrigerant flow through the chiller (flooded evaporator)

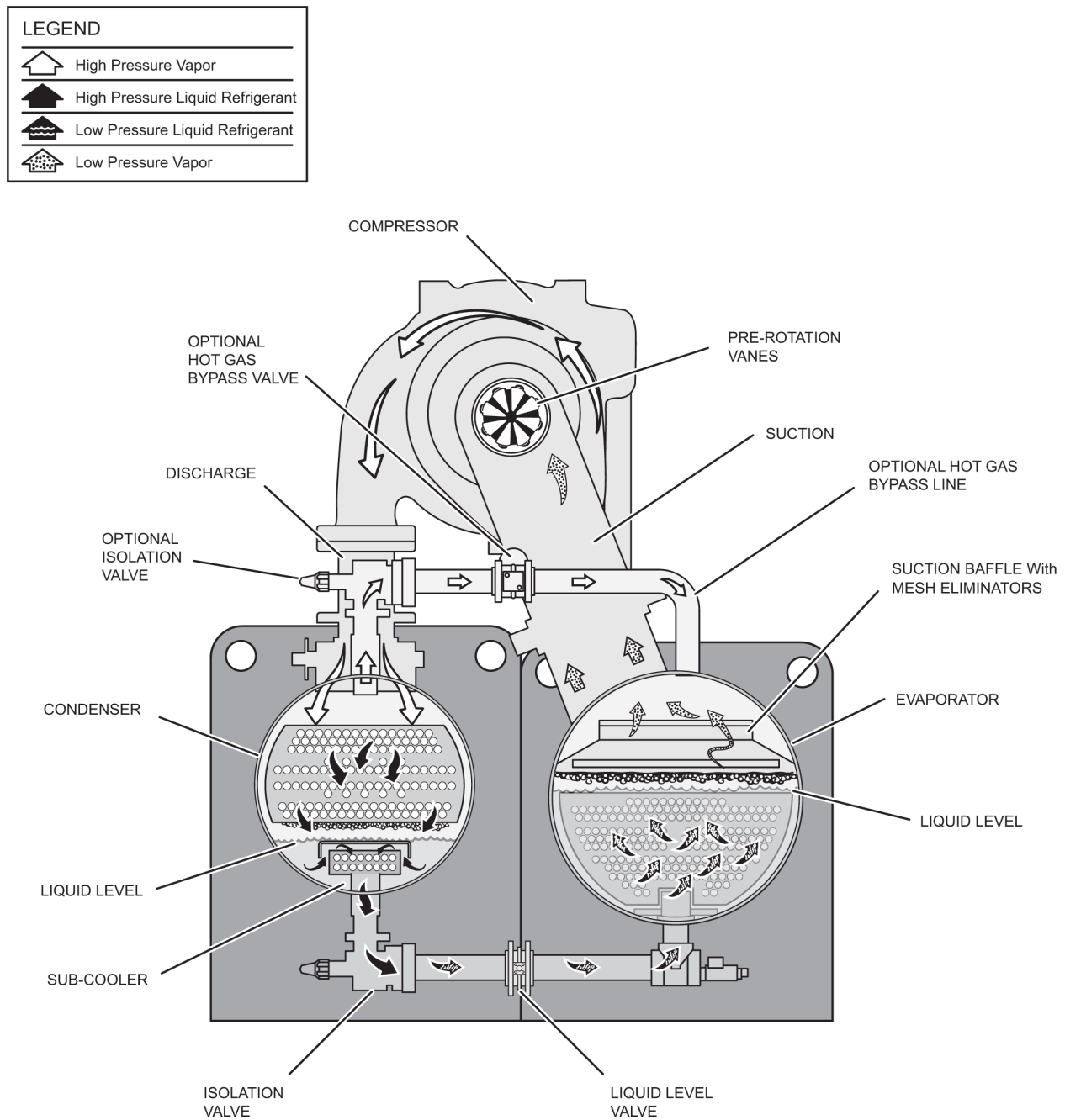
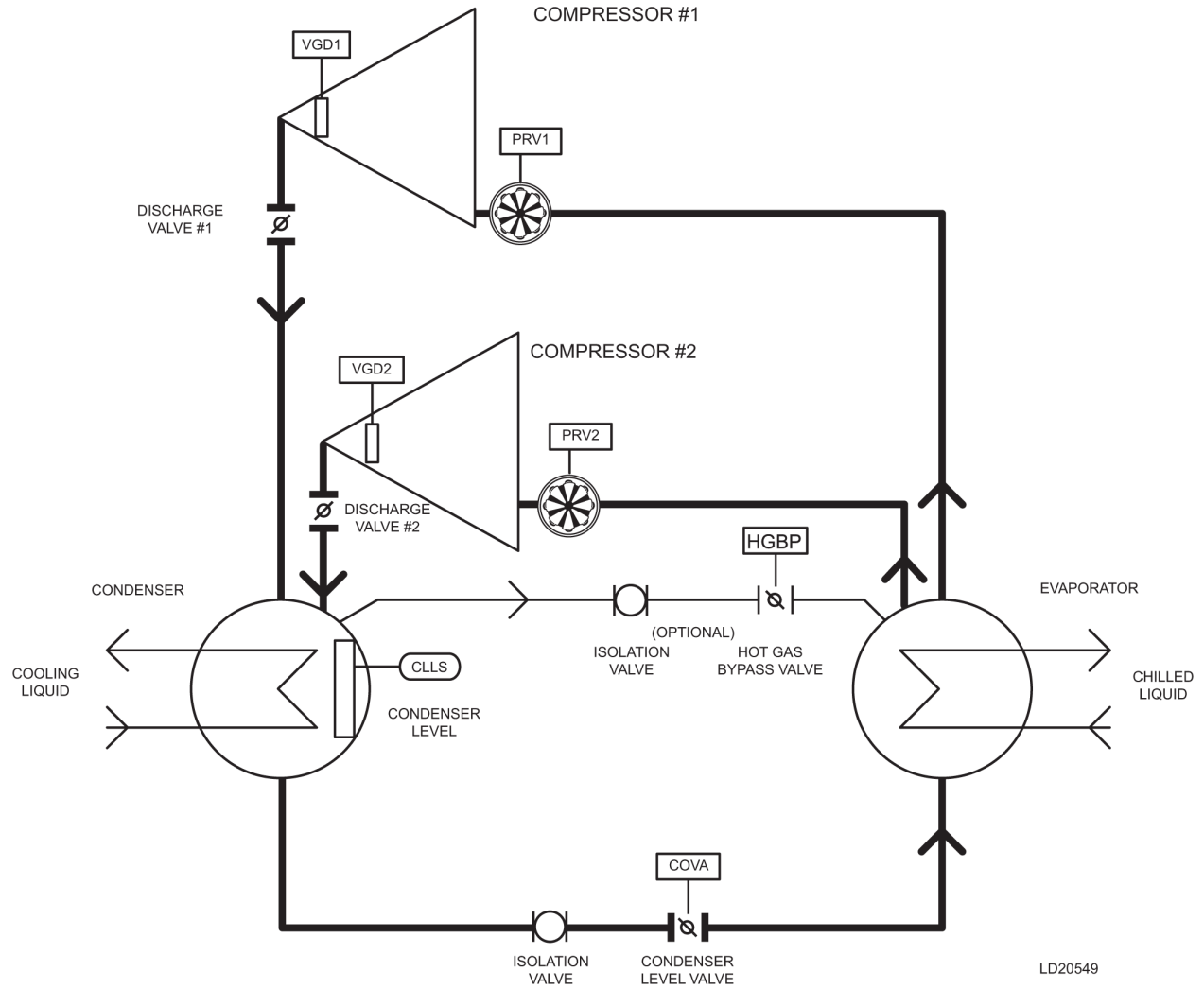


Figure 5: Refrigerant instrumentation diagram



OptiView™ Control Center

- ① **Note:** Refer to the OptiView Control Center Operator's Manual, (Form 160.70-03), for a complete description of features and functionality.

The YORK OptiView Control Center is a factory-mounted, wired and tested microprocessor based control system for centrifugal chillers. For the YD, it controls the leaving chilled liquid temperature and limits the motor current through control of the variable geometry diffuser (VGD) and if used, the variable speed drive.

Figure 6: OptiView Control Center



The panel comes configured with a full screen LCD graphic display mounted in the middle of a keypad interface with soft keys, which are redefined with one keystroke based on the screen displayed at the time. The graphic display allows the presentation of several operating parameters at once. In addition, the operator may view a graphical representation of the historical operation of the chiller and the present operation. The locations of various chiller parameters are clearly and intuitively marked. Instructions for specific operations are provided on many of the screens. To prevent unauthorized changes of setpoints and operating conditions, security access is provided with three different levels of access and passwords.

The graphic display also allows information to be represented in both Imperial (temperatures in °F and pressures in psig) and Metric (temperatures in °C and pressures in kPa) mode. The control center displays multiple languages.

The Control Center continually monitors the system operation and records the cause of any shutdowns, either safety, cycling, or normal. This information is recorded in memory and is preserved even through a power failure condition. The user may recall it for viewing at any time. During operation, the user is continually advised of the operating conditions by various status and warning messages. In addition, it may be configured to notify the user of certain conditions via alarms.

The Control Center expands the capabilities of remote control and communications. By providing a common networking protocol through the Building Automation System (BAS), YORK chillers not only work well individually, but also as a team. This new protocol allows increased remote control of the chiller and 24-hour performance monitoring through a remote site. In addition, compatibility is maintained with the present network of BAS communications. The chiller also

maintains the standard digital remote capabilities. Both of these remote control capabilities allow for the standard Energy Management System (EMS) interface:

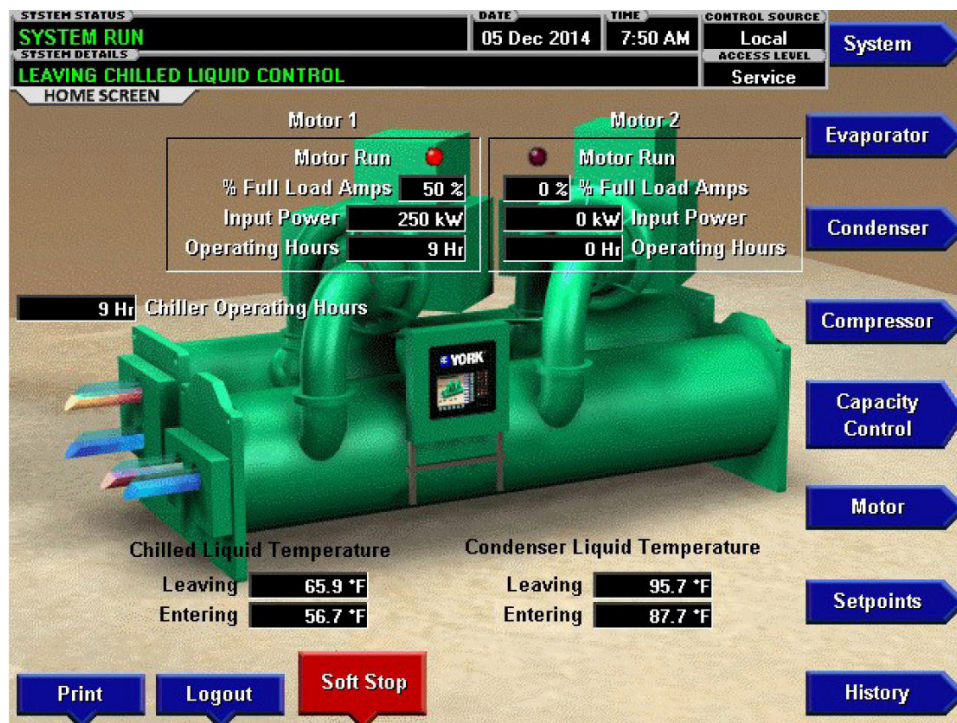
- Remote run/start
- Remote leaving chilled liquid temperature setpoint adjustment (0 VDC to 10 VDC, 2 VDC to 10 VDC, 0 mA to 20 mA, or 4 mA to 20 mA) or pulse-width modulation (PWM).
- Remote current limit setpoint adjustment (0 VDC to 10 VDC, 2 VDC to 10 VDC, 0 mA to 20 mA, or 4 mA to 20 mA, or PWM)
- Remote ready to start Contacts
- Safety shutdown contacts
- Cycling shutdown contacts

The following sections outline examples of the information displayed on some of the more important screens.

System screen

The system screen gives a general overview of common chiller parameters.

Figure 7: System screen

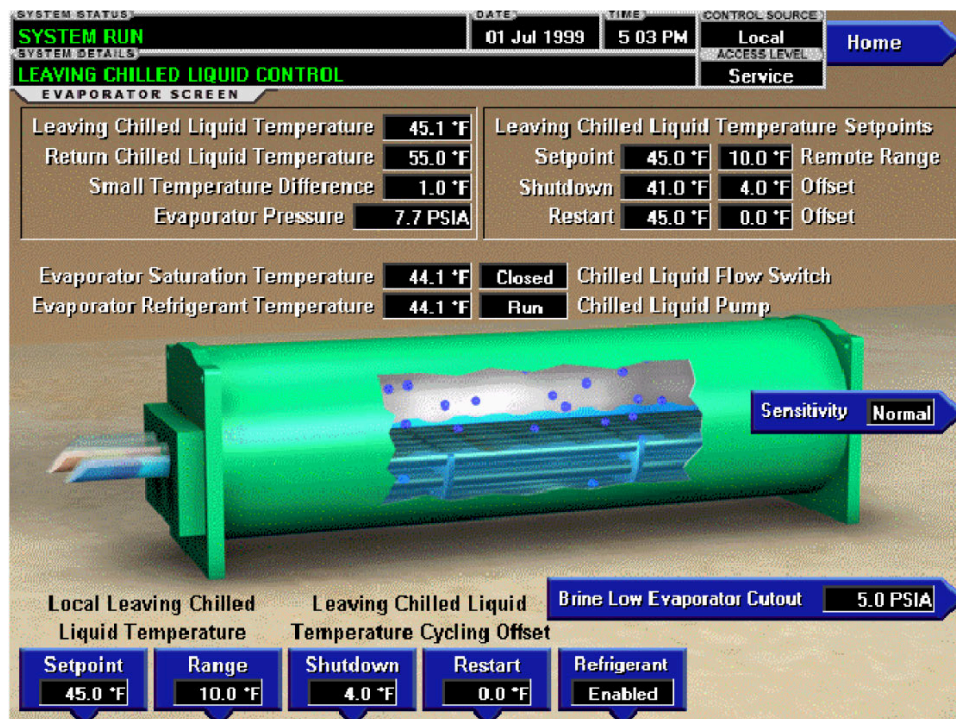


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Evaporator screen

The evaporator screen displays a cutaway view of the chiller evaporator. All setpoints relating to the evaporator side of the chiller are maintained on this screen. Animation of the evaporation process indicates whether the chiller is presently in a RUN condition (bubbling) and liquid flow in the pipes is indicated by alternating shades of color moving in and out of the pipes.

Figure 8: Evaporator screen

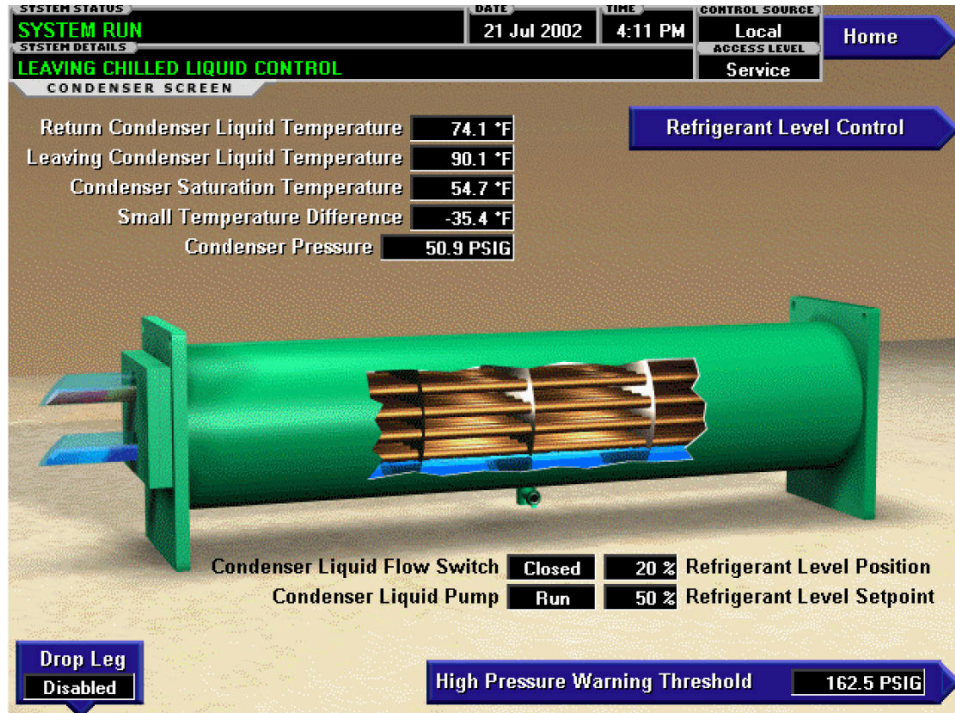


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Condenser screen

The condenser screen displays a cutaway view of the chiller condenser. All setpoints relating to the condenser side of the chiller are maintained on this screen. Animation indicates condenser liquid flow.

Figure 9: Condenser screen

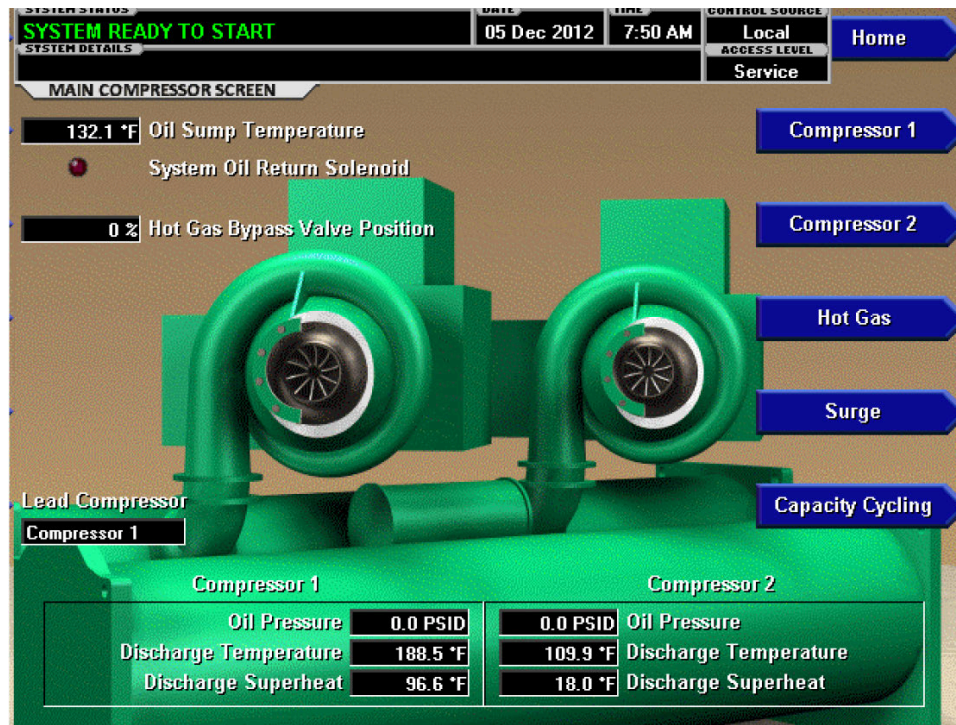


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Compressor screen

The compressor screen displays a cutaway view of the chiller compressors, revealing the impellers, and shows all conditions associated with the compressor. Animation of the compressor impeller indicates whether the chiller is presently in a RUN condition. This screen also serves as a gateway to subscreens Hot Gas Bypass, Surge Protection, and Compressor Capacity Cycling Setup. It enables the viewing and calibration of individual compressor functions.

Figure 10: Compressor screen

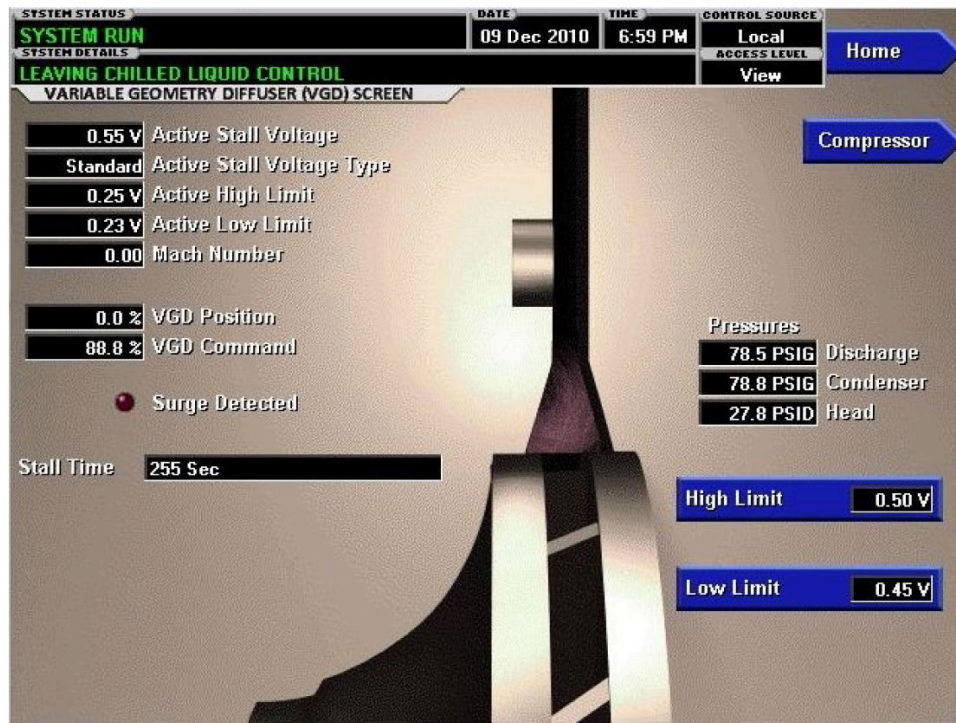


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Variable geometry diffuser screen

The variable geometry diffuser screen can be accessed from the compressor screen and gives the basic stall, position, and pressure details.

Figure 11: Variable geometry diffuser screen

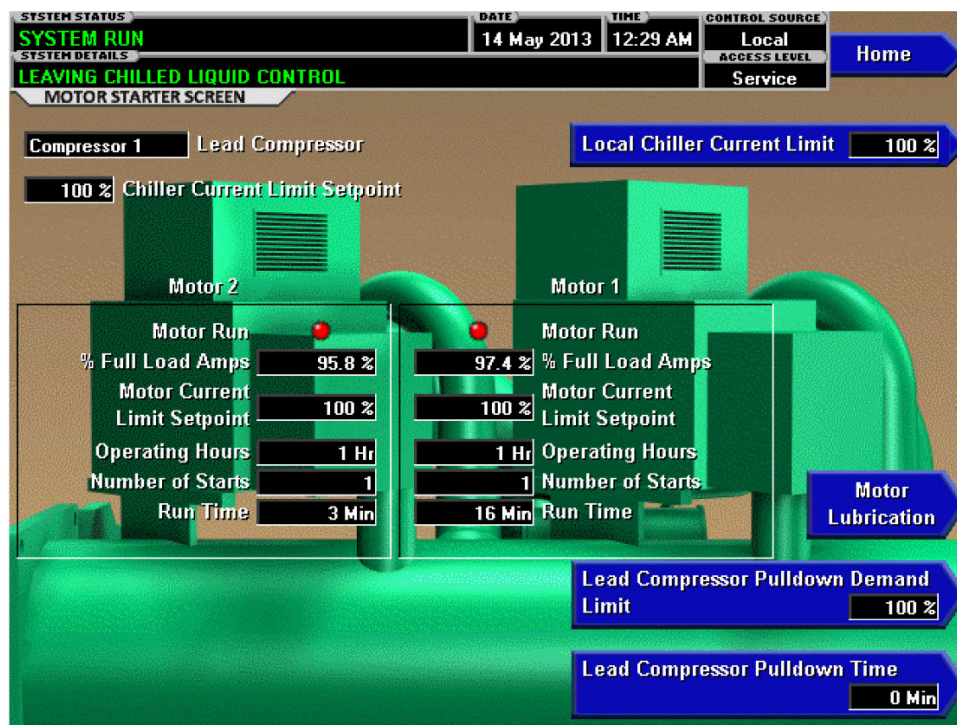


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Starter screen

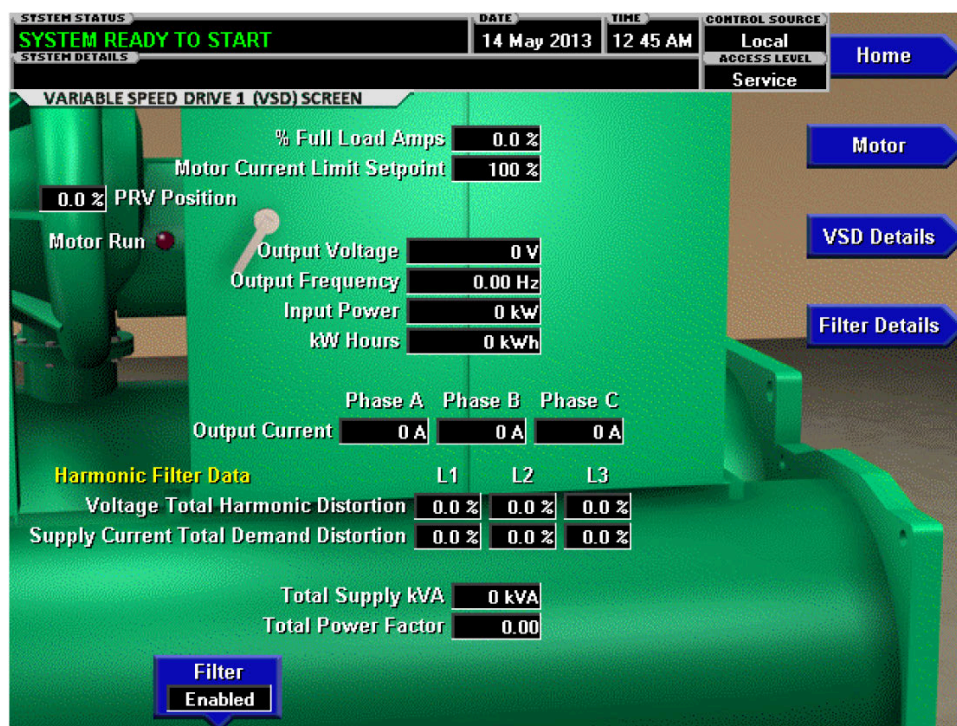
The starter screen displays all information pertaining to the electromechanical starter, solid state starter, or variable speed drive screen, depending on chiller configuration.

Figure 12: Remote mounted low, medium, and high voltage electromechanical starter



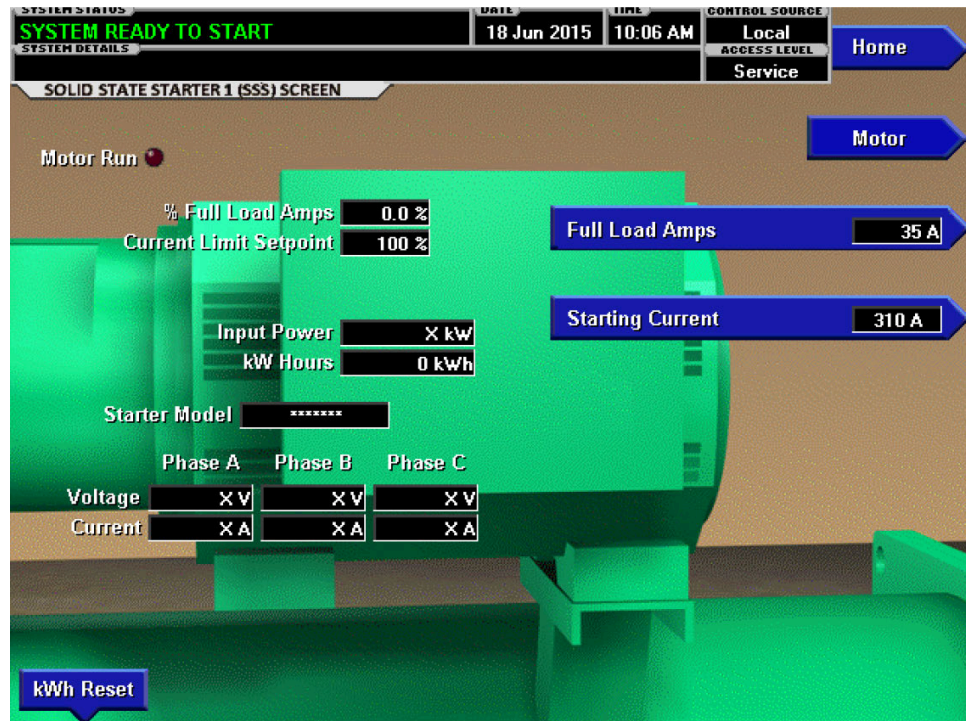
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Figure 13: Unit mounted low voltage variable speed drive



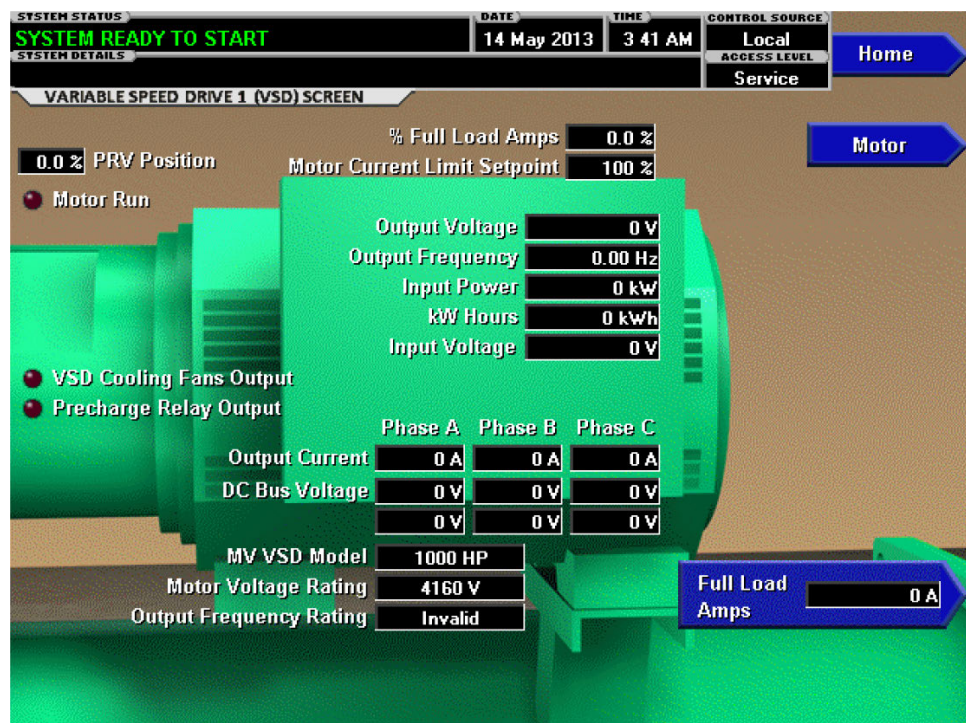
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Figure 14: Unit and remote mounted medium and high voltage solid state starter



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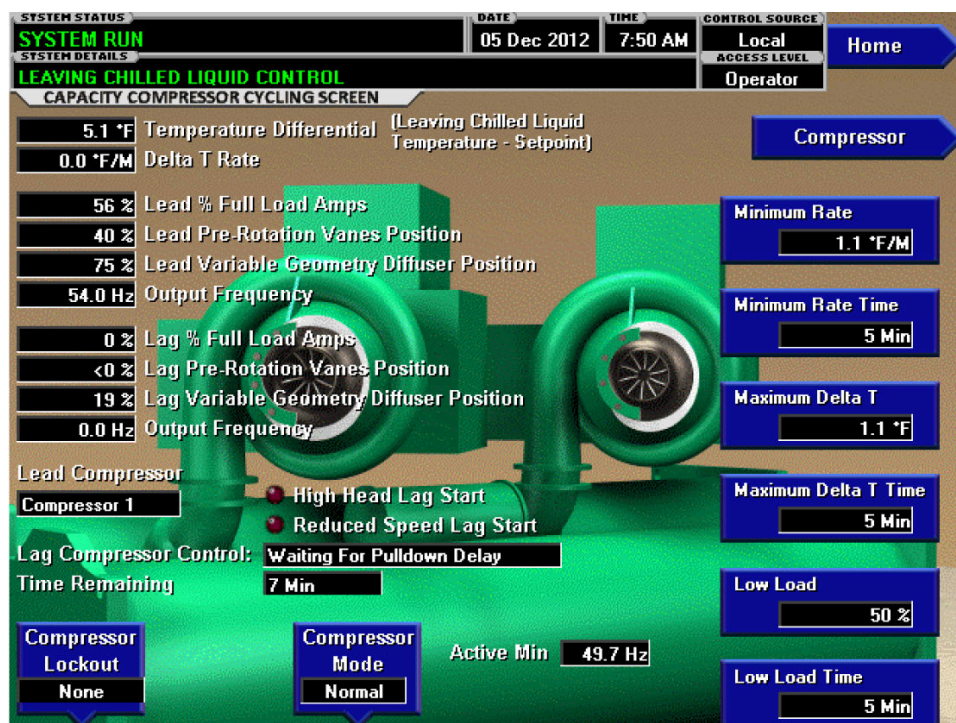
Figure 15: Remote mounted medium and high voltage variable speed drive



Capacity control screen

From the capacity control screen, you can specify the chiller load conditions under which the lag compressor is cycled on and off. Both compressors are not started at the same time. The lead compressor is started first. If it does not meet the load requirements as established with the following setpoints, the lag compressor is started. After the lag compressor is running, it is shutdown if the load decreases to the point established by the following setpoints.

Figure 16: Capacity control screen



LD18365

Setpoints screen

The setpoints screen provides a convenient location for programming the most common chiller control setpoints. Changing setpoints and setup requires proper password access. This screen also serves as a gateway to a subscreen for defining the setup of general system parameters.

Figure 17: Setpoints screen

SYSTEM STATUS
SYSTEM RUN

SYSTEM DETAILS
LEAVING CHILLED LIQUID CONTROL

SETPOINTS SCREEN

DATE 21 Jul 2002 **TIME** 4:07 PM **CONTROL SOURCE** Local **ACCESS LEVEL** Service **Home**

Leaving Chilled Liquid Temperature **Setup**

Setpoint 45.0 °F
Remote Range 10.0 °F

Leaving Chilled Liquid Temperature Cycling

Shutdown 41.0 °F Offset 4.0 °F
Restart 45.0 °F Offset 0.0 °F

Chiller Current Limit Setpoint 100 %

Local Chiller Current Limit 100 %
Chiller Pulldown Demand Limit 100 %

Local Leaving Chilled Liquid Temperature **Leaving Chilled Liquid Temperature Cycling Offset** **Remote Analog Input Range** 0-10 Volts

Setpoint 45.0 °F **Range** 10.0 °F **Shutdown** 4.0 °F **Restart** 0.0 °F **Print**

LD08625

Setup screen

The setup screen is the top level of the general configuration parameters. From this screen you can program the time and date, as well as how the time is displayed. The chiller configuration as determined by the microprocessor and program switches is also displayed.

Figure 18: Setup screen



LD18366

Schedule screen

From the schedule screen, you can program the start and stop times for any day of the week up to six weeks in advance. You can also define a standard set of start and stop times that are used every week or specify exceptions to create a special week.

Figure 19: Schedule screen

SYSTEM STATUS
SYSTEM RUN
SYSTEM DETAILS
LEAVING CHILLED LIQUID CONTROL

DATE 06 Jul 1999 **TIME** 11 45 AM **CONTROL SOURCE** Local
ACCESS LEVEL Service

SCHEDULE SCREEN

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Standard Weekly	Off	9:00 AM	9:00 AM	9:00 AM	9:00 AM	9:00 AM	Off
	Off	5:00 PM	5:00 PM	5:00 PM	5:00 PM	5:00 PM	Off
4		5	6	7	8	9	10
11		12	13	14	15	16	17
18		19	20	21	22	23	24
25		26	27	28	29	30	31
1		2	3	4	5	6	7
8		9	10	11	12	13	14

Press Select button to start programming.
 Use cursor keys to select desired time.
 Press Enter key to input start/stop time.
 Press +/- key to switch from AM to PM.

Print

Home
Setup
Select
Schedule
Disabled
Reset Exceptions
Repeat Sunday

00331vipc

User screen

From the user screen you can select the language the chiller displays and define the unit of measure used.

Figure 20: User screen

The screenshot displays the 'USER SCREEN' interface. At the top, a status bar shows 'SYSTEM READY TO START' in green, along with the date '05 Dec 2012', time '7:50 AM', and 'CONTROL SOURCE' set to 'Local'. Below this, a 'SYSTEM DETAILS' section shows 'ACCESS LEVEL' as 'Service'. The main area is titled 'USER SCREEN' and contains a table of user details, a list of configuration options, and programming instructions.

	User ID	Password	User Level
User 1	1	0	View
User 2	2	0	View
User 3	3	0	View
User 4	4	0	View

----- User Attributes Programming Instructions -----
1. Press 'Change User Attributes' to start programming.
2. Use cursor keys to select desired parameter.
3. Press Enter key to input parameter.

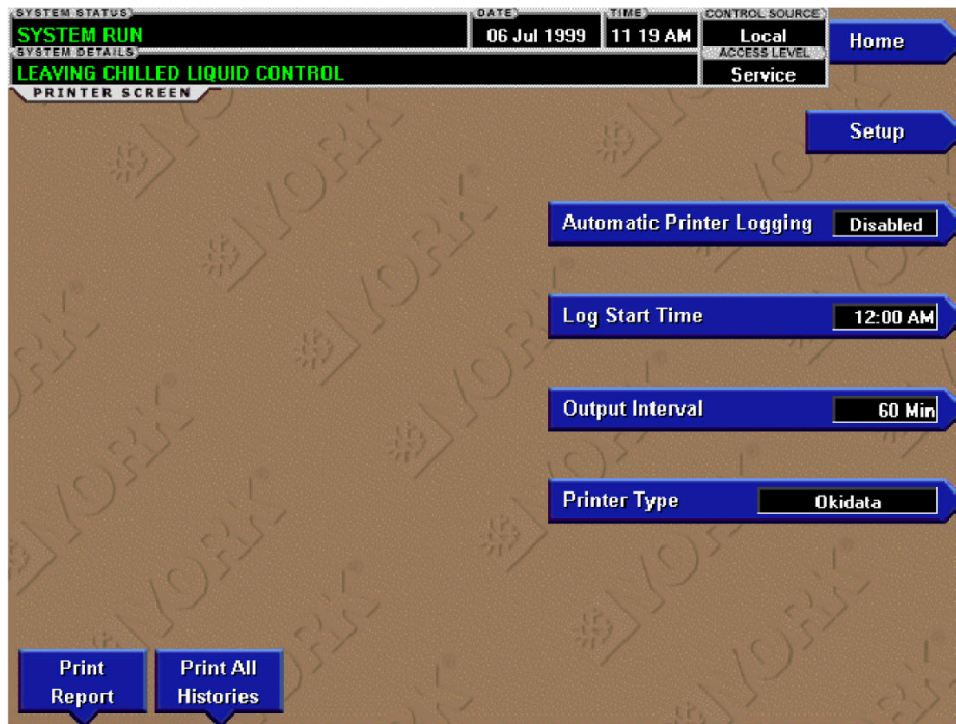
Configuration options on the right include: 'Data Display Mode' set to 'English', 'System Language' set to 'English', 'Change User Attributes' (a button), and 'Date Format' set to 'DD MMM YYYY'. Navigation buttons at the top right include 'Home', 'Setup', and 'Change User Attributes'.

LD18367

Printer screen

From the printer screen you can define the necessary communications parameters for the printer. A printer or a PC can be connected to gather status reports, event logs, and history reports.

Figure 21: Printer screen



03191vipc

Sales order screen

The sales order screen displays the order parameters. This information is loaded at the factory or by the installation or service technician.

Figure 22: Sales order screen

The screenshot displays the 'SALES ORDER SCREEN' interface. At the top, a status bar shows 'SYSTEM STATUS' as 'SYSTEM READY TO START' in green, with 'DATE' as '05 Dec 2012' and 'TIME' as '7:50 AM'. The 'CONTROL SOURCE' is set to 'Local' and the 'ACCESS LEVEL' is 'Operator'. A 'Home' button is located in the top right. Below the status bar, the 'SALES ORDER SCREEN' title is centered. The main area is divided into four sections: 'Order Information', 'Nameplate Information', 'Design Load', and 'System Information'. Each section contains a list of parameters with corresponding input fields. A 'Setup' button is located to the right of the 'Nameplate Information' section, and a 'Print' button is at the bottom right.

Order Information		Nameplate Information	
Commissioning Date	00 000 0000	Motor Code	
Job Name		Volts	
Job Location		Phases	
Model Number		Frequency (Hz)	
York Order Number		LRA	
Panel Serial Number		Full Load Amps	
Chiller Serial Number		Inrush Amps	

Design Load		System Information		
	Evaporator	Condenser		
Passes			Refrigerant	
Design Working Pressure			Tons	
Fouling Factor			Gear Code	
Pressure Drop			Liquid Type	
Nozzle Arrangement In			Brine Percent	
Nozzle Arrangement Out			VSD/SSS/EM	
Leaving Temperature			Kilowatts Input	
Return Temperature				
GPM				
Tube Code				

LD18368

Operations screen

From the operations screen you can define the parameters related to the operation of the chiller. This includes the control source, such as

- Local
- Digital Remote
- Analog Remote
- Modem Remote
- BAS Remote

Also displayed is Run Time, Operating Hours, and the number of starts for the chiller.

Figure 23: Operations screen

The screenshot displays the 'OPERATIONS SCREEN' for a chiller system. At the top, a status bar shows 'SYSTEM STATUS' as 'SYSTEM READY TO START' in green, 'DATE' as '05 Dec 2012', 'TIME' as '7:50 AM', and 'CONTROL SOURCE' as 'Local'. Below this, a 'SYSTEM DETAILS' section shows 'Johnson Controls North America' and '1-800-861-1001'. The main area is divided into two columns. The left column contains a 'Chiller Run Time' section with '0 Days', '0 Hr', and '0 Min'. The right column contains several settings: 'Control Source' set to 'Local', 'Chiller Number Of Starts' set to '5', 'Chiller Operating Hours' set to '300 Hr', 'Edit Phone Numbers', and 'Chiller Style/Compressor' set to 'Style J1-J5,K1-K4'. At the bottom, four status indicators are shown: 'Hot Gas' (Enabled), 'Level Control' (Enabled), 'Flow Switch' (Analog), and 'VGD' (Enabled). Navigation buttons 'Home' and 'Setup' are located in the top right corner.

SYSTEM STATUS	DATE	TIME	CONTROL SOURCE
SYSTEM READY TO START	05 Dec 2012	7:50 AM	Local

SYSTEM DETAILS
Johnson Controls North America 1-800-861-1001

OPERATIONS SCREEN					
Chiller Run Time 0 Days 0 Hr 0 Min	Control Source Local	Chiller Number Of Starts 5	Chiller Operating Hours 300 Hr	Edit Phone Numbers	Chiller Style/Compressor Style J1-J5,K1-K4
Hot Gas Enabled	Level Control Enabled	Flow Switch Analog	VGD Enabled		

LD18369

History screen

From the history screen, you can browse through the last ten faults from either safety or cycling shutdowns with the conditions while the chiller is running or stopped. The faults are color coded for ease in determining the severity, recording the date, time, and description.

The OptiView Control Center continually monitors the operating system displaying and recording the cause of any shutdowns, either safety, cycling, or normal. The condition of the chiller is displayed at the system status line that contains a message describing the operating state of the chiller:

- Stopped
- Running
- Starting
- Shutting down

A system details line displays the following messages:

- Warning
- Cycling
- Safety
- Start inhibit
- Other messages that provide further details on status bar messages

To aid in identifying problems quickly, messages are color coded as follows:

- Green: Normal operations
- Yellow: Warnings
- Orange: Cycling shutdowns
- Red: Safety shutdowns

Figure 24: History screen

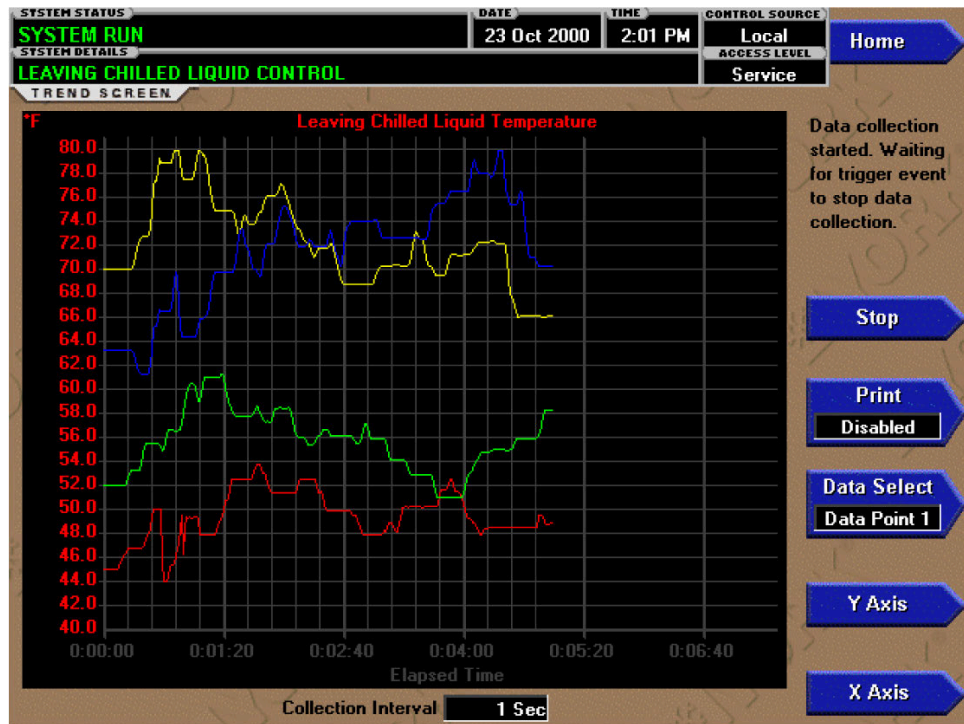


LD08628

Trending screen

On the trending screen, up to six user-selected parameters, selected from a list of over 140, can be plotted in a time-line graph format. The graph can be customized to record points once every second up to once every hour. There are two types of charts that can be created: a single or continuous screen. The single screen collects data for one screen width, of 450 data points across the X-axis, then stops. The continuous screen keeps collecting the data, but the oldest data drops off the graph from left to right at the next data collection interval. For ease of identification, each plotted parameter, title, and associated Y-axis labeling is color coordinated.

Figure 25: Trending screen



00472VIPC

Starters and Drives

Compressor motor starter and drives

The YORK YD is available with a variety of motor starter options as described in [Table 1](#).

Table 1: York YD motor starter options

Starter options	Variable speed drive		Solid state starter		Star-delta closed (EMS)	Across-the-line (EMS)	Auto transformer (EMS)	Primary reactor (EMS)
	Unit Mounted	Remote Mounted	Unit Mounted	Remote Mounted	Remote Mounted	Remote Mounted	Remote Mounted	Remote Mounted
Assembly	Unit Mounted	Remote Mounted	Unit Mounted	Remote Mounted	Remote Mounted	Remote Mounted	Remote Mounted	Remote Mounted
Voltage	Low	Medium/ High	Medium	Medium/ High	Low	Medium/ High	Medium/ High	Medium/ High
60 Hz	380 to 460	2300 to 13,800	2,300 or 4,160	2,300 to 13,200	380 to 575	2,300 to 13,,200	2,300 to 13,200	2,300 to 13,200
50 Hz	380 to 415	3,300 to 11,000	3,300	2,300 to 11,000	380 to 415	2,300 to 11,000	2,300 to 11,000	2,300 to 11,000

Johnson Controls variable speed drive

When a YORK YD chiller is equipped with a variable speed drive, it is designed to vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The capacity control logic automatically adjusts motor speed and compressor PRV position independently for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.

The variable speed drive was specifically developed for commercial air-conditioning applications. No one matches Johnson Controls experience in the application of variable speed drive technology to chillers. Since pioneering the concept in 1978, Johnson Controls has installed more variable speed drive chillers than all other chiller manufacturers combined.

Variable speed drives save in both single-chiller installations and multiple-chiller installations. In multiple-chiller installations, cycling chillers off as the building load falls results in higher loads on the remaining chillers. This would seem to reduce the opportunity for drives to save energy. However, even though chiller loads remain high, entering condenser-water temperature has most likely fallen. And, reductions in entering condenser water temperature offer a far greater potential to enhance chiller efficiency than load reductions do. Therefore, variable speed drives deliver major energy savings in multiple-chiller plants, too.

The variable speed drive is available for low, medium, and high incoming line voltages applications.

Unit mounted low voltage variable speed drive

The unit mounted low voltage variable speed drive (LVVSD) is factory-packaged and mounted on the YORK YD chiller. It is designed to vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The capacity control logic automatically adjusts motor speed and compressor pre-rotation vane position independently for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.

Table 2: Unit mounted LVVSD

Starter options	Unit mounted LVVSD		
	380	460	575
60 Hz	X	X	X
50 Hz	380	400	415
	X	X	X

Note: X=Standard option

A YD dual compressor chiller requires two unit-mounted LVVSDs on a unit, one for each motor.

Each unit-mounted LVVSD is mounted in a NEMA-1 enclosure with all power and control wiring between the drive and chiller factory-installed. Electrical lugs for incoming power wiring are provided.

Figure 26: Unit-mounted LVVSD

The unit-mounted LVVSD provides automatic displacement power factor correction to 0.95 or better at all load conditions. Separate displacement power factor correction capacitors are not required. The displacement power factor is 0.98 or better when the optional harmonic filter is provided. See [Table 3](#) for additional advantages of unit mounted LVVSDs.

Standard features include the following:

- A door interlocked lockable circuit breaker
- UL/cUL listed ground fault protection
- Overvoltage and undervoltage protection
- Three-phase sensing motor overcurrent protection
- Single-phase protection
- Insensitive to phase rotation
- Over-temperature protection
- Digital readout at the OptiView Control Center of the following:
 - Output frequency

- Output voltage
- Three-phase output current
- Input power (kW)
- Self diagnostic service parameters
- Kilowatt-hours (kWH)

An optional harmonic filter limits electrical power supply distortion from the unit mounted LVVSD to help the building comply with the guidelines of IEEE Std. 519. The filter is unit mounted within the same NEMA-1 enclosure and is UL listed. The following digital readout is standard with the optional filter:

- Input kVA
- Total power-factor
- Three-phase input voltage
- Three-phase input current
- Three-phase input voltage total harmonic distortion (THD)
- Three-phase input current total demand distortion (TDD)
- Self-diagnostic service parameters

Table 3: Unit mounted LVVSD

Starter type	Advantages
Unit mounted LVVSD	<ul style="list-style-type: none"> - Lowest chiller life cycle through part load energy savings. - Application-specific designs enable efficient, precise load control and seamless integration with equipment control panel and BAS. - Soft start with input current less than full load current. - Smooth acceleration reduces stresses on motor and driveline. - Reduces compressor sound levels at most operating conditions. - Rugged and reliable with no moving parts. - Helps building comply with IEEE Std. 519 if used with an optional harmonic filter.

Remote mounted medium and high voltage variable speed drive

The remote mounted medium and high voltage variable speed drive (M/HVVSD) is factory-packaged and configured for easy remote installation. It is designed to vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The capacity control logic automatically adjusts motor speed and compressor pre-rotation vane position independently for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.

Table 4: Remote mounted M/HVVSD

Starter options	Remote mounted M/HVVSD						
60 Hz	2,300	3,300	4,000	4,160	6,600	12,470	13,800
	O	O	X	X	O	O	O
50 Hz		3,300			6,600	10,000	11,000
		O			O	O	O, §

① Note:

X = Standard option

O = The unit uses a 4,000 V or 4,160 V (60 Hz) motor.

§ = Requires a Special Quote (SQ) if the unit uses a special VSD requiring a 4,000 V (50 Hz) motor.

A YD dual compressor chiller requires two remote mounted M/HVVSDs in a unit, one for each motor.

Each remote mounted M/HVVSD is mounted in a NEMA-1 enclosure and comes with a certification label from a nationally recognized testing laboratory. The connection points between the drive and chiller are factory labeled. Electrical lugs for incoming power wiring are not provided.

Remote mounted M/HVVSDs provide automatic displacement power factor correction to 0.98 or better at all load conditions. Separate displacement power factor correction capacitors are not required.

Figure 27: Remote mounted MVVSD

Id19233

Standard features include the following:

- A lockable door interlocked disconnect switch
- UL listed ground fault protection
- Overvoltage and undervoltage protection
- Three-phase sensing motor overcurrent protection
- Single-phase protection
- Insensitive to phase rotation
- Over-temperature protection
- Digital readout at the Control Center of the following:
 - Output frequency
 - Three-phase output voltage
 - Three-phase output current
 - Input power (kW)
 - Self diagnostic service parameters
 - Kilowatt-hours (kWH)
 - Input kVA
 - Total power-factor
 - Three-phase input voltage
 - Three-phase input current
 - Self diagnostic service parameters

The 24-pulse design limits the electrical power supply distortion from the remote mounted MVVSD to help the building comply with the guidelines of IEEE Std. 519.

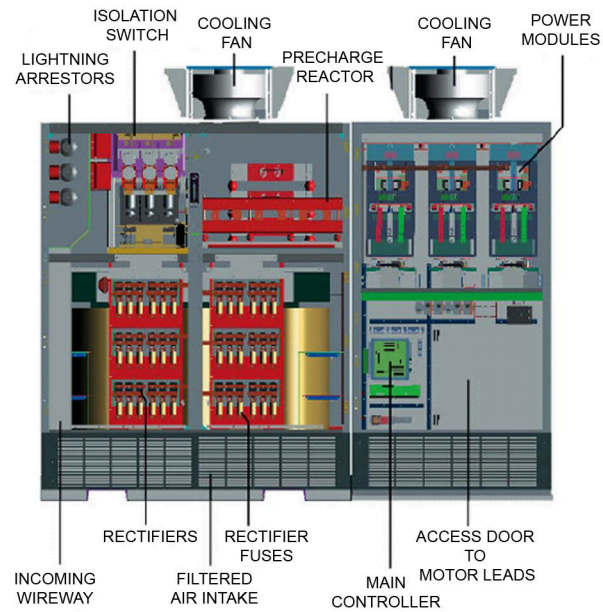
Each remote mounted M/HVVSD delivers reliable operation and improves the off-design performance. In 50 Hz countries, you can save more, reducing the initial cost, because the M/HVVSD converts the frequency from 50 Hz to 60 Hz. As a result, the remote mounted MVSD can handle more amps with the same hardware. In addition, a potential lower cost is realized in 4,160 V (60 Hz) units versus 3,300 V (50 Hz) units.

The 24-pulse phase shifting isolation transformer provides protection for the drive. It also acts as a buffer between power line surges and acts as a filter to stop these disturbances from reaching sensitive electronic devices.

The Johnson Controls transformer also protects the building's electrical system from unlikely drive failures which may cause a surge or disturbance on the line that is feeding the system.

Johnson Controls front-end transformer also provides the ability to match incoming line voltage to the motor voltage in use without further penalizing efficiency. Johnson Controls offers the widest input voltage range for remote mounted M/HVVSD chillers in the industry, such as 11,000 V, 12,470 V, or 13,800 V.

Figure 28: Remote mounted MVVSD from 2,300 V to 4,160 V input

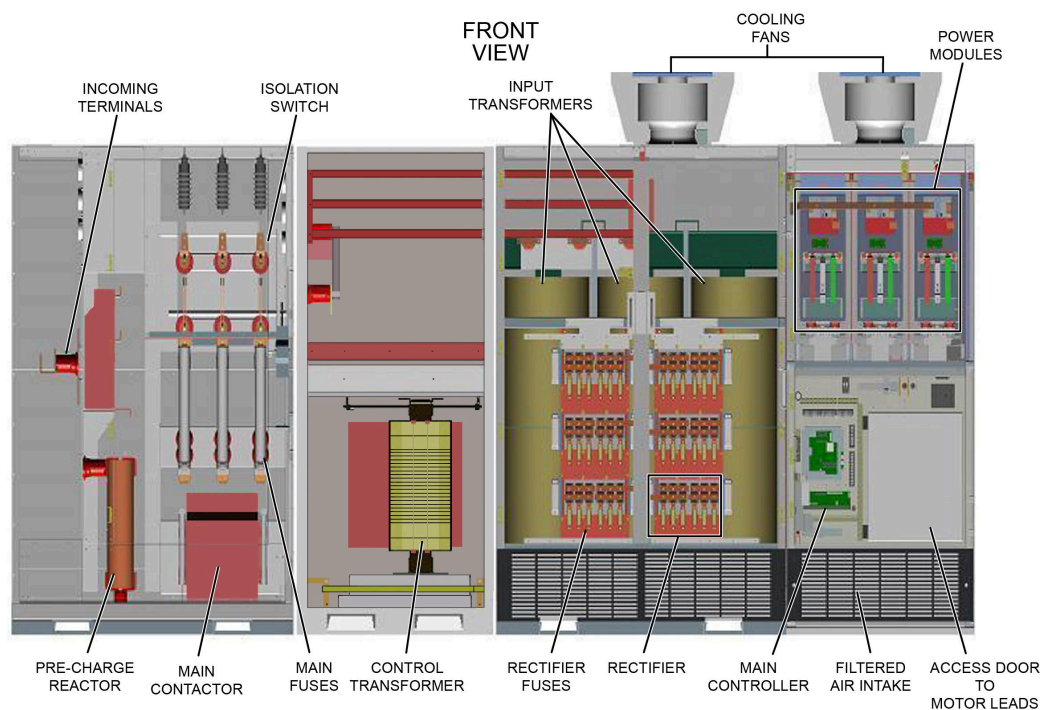


LD20517

Table 5: Remote mounted MVVSD

Stater type	Advantages
Remote mounted MVVSD	<ul style="list-style-type: none"> • Lowest chiller life cycle through part load energy savings • Application-specific designs enable efficient, precise load control and seamless integration with equipment control panel and BAS • Soft start with input current less than full load current • Smooth acceleration reduces stresses on motor and driveline • Reduces compressor sound levels at most operating conditions • Rugged and reliable with no moving parts. Helps building comply with IEEE Std. 519. No optional filter needed • Multilevel PWM output closely simulates a true sine wave, allowing the use of standard motors and bearings

Figure 29: Remote mounted HVVSD from 6000 V to 13800 V input



LD20518

Table 6: Remote mounted HVVSD

Starter type	Advantages
Remote mounted HVVSD	<ul style="list-style-type: none"> • Lowest chiller life cycle through part load energy savings. • Application-specific designs enable efficient, precise load control and seamless integration with equipment control panel and BAS • Soft start with input current less than full load current • Smooth acceleration reduces stresses on motor and driveline • Reduces compressor sound levels at most operating conditions • Rugged and reliable with no moving parts. Helps the building comply with IEEE Std. 519. No optional filter needed • Multilevel PWM output closely simulates a true sine wave, allowing the use of standard motors and bearings

Unit and remote mounted medium and high voltage solid state starter

The unit and remote mounted medium and high voltage solid state starter (M/HVSSS) is a reduced voltage in-line bypass starter that controls and maintains a constant current flow to the motor during startup. The starter is available for 2,300 V to 13,200 V. See [Table 7](#). The starter enclosure is NEMA-1, with a hinged access door with lock and key. Electrical lugs for incoming power wiring are not provided.

Table 7: Unit and remote mounted M/HVSSS

Starter options	Starter type						
60 Hz	Remote mounted M/HVSSS						
	2,300	3,300	4,000	4,160	6,600	12,470	13,200
	O	O	O	O	O	O	O
	Unit mounted MVSSS						
	2,300	3,300	4,000	4,160			
	X	X	X	X			
50 Hz	Remote mounted M/HVSSS						
	2,300	3300			6,600	10,000	11,000
	O	O			O	O	O
	Unit mounted MVSSS						
		3,300					
		X					



Note:

X = Standard option

O = Require a Special Quote (SQ)

Figure 30: Unit mounted MVSSS



LD13585

Standard features include digital readout at the Control Center of the following:

- Display only
 - Three-phase input voltage
 - Three-phase current
 - Input Power (kW)
 - Kilowatt-Hours (kWH)
 - Starter model
 - Motor run (LED)
 - Motor current % full load amps
 - Current limit setpoints
 - Pulldown demand time left
- Programmable
 - Local motor current limit
 - Pulldown demand limit
 - Pulldown demand time

Other features include the following:

- Low line voltage
- 115 V control transformer
- Three-leg motor current sensing overloads
- Phase rotation and single-phase failure protection
- High temperature safety protection
- Motor current imbalance and undervoltage safeties
- Open and shorted SCR protection
- Momentary power interruption protection

The unit and remote mounted M/HVSSS is air cooled generating about the same heat as an auto-transformer E-M starter. Ground fault protection and surge protection are also standard features. The 50,000 A short circuit withstand rating is in accordance with UL Standard 508. See [Table 7](#) for availability of unit and remote mounted M/HVSSSs.

Table 8: Unit and remote mounted M/HVSSS

Starter type	Advantages
Unit mounted MVSSS	<ul style="list-style-type: none">• Smooth, controlled start profile• Unit mounted, factory wired and tested• Rugged and reliable with no moving parts• Application-specific designs enable seamless integration with equipment control panel and BAS

Remote mounted low, medium, and high voltage electromechanical starter

A remote mounted low, medium, and high voltage electromechanical starter (L/M/HVEMS) is available, selected for correct size and type for job requirements and in accordance with YORK Engineering Standard (R-1206) for starters. The starter assembly has contactors and accessories for controlling the two compressor motors on each chiller.

Characteristics

Until the development of the solid state starter, all centrifugal chillers required the use of starters using electromechanical contactors, which are limited to operating totally ON, or totally OFF. There was no alternative to this mechanical equipment with its inability to control applied voltage or power. This contrasts markedly with the unit mounted MVSSS and remote mounted M/HVSSS which automatically maintain a predetermined current during starting, regardless of variations in line voltage or motor load, to give optimum acceleration without surges. Even with the addition of transformers, reactors, resistors and additional contactors, timers and relays, the mechanical controllers offer limited adjustment, no positive control during starting and impose an objectionable transition spike. Some also require modified motors. A field-installed, electromechanical compressor motor starter is available, selected for the correct size and type for job requirements and in accordance with Johnson Controls Engineering Standard (R-1206) for Starters. See [Table 9](#).

Table 9: Remote mounted LVEMS: star-delta closed

Starter options	Remote mounted LVEMS (star-delta closed)		
60 Hz	380	460	575
	X	X	X
50 Hz	380	400	415
	X	X	X

Note: X = Standard option

Table 10: Remote mounted M/HVEM: across-the-line, auto transformer, primary reactor

Starter options	Remote mounted M/HVEMS: across-the-line, auto transformer, primary reactor						
60 Hz	2,300	3,300	4,000	4,160	6,600	12,470	13,800
	X	X	X	X	X	X	X
50 Hz	2,300	3,300			6,600	10,000	11,000
	X	X			X	X	X

Note: X = Standard option

The most common failure mode of mechanical contactors is OFF. This occurs due to the coil open-circuiting or failure of a pole to make an electrical contact when it closes. However, failure in the ON mode is not completely uncommon and can be a more serious type of failure, particularly if this failure mode exists at the same time that equipment safety controls are demanding a shutdown.

When contacts are made, the current builds up to its maximum value from zero, but when contacts are separated the current tends to flow through the gap and forms to causes an arc. This arcing depends upon the voltage between the separating contacts. For medium voltage starters, the use of vacuum contactors mitigates this problem somewhat by providing an environment to extinguish the arc. In the alternating current circuit, the separation of contacts may take place when the current is zero or maximum or at any value in between. An alternating current passes through zero and reverses its polarity twice during each cycle. If two or more contacts, one in each leg of a polyphase system, are separated simultaneously, the current values in each varies. In a three-phase system, if one contact has zero current when opened, the other two contacts has 86.6% of their maximum values, as an example. Additionally, when inductive circuits are broken, the voltage is increased at the contacts due to the counter (induced) EMF of the circuit. The instant the contacts separate, the voltage between them momentarily rises from zero to the maximum of the circuit, or higher if inductance is present in the circuit. In practice, every time the contacts close, they bounce.

When they bounce, they arc. The arcing occurs as the contacts make or break may result in rapid and excessive erosion of the contacts, causing prematurely short contact life.

YORK chillers are designed for use with the following types of electromechanical starters.

Across-the-line (ACL): These are the simplest and lowest-cost starters available. They apply full voltage to the three motor leads at the instant of starting. Because inrush is 100% of LRA and starting torque is 100%, this is the roughest type of starting on the motor and driveline. In physical size, the ACL is the smallest of electromechanical starters and there is no transition surge. In most areas, utilities do not permit the use of this type of starter for chiller-size motors because of their large current draw on startup.

Auto transformer (AT): These starters are reduced-voltage starters. Transformers are used to step down the voltage to the motor during startup. The result is reduced inrush current and starting torque at the level of 42% or 64% depending upon whether 65% or 80% voltage taps are used. They provide closed transition (with three-lead motors) with reduced line disturbance.

Star-delta: During startup, the motor is connected in a Star or Wye configuration. This reduces the voltage to the motor stator by a factor of three. This $\frac{1}{3}$ voltage results in $\frac{1}{3}$ current into the motor at start and $\frac{1}{3}$ torque to the shaft. Centrifugal compressor starting torque requirements are low enough to allow the motor to start at $\frac{1}{3}$ of full load torque.

Primary reactor: These starters are reduced-voltage starters. Transformers are used to step down the voltage to the motor during startup. The result is reduced starting torque at the level of 42% or 64%, but with reduced inrush current of 65% or 80% depending upon whether 65% or 80% voltage taps are used. The starters provide closed transition, with three-lead motors, and reduced line disturbance.

Accessories and modifications

BAS remote control

A communication interface permitting an exchange of chiller data with a BACnet MS/TP, Modbus RTU, LONworks, or N2 Metasys network is available by means of an optional SC-EQUIP board (Smart Chiller – Equipment Board) or E-Link® board gateway. The Johnson Controls Gateway mounts conveniently inside the OptiView panel and allows remote BAS networks to monitor values and issue commands to the chiller to control operation.

Dual oil filters

Dual oil filters with a multi-port changeover valve and manual shutoff valves are optional to allow changing of one filter while the chiller is operating.

Factory insulation of evaporator

Factory-applied thermal insulation of the flexible, closed-cell plastic type, 3/4 in. (19 mm) thick, is attached with vaporproof cement to the evaporator shell, tube sheets, suction connection, and to the auxiliary tubing as necessary. Insulation of waterboxes and nozzles are not included. This insulation normally prevents condensation in environments with relative humidities up to 75% and dry bulb temperatures ranging from 50°F to 90°F (10°C to 32.2°C). Insulation with a thickness of 1 1/2 in. (38 mm) is also available for relative humidities up to 90% and dry bulb temperatures ranging from 50°F to 90°F (10°C to 32.2°C).

Knockdown shipment

All YD chillers can be shipped knocked-down into the following major subassemblies:

- Evaporator
- Condenser
- Driveline
- Similar components

These subassemblies are provided as required to rig into tight spaces. They particularly convenient for existing buildings where equipment room access does not allow rigging a factory-packaged chiller.

High ambient temperature

Chiller modifications are available to allow for installation in high ambients of up to 122°F (50°C). Special drive motors are required above 104°F (40°C). H9 and K compressor evaporator design pressures must be increased for ambient temperatures above 112.8°F (45°C). The OptiView panel and unit mounted LVVSD are suited for 122°F (50°C) ambient. Unit mounted low and medium voltage solid state starters must be derated or modified above 110°F (43.3°C). The remote mounted M/HVVSD and M/HVSSS options must be derated above its standard 104°F (40°C) limit.

High voltage motors

High voltage motors from 6,000 V to 13,800 V (60 Hz) and 6,000 V to 11,000 V (50 Hz) are available.

Hinges and davit arms

Hinges and davit arms are available to ease serviceability. Hinges on the nozzle end of a compact waterbox still require that facility water piping be disconnected.

Marine waterboxes

Marine waterboxes 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 couplings nozzle connections are standard, but flanges are optional. Marine waterboxes are available for condenser and evaporator.

Refrigerant storage and recycling system

A refrigerant storage and recycling system is a self-contained package consisting of the following:

- Refrigerant compressor with oil separator
- Storage receiver
- Water-cooled condenser
- Filter drier
- Necessary valves and hoses to remove, replace, and distill refrigerant

① **Note:** All necessary controls and safety devices are a permanent part of the system.

Special motors enclosures

There are job applications, primarily in manufacturing plants, and process applications, where more motor protection is required. The following lists several alternatives.

① **Note:** Chiller certification to UL by a third party could be affected. Contact a Johnson Controls sales office for a specific selection.

Weather-Protected Type I Motors (WP-I): A Weather-Protected Type I motor is an open machine with its ventilating passages constructed to prevent the passage of a cylindrical rod 3/4 in. (19 mm) in diameter. This affords protection against intrusion of rodents and some types of debris. These are regularly used in the pulp industry and where grime is present.

Weather-Protected Type II Motors (WP-II): A Weather-Protected Type II motor has, in addition to the enclosure defined for Weather-Protected Type I motor, ventilating passages at both intake and exhaust so arranged that high-velocity air and air-borne particles, blown into the motor, can be discharged without entering the internal ventilating passages leading directly to the electric parts of the machine itself. Space heaters are required with WP-II.

Totally Enclosed Fan-Cooled Motors (TEFC): TEFC motors are used where the location is extremely dirty, dusty, or wet, both indoors and outdoors. A totally enclosed fan-cooled unit is enclosed to prevent the free exchange of air between the inside and outside of the case but not sufficiently enclosed as to be termed air-tight. It is air-cooled by means of a fully guarded fan blowing cooling air over the outside of the motor. The fan is externally mounted on the motor shaft.

Totally Enclosed Air-to-Air Cooled (TEAAC): TEAAC motors are used when the environment is dirty or corrosive. A TEAAC motor is a totally enclosed motor, cooled by circulating the internal air through an air-to-air heat exchanger.

Totally Enclosed Water-to-Air Cooled (TEWAC): TEWAC motors are used when the environment is dirty or corrosive, in hazardous areas, or where minimum noise levels are required. A TEWAC motor is a totally enclosed machine which is cooled by circulating internal air that, in turn, is cooled by circulating water. It is provided with an internal water-cooled heat exchanger for cooling the internal air and fans, integral with the rotor shaft for circulating the internal air.

Spring isolation mounting

Spring isolation mounting is available instead of standard isolation mounting pads when required. Four level-adjusting, spring-type vibration isolator assemblies with non-skid pads are provided for field installation. Isolators are designed for 1 in. (25 mm) deflection.

Tube or tube sheet materials and waterbox coating

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

Water flanges

Four 150 psig (1.14 MPa) 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.

Application data

The following discussion is a user's guide in the application and installation of YD 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.

Brine applications

Various types of brine can be used in both the evaporator and condenser in lieu of water. The OptiView panel is programmed in the factory to allow extending the evaporator leaving brine temperature setpoint below 36°F (2.2°C). The low evaporator pressure cutout is factory programmed to the appropriate value depending on the percentage concentration and type of brine solution.

When the chiller is not running, brine should not be flowing through the evaporator. However, if there is brine flowing through the evaporator, there must be flow through the condenser to prevent tubes from freezing. In brine applications, the condenser pump control will close when the condenser saturation temperature reaches 35°F (1.7°C) and the pump will shut off when the temperature increases to 40°F (4.4°C). This is applicable if tied to the condenser pump control.

Location

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

The unit site must be a floor, mounting pad, or foundation that is level within 1/4 in. (6.4 mm) and is 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.

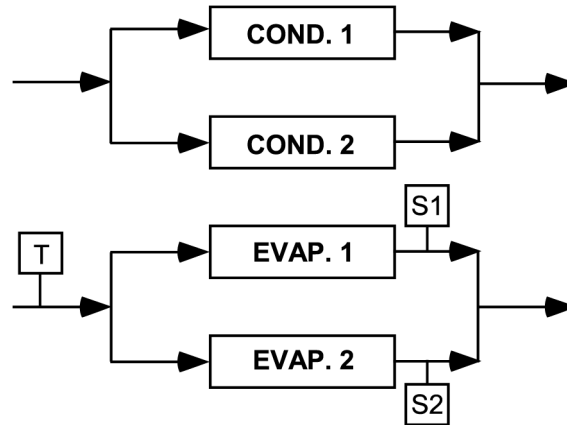
The chiller must be installed in an indoor location where temperatures range from 40°F to 104°F (4.4°C to 40°C). The dew point temperature in the equipment room must be below the entering condenser water temperature to prevent condensing water vapor inside of the solid state starter or low voltage variable speed drive cabinet, if applicable. Applications using cooling sources other than evaporative or closed loop air exchange methods need to request a factory-supplied temperature control valve to prevent condensation inside the unit mounted medium voltage solid state starter and unit mounted low voltage variable speed drive cabinets, if applicable. Other areas susceptible to water vapor condensate are outside of the condenser shell and condenser waterboxes. Example applications include when the condenser water comes from chilled water, wells, river, or other low temperature fluids.

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 YD chiller has been designed to be readily adapted to the requirements of these various arrangements.

Parallel arrangement: See [Figure 31](#). Chillers may be applied in multiples with chilled and condenser water circuits connected in parallel between the units. [Figure 31](#) 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.

Figure 31: Parallel evaporators parallel condensers

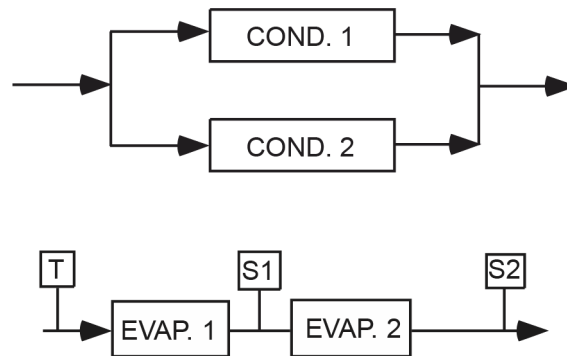


LD18370

Depending on the number of units and operating characteristics of the units, loading and unloading schemes must be designed to optimize the overall efficiency of the chiller plant. Use an evaporator bypass piping arrangement to bypass fluid around evaporator of any unit that has cycled off at reduced load conditions. Alternate the chiller cycling order to equalize chiller starts and run hours.

Series arrangement: See [Figure 32](#). 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.

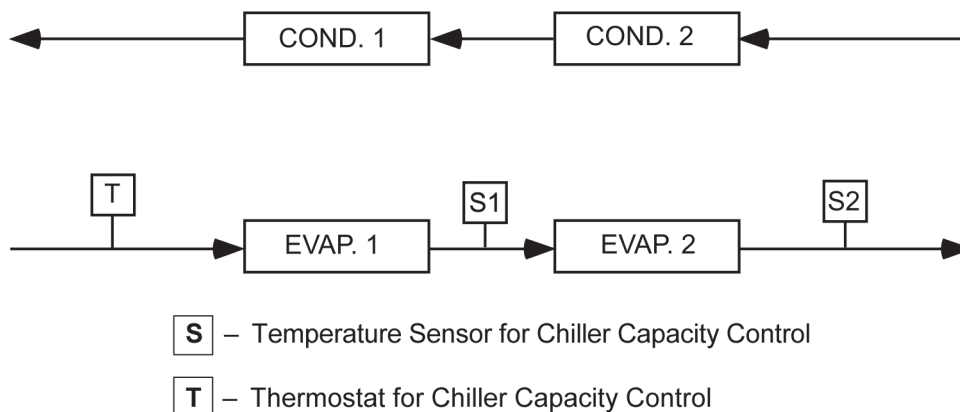
Figure 32: Series evaporators parallel condensers



LD18371

Series counterflow arrangement: See [Figure 33](#). Chillers may be applied in pairs with chilled water circuits connected in series and with the condenser water in series counterflow. All of the chilled water flows through both evaporators. All of the condenser water flows through both condensers. The water ranges are split, which allows a lower temperature difference or head on each chiller, than multiple units in parallel. For equal chillers, the machine at higher temperature level typically provides slightly more than half the capacity. The compressor motors and gear codes on the two chillers are often matched, such that the high temperature machine can operate at the low temperature conditions when one unit is cycled off at part loads, as compared to series parallel chillers which are typically not identical.

Figure 33: Series evaporators series - counterflow condensers



LD18372

A series counterflow application can provide a significant building energy savings for large capacity plants that have chilled and condenser water temperature ranges greater than typical AHRI.

Refrigerant relief piping

Each chiller is equipped with relief valves on the condenser and evaporator shells. The condenser contains redundant relief valves that 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.

A vent line, which is sized to the requirements of applicable codes, 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 must include at least one flexible connection.

Sound and vibration considerations

A YD 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 in. (25 mm) static deflection are available from Johnson Controls.

YD 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-in. (19 mm) or 1 1/2-in. (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-in. (19 mm) thickness] or 90% [1 1/2-in. (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 waterboxes at the job site, it must be removable to permit access to the tubes for routine maintenance.

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. Because the YD chiller motors are air-cooled, ventilation must allow for the removal of heat from the motors.

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

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 ft/s and 12 ft/s (0.91 m/s and 3.66 m/s) for constant flow applications. Variable flow applications are possible, and initial chiller selections must be made accordingly to allow correct range of flow while maintaining the minimum velocity indicated at the certified rating for the unit. 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 increases 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 are more effective with full design flow. See [Table 11](#) for flow limits.

Temperature ranges: For normal water chilling duty, leaving chilled water temperatures may be selected between 38°F (3.3°C), or 36°F (2.2°C) with Smart Freeze enabled, and 70°F (21.1°C) to obtain temperature deltas between entering chilled and leaving chilled water temperature of 3°F up to 30°F (1.7°C to 16.7°C).

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 factors degrade chiller performance and increase operating and maintenance costs. Normally, performance can be maintained by corrective water treatment and periodic cleaning of tubes. If water conditions exist that cannot be corrected by sufficient water treatment, it may be necessary to provide a larger allowance for fouling and to specify special materials of construction. See the *Application Guide 160.00-AD5* for more details.

General piping: All chilled water and condenser water piping must be designed and installed in accordance with accepted piping practice. Chilled water and condenser water pumps must be located to discharge through the chiller to ensure positive pressure and flow through the unit. Piping must include offsets to provide flexibility and must 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 helpful 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 waterboxes are equipped with plugged vent and drain connections except, for marine waterboxes with vertical nozzles where there are drain connections only. If required, vent and drain valves may be installed with or without piping to an open drain. Pressure gauges with stopcocks 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 (1.14 MPa) design working pressure in both the chilled water and condenser water circuits. The connections (water nozzles) to these circuits are furnished with grooves to ANSI/AWWA C 606 Standard for grooved and shouldered joints. Arrange the piping for ease of disassembly at the unit for tube cleaning. All water piping must be thoroughly cleaned of all dirt and debris before final connections are made to the chiller.

Fluid Strainer: A fluid strainer with perforated holes no larger than 1/8 in. (3.2 mm) must be field-installed in the chilled fluid inlet line as close as possible to the chiller. If located close enough to the chiller, the chilled fluid pump may be protected by the same strainer. The strainer is to protect the chiller from debris or objects which could block flow through individual heat exchanger tubes. A reduction in flow through tubes could seriously impair the chiller performance or even result in tube freeze up. A thermal-type flow switch is factory installed in the evaporator nozzle and connected to the OptiView panel, which assures adequate chilled fluid flow during operation.

Low Entering Condenser Temperature: The chiller is engineered for maximum efficiency at both design and part-load operation by taking advantage of the colder cooling tower fluid temperatures which naturally occur during the winter months and off-design conditions. Appreciable power savings are realized from these reduced heads.

The unique design of YORK YD centrifugal chillers in the HVAC industry allows cold condenser fluid starts, without the trips experienced by other manufacturers, as detailed below:

- The condenser shell is higher than the evaporator, so when the chiller is not in operation, gravity moves refrigerant from the condenser into the evaporator. On start-up, the compressor begins pumping refrigerant gas from the evaporator into the condenser, building head pressure.
- The butterfly type liquid expansion valve (variable orifice valve) is controlled by the condenser liquid level at the sub-cooler inlet. As the condenser liquid level increases, the valve would be driven open to allow maximum refrigerant flow.
- YORK YD centrifugal chillers start up with vanes closed, which reduces the amount of refrigerant gas pumped out of the evaporator over time.
- The control system is set to stop the vanes from further opening if the evaporator fluid temperature reaches 1°F (0.6°C) above the trip setpoint for low water temperature cutout, typically 4°F (2.2°C) below setpoint.

At initial start-up, entering condenser water temperature may be 25°F (13.9°C) colder than standby chilled water temperature, but the minimum temperature must be above the freezing point of the chilled liquid.

Handling cold condenser fluid at the onset of changeover from free cooling with tower/heat exchangers is often necessary. The chiller starts and continues to operate because pressure differential increases quickly, which prevents nuisance trips on low evaporator pressure that are usually caused by system depression, refrigerant stack-up in the condenser, or starvation of the evaporator.

For continuous operation, the minimum entering condenser fluid temperature for both full and part load conditions is provided by the following equation:

Imperial

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

SI

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

Where:

- ECFT = entering condensing fluid temperature
- LCHFT = leaving chilled fluid temperature
- COND.RANGE = leaving condenser fluid temperature - entering condenser
- Fluid temperature at given load condition.

Examples:

1. 2000 TR (7032 kW) chiller
2. 44°F (6.7°C) leaving chilled fluid temperature
3. 85/94.3°F (29.4/34.6°C) condenser fluid temperature range at full load

The example using Imperial units at full load is as follows:

$$\text{Min. ECFT} = 44 - (94.3 - 85) + 5 + 12 \left(\frac{100}{100} \right) = 44 - 9.3 + 5 + 12 = 51.7^{\circ}\text{F}$$

The example using Imperial units at 20% load is as follows:

$$\text{Min. ECFT} = 44 - (87 - 85) + 5 + 12 \left(\frac{20}{100} \right) = 44 - 2 + 5 + 2.4 = 49.4^{\circ}\text{F}$$

The example using SI units at full load is as follows:

$$\text{Min. ECFT} = 6.7 - (34.6 - 29.4) + 2.8 + 6.6 \left(\frac{100}{100} \right) = 6.7 - 5.2 + 2.8 + 6.6 = 10.9^{\circ}\text{C}$$

The example using SI units at 20% load is as follows:

$$\text{Min. ECFT} = 6.7 - (30.6 - 29.4) + 2.8 + 6.6 \left(\frac{20}{100} \right) = 6.7 - 1.2 + 2.8 + 1.3 = 9.6^{\circ}\text{C}$$

Table 11: Water flow rate limits, gpm (L/s), based on constant flow application and standard tubes

Comp	Length (ft)	Flow/PD	Shell code	Evaporator						Shell code	Condenser									
				1 pass		2 pass		3 pass			1 pass		2 pass		3 pass					
				Min.	Max.	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.	Min.	Max.				
H9	16	gpm (L/s)	QQ	2825 (178)	11,200 (707)	1410 (89)	3825 (241)	950 (60)	2615 (165)	QQ	3675 (232)	13,100 (826)	1825 (115)	5325 (336)	1225 (77)	3570 (225)				
		ft (kPa)		3 (8)	46 (138)	7 (21)	43 (127)	11 (31)	66 (197)		4 (11)	36 (106)	6 (19)	42 (125)	9 (28)	62 (186)				
		gpm (L/s)		QR	3200 (202)	12,750 (804)	1600 (101)	4400 (278)	1065 (67)		2950 (186)	QR	4100 (259)	14,750 (931)	2050 (129)	5900 (372)	1360 (86)	3900 (246)		
		ft (kPa)			4 (12)	49 (145)	7 (21)	44 (132)	10 (31)		66 (196)		4 (11)	38 (113)	6 (19)	42 (125)	9 (27)	60 (180)		
		gpm (L/s)	QS		3450 (218)	13,275 (838)	1715 (108)	4690 (296)	1150 (73)	3165 (200)	QS		4550 (287)	16,300 (1028)	2290 (144)	6475 (409)				
		ft (kPa)			4 (12)	50 (151)	7 (22)	44 (132)	11 (32)	66 (198)			4 (12)	39 (118)	7 (20)	42 (125)				
		gpm (L/s)		Q2	2600 (164)	10,275 (648)	1300 (82)	4020 (254)	860 (54)	2685 (169)		Q2	3170 (200)	11,400 (719)	1570 (99)	5700 (360)			1050 (66)	3800 (240)
		ft (kPa)			3 (8)	40 (119)	5 (14)	45 (134)	7 (21)	67 (201)			2 (7)	25 (74)	4 (11)	39 (115)			6 (16)	55 (164)
		gpm (L/s)	Q3		3020 (191)	12,020 (758)	1505 (95)	4660 (294)	1010 (64)	3135 (198)	Q3		3860 (244)	13,900 (877)	1930 (122)	6925 (437)	1290 (81)	4630 (292)		
		ft (kPa)			3 (8)	42 (125)	5 (14)	45 (134)	7 (21)	67 (201)			3 (8)	27 (81)	4 (12)	40 (120)	6 (17)	57 (170)		
		gpm (L/s)		Q4	3425 (216)	13,665 (862)	1710 (108)	5220 (329)	1140 (72)	3730 (235)		Q4	4700 (297)	16,875 (1065)	2350 (148)	8395 (530)				
		ft (kPa)			3 (8)	45 (134)	5 (15)	45 (134)	7 (21)	68 (202)			3 (9)	31 (91)	4 (13)	42 (127)				
		gpm (L/s)	RP		3175 (200)	12,675 (800)	1585 (100)	4500 (284)	1060 (67)	2910 (184)	RQ		4900 (309)	17,675 (1115)	2450 (155)	7105 (448)			1630 (103)	4710 (297)
		ft (kPa)			4 (11)	45 (135)	7 (20)	44 (132)	10 (31)	64 (191)			3 (10)	32 (96)	6 (19)	42 (125)			91 (270)	63 (187)
		gpm (L/s)		RR	3910 (247)	15,625 (986)	1960 (124)	5500 (347)	1305 (82)	3620 (228)		RR	5390 (340)	19,410 (1225)	2700 (170)	7725 (487)	1790 (113)	5130 (324)		
		ft (kPa)			4 (12)	48 (145)	7 (21)	44 (132)	11 (31)	66 (197)			3 (10)	33 (97)	6 (19)	42 (125)	10 (29)	63 (187)		
		gpm (L/s)	RT		4735 (299)	18,930 (1194)	2385 (150)	6585 (415)	1585 (100)	4330 (273)	RS		5775 (364)	20,730 (1308)	2870 (181)	8215 (518)				
		ft (kPa)			4 (13)	53 (159)	7 (21)	45 (133)	11 (32)	66 (198)			3 (10)	33 (99)	6 (19)	42 (125)				
		gpm (L/s)		R2	3870 (244)	15,465 (976)	1940 (122)	6090 (384)	1290 (81)	4000 (252)		R2	4170 (263)	14,975 (945)	2075 (131)	7485 (472)			1385 (87)	4990 (315)
		ft (kPa)			3 (8)	43 (128)	5 (14)	45 (134)	7 (21)	67 (200)			2 (7)	22 (65)	4 (12)	39 (116)			6 (17)	57 (171)
		gpm (L/s)	R4		4350 (274)	17,480 (1103)	2185 (138)	6845 (432)	1460 (92)	4500 (284)	R3		4930 (311)	17,700 (1117)	2470 (156)	8860 (559)	1640 (103)	5915 (373)		
		ft (kPa)			3 (9)	45 (135)	5 (14)	45 (134)	7 (21)	67 (200)			2 (7)	22 (67)	4 (12)	40 (121)	6 (18)	60 (178)		
		gpm (L/s)		R6	4920 (310)	19,610 (1237)	2455 (155)	7600 (479)	1640 (103)	5020 (317)		R4	5900 (372)	21,050 (1328)	2920 (184)	10,485 (661)				
		ft (kPa)			3 (9)	48 (145)	5 (14)	45 (134)	7 (22)	67 (201)			2 (7)	24 (71)	4 (13)	42 (127)				

Table 11: Water flow rate limits, gpm (L/s), based on constant flow application and standard tubes

Comp	Length (ft)	Flow/PD	Shell code	Evaporator						Shell code	Condenser									
				1 pass		2 pass		3 pass			1 pass		2 pass		3 pass					
				Min.	Max.	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.	Min.	Max.				
K1	18	gpm (L/s)	BB	3851 (243)	15,405 (972)	1923 (121)	5094 (321)	1282 (81)	3357 (212)	LB	4983 (314)	17,956 (1133)	2492 (157)	6790 (428)	1660 (105)	4556 (287)				
		ft (kPa)		4 (13)	52 (157)	8 (24)	45 (134)	12 (36)	67 (201)		4 (13)	38 (114)	8 (23)	45 (134)	11 (33)	67 (201)				
		gpm (L/s)		BC	4704 (297)	18,816 (1187)	2352 (148)	6162 (389)	1568 (99)		4069 (257)	LC	5466 (345)	19,695 (1243)	2730 (172)	7398 (467)	1820 (115)	4981 (314)		
		ft (kPa)			5 (14)	57 (170)	8 (24)	45 (134)	12 (36)		67 (201)		4 (13)	39 (118)	8 (23)	45 (134)	11 (33)	68 (202)		
		gpm (L/s)	BD		5522 (348)	22,088 (1394)	2761 (174)	7151 (451)	1841 (116)	4731 (298)	LD		5828 (368)	21,002 (1325)	2914 (184)	7836 (494)				
		ft (kPa)			5 (15)	63 (187)	8 (24)	45 (134)	12 (36)	67 (201)			4 (13)	41 (121)	8 (23)	45 (134)				
		gpm (L/s)		B2	3957 (250)	15,828 (999)	1979 (125)	6786 (428)	1319 (83)	4478 (283)		L2	4303 (271)	17,087 (1078)	2152 (136)	8201 (517)			1434 (90)	5561 (351)
		ft (kPa)			3 (9)	37 (109)	5 (14)	45 (134)	7 (22)	67 (201)			3 (8)	26 (78)	5 (14)	45 (134)			7 (19)	64 (192)
		gpm (L/s)	B3		4706 (297)	18,825 (1188)	2353 (148)	7953 (502)	1569 (99)	5255 (332)	L3		5072 (320)	19,857 (1253)	2536 (160)	9370 (591)	1691 (107)	6396 (403)		
		ft (kPa)			3 (9)	41 (122)	5 (15)	45 (134)	7 (22)	68 (202)			3 (9)	28 (84)	5 (14)	45 (134)	7 (20)	66 (196)		
		gpm (L/s)		B4	5359 (338)	21,435 (1352)	2679 (169)	8922 (563)	1786 (113)	5912 (373)		L4	5989 (378)	23,163 (1461)	2995 (189)	10,684 (674)				
		ft (kPa)			3 (10)	45 (134)	5 (15)	45 (134)	8 (22)	68 (202)			3 (9)	31 (92)	5 (15)	45 (134)				
		gpm (L/s)	MB		3851 (243)	15,406 (972)	1926 (121)	4574 (289)	1284 (81)	3011 (190)	MB		4980 (314)	17,956 (1133)	2490 (157)	6116 (386)			1660 (105)	4093 (258)
		ft (kPa)			5 (16)	62 (185)	10 (29)	45 (134)	15 (43)	67 (201)			5 (16)	52 (156)	9 (26)	45 (134)			13 (40)	67 (201)
		gpm (L/s)		MC	4704 (297)	18,817 (1187)	2352 (148)	5551 (350)	1568 (99)	3654 (230)		MC	5460 (344)	19,695 (1243)	2730 (172)	6672 (421)	1820 (115)	4472 (282)		
		ft (kPa)			6 (16)	67 (199)	10 (29)	45 (134)	15 (44)	67 (201)			5 (16)	55 (164)	9 (26)	45 (134)	13 (40)	67 (201)		
		gpm (L/s)	MD		5522 (348)	22,088 (1394)	2761 (174)	6447 (407)	1841 (116)	4261 (269)	MD		5820 (367)	21,002 (1325)	2914 (184)	7075 (446)				
		ft (kPa)			6 (17)	72 (215)	10 (29)	45 (134)	15 (44)	67 (201)			6 (18)	57 (170)	9 (27)	45 (134)				
		gpm (L/s)		M2	3957 (250)	15,828 (999)	1979 (125)	6133 (387)	1319 (83)	4043 (255)		M2	4303 (271)	17,087 (1078)	2152 (136)	7433 (469)			1434 (90)	5005 (316)
		ft (kPa)			3 (10)	42 (126)	6 (17)	45 (134)	9 (26)	68 (202)			4 (11)	37 (109)	6 (16)	45 (134)			8 (24)	68 (202)
		gpm (L/s)	M3		4706 (297)	18,825 (1188)	2353 (148)	7200 (454)	1569 (99)	4753 (300)	M3		5072 (320)	19,557 (1234)	2536 (160)	8514 (537)	1691 (107)	5775 (364)		
		ft (kPa)			4 (11)	46 (139)	6 (18)	45 (134)	9 (27)	67 (201)			4 (12)	41 (123)	6 (16)	45 (134)	8 (24)	67 (201)		
		gpm (L/s)		M4	5359 (338)	21,435 (1352)	2679 (169)	8105 (511)	1786 (113)	5359 (338)		M4	5989 (378)	23,163 (1461)	3995 (252)	9728 (614)				
		ft (kPa)			4 (12)	51 (151)	6 (18)	45 (134)	9 (27)	68 (202)			4 (13)	47 (140)	10 (30)	45 (134)				

Table 11: Water flow rate limits, gpm (L/s), based on constant flow application and standard tubes

Comp	Length (ft)	Flow/PD	Shell code	Evaporator						Shell code	Condenser											
				1 pass		2 pass		3 pass			1 pass		2 pass		3 pass							
				Min.	Max.	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.	Min.	Max.						
K2	18	gpm (L/s)	NB	4872 (307)	19,489 (1230)	2436 (154)	6370 (402)	1624 (102)	4206 (265)	BB	6213 (392)	22,389 (1412)	3107 (196)	8312 (524)	2070 (131)	5634 (355)						
		ft (kPa)		5 (14)	58 (174)	8 (24)	45 (134)	12 (36)	67 (201)		4 (13)	42 (124)	8 (23)	45 (134)	11 (34)	68 (202)						
		gpm (L/s)		NC	5386 (340)	21,543 (1359)	2693 (170)	6988 (441)	1795 (113)		4623 (292)	BC	6740 (425)	24,286 (1532)	3370 (213)	8925 (563)	2245 (142)	6082 (384)				
		ft (kPa)			5 (15)	62 (184)	8 (24)	45 (134)	12 (36)		67 (201)		5 (14)	43 (129)	8 (24)	45 (134)	11 (34)	67 (201)				
		gpm (L/s)	ND		5864 (370)	23,457 (1480)	2932 (185)	7565 (477)	1955 (123)	4994 (315)	BD		7115 (449)	25,639 (1618)	3557 (224)	9358 (590)	2370 (150)	6399 (404)				
		ft (kPa)			5 (15)	65 (194)	8 (24)	45 (134)	12 (37)	68 (202)			5 (14)	45 (133)	8 (24)	45 (134)	12 (34)	68 (202)				
		gpm (L/s)		BE								7449 (470)	26,544 (1675)	3725 (235)	9731 (614)							
		ft (kPa)										5 (14)	46 (137)	8 (24)	45 (134)							
		gpm (L/s)	N2	4875 (308)	19,501 (1230)	2438 (154)	8215 (518)	1625 (103)	5428 (342)	B2	5772 (364)	22,381 (1412)	2886 (182)	10,379 (655)	1924 (121)	7143 (451)						
		ft (kPa)		3 (10)	42 (125)	5 (15)	45 (134)	7 (22)	67 (201)		3 (9)	30 (90)	5 (15)	45 (134)	7 (20)	67 (199)						
		gpm (L/s)		N3	5763 (364)	23,054 (1454)	2882 (182)	9810 (619)	1921 (121)		6311 (398)	B3	6380 (403)	24,570 (1550)	3190 (201)	11,210 (707)	2127 (134)	7770 (490)				
		ft (kPa)			4 (11)	48 (142)	5 (15)	45 (134)	8 (23)		67 (201)		3 (10)	32 (96)	5 (15)	45 (134)	7 (21)	67 (201)				
		gpm (L/s)	N4		6422 (405)	25,688 (1621)	3211 (203)	10,420 (657)	2141 (135)	6925 (437)	B4		6981 (440)	26,737 (1687)	3491 (220)	11,981 (756)	2327 (147)	8377 (529)				
		ft (kPa)			4 (12)	53 (157)	5 (16)	45 (134)	8 (23)	68 (202)			3 (10)	34 (102)	5 (16)	45 (134)	7 (21)	67 (201)				
		gpm (L/s)										7713 (487)	29,372 (1853)	3856 (243)	12,869 (812)							
		ft (kPa)										4 (10)	37 (111)	5 (16)	45 (134)							
		K3	22	gpm (L/s)	EB	6353 (401)	25,410 (1603)	3176 (200)	7464 (471)	2118 (134)	4934 (311)	CB	6241 (394)	22,491 (1419)	3121 (197)	7661 (483)	2080 (131)	5079 (320)				
				ft (kPa)		5 (16)	65 (193)	10 (29)	45 (134)	15 (44)	68 (202)		5 (16)	49 (145)	9 (27)	45 (134)	14 (40)	67 (201)				
				gpm (L/s)		EC	7159 (452)	28,631 (1806)	3579 (226)	8339 (526)	2386 (151)		5523 (348)	CC	6967 (440)	25,105 (1584)	3483 (220)	8488 (536)	2322 (146)	5638 (356)		
				ft (kPa)			6 (17)	68 (203)	10 (30)	45 (134)	15 (44)		68 (202)		5 (16)	51 (152)	9 (27)	45 (134)	14 (41)	67 (201)		
				gpm (L/s)	ED		7938 (501)	31,750 (2003)	3969 (250)	9168 (578)	2646 (167)	6085 (384)	CD		7900 (498)	28,469 (1796)	3950 (249)	9519 (601)				
				ft (kPa)			6 (17)	71 (213)	10 (30)	45 (134)	15 (45)	68 (202)			6 (17)	55 (163)	9 (28)	45 (134)				
				gpm (L/s)		E2	6428 (406)	25,712 (1622)	3214 (203)	9754 (615)	2143 (135)	6483 (409)		C2	4969 (313)	19,879 (1254)	2484 (157)	8697 (549)			2030 (128)	5782 (365)
				ft (kPa)			4 (10)	45 (134)	6 (18)	45 (134)	9 (27)	68 (202)			3 (10)	33 (97)	5 (16)	45 (134)			12 (35)	68 (202)
				gpm (L/s)	E3		7117 (449)	28,467 (1796)	3558 (224)	10,693 (675)	2372 (150)	7117 (449)	C3		6487 (409)	25,352 (1599)	3244 (205)	10,838 (684)	2162 (136)	7246 (457)		
				ft (kPa)			4 (11)	48 (142)	6 (18)	45 (134)	9 (27)	67 (201)			4 (11)	37 (111)	6 (16)	45 (134)	8 (25)	68 (202)		
				gpm (L/s)		E4	7842 (495)	31,367 (1979)	3921 (247)	11,645 (735)	2614 (165)	7776 (491)		C4	8099 (511)	31,159 (1966)	4049 (255)	12,951 (817)				
				ft (kPa)			4 (12)	51 (151)	6 (19)	45 (134)	9 (27)	68 (202)			4 (12)	44 (130)	6 (17)	45 (134)				

Table 11: Water flow rate limits, gpm (L/s), based on constant flow application and standard tubes

Comp	Length (ft)	Flow/PD	Shell code	Evaporator						Shell code	Condenser																
				1 pass		2 pass		3 pass			1 pass		2 pass		3 pass												
				Min.	Max.	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.	Min.	Max.											
K3	18	gpm (L/s)	FB	7995 (504)	31,978 (2018)	3997 (252)	10,213 (644)	2665 (168)	6915 (436)	DB	7569 (478)	27,275 (1721)	3780 (238)	10,143 (640)	2520 (159)	6876 (434)											
		ft (kPa)		5 (15)	62 (186)	8 (25)	45 (134)	12 (36)	67 (201)		5 (14)	46 (138)	8 (22)	45 (134)	11 (32)	68 (202)											
		gpm (L/s)		FC	8946 (564)	35,782 (2257)	4473 (282)	11,294 (713)	2982 (188)		7678 (484)	DC	8440 (532)	30,412 (1919)	4215 (266)	11,176 (705)	2810 (177)	7628 (481)									
		ft (kPa)			5 (16)	67 (200)	9 (25)	45 (134)	12 (36)		68 (202)		5 (15)	50 (148)	8 (23)	45 (134)	11 (33)	67 (201)									
		gpm (L/s)	FD		9009 (568)	39,637 (2501)	4955 (313)	12,337 (778)	3303 (208)	8456 (533)	DD		9326 (588)	33,606 (2120)	4663 (294)	12,182 (769)	3105 (196)	8359 (527)									
		ft (kPa)			6 (17)	72 (216)	9 (26)	45 (134)	12 (37)	68 (202)			5 (16)	54 (160)	8 (23)	45 (134)	11 (33)	68 (202)									
		gpm (L/s)								DE		9714 (613)	35,003 (2208)	4857 (306)	12,601 (795)												
		ft (kPa)										5 (16)	56 (166)	8 (24)	45 (134)												
		gpm (L/s)	F2								8047 (508)	32,188 (2031)	4024 (254)	13,056 (824)	2682 (169)			8986 (567)	D2	7206 (455)	27,943 (1763)	3603 (227)	12,958 (818)	2402 (152)	8930 (563)		
		ft (kPa)									3 (10)	46 (137)	5 (16)	45 (134)	7 (22)			68 (202)		3 (10)	36 (106)	5 (14)	45 (134)	7 (20)	67 (201)		
		gpm (L/s)		F3	8941 (564)	35,765 (2256)	4471 (282)	14,216 (897)	2980 (188)	9880 (623)	D3	7944 (501)	30,601 (1931)	3972 (251)	13,962 (881)	2648 (167)	9703 (612)										
		ft (kPa)			4 (11)	50 (151)	5 (16)	45 (134)	8 (22)	67 (201)		4 (11)	39 (115)	5 (15)	45 (134)	7 (21)	67 (201)										
		gpm (L/s)	F4		9920 (626)	39,800 (2510)	4960 (313)	15,425 (973)	3307 (209)	10,829 (683)		D4	8756 (552)	33,527 (2115)	4378 (276)	15,003 (947)	2919 (184)	10,533 (665)									
		ft (kPa)			4 (12)	56 (167)	6 (17)	45 (134)	8 (23)	68 (202)			4 (12)	42 (126)	5 (16)	45 (134)	7 (21)	67 (201)									
		gpm (L/s)								D5	9909 (625)		37,681 (2377)	4954 (313)	16,391 (1034)												
		ft (kPa)									4 (13)		48 (142)	5 (16)	45 (134)												
		K4	22								gpm (L/s)	GB	7995 (504)	31,978 (2018)	3997 (252)			9234 (583)	2665 (168)	6209 (392)	EB	7708 (486)	27,775 (1752)	3850 (243)	9322 (588)	2565 (162)	6307 (398)
											ft (kPa)		6 (17)	72 (214)	10 (30)			45 (134)	15 (44)	67 (201)		6 (17)	54 (162)	9 (28)	45 (134)	14 (42)	67 (201)
				gpm (L/s)	GC	8946 (564)	35,872 (2263)	4473 (282)	10,220 (645)	2982 (188)	6918 (436)		EC	8578 (541)	30,912 (1950)	4285 (270)	10,259 (647)	2855 (180)	6981 (440)								
				ft (kPa)		6 (18)	76 (228)	11 (32)	45 (134)	15 (44)	67 (201)			6 (17)	58 (173)	9 (27)	45 (134)	14 (41)	68 (202)								
gpm (L/s)	GD			9909 (625)		39,637 (2501)	4955 (313)	11,197 (706)	3303 (208)	7614 (480)	ED	9465 (597)		34,106 (2152)	4732 (299)	11,191 (706)	3150 (199)	7660 (483)									
ft (kPa)				6 (19)		82 (244)	10 (31)	45 (134)	15 (45)	68 (202)		6 (19)		62 (185)	10 (29)	45 (134)	14 (41)	67 (201)									
gpm (L/s)										EE		9853 (622)	35,503 (2240)	4926 (311)	11,583 (731)												
ft (kPa)												6 (19)	64 (190)	10 (29)	45 (134)												

Table 11: Water flow rate limits, gpm (L/s), based on constant flow application and standard tubes

Comp	Length (ft)	Flow/PD	Shell code	Evaporator						Shell code	Condenser														
				1 pass		2 pass		3 pass			1 pass		2 pass		3 pass										
				Min.	Max.	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.	Min.	Max.									
K4	22	gpm (L/s)	G2	8047 (508)	32,188 (2031)	4024 (254)	11,910 (751)	2682 (169)	8128 (513)	E2	7345 (463)	28,926 (1825)	3673 (232)	12,149 (766)	2448 (154)	8352 (527)									
		ft (kPa)		4 (12)	52 (154)	6 (19)	45 (134)	9 (27)	68 (202)		4 (11)	41 (123)	6 (17)	45 (134)	8 (25)	68 (202)									
		gpm (L/s)	G3	8941 (564)	35,765 (2256)	4471 (282)	13,009 (821)	2980 (188)	8956 (565)	E3	8083 (510)	31,584 (1993)	4041 (255)	13,087 (826)	2694 (170)	9054 (571)									
		ft (kPa)		4 (13)	56 (168)	6 (19)	45 (134)	9 (27)	67 (201)		4 (13)	44 (133)	6 (18)	45 (134)	8 (25)	67 (201)									
		gpm (L/s)	G4	9920 (626)	39,680 (2503)	4960 (313)	14,161 (893)	3307 (209)	9837 (621)	E4	8895 (561)	34,510 (2177)	4447 (281)	14,063 (887)	2965 (187)	9806 (619)									
		ft (kPa)		5 (14)	62 (184)	7 (20)	45 (134)	9 (27)	67 (201)		5 (14)	48 (144)	6 (19)	45 (134)	9 (26)	67 (201)									
		gpm (L/s)									E5	10,048 (634)	38,664 (2439)	5024 (317)	15,393 (971)										
		ft (kPa)										5 (15)	54 (161)	7 (20)	45 (134)										
		K4	18	gpm (L/s)	HB	9155 (578)	36,619 (2310)	4577 (289)	11,512 (726)	3052 (193)	7858 (496)	FB	9121 (575)	32,867 (2074)	4560 (288)	12,428 (784)	3040 (192)	8326 (525)							
				ft (kPa)		5 (16)	68 (203)	9 (25)	45 (134)	12 (36)	67 (201)		5 (16)	54 (161)	8 (23)	45 (134)	12 (35)	68 (202)							
gpm (L/s)	HC			10,068 (635)	40,271 (2541)	5034 (318)	12,484 (788)	3356 (212)	8574 (541)	FC	10,098 (637)	36,390 (2296)	5049 (319)	13,646 (861)	3366 (212)	9158 (578)									
ft (kPa)				6 (17)	73 (219)	9 (26)	45 (134)	12 (37)	67 (201)		6 (17)	58 (174)	8 (24)	45 (134)	12 (35)	67 (201)									
gpm (L/s)	HD			11,247 (710)	44,988 (2838)	5623 (355)	13,693 (864)	3749 (237)	9485 (598)	FD	10,865 (685)	39,152 (2470)	5432 (343)	14,584 (920)	3622 (229)	9820 (620)									
ft (kPa)				6 (18)	81 (241)	9 (27)	45 (134)	13 (37)	67 (201)		6 (18)	62 (186)	8 (24)	45 (134)	12 (35)	67 (201)									
gpm (L/s)											FE	11,281 (712)	40,652 (2565)	5641 (356)	15,092 (952)										
ft (kPa)												6 (19)	65 (193)	8 (24)	45 (134)										
gpm (L/s)	H2			9002 (568)	36,006 (2272)	4501 (284)	14,290 (902)	3001 (189)	9947 (628)	F2	8721 (550)	33,884 (2138)	4361 (275)	16,116 (1017)	2907 (183)	10,899 (688)									
ft (kPa)				4 (11)	51 (151)	5 (16)	45 (134)	8 (22)	68 (202)		4 (12)	43 (129)	5 (15)	45 (134)	7 (21)	67 (201)									
gpm (L/s)	H3			10,004 (631)	40,018 (2525)	5002 (316)	15,532 (980)	3335 (210)	10,922 (689)	F3	9620 (607)	37,123 (2342)	4810 (303)	16,116 (1017)	3207 (202)	11,848 (748)									
ft (kPa)				4 (12)	56 (168)	6 (17)	45 (134)	8 (23)	67 (201)		4 (13)	48 (142)	5 (15)	45 (134)	7 (21)	68 (202)									
gpm (L/s)	H4			11,116 (701)	44,464 (2805)	5558 (351)	16,813 (1061)	3705 (234)	11,950 (754)	F4	10,590 (668)	40,674 (2566)	5303 (335)	18,863 (1190)	3535 (223)	12,863 (812)									
ft (kPa)				5 (13)	63 (189)	6 (17)	45 (134)	8 (23)	67 (201)		4 (13)	53 (158)	5 (15)	45 (134)	7 (22)	67 (201)									
gpm (L/s)											F5	11,703 (738)	44,628 (2816)	5851 (369)	20,361 (1285)										
ft (kPa)												5 (15)	59 (177)	5 (16)	45 (134)										

Table 11: Water flow rate limits, gpm (L/s), based on constant flow application and standard tubes

Comp	Length (ft)	Flow/PD	Shell code	Evaporator						Shell code	Condenser														
				1 pass		2 pass		3 pass			1 pass		2 pass		3 pass										
				Min.	Max.	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.	Min.	Max.									
K7	22	gpm (L/s)	KB	9155 (578)	36,619 (2310)	4577 (289)	10,459 (660)	3052 (193)	7064 (446)	KB	10,767 (679)	38,799 (2448)	5384 (340)	13,070 (825)	3589 (226)	8762 (553)									
		ft (kPa)		6 (19)	78 (231)	10 (30)	45 (134)	15 (44)	67 (201)		7 (20)	69 (206)	9 (28)	45 (134)	14 (42)	67 (201)									
		gpm (L/s)		KC	10,068 (635)	40,271 (2541)	5034 (318)	11,376 (718)	3356 (212)		7735 (488)	KC	11,969 (755)	43,129 (2721)	5984 (378)	14,367 (906)	3990 (252)	9668 (610)							
		ft (kPa)			7 (19)	83 (247)	10 (30)	45 (134)	15 (45)		67 (201)		7 (22)	76 (227)	10 (29)	45 (134)	14 (43)	68 (202)							
		gpm (L/s)	KD		11,247 (710)	44,988 (2838)	5623 (355)	12,512 (789)	3749 (237)	8566 (540)	KD		12,647 (798)	45,573 (2875)	6323 (399)	15,096 (952)	4216 (266)	10,178 (642)							
		ft (kPa)			7 (21)	90 (269)	10 (31)	45 (134)	15 (45)	67 (201)			8 (23)	80 (239)	10 (29)	45 (134)	14 (43)	68 (202)							
		gpm (L/s)								KE		13,303 (839)	47,936 (3024)	6651 (420)	15,789 (996)										
		ft (kPa)										8 (24)	84 (251)	10 (30)	45 (134)										
		gpm (L/s)	K2								9002 (568)	26,006 (1641)	4501 (284)	13,097 (826)	3001 (189)			9017 (569)	K2	9944 (627)	38,642 (2438)	4972 (314)	16,423 (1036)	3315 (209)	11,126 (702)
		ft (kPa)									4 (13)	57 (169)	6 (19)	45 (134)	9 (27)			67 (201)		5 (15)	54 (162)	6 (18)	45 (134)	9 (25)	67 (201)
		gpm (L/s)		K3	10,004 (631)	40,018 (2525)	5002 (316)	14,256 (899)	3335 (210)	9921 (626)	K3	10,961 (692)	42,305 (2669)	5480 (346)	17,768 (1121)	3654 (231)	12,075 (762)								
		ft (kPa)			5 (14)	62 (185)	7 (20)	45 (134)	9 (27)	68 (202)		5 (16)	60 (179)	6 (18)	45 (134)	9 (26)	68 (202)								
		gpm (L/s)	K4		16,500 (1041)	44,464 (2805)	5558 (351)	15,479 (977)	3705 (234)	10,894 (687)		K4	12,082 (762)	46,348 (2924)	6041 (381)	19,176 (1210)	4027 (254)	13,113 (827)							
		ft (kPa)			11 (32)	69 (206)	7 (20)	45 (134)	9 (28)	67 (201)			6 (17)	67 (200)	6 (18)	45 (134)	9 (25)	68 (202)							
		gpm (L/s)								K5	13,682 (863)		52,111 (3288)	6841 (432)	21,105 (1331)										
		ft (kPa)									7 (19)		78 (232)	6 (19)	45 (134)										

Electrical considerations

Starters

The YD chiller requires two starters, one connected to each of the chiller's compressor motors. The two starters can be individually connected to a power source, or furnished as a package with the two incoming feeds bussed or cabled together. A unit-mounted LVVSD or remote-mounted M/HVVSD is available as well as a unit mounted MVSSS or remote mounted M/HVSSS. These chillers are also available with a remote-mounted L/M/HVEMS that can be furnished in accordance with YORK Standard Specifications (R-1206). This ensures that starter components, controls, circuits, and terminal markings are suitable for required overall system performance.

Motor voltage: Low voltage motors (380 V to 575 V) are furnished with six leads or multiples of six leads. Medium and high voltage (2,300 V and above) 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 12](#) 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 12: Motor voltage variations

Frequency	Rated voltage	Nameplate voltage *	Operating voltage	
			Minimum	Maximum
60 Hz	380	380	342	415
	460	440/460/480	414	508
	575	575/600	520	635
	2,300	2,300	2,070	2,530
	3,300	3,300	2,970	3,630
	4,000	4,000/4,160	3,600	4,576
50 Hz	380	380/400	342	423
	415	415	374	440
	2,300	2,300	2,070	2,530
	3,300	3,300	2,970	3,630

① **Note:** * For motor voltage above 4,160 V/60 Hz and 3,300 V/50 Hz, contact the Johnson Controls Sales Office for a specific selection.

Copper conductors: Connect copper conductors to compressor motors and starters. Aluminum conductors are not effective 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 constant speed chiller for the purpose of power factor correction. For remote-mounted electromechanical 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.

Controls and oil pump power supplies: The YD chiller is equipped with an auxiliary variable speed oil pump drive panel. This panel operates the two oil pump motors and the two oil reservoir heaters. This panel houses the control power supply changeover switch to allow the operation of either compressor/motor in the event that the other compressor/motor must be totally deenergized and locked out for service. It requires a three-phase power supply and 115 V power

source from each of the starters/drives. If a separate power source is required, a Special Quote (SQ) is required.

Chillers with unit mounted starters/drives are supplied with factory wired power connections. Remote mounted starters/drives require these power connections to be installed by the electrical installation contractor

Ampacity on load side of starter: The electrical power wire size to each chiller motor is based on the minimum 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 for each conductor (1 of 6):
 $\text{Ampacity} = 0.721 \times \text{compressor motor amps}$
- Three-lead type of starting
(Across-the-Line, Autotransformer, and Primary Reactor)
- Minimum circuit ampacity for each conductor (1 of 3):
 $\text{Ampacity} = 1.25 \times \text{compressor motor amps}$

Ampacity on line-side of starter: The YD chiller uses two compressor motors and starters. If the starters are connected together to the line side, multiply the individual ampacity requirements by two to obtain the total. The additional load on the circuit for the chiller would be the control transformer and oil pump motors 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 devices 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 the submittal drawings for the specific calculations for each application.

Variable speed oil pump (VSOP) control panel power supply controls: For a remote-mounted medium or high voltage variable speed drive (M/HVVSD), remote-mounted medium or high voltage solid state starter (M/HVSSS), and remote-mounted low, medium, or high voltage electromechanical starter (L/M/HVEMS), a 115 V, single phase, 60 Hz or 50 Hz, 2 kVa power supply must be furnished at the starter. These chillers with remote starters/drives requires a three-phase supply for the auxiliary power (heater and oil pump). For chillers with a unit-mounted low voltage variable speed drive (LVVSD) or unit-mounted medium voltage solid state starter, the VSOP control panel power does not require an additional control power transformer, but is included in the Johnson Controls furnished starter.

Motor electrical data

The smallest motor available which equals or exceeds the input power (kW) from the chiller rating program is selected from [Table 13](#) through [Table 23](#). 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:

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

Table 13: Available 60 Hz compressor, shell, and motor combinations

Compressor code	Evaporator code	Condenser code	Motor codes			
			60 Hz			
			Low voltage (none or EMS)	Low voltage (VSD)	Medium or high voltage (none or EMS)	Medium voltage (VAS)
H9	QQ, QR, QS, Q2, Q3, Q4, RP, RR, RT, R2, R4, R6	QQ, QR, QS, Q2, Q3, Q4, RQ, RR, RT, R2, R3, R4	ER-EA	ER-EA	CT-CA	CT-CA
K1	BB, BC, BD, B2, B3, B4	LB, LC, LD, L2, L3, L4	EW-FD	EW-FD	CW-DC	CW-DC
K2	MB, MC, MD, M2, M3, M4, NB, NC, ND, N2, N3, N4	MB, MC, MD, M2, M3, M4, BB, BC, BD, BE, B2, B3, B4, B5	EW-FD	EW-FD	CW-DC	CW-DC
K3	EB, EC, ED, E2, E3, E4, FB, FC, FD, F2, F3, F4	CB, CC, CD, C2, C3, C4, DB, DC, DD, DE, D2, D3, D4, D5	FA-FD	FA-FB	DA-DJ	DA-DJ
K4	GB, GC, GD, G2, G3, G4, HB, HC, HD, H2, H3, H4	EB, EC, ED, EE, E2, E3, E4, E5, FB, FC, FD, FE, F2, F3, F4, F5	FA-FD	FA-FB	DA-DJ	DA-DJ
K7	KB, KC, KD, K2, K3, K4	K7, KB, KC, KD, KE, K2, K3, K4, K5	-	-	DD-DL	DD-DL
Voltage (V)			380 up to 575	380 up to 575	2300 up to 13200	2300 up to 4160

FLA correction facilitates the use of smaller power wiring and starter size.

The locked rotor amperes (LRA) are read directly from [Table 13](#) through [Table 23](#) 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).

In-rush amperes (IRA) depend on LRA and the type of starter applied. The in-rush can be calculated using a percentage of LRA shown in [Table 15](#).

Table 14: Available 50 Hz compressor, shell, and motor combinations

Compressor code	Evaporator code	Condenser code	Motor codes			
			50 Hz			
			Low voltage (none/EM)	Low voltage (VSD)	Medium voltage (none/EM/PR/AT)	Medium voltage (VSD)
H9	QQ, QR, QS, Q2, Q3, Q4. RP, RR, RT, R2, R4, R6	QQ, QR, QS, Q2, Q3, Q4, RQ, RR, RT, R2, R3, R4	5EM-5EW	5EM-5EW	5CO-5CW	5CO-5CW
K1	BB, BC, BD, B2, B3, B4	LB, LC, LD, L2, L3, L4	5ES-5FB	5ES-5FA	5CS-5DC	5CS-5DC
K2	MB, MC, MD, M2, M3, M4, NB, NC, ND, N2, N3, N4	MB, MC, MD, M2, M3, M4, BB, BC, BD, BE, B2, B3, B4, B5	5ES-5FB	5ES-5FA	5CS-5DC	5CS-5DC
K3	EB, EC, ED, E2, E3, E4, FB, FC, FD, F2, F3, F4	CB, CC, CD, C2, C3, C4, DB, DC, DD, DE, D2, D3, D4, D5	5FA-5FB	5FA-5FA	5DA-5DH	5DA-5DH
K4	GB, GC, GD, G2, G3, G4, HB, HC, HD, H2, H3, H4	EB, EC, ED, EE, E2, E3, E4, E5, FB, FC, FD, FE, F2, F3, F4, F5	5FA-5FB	5FA-5FA	5DA-5DJ	5DA-5DJ
K7	KB, KC, KD, K2, K3, K4	K7, KB, KC, KD, KE, K2, K3, K4, K5	5FA-5FB	5FA-5FA	5DD-5DL	5DD-5DL
Voltage (V)			380 up to 415	380 up to 415	2300 up to 11000	3300

60 Hz electrical data

Table 15: 60 Hz electrical data

Motor code	CT	CU	CV	CW	CX	CY	CZ	CA	CB	DA	DB	DC	DD	DE	DF	DH	DJ	DK	DL	
Shaft HP (MAX)	503	554	608	655	690	740	790	845	900	1000	1100	1200	1300	1400	1500	1750	2000	2250	2500	
Input kW (MAX)	395	435	477	514	542	578	618	660	703	781	859	937	1015	1093	1171	1359	1554	1748	1942	
F.L. EFF. - %	95.0	95.0	95.0	95.0	95.0	95.5	95.3	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	96.0	96.0	96.0	96.0	
F.L. Power Factor	0.87	0.87	0.87	0.87	0.87	0.88	0.88	0.89	0.89	0.87	0.87	0.87	0.88	0.88	0.88	0.87	0.89	0.89	0.89	
Volts	Amperes (max.)																			
2300	FLA	113	124	135	146	154	165	176	186	198	225	248	267	290	312	334	383	438	493	548
	LRA	719	791	867	935	960	1008	1100	1172	1230	1350	1592	1592	1882	2031	2171	2390	2879	3199	3356
3300	FLA	79	86	94	102	108	115	123	130	138	157	173	186	202	217	233	267	306	344	382
	LRA	501	551	576	652	682	719	744	819	858	942	1110	1110	1311	1416	1514	1661	2011	2388	2479
4000	FLA	65	71	78	84	89	95	101	107	114	130	143	154	166	179	192	220	252	283	315
	LRA	413	455	499	538	540	554	631	674	713	780	923	923	1077	1177	1246	1428	1669	1842	2047
4160	FLA	63	68	75	81	85	91	97	102	110	125	137	148	160	172	185	212	242	273	303
	LRA	430	473	519	560	562	576	656	701	742	811	960	960	1120	1224	1296	1485	1736	1772	1968

- ① **Note:** High voltage and special motor designs may not meet efficiency, power factor, or amperes values shown for standard motors.

Table 16: 60 Hz electrical data - premium efficiency

Motor code	ER	ES	ET	EU	EV	EW	EX	EY	EZ	EA	EB	FA	FB	FC	FD	
Shaft HP (max)	424	468	503	554	608	655	690	740	790	845	900	1000	1100	1200	1300	
Input kW (max)	330	363	390	431	473	508	535	574	612	655	698	775	853	930	1008	
F.L. EFF. - %	95.8	96.2	96.2	95.8	95.8	96.2	96.2	96.2	96.2	96.2	96.2	96.2	96.2	96.2	96.2	
F.L. power factor	0.88	0.88	0.88	0.88	0.88	0.87	0.87	0.88	0.87	0.88	0.88	0.87	0.87	0.87	0.87	
Volts	Amperes (max.)															
380	FLA	570	626	673	745	817	887	934	990	1069	1131	1204	1354	1489	1624	-
	LRA	3810	4179	4480	4671	5326	5780	5859	6244	6644	7106	7513	7794	8491	9431	-
440	FLA	492	541	581	643	706	766	807	855	924	977	1040	1169	1286	1403	1520
	LRA	2976	3300	3348	3644	4687	4668	4744	5050	5098	5529	5782	6160	6709	7455	9003
460	FLA	471	517	556	615	675	732	772	818	883	934	995	1118	1230	1342	1454
	LRA	3111	3450	3500	3810	4900	4880	4960	5280	5330	5780	6045	6440	7014	7794	9412
480	FLA	451	496	533	589	647	702	739	784	847	895	954	1072	1179	1286	1393
	LRA	3246	3600	3652	3976	5113	5092	5175	5510	5562	6031	6308	6720	7319	8133	9821
575	FLA	377	414	445	492	540	586	617	654	707	747	796	895	984	1074	1163
	LRA	2413	2760	2960	3089	3550	4039	4100	4200	4200	4694	4963	5148	5610	6232	7527

- ① **Note:** These motors are designed to meet or exceed NEMA Premium (MG1-2006) and European IE2 efficiency requirements.

50 Hz electrical data

Table 17: 50 Hz electrical data

Motor code	5CO	5CP	5CQ	5CR	5CS	5CT	5CU	5CV	5CW	5CX	5DA	5DB	5DC	5DD	5DE	5DF	5DG	5DH	5DJ	5DK	5DL
Shaft HP (max)	507	546	575	617	658	704	750	800	850	900	1000	1100	1200	1300	1400	1500	1650	1750	2000	2250	2500
Input kW (max)	398	429	451	484	516	553	589	628	667	706	785	863	942	1015	1093	1171	1288	1359	1554	1748	1942
F.L. EFF. - %	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.5	95.5	95.5	95.5	96.0	96.0	96.0	96.0
F.L. Power Factor	0.87	0.87	0.87	0.87	0.88	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
Volts	Amperes (max.)																				
3300	FLA	80	86.2	90.8	97.4	103	110	116	123	131	139	156	174	187	202	217	233	256	267	306	344
	LRA	499	516	572	614	644	693	725	744	819	875	871	1135	1135	1135	1415	1415	1415	1667	1836	2233

Note: High voltage and special motor designs may not meet efficiency, power factor, or amperes values shown for standard motors.

Minimum reduced voltage tap for 5DJ motor is 80%.

Table 18: 50 Hz electrical data - premium efficiency

Motor code	5EM	5EN	5EO	5EP	5EQ	5ER	5ES	5ET	5EU	5EV	5EW	5EX	5FA	5FB
Shaft HP (max)	419	462	507	546	575	617	658	704	750	800	850	900	1000	1100
Input kW (max)	328	361	396	425	448	480	512	548	584	623	662	701	778	856
F.L. EFF. - %	95.4	95.4	95.4	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8
F.L. power factor	0.88	0.88	0.88	0.87	0.87	0.87	0.87	0.88	0.88	0.87	0.87	0.87	0.87	0.87
Volts	Amperes (max.)													
380	FLA	565	623	684	742	782	839	894	946	1008	1087	1155	1223	1359
	LRA	3700	3810	4690	4610	4892	5600	5491	5491	6313	6694	7113	7404	7794
400	FLA	537	592	650	705	743	797	850	899	958	1033	1098	1162	1291
	LRA	3895	4011	4937	4853	5149	5895	5780	5780	6645	7046	7487	7794	8395
415	FLA	518	571	627	680	716	768	819	866	923	996	1058	1120	1245
	LRA	3402	3478	4027	4221	4480	5130	5108	5512	5780	6131	6513	6938	7138

Note: These motors are designed to meet or exceed NEMA Premium (MG1-2006) and European IE2 efficiency requirements.

Motor starters

Table 19: Motor starters

Starter options	Variable speed drive (VSD)		Solid state (SSS)		Star-delta closed (EMS)	Across-the-line (EMS)	Auto transformer (EMS)	Primary reactor (EMS)
Assembly	Unit Mounted	Remote Mounted	Unit Mounted	Remote Mounted	Remote Mounted	Remote Mounted	Remote Mounted	Remote Mounted
Voltage	Low	Medium/High	Medium	Medium/High	Low	Medium/High	Medium/ High	Medium/ High
60 Hz	380 to 575	2300 to 13800	2300 to 4160	2300 to 13200	380 to 575	2300 to 13200	2300 to 13200	2300 to 13200
50 Hz	380 to 415	3300 to 11000	3300	2300 to 11000	380 to 415	2300 to 4160	2300 to 11000	2300 to 11000
Transition	—	—	—	—	Closed	—	Closed	Closed
% TAP	—	—	—	—	—	—	65 80	65 80

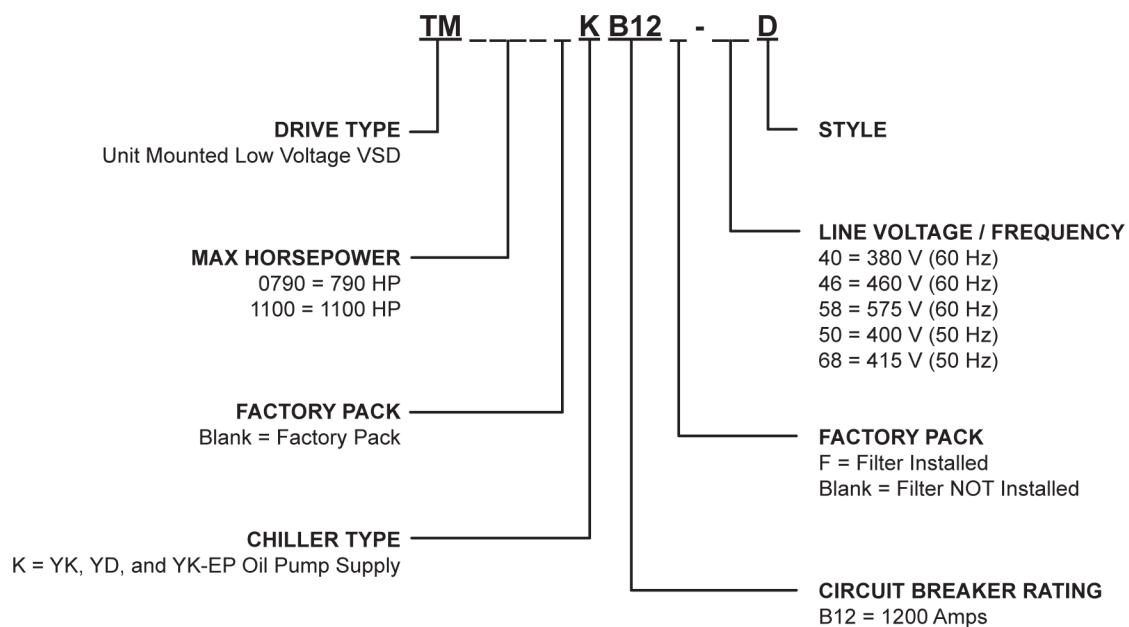
Note: Minimum tap for 5DJ motor is 80%.

Unit mounted low voltage variable speed drive models

Table 20: Unit mounted low voltage variable speed drive models

Model	Starter type	Size (in.) H x W x D	Qty	Line		Motor			
				Voltage	Hz	Voltage	Hz	Min. FLA	Max. FLA
VSD608K-58	10, 11	60 x 59 x 27	2	575	60	575	60	120	540
TM1100_KB12_-40D				380/400		380		300	1126
TM790_KB12_-46D				440/460/480		460		200	880
TM1100_KB12_-46D					50		50	300	1180
TM790_KB12_-50D				380/400		380		200	880
TM1100_KB12_-50D								300	1180
TM790_KB12_-68D				415		415		200	876
TM1100_KB12_-68D								300	1108

Figure 34: Unit mounted low voltage variable speed drive nomenclature

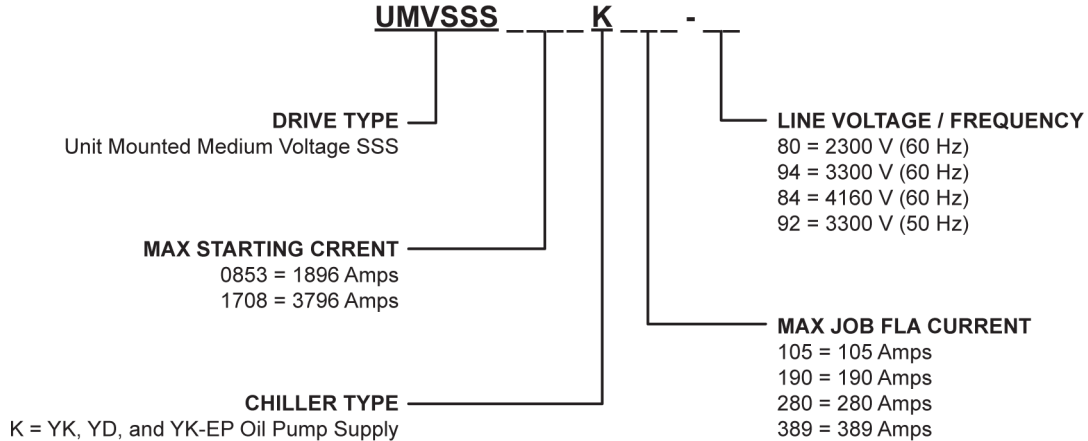


Unit mounted medium voltage solid state starter models

Table 21: Unit mounted medium voltage solid state starter models

Model	Starter type	Size (in) H x W x D	Qty	Line		Motor		
				Voltage	Hz	Max. LRA	45% LRA	Max. FLA
UMVSSS0853K105-80	13	60 x 59 x 27	2	2300	60	1896	853	105
UMVSSS0853K190-80								190
UMVSSS0853K280-80								280
UMVSSS0853K389-80								389
UMVSSS1708K389-80						3796	1708	389
UMVSSS0853K105-84	13	60 x 59 x 27	2	4160	60	1896	853	105
UMVSSS0853K190-84								190
UMVSSS0853K280-84								280
UMVSSS0853K360-84								389
UMVSSS1708K360-84						3796	1708	389
UMVSSS0853K105-94	13	60 x 59 x 27	2	3300	60	1896	853	105
UMVSSS0853K190-94								190
UMVSSS 0853K280-94								280
UMVSSS 0853K389-94								389
UMVSSS 1708K389-94						3796	1708	389
UMVSSS 0853K105-92	13	60 x 59 x 27	2	3300	50	1896	853	105
UMVSSS 0853K190-92								190
UMVSSS 0853K280-92								280
UMVSSS 0853K389-92								389
UMVSSS 1708K389-92						3796	1708	389

Figure 35: Unit mounted medium voltage solid state starter nomenclature

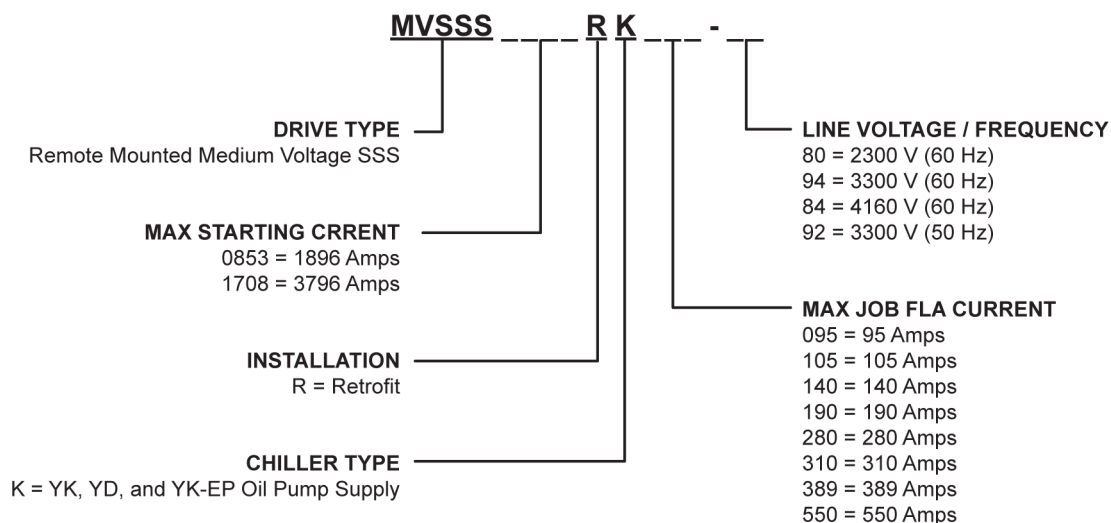


Remote mounted medium voltage solid state starter models

Table 22: Remote mounted medium voltage solid state starter models

Model	Starter type	Size (in.) H x W x D	Qty	Line		Motor		
				Voltage	Hz	Max. LRA	45% LRA	Max. FLA
MVSSS0853RK95-80	12	92 x 36 x 36	2	2300	60	1896	853	95
MVSSS0853RK105-80								105
MVSSS0853RK140-80								140
MVSSS0853RK190-80								190
MVSSS0853RK280-80								280
MVSSS0853RK310-80								310
MVSSS0853RK389-80								389
MVSSS1708RK389-80								3796
MVSSS1708RK550-80		550						
MVSSS0853RK95-84	12	92 x 36 x 36	2	4160	60	1896	853	95
MVSSS0853RK105-84								105
MVSSS0853RK140-84								140
MVSSS0853RK190-84								190
MVSSS0853RK280-84								280
MVSSS0853RK310-84								310
MVSSS0853RK389-84								389
MVSSS1708RK389-84								3796
MVSSS1708RK550-84		550						
MVSSS0853RK95-94	12	92 x 36 x 36	2	3300	60	1896	853	95
MVSSS0853RK105-94								105
MVSSS0853RK140-94								140
MVSSS0853RK190-94								190
MVSSS0853RK280-94								280
MVSSS0853RK310-94								310
MVSSS0853RK389-94								389
MVSSS1708RK389-94								3796
MVSSS1708RK550-94		550						
MVSSS0853RK95-92	12	92 x 36 x 36	2	3300	50	1896	853	95
MVSSS0853RK105-92								105
MVSSS0853RK140-92								140
MVSSS0853RK190-92								190
MVSSS0853RK280-92								280
MVSSS0853RK310-92								310
MVSSS0853RK389-92								389
MVSSS1708RK389-92								3796
MVSSS1708RK550-92		550						

Figure 36: Remote mounted medium voltage solid state starter nomenclature



Remote mounted medium voltage variable speed drive models

Table 23: Remote mounted medium voltage variable speed drive models

Model	Starter type	Size (in.) H x W x D	Qty	9th digit nomenclature	Line		Motor		
					Voltage	Hz	Voltage	Hz	Max FLA
MVVSD0500RK-80	11	122 x 44 x 104	2	—	2300	60	2300	60	107
MVVSD0600RK-80	11	122 x 44 x 104	2	—	2300	60	2300	60	129
MVVSD0700RK-80	11	122 x 44 x 104	2	—	2300	60	2300	60	157
MVVSD0800RK-80	11	122 x 44 x 104	2	—	2300	60	2300	60	172
MVVSD0900RK-80	11	122 x 44 x 104	2	—	2300	60	2300	60	202
MVVSD1000RK-80	11	122 x 44 x 104	2	—	2300	60	2300	60	224
MVVSD1500RK-80	11	174 x 50 x 104	2	—	2300	60	2300	60	336
MVVSD1750RK-80	11	174 x 50 x 104	2	—	2300	60	2300	60	392
MVVSD2250RK-80	11	222 x 50 x 104	2	—	2300	60	2300	60	494
MVVSD2500RK-80	11	222 x 50 x 104	2	—	2300	60	2300	60	561
MVVSD0500RK-92	11	74 x 44 x 104	2	5	3300	50	3300	50	78
MVVSD0600RK-92	11	74 x 44 x 104	2	5	3300	50	3300	50	93
MVVSD0700RK-92	11	74 x 44 x 104	2	5	3300	50	3300	50	110
MVVSD0800RK-92	11	122 x 44 x 104	2	5	3300	50	3300	50	124
MVVSD0900RK-92	11	122 x 44 x 104	2	5	3300	50	3300	50	141
MVVSD1000RK-92	11	122 x 44 x 104	2	5	3300	50	3300	50	156
MVVSD1250RK-92	11	122 x 44 x 104	2	5	3300	50	3300	50	195
MVVSD1500RK-92	11	122 x 44 x 104	2	5	3300	50	3300	50	235
MVVSD1750RK-92	11	164 x 50 x 104	2	5	3300	50	3300	50	274
MVVSD2000RK-92	11	164 x 50 x 104	2	5	3300	50	3300	50	312
MVVSD2250RK-92	11	174 x 50 x 104	2	5	3300	50	3300	50	345
MVVSD2500RK-92	11	174 x 50 x 104	2	5	3300	50	3300	50	391
MVVSD0500RK-94	11	74 x 44 x 104	2	—	3300	60	3300	60	78
MVVSD0600RK-94	11	74 x 44 x 104	2	—	3300	60	3300	60	93
MVVSD0700RK-94	11	74 x 44 x 104	2	—	3300	60	3300	60	110
MVVSD0800RK-94	11	122 x 44 x 104	2	—	3300	60	3300	60	124
MVVSD0900RK-94	11	122 x 44 x 104	2	—	3300	60	3300	60	141
MVVSD1000RK-94	11	122 x 44 x 104	2	—	3300	60	3300	60	156
MVVSD1250RK-94	11	122 x 44 x 104	2	—	3300	60	3300	60	195
MVVSD1500RK-94	11	122 x 44 x 104	2	—	3300	60	3300	60	235
MVVSD1750RK-94	11	164 x 50 x 104	2	—	3300	60	3300	60	274
MVVSD2000RK-94	11	164 x 50 x 104	2	—	3300	60	3300	60	312

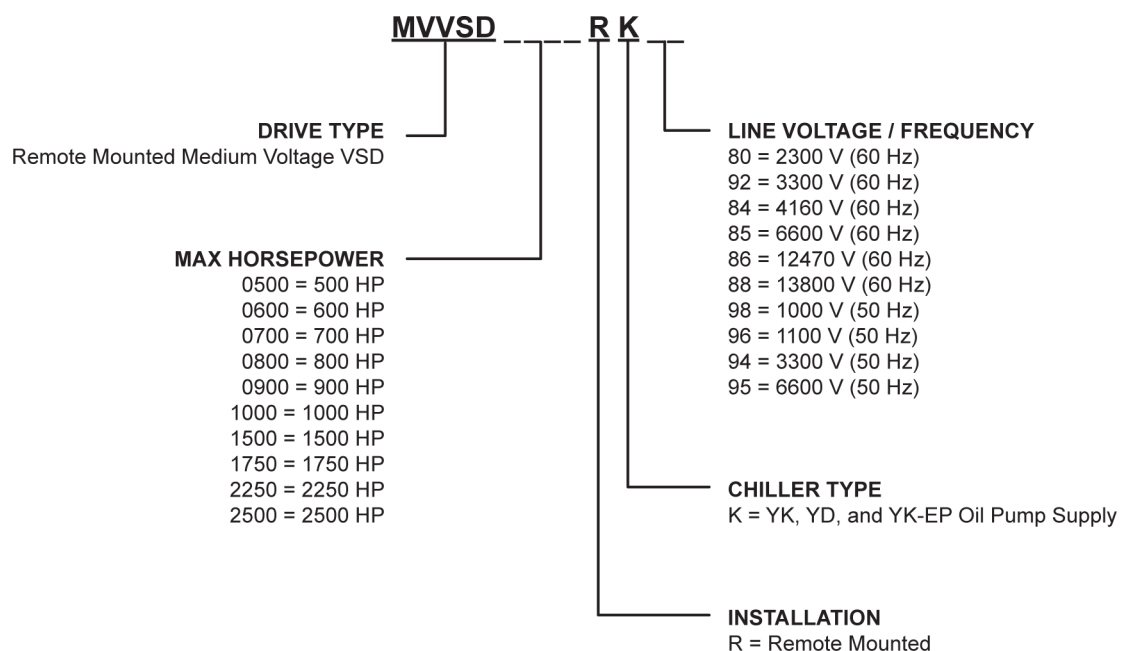
Table 23: Remote mounted medium voltage variable speed drive models

Model	Starter type	Size (in.) H x W x D	Qty	9th digit nomenclature	Line		Motor		
					Voltage	Hz	Voltage	Hz	Max FLA
MVVSD2250RK-94	11	174 x 50 x 104	2	—	3300	60	3300	60	345
MVVSD2500RK-94	11	174 x 50 x 104	2	—	3300	60	3300	60	391
MVVSD0500RK-84	11	74 x 44 x 104	2	—	4160	60	4160	60	62
MVVSD0600RK-84	11	74 x 44 x 104	2	—	4160	60	4160	60	74
MVVSD0700RK-84	11	74 x 44 x 104	2	—	4160	60	4160	60	87
MVVSD0800RK-84	11	74 x 44 x 104	2	—	4160	60	4160	60	99
MVVSD0900RK-84	11	74 x 44 x 104	2	—	4160	60	4160	60	112
MVVSD1000RK-84	11	122 x 44 x 104	2	—	4160	60	4160	60	125
MVVSD1250RK-84	11	122 x 44 x 104	2	—	4160	60	4160	60	155
MVVSD1500RK-84	11	122 x 44 x 104	2	—	4160	60	4160	60	186
MVVSD1750RK-84	11	122 x 44 x 104	2	—	4160	60	4160	60	217
MVVSD2000RK-84	11	122 x 44 x 104	2	—	4160	60	4160	60	248
MVVSD2250RK-84	11	164 x 50 x 104	2	—	4160	60	4160	60	274
MVVSD2500RK-84	11	164 x 50 x 104	2	—	4160	60	4160	60	310
MVVSD0500RK-95	16	74 x 44 x 104	2	M	6600	50	4160	60	62
MVVSD0600RK-95	16	74 x 44 x 104	2	M	6600	50	4160	60	74
MVVSD0700RK-95	16	74 x 44 x 104	2	M	6600	50	4160	60	87
MVVSD0800RK-95	16	74 x 44 x 104	2	M	6600	50	4160	60	99
MVVSD0900RK-95	16	74 x 44 x 104	2	M	6600	50	4160	60	112
MVVSD1000RK-95	16	122 x 44 x 104	2	M	6600	50	4160	60	125
MVVSD1250RK-95	16	122 x 44 x 104	2	M	6600	50	4160	60	155
MVVSD1500RK-95	16	122 x 44 x 104	2	M	6600	50	4160	60	186
MVVSD1750RK-95	16	122 x 44 x 104	2	M	6600	50	4160	60	217
MVVSD2000RK-95	16	122 x 44 x 104	2	M	6600	50	4160	60	248
MVVSD2250RK-95	16	164 x 50 x 104	2	M	6600	50	4160	60	274
MVVSD2500RK-95	16	164 x 50 x 104	2	M	6600	50	4160	60	310
MVVSD0500RK-85	16	74 x 44 x 104	2	—	6600	60	4160	60	62
MVVSD0600RK-85	16	74 x 44 x 104	2	—	6600	60	4160	60	74
MVVSD0700RK-85	16	74 x 44 x 104	2	—	6600	60	4160	60	87
MVVSD0800RK-85	16	74 x 44 x 104	2	—	6600	60	4160	60	99
MVVSD0900RK-85	16	74 x 44 x 104	2	—	6600	60	4160	60	112
MVVSD1000RK-85	16	122 x 44 x 104	2	—	6600	60	4160	60	125
MVVSD1250RK-85	16	122 x 44 x 104	2	—	6600	60	4160	60	155
MVVSD1500RK-85	16	122 x 44 x 104	2	—	6600	60	4160	60	186
MVVSD1750RK-85	16	122 x 44 x 104	2	—	6600	60	4160	60	217
MVVSD2000RK-85	16	122 x 44 x 104	2	—	6600	60	4160	60	248
MVVSD2250RK-85	16	164 x 50 x 104	2	—	6600	60	4160	60	274
MVVSD2500RK-85	16	164 x 50 x 104	2	—	6600	60	4160	60	310
MVVSD0500RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	62
MVVSD0600RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	74
MVVSD0700RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	87
MVVSD0800RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	99
MVVSD0900RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	112
MVVSD1000RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	125
MVVSD1250RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	155
MVVSD1500RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	186
MVVSD1750RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	217
MVVSD2000RK-98	16	236 x 44 x 104	2	M	10000	50	4160	60	248
MVVSD2250RK-98	16	278 x 50 x 104	2	M	10000	50	4160	60	274
MVVSD2500RK-98	16	278 x 50 x 104	2	M	10000	50	4160	60	310
MVVSD0500RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	62
MVVSD0600RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	74

Table 23: Remote mounted medium voltage variable speed drive models

Model	Starter type	Size (in.) H x W x D	Qty	9th digit nomenclature	Line		Motor		
					Voltage	Hz	Voltage	Hz	Max FLA
MVVSD0700RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	87
MVVSD0800RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	99
MVVSD0900RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	112
MVVSD1000RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	125
MVVSD1250RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	155
MVVSD1500RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	186
MVVSD1750RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	217
MVVSD2000RK-96	16	236 x 44 x 104	2	M	11000	50	4160	60	248
MVVSD2250RK-96	16	278 x 50 x 104	2	M	11000	50	4160	60	274
MVVSD2500RK-96	16	278 x 50 x 104	2	M	11000	50	4160	60	310
MVVSD0500RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	62
MVVSD0600RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	74
MVVSD0700RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	87
MVVSD0800RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	99
MVVSD0900RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	112
MVVSD1000RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	125
MVVSD1250RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	155
MVVSD1500RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	186
MVVSD1750RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	217
MVVSD2000RK-86	16	236 x 44 x 104	2	—	12470	60	4160	60	248
MVVSD2250RK-86	16	278 x 50 x 104	2	—	12470	60	4160	60	274
MVVSD2500RK-86	16	278 x 50 x 104	2	—	12470	60	4160	60	310
MVVSD0500RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	62
MVVSD0600RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	74
MVVSD0700RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	87
MVVSD0800RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	99
MVVSD0900RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	112
MVVSD1000RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	125
MVVSD1250RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	155
MVVSD1500RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	186
MVVSD1750RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	217
MVVSD2000RK-88	16	236 x 44 x 104	2	—	13800	60	4160	60	248
MVVSD2250RK-88	16	278 x 50 x 104	2	—	13800	60	4160	60	274
MVVSD2500RK-88	16	278 x 50 x 104	2	—	13800	60	4160	60	310

Figure 37: Remote mounted medium voltage variable speed drive nomenclature



Dimensions

YD Style D unit dimensions

Figure 38: YD style D unit side view dimensions

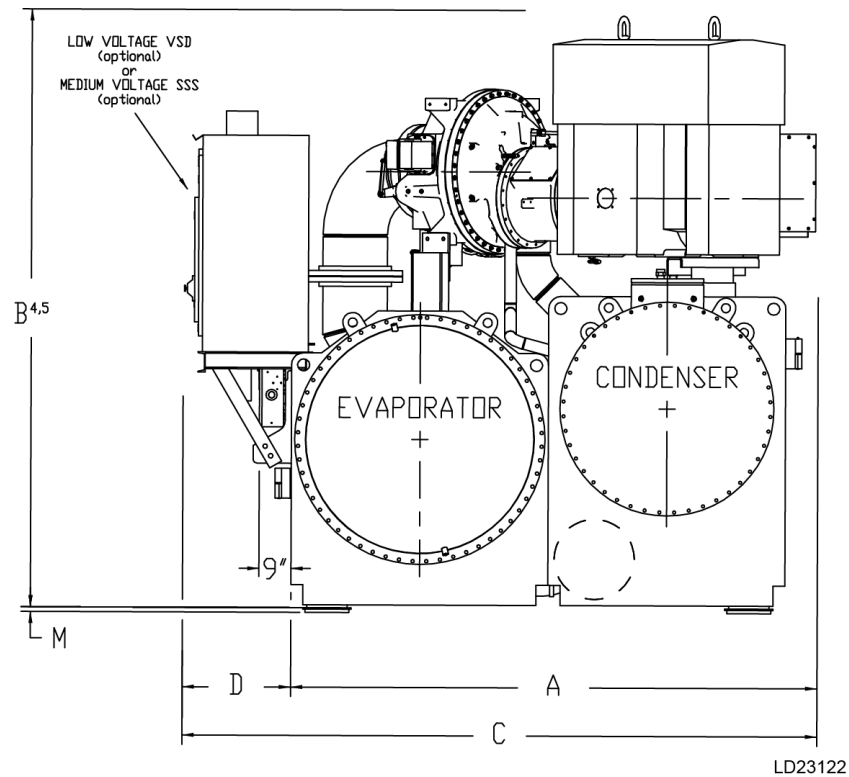


Figure 39: YD style D unit front view dimensions

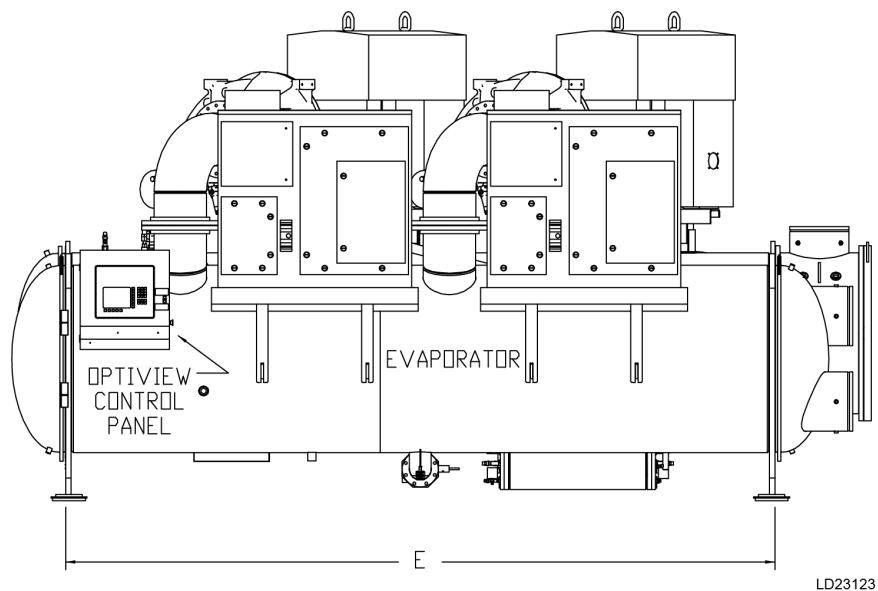


Table 24: YD style D unit dimensions

Dim. type	Evaporator-condenser shell codes dimensions, ft-in. (mm)									
	Q-Q	R-R	B-L	M-M	N-B	E-C	F-D	G-E	H-F	K-K
A	10 ft 11 in. (3,327)	11 ft 3 in. (3,429)	11 ft 8 in. (3,556)	11 ft 8 in. (3,556)	12 ft 1 in. (3,683)	13 ft 10 in. (4,216)	15 ft 3 in. (4,648)	15 ft 2 in. (4,623)	15 ft 6 in. (4,724)	16 ft 11 in. (5,156)
B	12 ft 0 in. (3,658)	12 ft 3 in. (3,734)	12 ft 5 in. (3,785)	12 ft 5 in. (3,785)	12 ft 9 in. (3,886)	13 ft 6 in. (4,115)	14 ft 4 in. (4,369)	14 ft 4 in. (4,369)	14 ft 10 in. (4,521)	15 ft 0 in. (4,572)
C	13 ft 3 in. (4,039)	13 ft 6 in. (4,115)	13 ft 11 in. (4,242)	13 ft 11 in. (4,242)	14 ft 4 in. (4,369)	16 ft-0 in. (4,877)	16 ft 9 in. (5,105)	16 ft 9 in. (5,105)	16 ft 9 in. (5,105)	18 ft 3 in. (5,563)
D	2 ft 4-1/2 in. (724)	2 ft 4 in. (711)	2 ft 4 in. (711)	2 ft 4 in. (711)	2 ft 3-1/2 in. (699)	2 ft 3 in. (686)	1 ft 7 in. (483)	1 ft 7 in. (483)	1 ft 4 in. (406)	1 ft 4 in. (406)
E	16 ft 0 in. (4,877)	16 ft 0 in. (4,877)	18 ft 0 in. (5,486)	22 ft 0 in. (6,706)	18 ft 0 in. (5,486)	22 ft 0 in. (6,706)	18 ft 0 in. (5,486)	22 ft 0 in. (6,706)	18 ft 0 in. (5,486)	22 ft 0 in. (6,706)

① **Note:** Dimension C is valid for Unit Mounted Low Voltage VSD and Unit Mounted Medium Voltage SSS.

Table 25: Additional operating height clearance

Type of chiller mounting	M
Neoprene pad isolators	1 in. (25 mm)
Spring isolators 1 in. deflection	1 in. (25 mm)
Direct mount	3/4 in. (19 mm)

① **Note:**

1. All dimensions are approximate. Certified dimensions are available on request.
2. For marine waterboxes, as shown previously, determine overall unit length by adding waterbox depth to tube sheet length. For compact waterboxes, see [Evaporators - compact waterboxes](#) and [Condensers - compact waterboxes](#).
3. Water nozzles can be located on either end of unit. Add 1/2 in. to nozzle length for flanges connections.
4. To determine overall height, add dimension M for the appropriate isolator type. See [Table 25](#).
5. Use of motors with motor hoods may increase overall unit dimensions. Add 6 in. for 5DJ size motor.
6. The dimension B is defined by the largest motor available in the unit. Ask for specific drawing to check the overall unit dimension.

Knocked-down unit component dimensions

Figure 40: Knocked-down unit component dimensions - evaporator

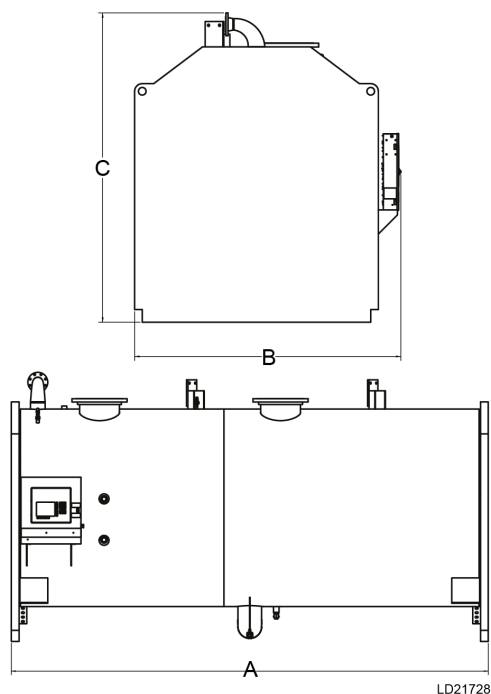


Table 26: Evaporator section dimensions

Unit model compr/shells	Dimensions, ft-in. (mm)		
	A	B	C
H9/Q	16 ft 0 in. (4877)	6 ft 0 in. (1829)	7 ft 6 in. (2286)
H9/R	16 ft 0 in. (4877)	6 ft 4 in. (1930)	7 ft 9 in. (2362)
K1/B	18 ft 0 in. (5486)	6 ft 4 in. (1930)	8 ft 0 in. (2438)
K2/M	22 ft 0 in. (6706)	6 ft 4 in. (1930)	7 ft 10 in. (2388)
K2/N	18 ft 0 in. (5486)	6 ft 11 in. (2108)	8 ft 2 in. (2489)
K3/E	22 ft 0 in. (6706)	7 ft 9 in. (2362)	9 ft 0 in. (2743)
K3/F	18 ft 0 in. (5486)	8 ft 6 in. (2591)	9 ft 9 in. (2972)
K4/G	22 ft 0 in. (6706)	8 ft 6 in. (2591)	9 ft 9 in. (2972)
K4/H	18 ft 0 in. (5486)	9 ft 0 in. (2743)	10 ft 3 in. (3124)
K7/K	22 ft 0 in. (6706)	9 ft 0 in. (2743)	10 ft 3 in. (3124)

Note: For knocked-down shipment, add the associated dimension for compact or marine waterboxes to the shells.

Figure 41: Knocked-down unit component dimensions - condenser

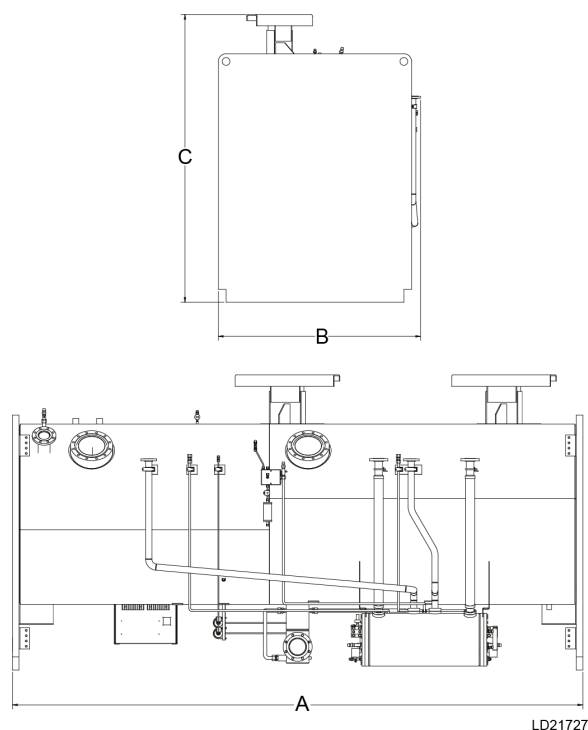
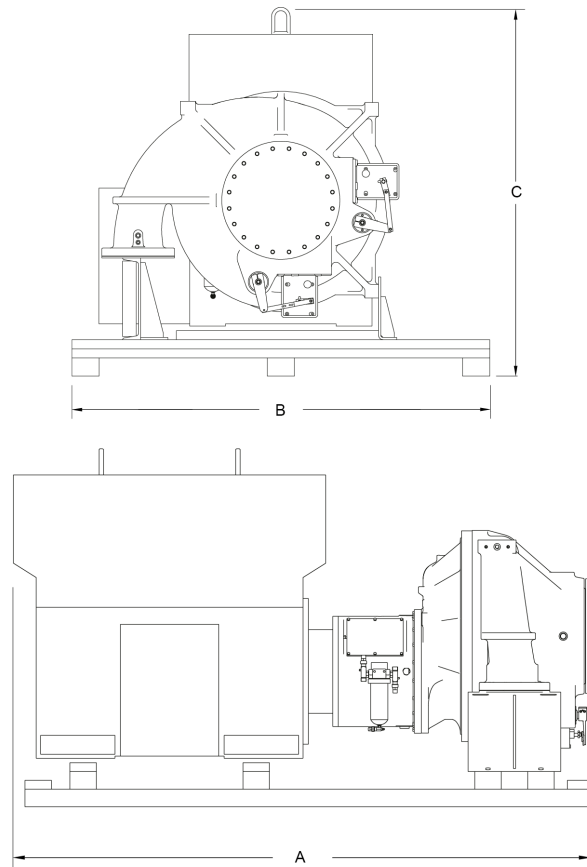


Table 27: Condenser section dimensions

Unit model compr/shells	Dimensions, ft-in. (mm)		
	A	B	C
H9/Q	16 ft 0 in. (4877)	5 ft 0 in. (1524)	7 ft 4 in. (2235)
H9/R	16 ft 0 in. (4877)	5 ft 3 in. (1600)	7 ft 7 in. (2311)
K1/L	18 ft 0 in. (5486)	5 ft 3 in. (1600)	7 ft 8 in. (2337)
K2/M	22 ft 0 in. (6706)	5 ft 3 in. (1600)	7 ft 8 in. (2337)
K2/B	18 ft 0 in. (5486)	5 ft 5 in. (1651)	8 ft 0 in. (2438)
K3/C	22 ft 0 in. (6706)	6 ft 2 in. (1880)	8 ft 8 in. (2642)
K3/D	18 ft 0 in. (5486)	6 ft 7 in. (2007)	9 ft 6 in. (2896)
K4/E	22 ft 0 in. (6706)	6 ft 7 in. (2007)	9 ft 6 in. (2896)
K4/F	18 ft 0 in. (5486)	6 ft 10 in. (2083)	10 ft 0 in. (3048)
K7/K	22 ft 0 in. (6706)	7 ft 8 in. (2337)	9 ft 10 in. (2997)

① **Note:** For knocked-down shipment, add the associated dimension for compact or marine waterboxes to the shells.

Figure 42: Knocked-down unit component dimensions - drivelines



LD18379

Table 28: Driveline section (two)

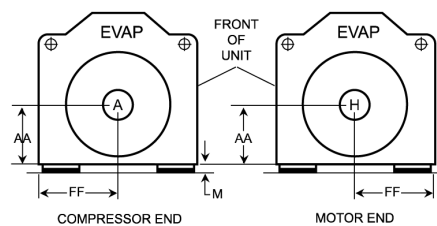
Unit model compressor	Dimensions, ft-in. (mm)		
	A	B	C
H9	12 ft 0 in. (3658)	6 ft 6 in. (1981)	7 ft 0 in. (2134)
K1	10 ft 9 in. (3277)	6 ft 6 in. (1981)	7 ft 8 in. (2337)
K2	10 ft 9 in. (3277)	6 ft 6 in. (1981)	7 ft 8 in. (2337)
K3	11 ft 3 in. (3429)	6 ft 10 in. (2083)	7 ft 8 in. (2337)
K4	11 ft 3 in. (3429)	6 ft 10 in. (2083)	7 ft 8 in. (2337)
K7	13 ft 0 in. (3962)	7 ft 0 in. (2134)	7 ft 0 in. (2134)

Note: For knocked-down shipment, [Figure 42](#) is missing the suction and discharge elbows. Consider these items as well as there being two drivelines for each YD chiller.

Evaporators - compact waterboxes

Figure 43: Evaporators – compact waterboxes

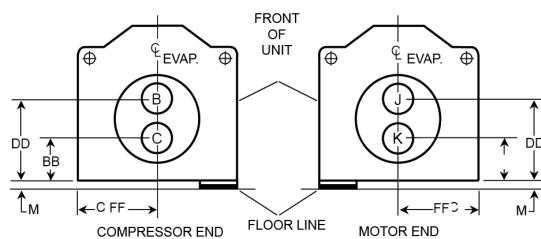
1-PASS



FOR SHELLS:
Q, R, B, M, N, E,
F, G, H, K

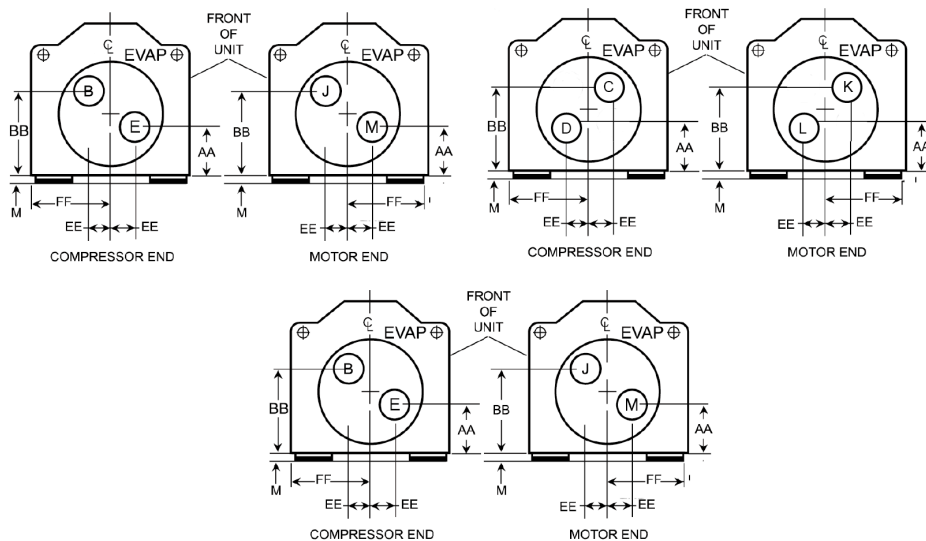
EVAPORATOR 1 PASS	
IN	OUT
A	H
H	A

2-PASS



FOR SHELL: Q
EVAPORATOR
2 PASS

IN	OUT
C	B
K	J



FOR SHELLS:
R, B, M, N
EVAPORATOR
2 PASS

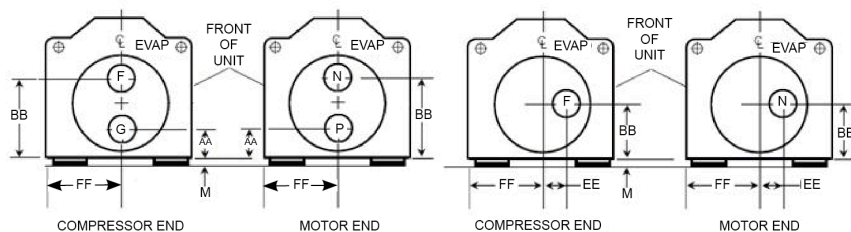
IN	OUT
E	B
M	J
D	C
L	K

FOR SHELLS:
E, F, G, H, K
EVAPORATOR
2 PASS

IN	OUT
E	B
M	J

3-PASS

FOR SHELLS:
Q, R, B, M, N
EVAPORATOR
3 PASS



FOR SHELLS:
E, F, G, H, K
EVAPORATOR
3 PASS

IN	OUT
F	N
N	F

Table 29: Evaporator - compact waterboxes

Evap. shell code	1 pass			2 pass					3 pass				
	Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)		Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)				Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)			
		AA ²	FF		AA	BB ²	EE	FF		AA	BB ²	EE	FF
Q	18 in.	3 ft 3 1/2 in. (1,003)	2 ft 5 1/2 in. (749)	14 in.	2 ft 0 in. (610)	4 ft 7 in. (1,397)	—	2 ft 5 1/2 in. (749)	12 in.	2 ft 0 in. (610)	4 ft 7 in. (1,397)	—	2 ft 5 1/2 in. (749)
R	20 in.	3 ft 5 1/4 in. (1,048)	2 ft 8 in. (813)	18 in.	2 ft 4 1/4 in. (718)	4 ft 6 1/4 in. (1,378)	10 ft 0 1/2 in. (267)	2 ft 8 in. (813)	14 in.	2 ft 3/4 in. (629)	4 ft 9 3/4 in. (1,467)	—	2 ft 8 in. (813)
B, M	20 in.	2 ft 8 1/4 in. (819)	2 ft 8 in. (813)	18 in.	—	2 ft 8 1/4 in. (819)	1 ft 3 in. (381)	2 ft 8 in. (813)	14 in.	—	2 ft 8 1/4 in. (819)	—	2 ft 8 in. (813)
N	20 in.	2 ft 10 1/2 in. (876)	2 ft 11 in. (889)	18 in.	—	2 ft 10 1/2 in. (889)	1 ft 1 in. (330)	2 ft 11 in. (889)	14 in.	—	2 ft 10 1/2 in. (876)	—	2 ft 11 in. (889)
E	24 in.	4 ft 1 in. (1,245)	3 ft 5 in. (1,041)	20 in.	3 ft 0 in. (914)	5 ft 2 in. (1,575)	1 ft 1 in. (330)	3 ft 5 in. (1,041)	16 in.	—	4 ft 1 in. (1,245)	1 ft 4 in. (406)	3 ft 5 in. (1,041)
F, G	24 in.	4 ft 9 1/2 in. (1,461)	3 ft 9 in. (1,143)	20 in.	3 ft 8 1/2 in. (1,130)	5 ft 10 1/2 in. (1,791)	1 ft 1 in. (330)	3 ft 9 in. (1,143)	16 in.	—	4 ft 9 1/2 in. (1,461)	1 ft 4 in. (406)	3 ft 9 in. (1,143)
H, K	24 in.	5 ft 0 1/2 in. (1,537)	4 ft 0 in. (1,219)	20 in.	3 ft 11 1/2 in. (1,207)	6 ft 1 1/2 in. (1,867)	1 ft 1 in. (330)	4 ft 0 in. (1,219)	16 in.	—	5 ft 0 1/2 in. (1,537)	1 ft 4 in. (406)	4 ft 0 in. (1,219)

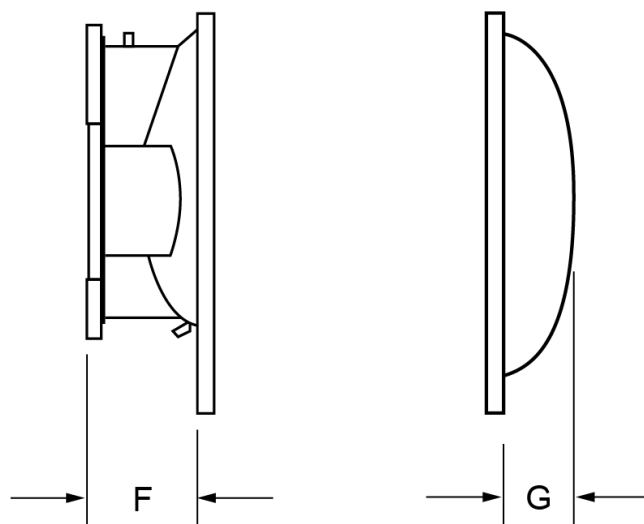
Table 30: Additional operating height clearance

Type of chiller mounting	M
Neoprene pad isolators	1 in. (25 mm)
Spring isolators 1 in. deflection	1 in. (25 mm)
Direct mount	3/4 in. (19 mm)

**Note:**

- Standard water nozzles are furnished as welding stub outs with ANSI/AWWA C-606 couplings 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 in. raised face), water flanged nozzles are optional (add 1/2 in. to nozzle length). Companion flanges, nuts, bolts, and gaskets are not furnished.
- Add dimension M for the appropriate isolator type.
- One, two, and three-pass nozzle arrangements are available only in pairs shown and for all shell codes. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles.
- Connected piping must allow for removal of compact waterboxes for tube access and cleaning.

Figure 44: Evaporators – compact waterboxes



LD18375

Table 31: Evaporators - compact waterboxes

Evap. shell code	Evaporator nozzle dimensions ft-in. (mm) vs. design working pressure psig (MPA)							
	1 pass		2 pass				3 pass	
	F		F		G		F	
	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)
Q	2 ft 0 1/8 in. (613)	Available for SQ	2 ft 0 1/8 in. (613)	Available for SQ	1 ft 3 3/8 in. (391)	Available for SQ	2 ft 0 1/8 in. (613)	Available for SQ
R	2 ft 0 1/8 in. (613)	Available for SQ	2 ft 0 1/8 in. (613)	Available for SQ	1 ft 4 3/8 in. (416)	Available for SQ	2 ft 0 1/8 in. (613)	Available for SQ
B, M	2 ft 0 3/4 in. (629)	Available for SQ	2 ft 0 3/4 in. (629)	Available for SQ	1 ft 4 1/2 in. (419)	Available for SQ	2 ft 0 3/4 in. (629)	Available for SQ
N	2 ft 1 11/16 in. (660)	Available for SQ	2 ft 1 11/16 in. (660)	Available for SQ	1 ft 5 11/16 in. (445)	Available for SQ	2 ft 1 11/16 in. (660)	Available for SQ
E	2 ft 0 13/16 in. (635)	Available for SQ	2 ft 0 13/16 in. (635)	Available for SQ	1 ft 4 3/16 in. (413)	Available for SQ	2 ft 0 13/16 in. (635)	Available for SQ
F, G	2 ft 3 in. (686)	Available for SQ	2 ft 3 in. (686)	Available for SQ	1 ft 6 1/4 in. (464)	Available for SQ	2 ft 3 in. (686)	Available for SQ
H, K	2 ft 3 9/16 in. (699)	Available for SQ	2 ft 3 9/16 in. (699)	Available for SQ	1 ft 6 7/8 in. (483)	Available for SQ	2 ft 3 9/16 in. (699)	Available for SQ

Evaporators - marine waterboxes

Figure 45: Evaporators - marine waterboxes

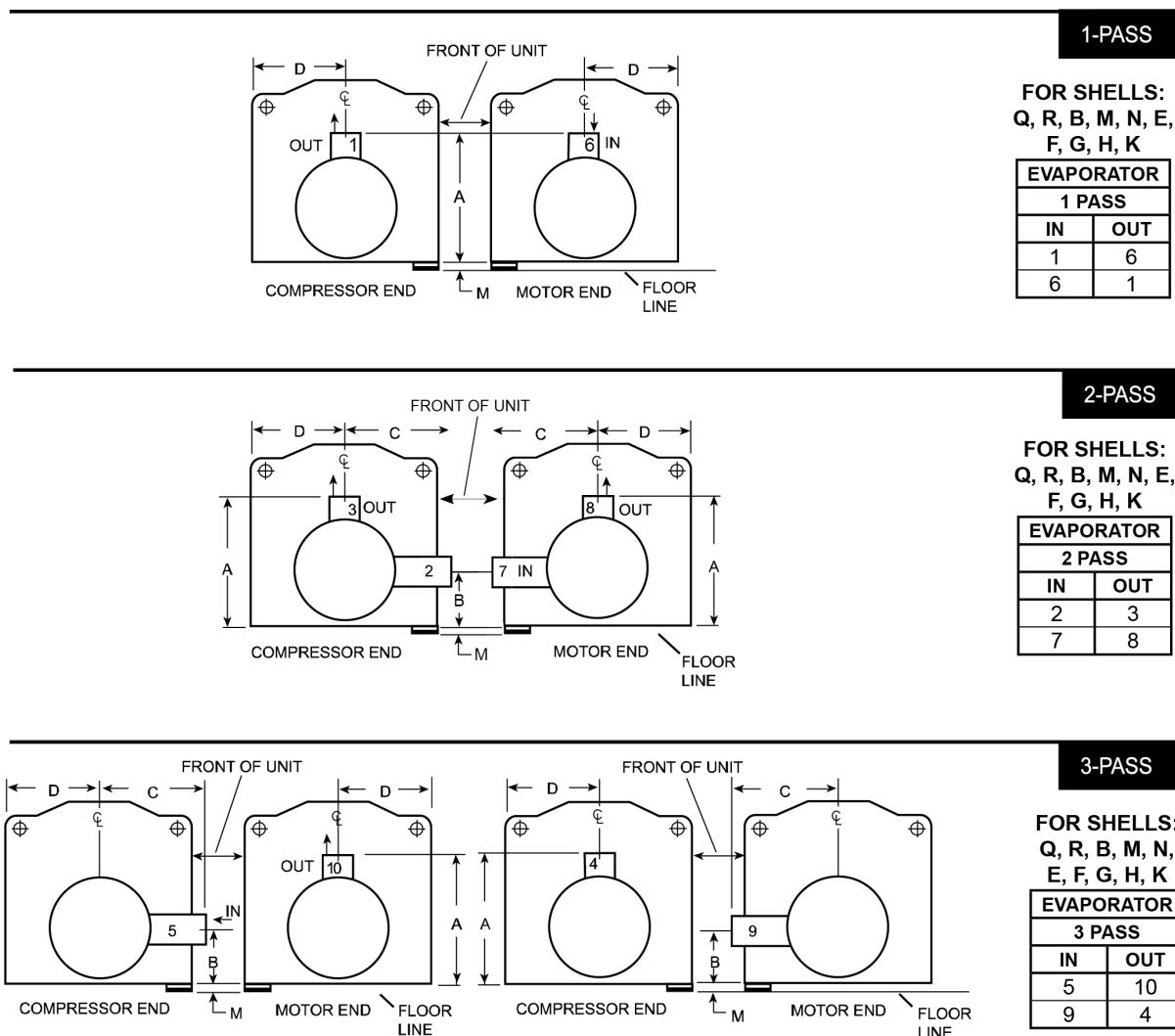


Table 32: Evaporator - marine waterboxes

Evap. shell code	1 pass			2 pass					Nozzle pipe size, in.	3 pass				
	Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)		Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)					Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)			
		A	D		A	B	C	D			A	B	C	D
Q	18 in.	6 ft 2 5/8 in. (1,895)	2 ft 5 1/2 in. (749)	14 in.	6 ft 2 5/8 in. (1,895)	1 ft 5 in. (432)	2 ft 9 1/2 in. (851)	2 ft 5 1/2 in. (749)	12 in.	6 ft 2 5/8 in. (1,895)	1 ft 5 in. (432)	2 ft 9 1/2 in. (851)	2 ft 5 1/2 in. (749)	
R	20 in.	6 ft 5 7/8 in. (1,978)	2 ft 8 in. (813)	18 in.	6 ft 5 7/8 in. (1,978)	1 ft 3 3/4 in. (400)	3 ft 2 3/4 in. (984)	2 ft 8 in. (813)	14 in.	6 ft 5 7/8 in. (1,978)	1 ft 3 3/4 in. (400)	3 ft 2 3/4 in. (984)	2 ft 8 in. (813)	
B, M	20 in.	6 ft 5 3/4 in. (1,975)	2 ft 8 in. (813)	18 in.	6 ft 5 3/4 in. (1,975)	1 ft 3 3/4 in. (400)	3 ft 0 1/4 in. (921)	2 ft 8 in. (813)	14 in.	6 ft 5 3/4 in. (1,975)	1 ft 3 3/4 in. (400)	3 ft 0 1/4 in. (921)	2 ft 8 in. (813)	

Table 32: Evaporator - marine waterboxes

Evap. shell code	1 pass			2 pass					3 pass				
	Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)		Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)				Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)			
		A	D		A	B	C	D		A	B	C	D
N	20 in.	7 ft 1 1/4 in. (2,165)	2 ft 11 1/2 in. (902)	18 in.	7 ft 1 1/4 in. (2,165)	1 ft 9 3/4 in. (540)	3 ft 0 3/4 in. (933)	2 ft 11 1/2 in. (902)	14 in.	7 ft 1 1/4 in. (2,165)	1 ft 9 3/4 in. (540)	3 ft 0 3/4 in. (933)	2 ft 11 1/2 in. (902)
E	24 in.	7 ft 8 1/2 in. (2,350)	3 ft 5 in. (1,041)	20 in.	7 ft 8 1/2 in. (2,350)	4 ft 1 in. (1,245)	3 ft 7 1/2 in. (1,105)	3 ft 5 in. (1,041)	16 in.	7 ft 8 1/2 in. (2,350)	4 ft 1 in. (1,245)	3 ft 7 1/2 in. (1,105)	3 ft 5 in. (1,041)
F, G	24 in.	8 ft 9 3/4 in. (2,686)	3 ft 9 in. (1,143)	20 in.	8 ft 9 3/4 in. (2,686)	4 ft 9 1/2 in. (1,461)	4 ft 0 1/4 in. (1,226)	3 ft 9 in. (1,143)	18 in.	8 ft 9 3/4 in. (2,686)	4 ft 9 1/2 in. (1,461)	4 ft 0 1/4 in. (1,226)	3 ft 9 in. (1,143)
H, K	24 in.	9 ft 4 in. (2,845)	4 ft 0 in. (1,219)	20 in.	9 ft 4 in. (2,845)	5 ft 0 1/2 in. (1,537)	4 ft 3 1/2 in. (1,308)	4 ft 0 in. (1,219)	18 in.	9 ft 4 in. (2,845)	5 ft 0 1/2 in. (1,537)	4 ft 3 1/2 in. (1,308)	4 ft 0 in. (1,219)

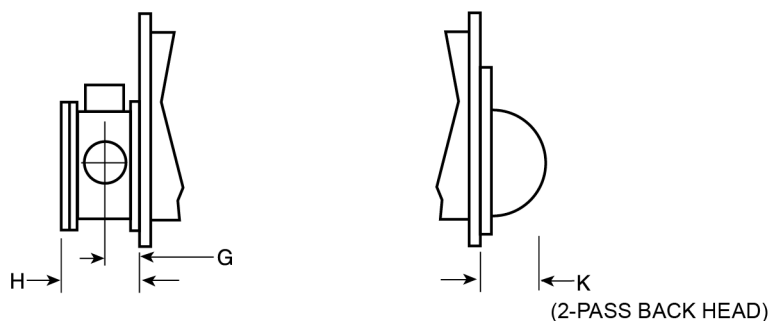
Table 33: Additional operating height clearance

Type of chiller mounting	M, in. (mm)
Neoprene pad isolators	1 in. (25 mm)
Spring isolators 1 in. deflection	1 in. (25 mm)
Direct mount	3/4 in. (19 mm)

① Note:

1. All dimensions are approximate. Certified dimensions are available upon request.
2. Standard water nozzles are Standard wall (0.375 in.) pipe size, furnished as welding stub outs with ANSI/AWWA C-606 couplings 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 in. raised face), water flanged nozzles are optional (add 1/2 in. to nozzle length). Companion flanges, nuts, bolts, and gaskets are not furnished.
3. One, two, and three-pass nozzle arrangements are available only in pairs shown and for all shell codes. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles. Compact waterboxes on one heat exchanger may be used with marine waterboxes on the other heat exchanger.
4. Water must enter the waterbox through the bottom connection to achieve rated performance.
5. Add dimension M for the appropriate isolator type.

Figure 46: Evaporators - marine waterboxes



LD07193

Table 34: Evaporators - marine waterboxes, 1 pass and 2 pass

Evap. shell code	Evaporator nozzle dimensions, ft-in. (mm) vs. design working pressure, psig (MPa)									
	1 pass					2 pass				
	G		H			G		H		K
	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)		150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)	150 (1.14) 300 (2.17)
Q	1 ft 1 1/2 in. (343)	Available for SQ	2 ft 7 7/16 in. (748)	Available for SQ		0 ft 11 1/2 in. (292)	Available for SQ	2 ft 1 7/16 in. (646)	Available for SQ	1 ft 3 3/8 in. (340) Available for SQ
R	1 ft 2 5/8 in. (371)	Available for SQ	2 ft 7 7/8 in. (810)	Available for SQ		1 ft 1 5/8 in. (346)	Available for SQ	2 ft 5 7/8 in. (759)	Available for SQ	1 ft 4 3/8 in. (418) Available for SQ
B, M	1 ft 2 1/2 in. (368)	1 ft 3 3/4 in. (400)	2 ft 8 in. (813)	2 ft 11 1/4 in. (895)		1 ft 1 1/2 in. (343)	1 ft 2 3/4 in. (375)	2 ft 6 in. (762)	2 ft 9 1/4 in. (845)	0 ft 11 in. (279) 1 ft 2 1/2 in. (368)
N	1 ft 2 1/2 in. (368)	1 ft 3 1/4 in. (387)	2 ft 8 in. (813)	2 ft 9 1/2 in. (851)		1 ft 1 1/2 in. (343)	1 ft 2 1/2 in. (368)	2 ft 6 in. (762)	2 ft 8 in. (813)	0 ft 11 in. (279) 1 ft 3 in. (381)
E	1 ft 6 1/2 in. (470)	1 ft 9 3/4 in. (552)	3 ft 4 1/2 in. (1,029)	3 ft 11 in. (1,194)		1 ft 4 1/4 in. (413)	1 ft 7 in. (483)	3 ft 0 in. (914)	3 ft 5 1/2 in. (1,054)	1 ft 4 in. (406) 1 ft 5 1/2 in. (445)
F, G	1 ft 7 in. (483)	1 ft 10 in. (559)	3 ft 5 3/4 in. (1,060)	4 ft 0 in. (1,219)		1 ft 4 1/2 in. (419)	1 ft 7 1/4 in. (489)	3 ft 1 1/4 in. (946)	3 ft 6 1/2 in. (1,080)	1 ft 6 1/4 in. (464) 1 ft 7 1/2 in. (495)
H, K	1 ft 6 1/2 in. (470)	1 ft 9 1/2 in. (546)	3 ft 5 in. (1,041)	3 ft 11 in. (1,194)		1 ft 4 1/4 in. (413)	1 ft 6 3/4 in. (476)	3 ft 0 1/2 in. (927)	3 ft 5 1/2 in. (1,054)	1 ft 7 in. (483) 1 ft 8 in. (508)

Table 35: Evaporators - marine waterboxes, 3 pass

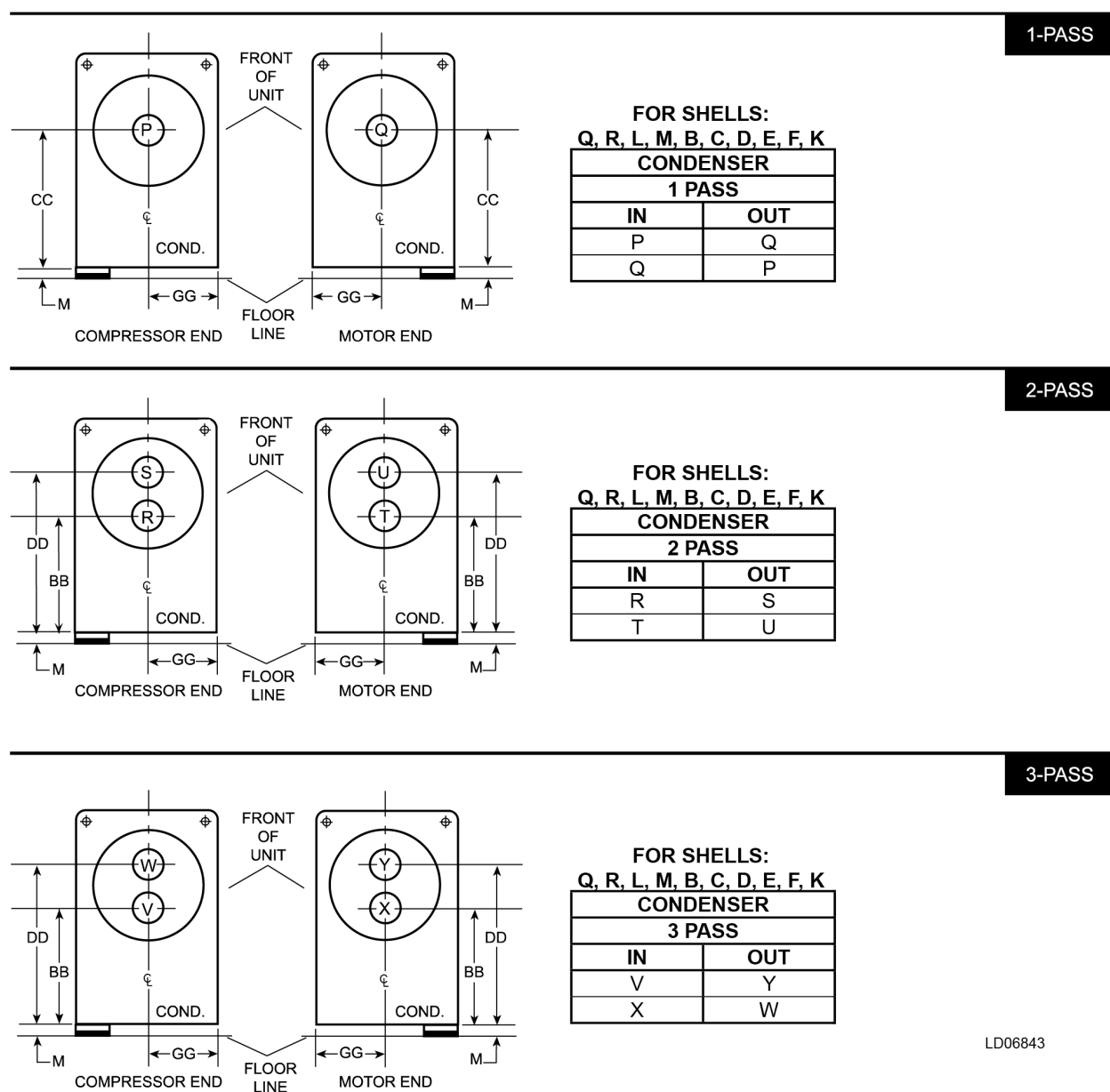
Evap. shell code	Evaporator nozzle dimensions, ft-in. (mm) vs. design working pressure, psig (MPa)			
	3 pass			
	G		H	
	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)
Q	2 ft 1 7/16 in. (646)	Available for SQ	1 ft 3 3/8 in. (340)	Available for SQ
R	1 ft 1 5/8 in. (346)	Available for SQ	2 ft 5 7/8 in. (759)	Available for SQ
B, M	1 ft 1 1/2 in. (343)	1 ft 2 3/4 in. (375)	2 ft 6 in. (762)	2 ft 9 1/4 in. (845)
N	1 ft 1 1/2 in. (343)	1 ft 2 1/2 in. (368)	2 ft 6 in. (762)	2 ft 8 in. (813)

Table 35: Evaporators - marine waterboxes, 3 pass

Evap. shell code	Evaporator nozzle dimensions, ft-in. (mm) vs. design working pressure, psig (MPa)			
	3 pass			
	G		H	
	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)
E	1 ft 2 1/4 in. (362)	1 ft 4 1/2 in. (419)	2 ft 8 in. (813)	3 ft 0 1/2 in. (927)
F, G	1 ft 3 1/2 in. (394)	1 ft 6 in. (457)	3 ft 10 3/4 in. (1,187)	3 ft 4 in. (1,016)
H, K	1 ft 3 in. (381)	1 ft 5 1/2 in. (445)	2 ft 10 in. (864)	3 ft 3 in. (991)

Condensers - compact waterboxes

Figure 47: Condensers - compact waterboxes



LD06843

Table 36: Condenser – compact waterboxes

Cond. shell tube	1 pass			2 pass			3 pass				
	Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)		Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)		Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)			
		CC ²	GG		BB ²	DD ²		GG	BB ²	DD ²	GG
Q	20 in.	3 ft 11 in. (1,194)	2 ft 4 1/4 in. (718)	16 in.	2 ft 10 in. (864)	5 ft 0 in. (1,524)	2 ft 4 1/4 in. (718)	14 in.	2 ft 10 in. (864)	5 ft 0 in. (1,524)	2 ft 4 1/4 in. (718)
R	20 in.	4 ft 1 in. (1,245)	2 ft 5 1/2 in. (749)	18 in.	3 ft 0 in. (914)	5 ft 2 in. (1,575)	2 ft 5 1/2 in. (749)	14 in.	3 ft 0 in. (914)	5 ft 2 in. (1,575)	2 ft 5 1/2 in. (749)
L, M	20 in.	3 ft 6 in. (1,067)	2 ft 5 1/2 in. (749)	18 in.	2 ft 5 in. (737)	4 ft 7 in. (1,397)	2 ft 5 1/2 in. (749)	14 in.	2 ft 5 in. (737)	4 ft 7 in. (1,397)	2 ft 5 1/2 in. (749)
B	24 in.	3 ft 6 3/4 in. (1,086)	2 ft 5 1/2 in. (749)	18 in.	2 ft 4 1/2 in. (724)	4 ft 9 1/4 in. (1,461)	2 ft 5 1/2 in. (749)	16 in.	2 ft 4 1/4 in. (718)	4 ft 9 1/4 in. (1,461)	2 ft 5 1/2 in. (749)
C	24 in.	3 ft 11 1/2 in. (1,207)	2 ft 8 in. (813)	20 in.	2 ft 7 1/2 in. (800)	5 ft 3 1/2 in. (1,613)	2 ft 8 in. (813)	16 in.	2 ft 7 1/2 in. (800)	5 ft 3 1/2 in. (1,613)	2 ft 8 in. (813)
D, E	24 in.	4 ft 0 in. (1,219)	3 ft 1 1/2 in. (953)	20 in.	2 ft 8 1/2 in. (826)	5 ft 3 1/2 in. (1,613)	3 ft 1 1/2 in. (953)	18 in.	2 ft 6 in. (762)	5 6 in. (1,676)	3 ft 1 1/2 in. (953)
F	24 in.	4 ft 4 in. (1,321)	3 ft 1 1/2 in. (953)	24 in.	2 ft 9 1/2 in. (851)	5 ft 10 1/2 in. (1,791)	3 ft 1 1/2 in. (953)	20 in.	2 ft 8 in. (813)	6 ft 0 in. (1,829)	3 ft 1 1/2 in. (953)
K	24 in.	4 ft 6 in. (1,372)	3 ft 4 in. (1,016)	24 in.	3 ft 0 in. (914)	6 ft 0 in. (1,829)	3 ft 4 in. (1,016)	20 in.	2 ft 9 3/4 in. (857)	6 ft 2 1/4 in. (1,886)	3 ft 4 in. (1,016)

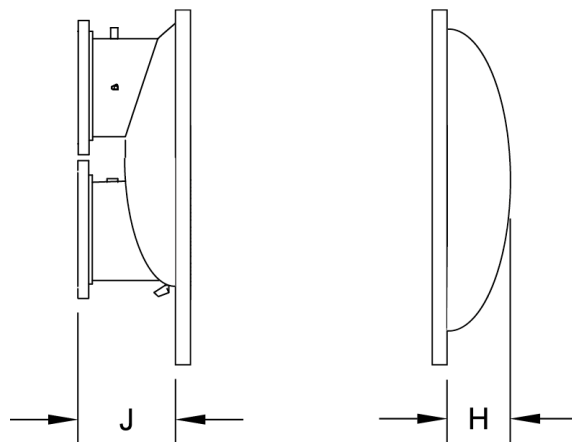
Table 37: Additional operating height clearance

Type of chiller mounting	M
Neoprene pad isolators	1 in. (25 mm)
Spring isolators 1 in. deflection	1 in. (25 mm)
Direct mount	3/4 in. (19 mm)

Note:

- Standard water nozzles are furnished as welding stub outs with ANSI/AWWA C-606 couplings 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 in. raised face), water flanged nozzles are optional (add 1/2 in. to nozzle length). Companion flanges, nuts, bolts, and gaskets are not furnished.
- Add dimension M for the appropriate isolator type.
- One, two and three-pass nozzle arrangements are available only in pairs shown and for all shell codes. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles.
- Connected piping must allow for removal of compact waterboxes for tube access and cleaning.

Figure 48: Condensers – compact waterboxes



LD18376

Table 38: Condensers - compact waterboxes

Cond. shell code	Condenser nozzle dimensions, ft-in. (mm) vs. design working pressure, psig (MPa)							
	1 pass		2 pass				3 pass	
	J		J		H		J	
	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)
Q	1 ft 8 3/4 in. (527)	Available for SQ	1 ft 8 3/4 in. (527)	Available for SQ	1 ft 1 5/8 in. (346)	Available for SQ	1 ft 8 3/4 in. (527)	Available for SQ
R	1 ft 9 3/4 in. (552)	Available for SQ	1 ft 9 3/4 in. (552)	Available for SQ	1 ft 2 7/8 in. (378)	Available for SQ	1 ft 9 3/4 in. (552)	Available for SQ
L, M	1 ft 7 3/8 in. (492)	Available for SQ	1 ft 7 3/8 in. (492)	Available for SQ	11 ft 0 11/16 in. (305)	Available for SQ	1 ft 7 3/8 in. (492)	Available for SQ
B	1 ft 7 1/2 in. (495)	Available for SQ	1 ft 7 1/2 in. (495)	Available for SQ	0 ft 11 in. (279)	Available for SQ	1 ft 7 1/2 in. (495)	Available for SQ
C	1 ft 7 3/8 in. (492)	Available for SQ	1 ft 7 3/8 in. (492)	Available for SQ	0 ft 11 in. (279)	Available for SQ	1 ft 7 3/8 in. (492)	Available for SQ
D, E	2 ft 1 1/2 in. (648)	Available for SQ	2 ft 1 1/2 in. (648)	Available for SQ	1 ft 2 9/16 in. (368)	Available for SQ	2 ft 1 1/2 in. (648)	Available for SQ
F	2 ft 2 in. (660)	Available for SQ	2 ft 2 in. (660)	Available for SQ	1 ft 3 9/16 in. (394)	Available for SQ	2 ft 2 in. (660)	Available for SQ
K	2 ft 0 13/16 in. (635)	Available for SQ	2 ft 13/16 in. (635)	Available for SQ	1 ft 4 3/16 in. (413)	Available for SQ	2 ft 13/16 in. (635)	Available for SQ

Condensers - marine waterboxes

Figure 49: Condensers - marine waterboxes

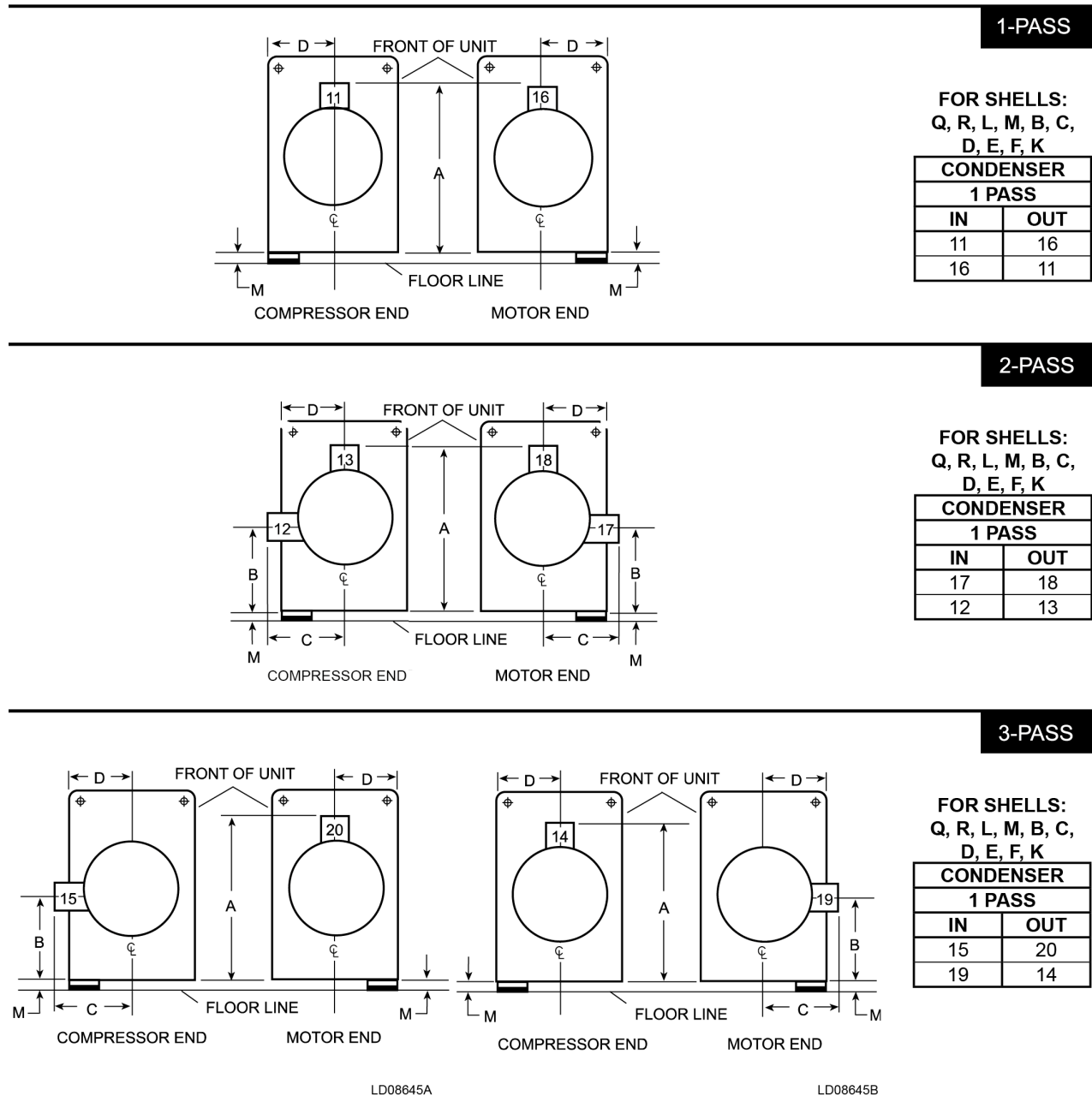


Table 39: Condensers – marine waterboxes

Cond. shell code	1 pass			2 pass					3 pass				
	Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)		Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)				Nozzle pipe size, in.	Nozzle dimensions, ft-in. (mm)			
		A ⁵	D		A ⁵	B ⁵	C	D		A ⁵	B ⁵	C	D
Q	18 in.	6 ft 5 1/2 in. (1,969)	2 ft 4 1/4 in. (718)	16 in.	6 ft 5 1/2 in. (1,969)	2 ft 7 1/2 in. (800)	2 ft 8 1/8 in. (816)	2 ft 4 1/4 in. (718)	12 in.	6 ft 5 1/2 in. (1,969)	2 ft 7 1/2 in. (800)	2 ft 8 1/8 in. (816)	2 ft 4 1/4 in. (718)
R	20 in.	6 ft 9 1/2 in. (2,070)	2 ft 5 1/2 in. (749)	18 in.	6 ft 9 1/2 in. (2,070)	2 ft 9 in. (838)	2 ft 10 1/8 in. (867)	2 ft 5 1/2 in. (749)	14 in.	6 ft 9 1/2 in. (2,070)	2 ft 9 in. (838)	2 ft 10 1/8 in. (867)	2 ft 5 1/2 in. (749)
L, M	20 in.	6 ft 2 1/2 in. (1,892)	2 ft 5 1/2 in. (749)	18 in.	6 ft 2 1/2 in. (1,892)	2 ft 2 in. (660)	2 ft 7 1/2 in. (800)	2 ft 5 1/2 in. (749)	14 in.	6 ft 2 1/2 in. (1,892)	2 ft 2 in. (660)	2 ft 7 1/2 in. (800)	2 ft 5 1/2 in. (749)
B	24 in.	6 ft 5 1/2 in. (1,969)	2 ft 5 1/2 in. (749)	18 in.	6 ft 5 1/2 in. (1,969)	2 ft 1 1/4 in. (641)	2 ft 10 in. (864)	2 ft 5 1/2 in. (749)	16 in.	6 ft 5 1/2 in. (1,969)	2 ft 1 1/4 in. (641)	2 ft 10 in. (864)	2 ft 5 1/2 in. (749)
C	24 in.	7 ft 0 in. (2,134)	2 ft 8 in. (813)	20 in.	7 ft 0 in. (2,134)	2 ft 6 in. (762)	2 ft 11 1/2 in. (902)	2 ft 8 in. (813)	16 in.	7 ft 0 in. (2,134)	2 ft 6 in. (762)	2 ft 11 1/2 in. (902)	2 ft 8 in. (813)
D, E	24 in.	7 ft 4 in. (2,235)	3 ft 1 1/2 in. (953)	20 in.	7 ft 4 in. (2,235)	2 ft 9 in. (838)	3 ft 4 in. (1,016)	3 ft 1 1/2 in. (953)	18 in.	7 ft 4 in. (2,235)	2 ft 5 in. (737)	3 ft 4 in. (1,016)	3 ft 1 1/2 in. (953)
F	24 in.	7 ft 10 in. (2,388)	3 ft 1 1/2 in. (953)	24 in.	7 ft 10 in. (2,388)	3 ft 1 in. (940)	3 ft 6 in. (1,067)	3 ft 1 1/2 in. (953)	20 in.	7 ft 10 in. (2,388)	2 ft 8 in. (813)	3 ft 6 in. (1,067)	3 ft 1 1/2 in. (953)
K	24 in.	8 ft 1 1/2 in. (2,477)	3 ft 4 in. (1,016)	24 in.	8 ft 1 1/2 in. (2,477)	3 ft 2 in. (965)	3 ft 7 1/2 in. (1,105)	3 ft 4 in. (1,016)	20 in.	8 ft 1 1/2 in. (2,477)	2 ft 10 in. (864)	3 ft 7 1/2 in. (1,105)	3 ft 4 in. (1,016)

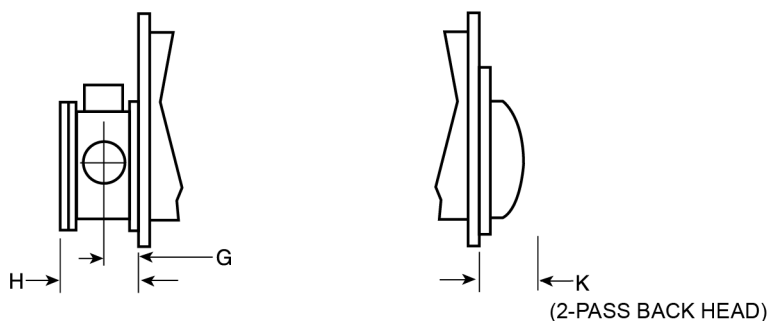
Table 40: Additional operating height clearance

Type of chiller mounting	M
Neoprene pad isolators	1 in. (25 mm)
Spring isolators 1 in. deflection	1 in. (25 mm)
Direct mount	3/4 in. (19 mm)

① Note:

1. All dimensions are approximate. Certified dimensions are available upon request.
2. Water nozzles are Standard wall (0.375 in.) pipe size, furnished as welding stub outs with ANSI/AWWA C-606 couplings 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 in. raised face), water flanged nozzles are optional (add 1/2 in. to nozzle length). Companion flanges, nuts, bolts, and gaskets are not furnished.
3. One, two, and three-pass nozzle arrangements are available only in pairs shown and for all shell codes. Any pair of evaporator nozzles may be used in combination with any pair of condenser nozzles. Compact waterboxes on one heat exchanger may be used with marine waterboxes on the other heat exchanger.
4. Water must enter the waterbox through the bottom connection to achieve rated performance.
5. Add dimension M for the appropriate isolator type.

Figure 50: Condensers – marine waterboxes



LD07193

Table 41: Condensers - marine waterboxes, 1 pass and 2 pass

Cond. shell code	Condenser nozzle dimensions, ft.-in. (mm) vs. design working pressure, psig (MPa)									
	1 pass				2 pass					
	G		H		G		H		K	
	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)
Q	1 ft 2 3/8 in. (365)	Available for SQ	2 ft 6 13/16 in. (783)	Available for SQ	1 ft 1 3/8 in. (314)	Available for SQ	2 ft 2 13/16 in. (681)	Available for SQ	1 ft 1 5/8 in. (346)	Available for SQ
R	1 ft 2 5/8 in. (371)	Available for SQ	2 ft 7 7/8 in. (810)	Available for SQ	1 ft 1 1/2 in. (343)	Available for SQ	2 ft 5 1/4 in. (743)	Available for SQ	1 ft 2 7/8 in. (378)	Available for SQ
L, M	1 ft 2 1/2 in. (368)	1 ft 3 1/2 in. (394)	2 ft 7 1/4 in. (794)	2 ft 10 1/4 in. (870)	1 ft 1 1/2 in. (343)	1 ft 2 1/2 in. (368)	2 ft 5 1/4 in. (743)	2 ft 8 1/4 in. (819)	0 ft 11 3/4 in. (298)	1 ft 0 in. (305)
B	1 ft 4 1/2 in. (419)	1 ft 5 1/4 in. (438)	2 ft 11 1/2 in. (902)	3 ft 2 in. (965)	1 ft 1 1/2 in. (343)	1 ft 2 1/4 in. (362)	2 ft 5 1/2 in. (749)	2 ft 8 in. (813)	0 ft 11 in. (279)	1 ft 1 1/2 in. (343)
C	1 ft 4 1/2 in. (419)	1 ft 5 1/2 in. (445)	3 ft 0 in. (914)	3 ft 3 3/4 in. (1,010)	1 ft 2 1/2 in. (368)	1 ft 3 3/4 in. (400)	2 ft 8 in. (813)	1 ft 11 1/4 in. (591)	0 ft 11 in. (279)	1 ft 2 1/2 in. (368)
D, E	1 ft 6 3/4 in. (476)	1 ft 9 3/4 ft (552)	3 ft 4 3/4 in. (1,035)	3 ft 10 3/4 in. (1,187)	1 ft 4 1/2 in. (419)	1 ft 5 1/2 in. (445)	3 ft 1 1/4 in. (921)	3 ft 2 1/4 in. (972)	1 ft 2 1/2 in. (368)	1 ft 3 1/2 in. (394)
F	1 ft 7 in. (483)	1 ft 11 in. (584)	3 ft 5 1/4 in. (1,048)	4 ft 1 1/4 in. (1,251)	1 ft 7 in. (483)	1 ft 11 in. (584)	3 ft 5 1/2 in. (1,048)	4 ft 1 1/4 in. (1,251)	1 ft 3 1/2 in. (394)	1 ft 4 1/2 in. (419)
K	1 ft 6 1/2 in. (470)	1 ft 9 3/4 in. (552)	3 ft 4 1/2 in. (1,029)	3 ft 11 in. (1,194)	1 ft 6 1/2 in. (470)	1 ft 9 3/4 in. (552)	3 ft 4 1/2 in. (1,029)	3 ft 11 in. (1,194)	1 ft 4 1/4 in. (413)	1 ft 5 1/2 in. (445)

Table 42: Condensers - marine waterboxes, 3 pass

Cond. shell code	Condenser nozzle dimensions, ft-in. (mm) vs. design working pressure, psig (MPa)			
	3 pass			
	G		H	
	150 (1.14)	300 (2.17)	150 (1.14)	300 (2.17)
Q	1 ft 1 3/8 in. (314)	Available for SQ	2 ft 2 13/16 in. (681)	Available for SQ
R	1 ft 1 1/2 in. (343)	Available for SQ	2 ft 5 1/4 in. (743)	Available for SQ
L, M	1 ft 1 1/2 in. (343)	1 ft 2 1/2 in. (368)	2 ft 5 1/4 in. (743)	2 ft 8 1/4 in. (819)
B	1 ft 1 1/2 in. (343)	1 ft 2 1/4 in. (362)	2 ft 5 1/2 in. (749)	2 ft 8 in. (813)
C	1 ft 2 1/2 in. (368)	1 ft 3 3/4 in. (400)	2 ft 8 in. (813)	2 ft 11 1/4 in. (591)
D, E	1 ft 3 1/4 in. (387)	1 ft 5 1/2 in. (495)	2 ft 9 3/4 in. (857)	3 ft 2 1/4 in. (972)
F	1 ft 4 3/4 in. (425)	1 ft 7 3/4 in. (502)	3 ft 3 3/4 in. (1,010)	3 ft 6 3/4 in. (1,086)
K	1 ft 4 1/4 in. (413)	1 ft 7 in. (483)	3 ft 0 in. (914)	3 ft 5 1/2 in. (1,054)

Isolators

Neoprene isolators

Figure 51: Neoprene isolators dimensions, in. - shells: Q/Q, R/R, B/L, M/M, N/B

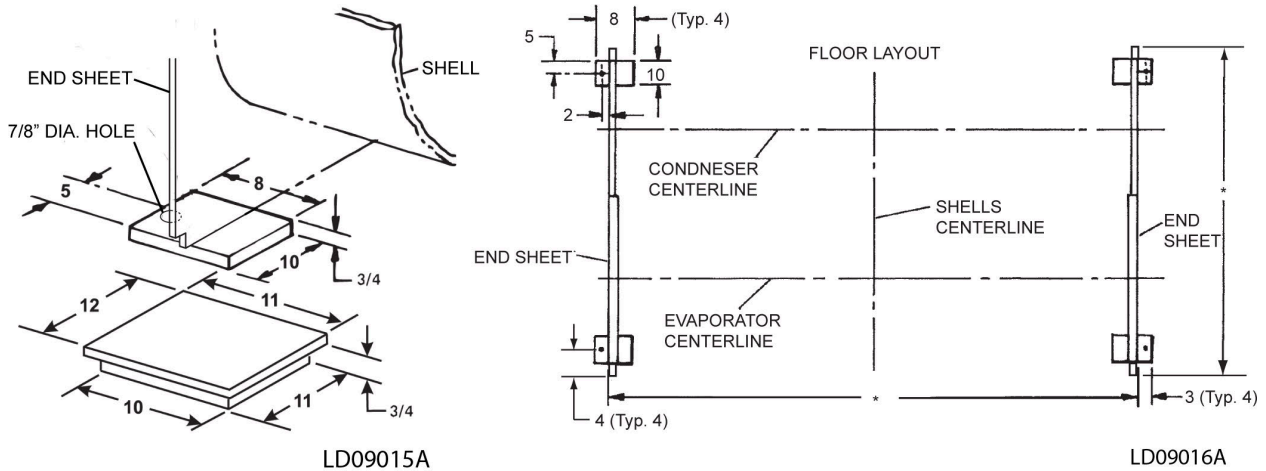


Figure 52: Neoprene isolators dimensions, mm - shells: Q/Q, R/R, B/L, M/M, N/B

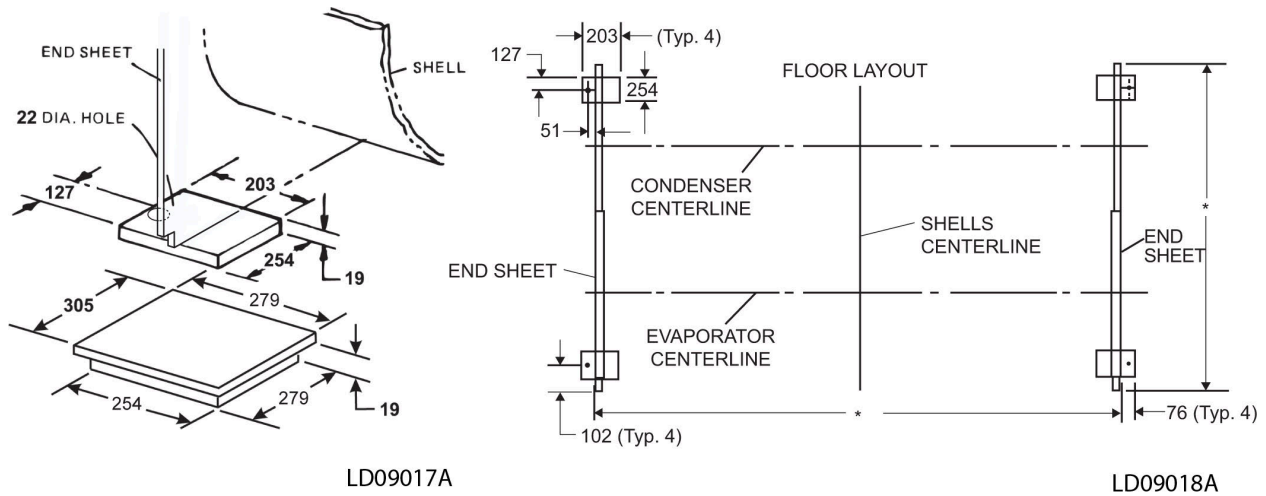


Figure 53: Neoprene isolators dimensions, in. - shells: E/C, F/D

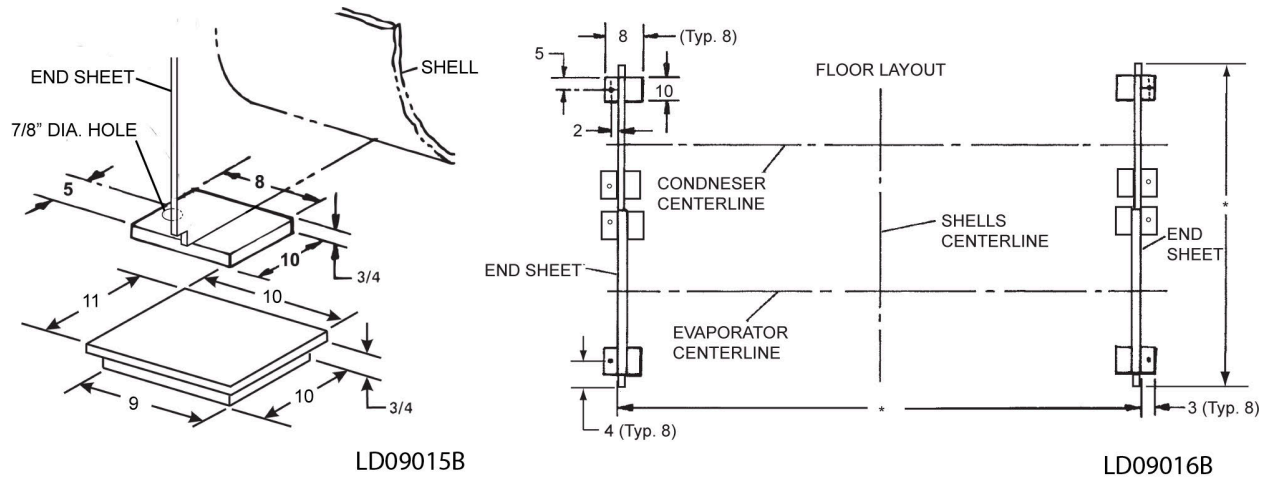


Figure 54: Neoprene isolators dimensions, mm - shells: E/C, F/D

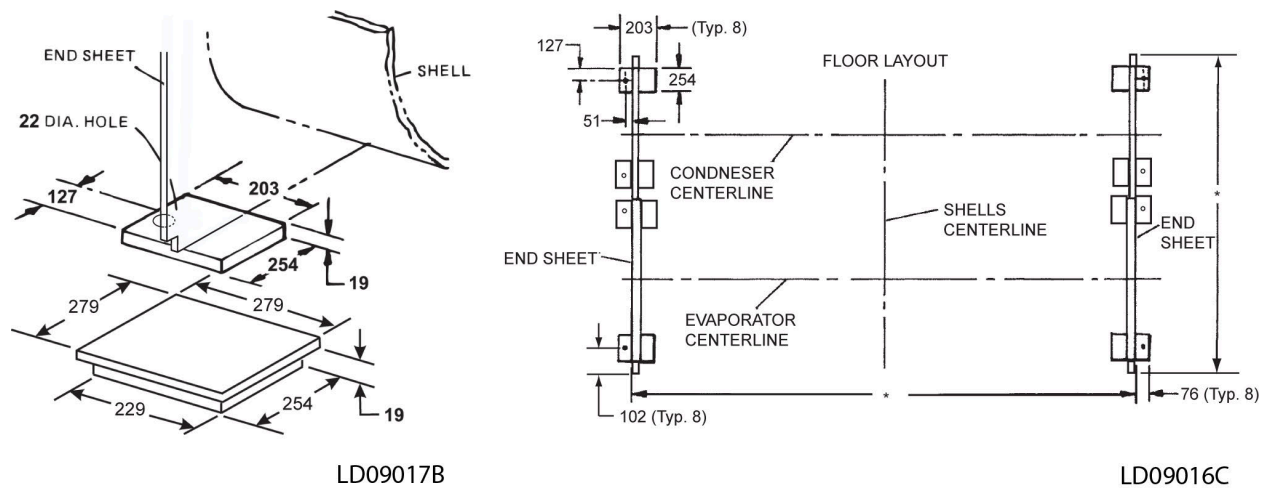
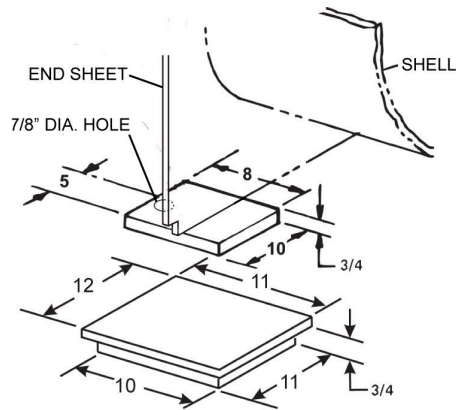
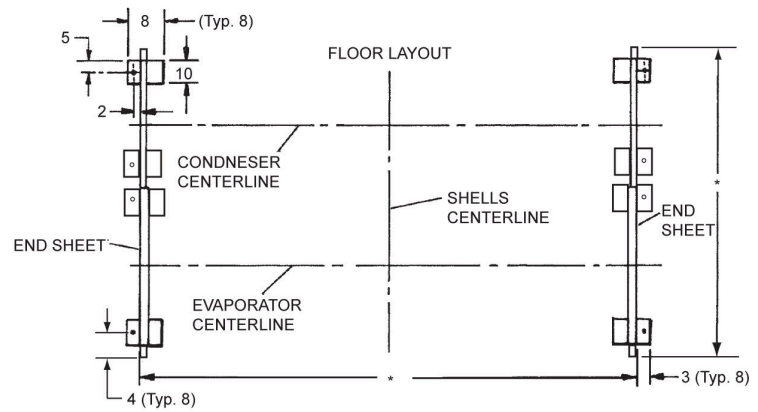


Figure 55: Neoprene isolators dimensions, in. - shells: G/E, H/F, K/K

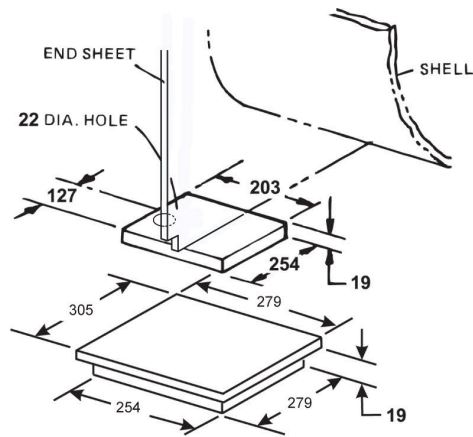


LD09015B

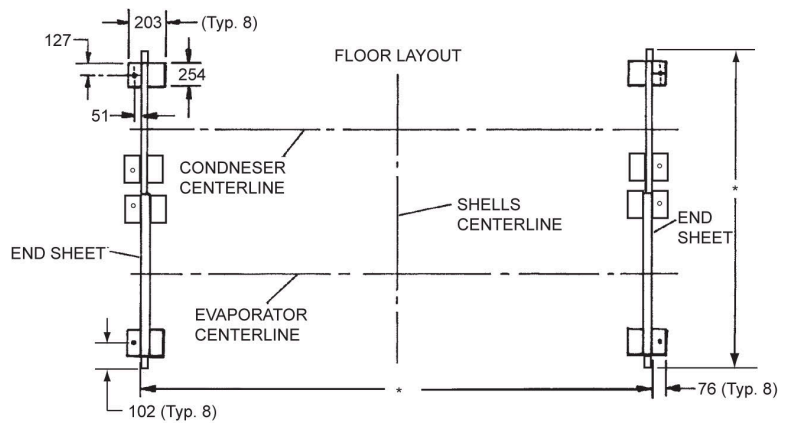


LD09016B

Figure 56: Neoprene isolators dimensions, mm - shells: G/E, H/F, K/K



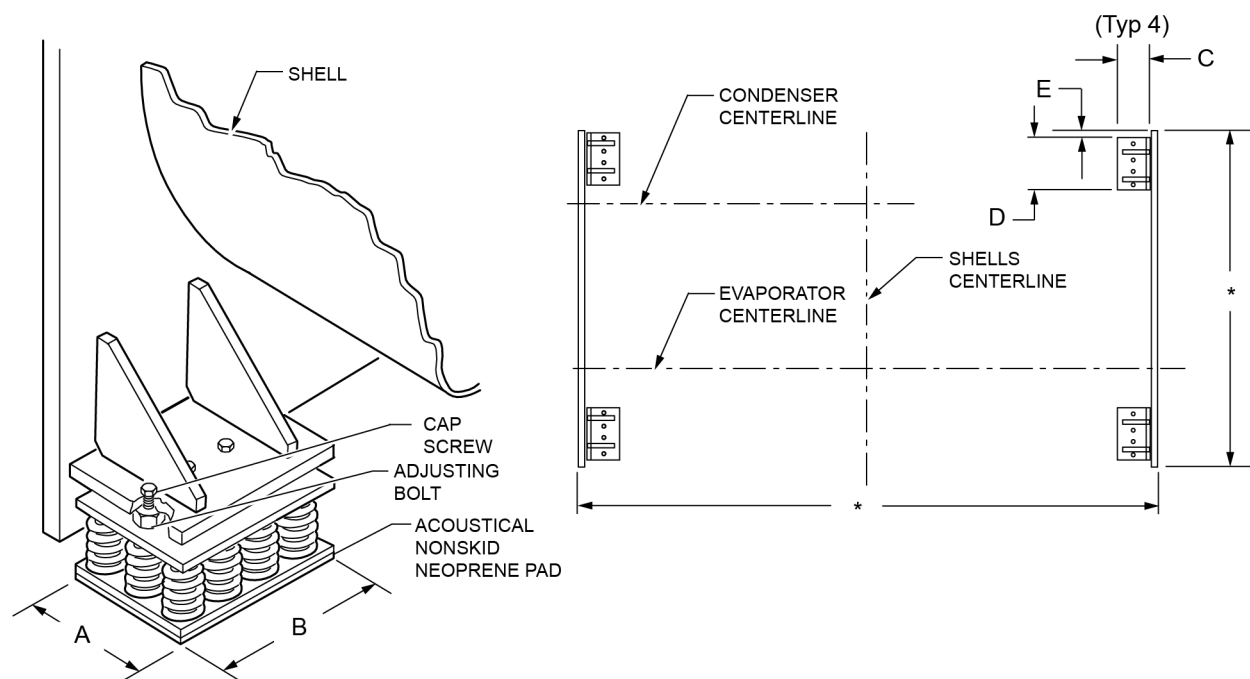
LD09017B



LD09016C

Spring isolators

Figure 57: Spring isolators



LD15143

Table 43: Spring isolator dimensions evaporator - condenser shell codes, in. (mm)

	Q-Q	R-R	B-L	M-M	N-B	E-C	F-D	G-E	H-F	K-K
A	11 (280)	11 (280)	11 (280)	11 (280)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)
B	14 (356)	14 (356)	14 (356)	14 (356)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)
C	8 (203)	8 (203)	8 (203)	8 (203)	17 (432)	17 (432)	17 (432)	17 (432)	17 (432)	17 (432)
D	13-1/2 (343)	13-1/2 (343)	13-1/2 (343)	13-1/2 (343)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)
E	1/2 (13)	1/2 (13)	1/2 (13)	1/2 (13)	3 (76)	3 (76)	3 (76)	3 (76)	3 (76)	3 (76)

Weights

For all fully assembled unit weights, refer to the General Arrangement (GA) drawing that is part of the unit submittal package. For individual component weights, refer to *Form 160.79-N1*.

Table 44: Marine waterbox weights, lb (kg)

Evap. code	Shipping weight increase, lb (kg)			Operating weight increase, lb (kg)			Cond. code	Shipping weight increase, lb (kg)			Operating weight increase, lb (kg)		
	1-pass	2-pass	3-pass	1-pass	2-pass	3-pass		1-pass	2-pass	3-pass	1-pass	2-pass	3-pass
Q	4724 (2142)	2315 (1050)	4654 (2111)	7205 (3268)	3291 (1492)	6583 (2985)	Q	3070 (1392)	1555 (705)	3132 (1420)	6162 (2794)	2981 (1352)	5949 (2698)
R	5918 (2684)	3013 (1366)	6038 (2738)	8005 (3630)	4505 (2043)	8979 (4072)	R	3912 (1774)	2425 (1100)	4052 (1838)	6750 (3061)	3674 (1666)	6644 (3013)
B	7124 (3231)	3851 (1747)	7086 (3214)	8966 (4067)	5520 (2504)	8755 (3971)	L	3808 (1727)	1947 (883)	3960 (1796)	5901 (2676)	3195 (1449)	5256 (2384)
M	7124 (3231)	3851 (1747)	7086 (3214)	8966 (4067)	5520 (2504)	8755 (3971)	M	3808 (1727)	1947 (883)	3960 (1796)	5901 (2676)	3195 (1449)	5256 (2384)
N	7088 (3215)	3604 (1635)	7244 (3286)	9319 (4227)	5758 (2612)	9320 (4227)	B	5092 (2309)	2498 (1133)	5060 (2295)	7103 (3222)	3945 (1789)	6631 (3007)
E	10,692 (4849)	6554 (2973)	13,316 (6039)	14,334 (6501)	9502 (4310)	15,708 (7124)	C	5768 (2616)	2882 (1307)	5826 (2642)	8127 (3686)	4864 (2206)	7872 (3570)
F	15,696 (7119)	8370 (3796)	16,778 (7610)	19,517 (8852)	12,191 (5529)	20,599 (9343)	D	7394 (3354)	3889 (1764)	7592 (3443)	10,256 (4652)	6333 (2872)	9722 (4409)
G	15,696 (7119)	8370 (3796)	16,778 (7610)	19,517 (8852)	12,191 (5529)	20,599 (9343)	E	7394 (3354)	3889 (1764)	7592 (3443)	10,256 (4652)	6333 (2872)	9722 (4409)
H	17,374 (7880)	8478 (3845)	16,744 (7594)	22,366 (10144)	12,630 (5728)	20,267 (9192)	F	8422 (3820)	4643 (2106)	8910 (4041)	11,745 (5327)	7965 (3613)	11,637 (5278)
K	17,374 (7880)	8478 (3845)	16,744 (7594)	22,366 (10144)	12,630 (5728)	20,267 (9192)	K	10,332 (4686)	5520 (2504)	10,798 (4897)	14,048 (6371)	9236 (4189)	13,809 (6263)

Guide specifications

General

Furnish and install where indicated on the drawings ____ dual centrifugal compressor liquid chilling Unit(s). Each unit shall produce a capacity of ____ tons (kW), cooling ____ GPM (L/s) of ____ from ____ °F (°C) to ____ °F (°C) when supplied with ____ GPM (L/s) of condenser water at ____ °F (°C). Total power input (two motors) shall not exceed ____ HP (kW) with an IPLV (NPLV) of _____. The evaporator shall be selected for ____ fouling factor and a maximum liquid pressure drop of ____ ft (m). Water side shall be designed for 150 psig (1.14 MPa) working pressure. The condenser shall be selected for ____ fouling factor and maximum liquid pressure drop of ____ ft (m). Waterside shall be designed for 150 psig (1.14 MPa) working pressure.

Low voltage units

Power shall be supplied to the compressor drive motors at ____ volts – 3 phase – (60) (50) Hertz.

Medium voltage units

Power shall be supplied to the compressor drive motors at ____ volts – 3 phase – (60) (50) Hertz. Auxiliary power to the oil pump motors shall be supplied at ____ volts – 3 phase – (60) (50) Hertz and controls shall be supplied at 115 volts – 1 phase – (60) (50) Hertz.

Units with unit-mounted starters shall not require additional auxiliary power supply for oil pump power and controls, which is factory wired from the unit mounted starter.

Performance shall be rated in accordance with the latest edition of AHRI Standard 550/590 as applicable.

Each unit shall be completely factory-packaged including evaporator, condenser, sub cooler, compressors, open motors, lubrication system, Control Center, and all interconnecting unit piping and wiring. The chiller shall be painted prior to shipment. Larger (K3 to K7 compressor) size chillers shall be shipped disassembled, with the drivelines removed and skidded and the evaporator and condenser split. The initial charge of oil and refrigerant shall be supplied, shipped in containers and cylinders for field installation in the chiller.

Compressors

Two centrifugal compressors shall be provided, operating in parallel and utilizing a common refrigerant circuit on the chiller. An electrically operated tight closing butterfly valve shall be furnished in the discharge of each compressor, to allow either compressor to be turned off at low chiller loads.

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 shall be designed for a minimum 235 psig (1.72 MPa) working pressure and hydrostatically pressure tested at a minimum of 352 psig (2.53 MPa). 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 overspeed 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 and 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 entering condenser fluid temperature 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 a common pump housing or oil reservoir. 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. Each compressor shall have an internal auxiliary reservoir to provide lubrication during coast down in the event of a power failure.

A common oil reservoir mounted below the dual centrifugal compressors shall contain a 2 hp (1.5 kW) submersible oil pump for each compressor. Each oil pump shall be built into a removable cover, one at each end of the reservoir. The oil reservoir shall be UL listed and shall be factory air strength tested at 1.1 times design working pressure.

Two 2.7 hp (2 kW) immersion oil heaters shall be provided, one in each pump cover. The heaters shall be thermostatically controlled to remove refrigerant from the oil.

Oil cooling shall be done via a refrigerant cooled oil cooler at the discharge of each oil pump. A thermostatically controlled expansion valve shall maintain the required oil temperature supply from each oil cooler to its compressor. Oil shall be filtered by externally mounted 1/2 µm 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 for 60 Hz operation and 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. This ensures 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 on each motor for field connected conduit. Jumpers shall be furnished for three lead types of starting. Overload/over current transformers shall be furnished for remote mounted electromechanical starters, and the current transformers shall be supplied inside the starter/drive panels for solid state starters or variable speed drives.

Evaporator

Evaporator shall be of the shell and tube, flooded type designed for a minimum of 180 psig (1.34 MPa) 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 in. (0.9 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/s (3.65 m/s). 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 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.

Waterboxes shall be removable to permit tube cleaning and replacement. Stub out water connections having ANSI/AWWA C 606 couplings grooves shall be provided. Waterboxes shall be designed for 150 psig (1.14 MPa) design working pressure and be tested at 225 psig (1.65 MPa). Vent and drain connections with plugs shall be provided on each waterbox, except for marine waterboxes with vertical nozzles where there are drain connections only. 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 (1.72 MPa) 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 use 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, the minimum tube wall thickness shall be 0.035 in. (0.9 mm). Each tube shall be roller-expanded into the tube sheets providing a leakproof seal, and be individually replaceable. Water velocity through the tubes shall not exceed 12 ft/s (3.65 m/s). A liquid level sight glass shall be provided on the side of the shell to aid in determining the correct refrigerant charge and to check the condition of the refrigerant charge. The condenser shall have redundant refrigerant relief devices, each sized to meet the requirements of the ASHRAE 15 Safety Code for Mechanical Refrigeration. The arrangement shall allow either valve to be isolated and replaced without removing the unit refrigerant charge.

The condenser shall be provided with positive shutoff valves in each compressor discharge line to the condenser. Additional tight closing valves shall be included in the liquid line leaving the condenser and the refrigerant liquid line to the oil coolers. This will allow pump down and storage of the refrigerant charge in the condenser. Due to the possibility of not seating properly, check valves are not acceptable for isolation purposes. If a check valve is used, a positive shutoff valve must be provided in series with the check valve.

Waterboxes shall be removable to permit tube cleaning and replacement. Stub out water connections having ANSI/AWWA C 606 couplings grooves shall be provided. Waterboxes shall be designed for 150 psig (1.14 MPa) design working pressure and be tested at 225 psig (1.65 MPa). Vent and drain connections with plugs shall be provided on each waterbox, except for marine waterboxes with vertical nozzles where there are drain connections only. Low flow protection shall be provided by a thermal type water flow sensor, factory mounted in the water nozzle connection and wired to the chiller control panel.

Refrigerant flow control

Refrigerant flow to the evaporator shall be controlled by a variable orifice control valve. The variable orifice control shall automatically adjust to maintain proper refrigerant level in the condenser and evaporator. This shall be controlled by monitoring refrigerant liquid level in the condenser, assuring optimal subcooler performance.

Control center

General – The chiller shall be controlled by a single microprocessor 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 parallel compressors, and shall provide cycling of compressors in response to load requirements.

Control Panel – The control panel shall include a 10.4 in. (265 mm). diagonal color liquid crystal display (LCD) surrounded by "soft" keys which are redefined based on the screen displayed at that time. This shall be mounted in the middle of a keypad interface and installed in a locked enclosure. The screen shall detail all operations and parameters, using a graphical representation of the chiller and its major components. Panel verbiage shall be available in other languages as an option, with English always available. Data shall be displayed in either English or Metric units. Smart Freeze Point Protection shall run the chiller at 36°F (2.2°C) leaving chilled water temperature, and not have nuisance trips on low water temperature. The sophisticated program and sensor shall monitor the chiller water temperature to prevent freeze up. The panel shall display countdown timer messages so the operator knows when functions are starting and stopping. Every programmable point shall have a pop up screen with the allowable ranges, so that the chiller cannot be programmed to operate outside of its design limits.

The chiller control panel shall also provide:

1. System operating information including:
 - Return and leaving chilled water temperature
 - Return and leaving condenser water temperature
 - Evaporator and condenser saturation temperature
 - Differential oil pressure (both compressors)
 - Percent motor current (both motors)
 - Compressor discharge temperature (both compressors)
 - Oil reservoir temperature
 - Compressor thrust bearing positioning (both compressors)
 - Chiller operating hours, and operating hours
 - Number of unit starts, and number of starts each compressor
2. Digital programming of setpoints through the universal keypad including:
 - Leaving chilled water temperature
 - Percent current limit
 - Pull down demand limiting
 - Six week schedule for starting and stopping the chiller, pumps and tower
 - Remote reset temperature range
3. Status messages indicating:
 - System ready to start
 - System running
 - System coast down
 - System safety shutdown – manual restart

- System cycling shutdown – auto restart
 - System prelube
 - Start inhibit
4. The text displayed within the system status and system details field shall be displayed as color coded message to indicate severity: red for safety fault, orange for cycling faults, yellow for warnings, and green for normal messages.
 5. Safety shutdowns enunciated through the display and the status bar, and consist of system status, system details, day, time, cause of shutdown, and type of restart required. Safety shutdowns shall include:
 - Evaporator – low pressure
 - Evaporator – transducer or leaving liquid probe
 - Evaporator – transducer or temperature sensor
 - Discharge – high pressure contacts open (each compressor)
 - Condenser – high pressure
 - Condenser – pressure transducer out of range
 - Auxiliary safety – contacts closed
 - Discharge – high temperature (each compressor)
 - Discharge – low temperature (each compressor)
 - Oil – high temperature
 - Oil – low differential pressure (each compressor)
 - Oil – high differential pressure (each compressor)
 - Oil – sump pressure transducer out of range
 - Oil – differential pressure calibration (each compressor)
 - Oil – variable speed pump – pressure setpoint not achieved (two)
 - Thrust bearing – proximity probe clearance (each compressor)
 - Thrust bearing – proximity probe out of range (each compressor)
 - Thrust bearing – proximity probe uncalibrated (each compressor)
 - Watchdog – software reboot
 - Surge detection – excess surge
 6. Cycling shutdowns enunciated through the display and the status bar, and consists of system status, system details, day, time, cause of shutdown, and type of restart required. Cycling shutdowns shall include:
 - Multi unit cycling – contacts open
 - System cycling – contacts open
 - Oil – low temperature differential
 - Oil – low temperature
 - Control panel – power failure
 - Leaving chilled liquid – low temperature
 - Leaving chilled liquid – flow switch open
 - Motor controller – contacts open (each motor)
 - Motor controller – loss of current (each motor)
 - Power fault for each motor
 - Control panel – schedule
 - Proximity probe – low supply voltage
 - Oil – variable speed pump – drive contacts open (each pump)

7. Cycling shutdowns with a VSD shall include (each VSD):
- VSD shutdown – requesting fault data
 - VSD – stop contacts open
 - VSD – initialization failed
 - VSD – high phase A, B, C instantaneous current
 - VSD – Phase A, B, C gate driver
 - VSD – single phase input power
 - VSD – high DC bus voltage
 - VSD – pre charge DC bus voltage imbalance
 - VSD – high internal ambient temperature
 - VSD – invalid current scale selection
 - VSD – invalid current scale selection
 - VSD – low phase A, B, C inverter heat-sink temp.
 - VSD – low converter heat-sink temperature
 - VSD – pre-charge – low DC bus voltage
 - VSD – logic board processor
 - VSD – run signal
 - VSD – serial communications
 - (Filter Option only for each low voltage VSD)
 - Harmonic filter – logic board or communications
 - Harmonic filter – high DC bus voltage
 - Harmonic filter – high phase A, B, C current
 - Harmonic filter – phase locked loop
 - Harmonic filter – pre-charge – low DC bus voltage
 - Harmonic filter – DC bus voltage imbalance
 - Harmonic filter – 110% input current overload
 - Harmonic filter – logic board power supply
 - Harmonic filter – run signal
 - Harmonic filter – DC current transformer 1
 - Harmonic filter – DC current transformer 2
8. 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 shall be through ID and password recognition, which is defined by three different levels of user competence: view, operator, and service.
9. Trending data with the ability to customize points of once every second to once every hour. The panel shall trend up to 6 different parameters from a list of over 140, without the need of an external monitoring system.
10. The operating program stored in non-volatile memory (EPROM) to eliminate reprogramming the chiller due to AC power failure or battery discharge. Programmed setpoints shall be retained in lithium battery backed RTC memory for a minimum of 11 years with power removed from the system.
11. A fused connection through a transformer mounted on the variable speed oil pump panel shall provide individual over current protected power for all controls.
12. A numbered terminal strip for all required field interlock wiring.

13. An RS 232 port to output all system operating data, shutdown/cycling message, and a record of the last alarm.
14. 10 cycling or safety shutdowns to a field supplied printer. Data logs to a printer at a set programmable interval. This data can be preprogrammed to print from 1 minute to 1 day.
15. The capability to interface with a building automation system to provide:
 - Remote chiller start and stop
 - Remote leaving chiller liquid temperature adjust
 - Remote current limit setpoint adjust
 - Remote ready to start contacts
 - Safety shutdown contacts
 - Cycling shutdown contacts
 - Run contacts

Unit mounted low voltage variable speed drive

A unit mounted low voltage variable speed drive (LVVSD) shall be factory-installed on the chiller. It shall vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.

The unit mounted LVVSD shall be PWM type utilizing IGBTs with a power-factor of 0.95 or better at all loads and speeds. The variable speed drive shall be unit-mounted in a NEMA-1 enclosure with all power and control wiring between the drive and chiller factory-installed, including power to the chiller oil pump. Field power wiring shall be a single-point connection and electrical lugs for incoming power wiring shall be provided. The entire chiller package shall be certified to UL standards by a nationally recognized testing laboratory.

The unit mounted LVVSD is cooled by a closed-loop, fresh water circuit consisting of a water-to-water heat exchanger and circulating pump. All interconnecting water piping is factory-installed and rated for 150 psig (1.14 MPa) working pressure.

The following features shall be provided: a door interlocked circuit breaker, capable of being padlocked; UL listed ground fault protection; overvoltage and under voltage protection; 3-phase sensing motor overcurrent protection; single phase protection; insensitive to phase rotation; over temperature protection; digital readout at the chiller unit control panel of:

- Output Frequency
- Output Voltage
- Three-phase output current
- Input Kilowatts (kW) and Kilowatt-hours (kWH)
- Self diagnostic service parameters
- Separate meters for this information shall not be acceptable.

(Optional) A harmonic filter that limits electrical power supply distortion for the unit mounted LVVSD to help the building comply with the guidelines of IEEE Std. 519 shall be provided. The filter shall be unit mounted within the same NEMA 1 enclosure and shall be UL listed. The following digital readouts shall be provided at the chiller unit control panel as part of the filter package:

- Input kVA
- Total power-factor
- Three-phase input voltage
- Three-phase input current
- Three-phase input voltage total harmonic distortion (THD)

- Three-phase input current total demand distortion (TDD)
- Self diagnostic service parameters
- Separate meters for this information shall not be acceptable.

Unit mounted medium voltage solid state starter

The chiller manufacturer shall furnish a reduced-voltage, unit mounted medium voltage solid state starter (MVSSS), in accordance with the chiller manufacturer's starter specifications. The unit mounted MVSSS shall be of modular construction with complete access to all parts. The unit mounted MVSSS shall be tested and the design starting current and overload settings adjusted at the factory. It shall provide, through the use of six in-line (not inside the Delta) silicon controlled rectifiers (2 per phase), a smooth acceleration of the motor without current transitions or transients. The unit shall have a starter dedicated for each driveline.

The following protective devices and convenience items shall be factory mounted and wired to the unit mounted MVSSS:

- Three-leg sensing electronic overloads – shuts unit down if current exceeds 105% of FLA to protect the motor windings.
- Phase rotation protection circuit – denies start-up when detecting incorrect power wiring phase sequence to the starter which could cause reverse motor rotation and damage the equipment.
- Single-phase failure protection circuit – ensures against motor burnout by shutting the unit down if power loss occurs in any of the incoming lines during start-up.
- High temperature safety protection system – temperature activated switches on heat sinks will shut the unit down if the SCR temperature exceeds acceptable limits.
- Three-phase digital ammeter and digital voltmeter readout via control center – easily crosscheck design current and voltage limitations against supply characteristics.
- Starter mounted load break rated input disconnect switch with interlocked padlockable handle. Positive disconnecting means shall be visible from outside the enclosure, in operator area. All doors shall be interlocked with the disconnecting means.
- Open/Shorted SCR Protection – Failed semiconductor devices are automatically detected and reported via the Control Center.
- Power Fault Protection – momentary power interruption protection detects power interruptions within three line cycles and interrupts power to the compressor motor within one additional line cycle.
- Electrical connections – these tin-plated or copper bus bars provide easy connection to incoming copper power lines.
- Wattmeter – An instantaneous wattmeter tells the customer how much power the chiller is consuming. A kilowatt-hour energy meter is also provided to measure power consumption over a period of time.
- Shut down History – The unit mounted medium voltage solid state starters shall provide the system control panel with ten histories of previous unit shutdowns initiated by the starter.

In addition, the unit mounted MVSSS shall include as standard, the following convenience items already mounted and wired to it at the factory:

- Auxiliary control supply transformer – eliminates the need for running separate 115V- 1 ph-50/60 Hz power source wiring to the chiller Control Center.
- Auxiliary Oil Pump supply transformer – eliminates the need for running separate low voltage three-phase power source wiring to the chiller Variable Speed Oil Pump Control Panel.

Remote mounted medium and high voltage electromechanical starter

A remote-mounted medium and high voltage electromechanical starter (M/HVEMS) shall be furnished for each compressor motor. The medium and high voltage electromechanical starter (M/HVEMS) shall be furnished in accordance with the chiller manufacturer's starter specifications, and as specified elsewhere in these specifications.

Remote mounted medium and high voltage variable speed drive

The remote mounted medium and high voltage variable speed drive (M/HVVSD) will vary the compressor motor speed by controlling the frequency and voltage of the electrical power to the motor. The capacity control logic shall automatically adjust motor speed and compressor pre-rotation vane position independently for maximum part-load efficiency by analyzing information fed to it by sensors located throughout the chiller.

Definitions

For the purpose of this Specification, the following definitions apply:

- **VSD** - Variable speed drive is a device that is used to vary the speed of a previously fixed speed motor.
- **NPC** - Neutral Point Clamp is an VSD topology that has the advantage of reducing the high line to neutral voltage that can occur in other traditional drive designs that can reach 2.7 to 3.3 times normal levels.
- **PWM** - Pulse Width Modulation is a method of controlling power devices to convert voltage levels. PWM is a popular method of control for converting DC voltage to AC voltage.
- **IGBT** - Insulated Gate Bipolar Transistor is a high speed electrical switching power device. It is very efficient requiring very low power for control circuits
- **HCT** - Hall Effect Current Transformer are used for detection of currents over a frequency range of DC to high frequency without direct contact or shunts.
- **CPT** - Control Power Transformer is typically used to power control circuits and relays for the VSD.
- **FLA** - Full Load Amps.

Components

The remote mounted M/HVVSD shall consist of the following components:

- Incoming Disconnect
- A 24 pulse input Isolation Transformer from high voltages to 4160V with rectifier that limits electrical power supply distortion.
- Frequency Converter/Inverter
- VSD Protective System/Devices
- Output filter or reactor (when required to limit reflected voltage)
- Output Disconnect(s) or bypass (when specified on Data Sheet)
- Diagnostics and Control Circuits
- Two control power transformers, for the Control Center and for chiller oil pump operation.

Features

The following features will be provided:

- PWM type utilizing IGBT's with a power factor of 0.95 or better at all loads and speeds.
- Door interlocked circuit breaker capable of being padlocked.
- UL listed ground fault protection.
- Over voltage and under voltage protection.
- Three-phase sensing motor over current protection.
- Single phase protection.
- Insensitive to phase rotation.
- Over temperature protection.
- Digital readout at the chiller unit control panel of output frequency, output voltage, 3-phase output current, input Kilowatts and Kilowatt-hours, self-diagnostic service parameters, Elapsed Time Meter.
- Separate meters for this information will not be acceptable.

General design and fabrication

The remote-mounted M/HVVSD inverter/chopper shall be of the pulse width modulated (PWM) Neutral Point Clamp (NPC) type. The output devices shall be Insulated Gate Bipolar Transistors (IGBTs) with a minimum voltage rating of 3300V. Use of lower rated devices is unacceptable due to the quantity of devices required in the design.

- All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.
- The equipment shall be completely factory built, assembled, wired, and tested. When it is necessary to disassemble the units for ease of transportation, adequate materials and instructions shall be provided for easy field reassembling.
- For VSD applications where the line voltage is higher than 6600 V and the drive uses an input voltage of 6600 V or less then any transformer used to reduce the line voltage from greater than 6600 V to less than 6600 V must have the transformer inefficiencies included in the chiller energy analysis.
- The remote mounted M/HVVSD shall be capable of continuous operation up to altitudes of 5,000 ft (1,500 m).

Enclosures and cooling

The remote mounted M/HVVSD enclosure shall be suitable for installation in an indoor, unclassified area.

All enclosure openings exceeding 1/4 in. (6 mm) in width shall be provided with screens to prevent the entrance of snakes, rodents, etc. The maximum screen mesh opening width shall be 1/4 in. (6 mm).

A "loss of cooling" fault shutdown shall be furnished with this forced cooled equipment. In the event of clogged filters or fan failure, the remote mounted M/HVVSD will shut down safely without electronic component failure.

Air filters shall be of a reusable type that can be easily cleaned. All doors or front panels will be fully gasketed. Air exhaust from cooling fans will be at the top of the enclosure away from personnel in front of the equipment.

Fan motors shall be protected by an input circuit breaker. Metal squirrel cage ball bearing 46 0V three-phase fan motors are to be used in the drive design. Plastic muffin fans are not acceptable.

As specified on the data sheet, fan power will be obtained from a remote 460 V three-phase power or from the primary 2300 / 3300 / 4160 V power through a tap on the input transformer.

The maximum noise level of the unit shall not exceed 80 dBA at a distance of 3.3 ft (1 m) from the unit and at a height of 4.9 ft (1.5 m) from the floor.

Painting

Use Manufacturer's standard finish.

Operational controls

All operator controls and adjustments are through the chiller control center.

The remote mounted M/HVVSD shall include necessary components to protect it and the motor against motor overload, internal faults, and disturbances in the incoming AC line.

The following conditions shall cause the remote mounted M/HVVSD to be shut down with the output voltage reduced to zero. The chiller control center shall annunciate the failure.

- Cooling fan loss
- Input transformer over temperature
- Heatsink over temperature
- Motor current overload
- Output current imbalance
- High output frequency
- Input phase loss
- DC Link Voltage imbalance
- DC Link Voltage overvoltage
- DC Link Voltage undervoltage
- Ground fault
- Power supply fault
- IGBT gate drive fault
- Communications fault
- Cabinet doors interlock

Input power transformer and rectifier

The remote-mounted M/HVVSD shall contain an incoming isolation transformer whose primary voltage shall be as specified on the Data Sheet.

- The transformer shall contain 12 three-phase secondary windings that provide the proper phase shifting to develop a 24-pulse rectification to reduce harmonic currents and voltages reflected to the primary power system.
- The transformer shall be aluminum wound and shall have a 428°F (220°C) insulation system to operate at 239°F (115°C) rise at full load conditions.
- The transformer and rectifier shall be an integral part of the VSD assembly along with primary disconnect switch, input vacuum contactor and secondary fusing eliminating the need for separate components field installation or wiring.
- Soft charge of the DC bus capacitors is accomplished by use of an input reactor on the primary of the input transformer. A vacuum contactor rated for drive full load amps will short the reactor after charge is accomplished.

Control power transformers

A 115 V single phase nominal 2 kVA transformer will be supplied for chiller controls.

A 460 V three-phase 50/60 Hz up to 3 kVA transformer will be supplied for chiller oil pump operation.

Operator panel displays

All operator displays are through the chiller control center.

The following items will be monitored and displayed:

- Output frequency
- Output voltage
- Motor current
- Input voltage
- Input power
- Energy consumption kWh

Power requirements

The remote mounted M/HVVSD shall be capable of providing rated output for continuous voltage deviations of +10%.

The remote mounted M/HVVSD input short circuit withstand rating shall be 50,000 A.

The remote mounted M/HVVSD shall be able to ride through voltage dips down to 10% of minimum, such as those experienced during motor starting.

The remote mounted M/HVVSD 40 second overload current rating shall be set at 105% of rated compressor current.

The remote mounted M/HVVSD shall help the building comply with the requirements of IEEE Std. 519.

Voltage distortion shall not exceed 3% and current distortion shall not exceed 5% at the input lugs of the remote mounted M/HVVSD over an operating power range of 30% to 100% of rated power with phase voltage imbalance per the 3% specification.

The remote mounted M/HVVSD converter section shall be configured as a 24 pulse or greater to eliminate the need for harmonic filters.

Power bus

All power bus bars, when part of the standard design and other current carrying parts shall be tin-plated copper for corrosion resistance. Power bus bar joints shall be tin plated.

Bus bars shall be braced to withstand short circuit currents shown on the Data Sheet with a minimum of 50KAIC.

Input and output connections shall be either top or bottom access in the standard design.

Inverter section design

The remote mounted M/HVVSD inverter section shall consist of three cells where each cell has two series DC power supplies per phase. Each DC supply is derived from a phase shifted secondary of the input transformer that cancels reflected harmonics back to the power line. The DC power supply is filtered by long lasting oil filled capacitors. Electrolytic capacitors are not permitted.

Each cell has eight 3300 V Insulated Gate Bipolar Transistors (IGBTs) in a single phase bridge connection such that when in combination with the other bridges, a 5 level output voltage is constructed to the motor. A bridge neutral point is connected with a jumper to each of the three cells. This configuration called Neutral Point Clamp (NPC) provides a normal phase to ground level voltages that are superior to other direct PWM or multi-level twelve cell remote mounted M/HVVSD designs that can cause 1.8 to 3.3 times normal line to ground voltage.

Each power device communicates to the microprocessor with fiber optic communications. No other isolation method is allowed.

A high resistance ground detection circuit at the neutral point is used for system shutdowns in the event the load has a ground fault.

Two Hall Effect Current Transformers (HCT) are used for current feedback on the remote mounted M/HVVSD output.

PWM firing pulses will result in an output voltage and current waveform that will result in less than 2% torque ripple over a 20 to 1 speed range on the motor.

Disconnects

The remote mounted M/HVVSD shall include a main disconnect device with an interlocked and padlockable handle mechanism. The disconnecting device shall be a medium voltage vacuum contactor with a bolted pressure disconnect switch whose blades are externally visible from outside the enclosure. The disconnect device shall have a momentary withstand rating greater than the available fault current indicated on the Data Sheet.

When multiple doors are supplied, all doors shall be electrically interlocked with the disconnect device. The interlocks shall include provisions to manually override for test and repair.

Wiring and terminations

Bus bar with standard four-hole pattern to be supplied for input and output shall be provided for connection of external wiring and shall be conveniently located, clearly numbered, and identified.

Control wire terminal blocks for external wiring terminations shall be compression screw type, designed to accommodate stripped insulation bare wire ends, and shall accept a minimum of two No. 14 AWG wires.

Connection points for inputs and outputs of different voltage levels shall be segregated to reduce possibility of electrical noise. If necessary, this may be accomplished through the use of terminal barriers and covers.

Where wiring is run through sheet metal or any barrier, bushings, grommets or other mechanical protection around the sheet or barrier opening shall be provided.

All internal wiring shall be terminated with no more than two conductors per terminal block point.

The remote mounted M/HVVSD shall have an internal mechanical ground connection suitable for terminating a stranded copper ground conductor of the same size as the incoming phase conductors. Ground connections shall be near the incoming and outgoing power cable termination points and control wiring connections.

Minimum wire bending space shall meet or exceed the value shown in NEC Table 430.10(b) for termination of the power cable and shall be documented on Manufacturer's drawings.

Inspection and testing

Manufacturer's standard tests shall be performed. Minimum testing shall include:

Power semiconductors shall be thermally cycled and printed circuit boards shall be burned in prior to final assembly into the remote mounted M/HVVSD.

Individual power cells shall undergo a visual inspection, an electrical inspection, and a complete full load test prior to final assembly into the remote mounted M/HVVSD. A test record for each power cell shall be furnished as part of the final data requirements if requested on the data sheets.

Mechanical operation tests shall be performed for each remote mounted M/HVVSD to verify satisfactory operation. These tests shall include checking operating mechanisms and interlock devices.

Electrical function tests shall be performed to ensure proper operation of all devices and components including operation of the remote mounted M/HVVSD at full load conditions. Instrumentation, software, and monitoring tests shall be included.

The final assembly will be tested at full load and voltage by a power back method that returns drive output power to the power line. An unloaded full voltage motor will also be used during testing.

Shipping

Preparation for shipment shall be in accordance with Manufacturer's standards.

Loose equipment shall be appropriately packaged and secured for shipment inside the enclosure or shipping container. These items shall be properly tagged for easy identification.

Documentation

Manufacturer Drawings and Data

Equipment shall be shipped with one set of installation, operation, and maintenance manuals.

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 (kPa)
	Pounds/sq. inch (psi)	6.895	Kilopascals (kPa)

Temperature

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

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:

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

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

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

kW / ton and COP are related as follows:

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

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

Table 45: Fouling factor

English I-P (ft ² °F hr/Btu)	Equivalent SI metric (m ² k/kW)
0.0001	0.018
0.00025	0.044
0.0005	0.088
0.00075	0.132