Product Manual	PM WSCWDC
	Group: **Chiller**
	Date: **October 1999**
	Supersedes: **PM PEH/PFH-1**

Centrifugal Compressor Water Chillers

THE DISTINCTION SERIES ä

Model WDC, Dual Compressor, 160 to 2700 Tons (560 to 9500 kW)

Model WSC, Single Compressor, 80 to 1300 Tons (280 to 4550 kW)

HFC 134a, The Global Refrigerant of Choice

Table of Contents

(Cover picture: Model WDC 126, 2300 ton dual compressor chiller)

Our facility is **ISO9002 Certified**

Initial Issue September, 1998

Introduction

THE DISTINCTION SERIES

As a result of extensive research and development efforts on both heat transfer and compressor components, McQuay will enter the 21st century with a new generation of centrifugal chillers. So advanced that they have been given a new model designation, WSC for single and WDC for dual compressor units. Their new name, the *DISTINCTION SERIES*Ô, was deemed highly appropriate. Distinction is defined as:

Excellent in performance

Recognition of superiority

The fact of being different

FEATURES	BENEFITS
Alternative refrigerant leadership- Complete HFC-134a centrifugal chiller line	The confident choice for the future-Positive pressure-Environmentally safe -Non-toxic- No purge unit
Dual compressors available up to 2,700 tons-(9500kW) Two of all mechanical and electrical components	Lower annual energy cost than any single compressor chiller - Dual compressor reliability – Small footprint
New generation MicroTech Control	A complete chiller plant controller-Open protocol-Loaded with customer benefits-See detailed specification
Bolt together construction at tube sheets	Easy disassembly and re-assembly at the job site for those difficult retrofit installations
Pumpdown capability-Entire charge can be valved off and stored in the condenser or in either vessel in dual compressor units	Eliminates the need for a separate pumpout vessel in most situations
Small footprint	Optimizes equipment room space
Units performance tested in the factory to job conditions, within established limits	Factory testing assures trouble free startups and reliable operation
Over 30 years of product refinement and factory ISO 9002 Certified	Insures consistent quality for long, trouble-free operation

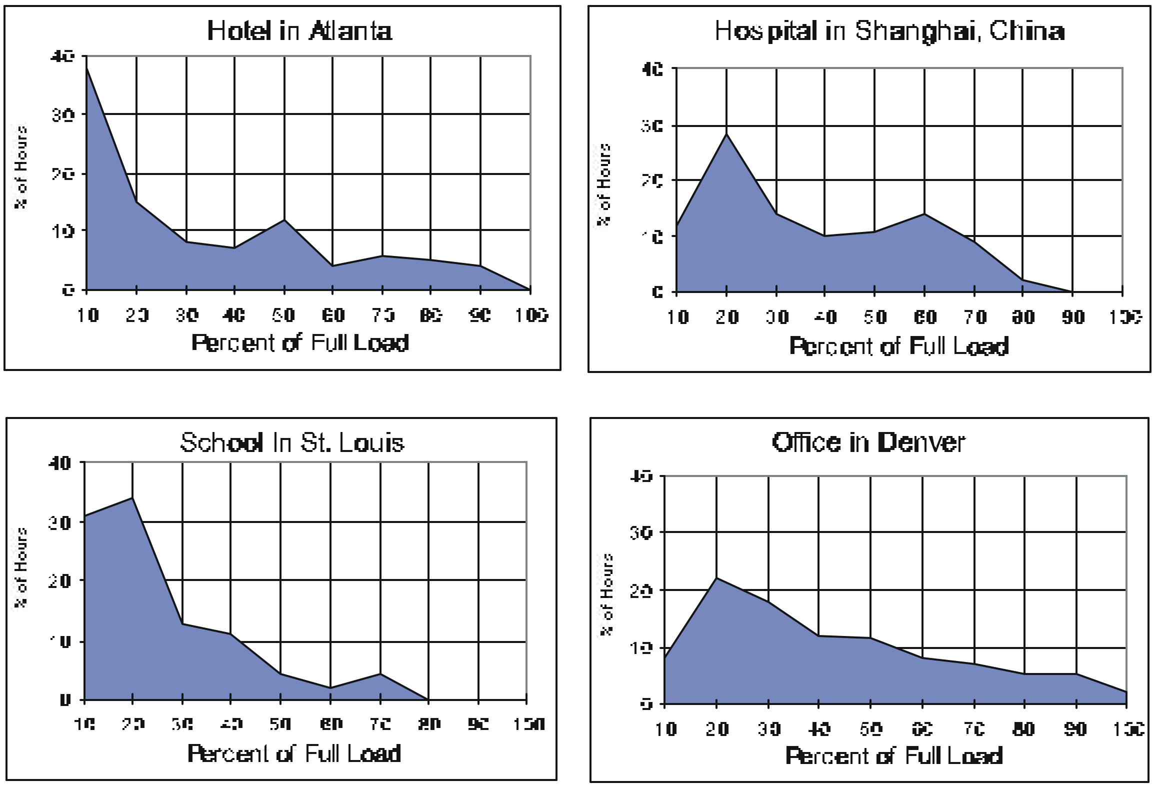
Certification

McQuay chillers for specific capacity and component assemblies have been submitted to Underwriters Laboratories Inc. for certification and listing. Their symbol will be affixed only to those units when required by specification or code. Consult the factory for selection on all applications where UL is required.

Full ARI 550 (now ARI 550/590) participation and certification has been an on-going commitment at McQuay International. The ARI label affixed to certified units certifies that the unit will meet the specified performance. This equipment is certified in accordance with ARI Standard 550/590, latest edition, provided the application ratings are within the scope of the certification program. This excludes the following applications: air and evaporative cooled chillers, capacity exceeding 2000 tons (7000 kW), voltages above 5000 volts, brine and special fluids other than water, 50 Hz, and heat recovery.

Dual Compressor Design

Dual Compressor Chillers Offer Better Efficiency, Lower Installed Costs, Less Floor Space, And Higher Reliability Than Single Compressor Designs



Note: Building part load data directly from a major manufacturer's load and energy program

Most buildings operate at their full design cooling load for only a few hours a year, yes, hours. In fact some buildings, schools for example, may never run at full design load. Except for some electrical demand considerations, why be concerned about a chiller's full load kW/ton (COP) at all? The real question should be "what does it cost to run the chiller in my building, at my loads, and my power costs?"

The answer to this question is in the part load efficiency of the chiller-and no chiller can do as well as the McQuay Dual Centrifugal. These chillers excel when it comes to operating efficiency in the five percent to sixty percent capacity range-where 70 percent of the annual operating occur in most buildings. The building part load curves shown above are from detailed energy studies performed on various building types.

See page 15 for a comprehensive discussion of dual compressor advantages.

HFC-134a:

Helping To Keep The Ozone Whole!

McQuay Positive Pressure Design:

No Purge

No Vacuum Prevention System

No Contaminants

HFC-134a operates above atmospheric pressure in the entire refrigerant circuit. Negative (low) pressure systems require a purge unit to remove non-condensables (air, water vapor, etc.) that leak into the chiller during operation and compromise chiller performance. Purge units, even the new "high efficiency" types, regularly have to vent refrigerant to the atmosphere, along with the non-condensables. The 1990 Clean Air Act has prohibited the intentional venting of refrigerant since July 1, 1992. The environmentally responsible positive pressure system eliminates this regular venting of refrigerant.

Great care is taken by manufacturers and service personnel to ensure that refrigeration systems are dry when they are manufactured or serviced. It makes no sense at all to buy a negative pressure HCFC-123 chiller that ingests water vapor during normal operation.

In addition to the refrigerant loss and maintenance problems of a purge system, negative pressure chillers require a vacuum prevention system. This system heats the refrigerant during off cycles to a positive pressure. Unfortunately, the vacuum prevention system only works when the chiller is off, and cannot prevent vacuum related problems when the chiller is operating. Plus, it’s a heating system requiring energy.

Sustainable Performance

Because of their positive pressure design, McQuay centrifugal chillers offer greater sustainable performance over the life of the chiller. Positive pressure means no intrusion of noncondensable gases that are known as "robbers" of efficiency. These foreign gases compete with refrigerant for heat exchange surface and can reduce efficiency by as much as 14% at full load.

Positive pressure eliminates oil degradation due to non-condensables. Contaminated oil will produce acids that attack and breakdown motor insulation and copper plate shafts and bearings. The contaminant free, extended life lubricant used in McQuay chillers offers a means to gauge the health of your machine over the years. Through diagnostic analysis methods available for synthetic lubricants, preventative action can be taken should a potential problem show itself.

No purge system to...

- Attack the ozone,
- Escalate operating costs,
- Increase annual maintenance,

Chiller systems utilizing negative pressure refrigerants are subject to the continuous introduction of equipment room moisture and non-condensables into the refrigerant circuit. Bolted surfaces, vane operator linkage outlets, motor terminals, control tubing connections and casing porosity all provide points of entry for the introduction of these foreign gases into the circuit. This can be especially destructive in maritime locations where salt laden air is present. These non-condensables must be isolated, collected and purged continuously from the equipment.

To prolong the useful life of low pressure refrigerant systems, an automatic purge unit is required as a standard accessory. A variety of types of compressor operated and non-compressor purge systems are used. Their efficiencies vary from 50% to 80% on older style units and are over 95% on newer high-efficiency systems. The efficiency is a measure of the quantity of refrigerant pumped to the atmosphere along with the undesirable contaminants. Thus the need for a purge system is accompanied by the periodic release of refrigerant into the atmosphere, and attendant annual refrigerant cost.

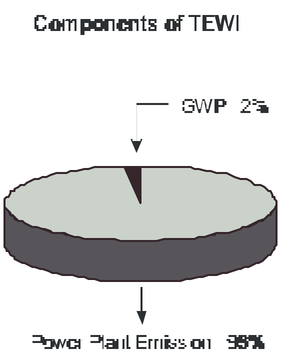
All McQuay centrifugal chillers use a positive pressure refrigerant. There is...

- No absorption of impurities into the refrigerant circuit
- No breakdown of motor insulation, refrigerant or lubricant
- No increase in operating cost due to displacement of heat transfer surface by non-condensables
- No crevice corrosion and tube failure due to moisture in the system
- No annual service expense to maintain and rebuild purge unit
- No abnormal annual service expense for oil, filter, and refrigerant replacement
- No periodic emissions of refrigerant into the atmosphere

Environmentally and Operator Safe - The Real Facts

As the air conditioning industry prepares for the future, HFC-134a stands out as the logical choice when using a balanced approach. The "balanced approach" takes into account the following facts on environmental concerns:

- ODP-Ozone Depletion Potential; measures the impact of a substance on the depletion of the ozone layer in the upper atmosphere. With refrigerants, this action is caused by chlorine, the first "C" in HCFC-123. HFC-134a contains no chlorine and has a zero ODP.
- GWP-Global Warming Potential; measures the contribution of a substance to the greenhouse gas effect which causes global warming. This is a pound to pound comparison, discounting the application of the substance and any other effects caused by its use. The numbers, relative to CO_2 for a 100 year integration time horizon are HCFC-123=90, HFC-134a=1300, HCFC-22=1500. Manufacturers utilizing HCFC-123 would have you believe that GWP is the primary measurement of global warming. This is untrue.
- TEWI-Total Equivalent Warming Impact; is a combination of the refrigerant GWP, unit refrigerant emissions rate, and the refrigeration system's energy efficiency. Science has agreed that a systems approach is necessary to evaluate the *real* effect of a substance on global warming. This is TEWI. In a chiller, the contribution of the GWP is insignificant when compared to the effect of a unit's power needs translated to power plant CO_2 emissions. There is no meaningful difference between the TEWI of HFC-134a, HCFC-22 or HCFC-123. The percentages shown on the right will vary slightly depending on unit refrigerant loss and on the efficiency of local power generation. Bottom line, equipment operators should keep equipment leak free and operate as efficiently as possible. Since annualized energy consumption (think power plant output) is a basis for measurement, McQuay's superior part load efficiencies mean lower overall power plant CO_2 emissions and lower TEWI.



- True System Efficiency (KW/ton or COP); deals with the total power consumption (annual kWh) of a chiller system including auxiliaries such as pumps, purge units, Pre-Vac heaters and fans---of great importance in determining facility energy cost and ultimate power plant CO_2 emissions.

- Toxicity and Flammability Rating; per 1997 ASHRAE Fundamentals Handbook
  - HFC-134a ⇒ A-1
  - HCFC-123 ⇒ B-1

Where A=No toxicity identified

B=Evidence of toxicity identified

1=No flame propagation in air at 100°C, 50% rh and one atmosphere pressure

A certain future for HFC-134a:
The Clean Air Act of November 1990 allows the EPA to accelerate the phase-out schedule of Class I (CFC) and Class II (HCFC) refrigerants if it deems it necessary. This leaves the future of HCFCs (which includes HCFC-22 and HCFC-123) uncertain. HFC-134a will not be regulated or phased out by the Clean Air Act or the Montreal Protocol. The commercial air conditioning, home appliance, and automotive industries are just a few of the many markets that will be using HFC-134a for years into the future. This large market demand for HFC-134a translates to a readily available and competitively priced product.

Compressor Design

Gear Drive Offers Greater Operating Efficiency Than Direct Drive

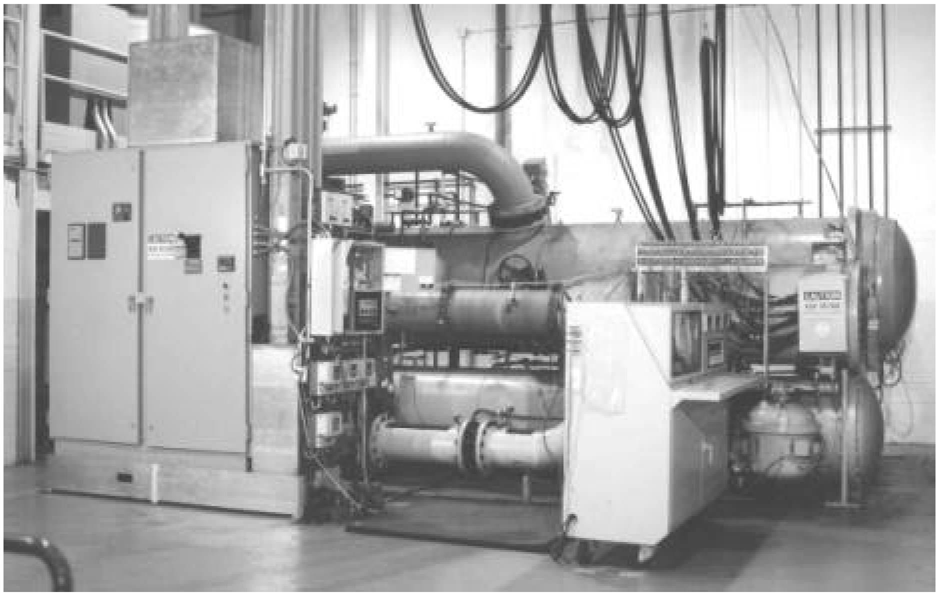
Centrifugal compressor efficiency is a function of impeller design and application to the refrigeration system. The increased heat transfer surface and efficiency of modern heat exchangers have changed compressor head and impeller tip speed requirements. Direct drive designs limit the manufacturer's ability, within a single compressor size, to select impellers at or near peak impeller efficiency. While a unit selected at poor impeller efficiency might produce the required performance at peak load, its operating characteristics over the entire range of part load performance are sharply curtailed, resulting in increased annual operating costs. McQuay gear drive centrifugal chillers provide a variety of tip speed ratios to permit selection of impellers for maximum efficiency over their entire part load to full load range and are ideal for 50 Hz application. Mechanical gear losses are limited by design standards to less than one-half of 1%. The impeller efficiency obtained by alternate gear selections may increase chiller efficiency by as much as 7%. As energy costs continue to rise, the economic advantages of gear drive to obtain maximum efficiencies will be universally sought.

Extended Motor Life

McQuay's modern compact compressor design equates to many operating advantages that improve its overall reliability and durability. One such advantage is prolonged motor life. A motor draws locked rotor current until it reaches break away torque at approximately 80% of its running speed. While drawing locked rotor current the stresses on the motor are over six times that of full load. The McQuay compressors absolutely minimize this stress through the unique gear drive and light weight drive train that allows a 500 ton (1750 kW) compressor to reach running speed in less than three seconds. The owner benefits from a longer motor life.

Safe Compressor Coast Down

Another advantage is the short coast down time. Under normal operating conditions the electric driven oil pump continues to feed oil to the bearings during coast-down. However, if a power failure occurs, the pump is unable to provide positive coast down lubrication. With McQuay's design, coast down takes less than 15 seconds and this short time allows an internal reservoir to provide positive oil flow to the bearings.



McQuay's new million dollar compressor test stand with state-of-the-art data acquisition provides comprehensive information on new compressor designs.

Single Stage Simplicity = Savings

Compressor efficiency is NOT a function of multiple impellers. Maintenance of optimum efficiency at peak and, more importantly, at part load is a function of the total compressor and chiller design. Included are:

- Motor efficiency
- Refrigerant type
- Condenser and evaporator surfaces
- Compressor mechanical friction
- Impeller and vane design
- Refrigerant flow passages

Of these, the least considered performance factor on actual versus theoretical performance is the refrigerant flow passages between the discharge of one impeller and the inlet to the next impeller on multi-stage machine design. The energy loss in a single passage will be greater or equal to the loss in the suction passage between the evaporator outlet and the first stage impeller inlet, depending upon the compactness of the total compressor design. Single stage impeller design eliminates that additional loss, and provides an opportunity for maximum system efficiency.

The primary advantage to multi-stage centrifugal operation, in the pressure and volume ranges characteristic of typical air conditioning systems, is the expansion of impeller head coefficients at reduced volumetric flows or cooling loads. The McQuay backward inclined SINGLE STAGE IMPELLER, combined with the patented movable diffuser at the impeller discharge, provides a stable operating range superior to multi-stage systems. Thus, selection of McQuay chillers permits operation from 100% to 10% capacity (to 5% on WDC dual compressor chillers) without surging and at maximum efficiency, i.e. no hot gas bypass.

Optimum compressor efficiency is designed into each McQuay impeller. Each is cast, fully shrouded, by the lost wax process that provides exact duplication despite a complex configuration of 16 backward inclined, strategically spaced blades. The McQuay designed impeller not only minimizes pressure loss at the inlet and maximizes compression efficiency, but also breaks up pure tone sound to operate at competitively low sound power levels. A simple short diffuser and a volute design passing compressed gas directly into the condenser maintain the compressor efficiency.

The REAL FACTS On Speed-Rpm and Tip Speed In Centrifugal Compressors

The question: "How fast does it spin?" is a common curiosity when discussing compressors. There is a widespread idea promoted by manufacturers of direct-drive compressors that rpm is the determining factor in the life, reliability and efficiency of the compressor. *This is absolutely false*. An engineering examination will show that rpm, as an absolute, is not considered in the design of rotating mechanical components. It is the combination of velocity of the outside edge of the impeller (tip speed), mass, and physical size that define the design criteria for these components. Shaft, bearing, and impeller design is based on parameters such as surface velocity, diameter, weight, rotational and torsional critical speed, as well as the type of material and lubrication system used.

Stress on an impeller is proportional to the square of the *tip speed*. Rotational speed is only part of the equation along with impeller diameter.

In designing a centrifugal compressor, two fundamental parameters, impeller diameter and impeller tip speed, must be determined. Impeller diameter is determined by the required volume flow rate supplied to the inlet of the impeller. Refrigerants which operate at a negative pressure such as HCFC-123 have high cfm/ton (m^3/kW) flow rates and require larger diameter impellers and refrigerant lines to keep pressure drop to reasonable levels. Pressure drop reduces refrigeration capacity and increases input power. Systems with refrigerants, which operate at a positive pressure such as HFC-134a, have smaller impellers and gas lines since these refrigerants require lower gas flow rates. HCFC-123 requires approximately six times the gas flow rate in cfm per ton than HFC-134a. At ARI standard conditions, 18.1 cfm (8.54 l/sec) of HCFC-123 is required per ton of refrigeration. Contrast this to HFC-134a which requires 3.2 cfm (1.5 l/sec) per ton. This means that for a given capacity, the cross-sectional area of the impeller inlet "wheel eye" as well as the suction and discharge lines will be six times larger for HCFC-123 than for HFC-134a at equivalent pressure drops. The wheel eye diameter is the major factor in determining the overall impeller diameter and geometry.

In addition to wheel eye diameter, designers of centrifugal equipment must consider the tip speed requirement. To produce the required pressure difference or "lift", a centrifugal impeller must achieve a given "tip speed." Tip speed is the velocity of the "tip" of the impeller relative to its surroundings. Imagine an observer standing on the impeller. The observer sees his surroundings pass by him at a certain velocity. This velocity is the impeller tip speed, usually expressed in feet per second (meters per second). An analogy may be drawn to a car driving down a road. The tip speed of the tire is equal to the speed of the car.

Since all the refrigerants that have been discussed require tip speeds in the range of 670 to 700 ft/sec (204 to 213 m/sec), we see that the impeller angular velocity (rpm) is largely affected by its diameter. It was pointed out earlier that negative pressure impellers must be larger than those in positive pressure machines due to the drastic differences in required gas flow rates. Larger diameter impellers must rotate at slower rpm than smaller diameter impellers. Referring again to the car example demonstrates that different combinations of diameter and rpm produce the same tip speed. Imagine a freeway carrying vehicles with different size tires all traveling at 55 mph. The tip speed of all of the tires is fixed at 55 mph even though the small tires of a utility trailer rotate at a much higher rpm than the large tires of a tractor-trailer.

The relationship of diameter and tip speed can be shown by the following equation:

$$rpm = \left[TipSpeed(fps)\,x229.2 \right] / Diameter(in.)$$

$$rpm = \left[TipSpeed(m/s)\,x1910 \right] / Diameter(cm.)$$

Again, this indicates that for a given speed requirement, a smaller diameter impeller in a compressor will operate at a higher rpm than a larger diameter impeller. Again:

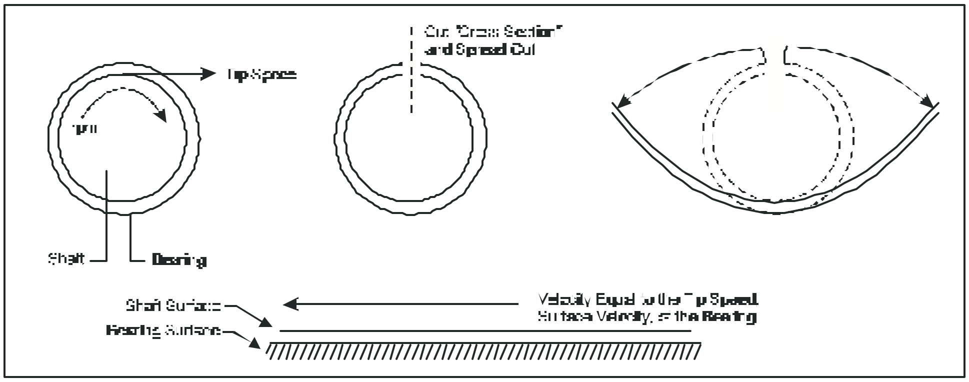
$$\textbf{Stress} \propto \textbf{Tip Speed}^2$$

Impellers with similar *tip speeds* have similar stress.

Since the impeller shaft must be sized to support the static, rotational and torsional loads applied by the impeller, as impellers become larger, shafts must also become proportionally larger. These factors also come into play in the design or selection of a bearing. The primary criteria used in bearing design are:

1. The load per unit of bearing area.
2. The relative velocity of the two bearing surfaces.
3. The bearing dimensions.
4. The viscosity of the lubricating oil.

Notice that item 2 returns to the phenomenon of tip speed. Surface velocity is simply the tip speed of the inner bearing surface or shaft with respect to the outer bearing surface as illustrated below.



A bearing is basically two infinite surfaces passing over one another with a velocity equal to the surface velocity.

Bearing design, and consequently bearing life, is determined largely by the above criteria. Rpm, by itself as an absolute, is only one half of the equation in the design process. One can also see that higher rpm and smaller, lighter parts actually reduce the load and wear on bearings.

It is the surface velocity in conjunction with the load to be supported that determines bearing life and therefore bearing selection. Referring to the analogy of the tractor trailer versus the utility trailer, one sees that even though the utility trailer tires operate at a much higher rpm, the tractor trailer wheel bearings must be much more massive due to the much heavier dynamic loading. Shaft rotating speed has little effect on bearing wear.

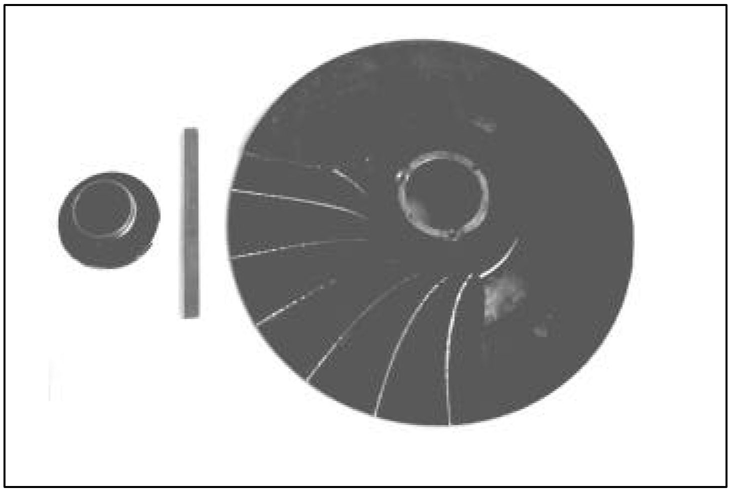
The smaller rotating mass of a machine will improve the life of the bearing. Before the shaft begins to spin, it rests on the bearing surface. Once the shaft starts rotating, an oil film develops between the shaft and the bearing that supports the shaft. The low mass of a positive pressure machine not only exerts a smaller static load on the bearings, but the fast spin-up enabled by the low inertia of the modern gear drive compressor permits the supportive oil film to build up more quickly. These two characteristics drastically reduce wear on the compressor at the time it is most likely to occur. The same phenomenon, although less extreme, also holds true during coast-down. The quicker, the better.

The table at the right compares refrigerants in common use today in centrifugal compressors. Note that required compressor tip speeds are all within eight percent of each other.

Refrigerant	HCFC 123	HFC 134a	HCFC 22
Condenser Press. (psig @ 100°F)	6.10	124.1	195.9
Evaporator Press. (psig @ 40°F) (Inches of Mercury Vacuum)	(18.1)	35.0	68.5
Refrig. Circulated (lbs/min./ton)	3.08	3.00	2.78
Gas Flow (cfm/ton)	18.15	3.17	1.83
Tip Speed (ft./sec.)	656	682	707
Ozone Depletion Potential (ODP)	0.02	0.00	0.05

All McQuay centrifugal chillers use refrigerant HFC-134a. The machine design characteristics of this refrigerant (and its predecessor, R-12) such as small moving parts, low mass, low inertia, quick spin-up and coast-down, and simplicity of design, have continuously proven themselves since the first chiller was introduced in 1962. The small and lightweight rotating parts lend themselves to easy servicing of the compressor and its associated parts and piping.

HFC 134a Impeller Compared to HCFC 123 Impeller



Left: Impeller from a McQuay single stage 300 ton (1050 kW) compressor; diameter = 6.3 in. (16 cm), weight = 3.0 lb (1.4 kg)

Right: One of *three* impellers from a 300 ton HCFC-123 compressor; diameter = 26 in. (66 cm), weight = 27 lb. 12.2 kg)

Compact Design

Small Footprint Cuts Installation Costs

At comparable cooling capacities, HFC-134a requires less than 3.2 cfm (1.5 l/sec) per ton of refrigeration to be circulated by the compressor. HCFC-123 requires over 18.0 cfm (8.5 l/sec) per ton. The substantial increase in refrigerant volume requires significantly larger suction piping and compressor components in negative pressure designs to maintain reasonable gas velocity, noise levels and refrigerant pressure losses. Conversely, the small physical size of McQuay centrifugal chillers will:

- Permit design of smaller equipment rooms.
- Cost less to rig and install.
- And, in smaller capacities, allow transit through standard equipment room doors, permitting building construction to proceed on schedule before receipt of the chiller equipment.
- Lower joint surface area for lower likelihood of leaks.

Bolted Design Eases Retrofit Installation

The major components; evaporator, condenser, and compressor, are bolted together and can be taken apart in the field to facilitate difficult rigging work. The chillers are shipped assembled from the factory and disassembled and reassembled on site under supervision of authorized McQuay service personnel. Individual component weights are shown in the Physical Data section.

Note: The compressor must be removed if the evaporator is to be rigged in a vertical position.

Heat Exchangers

High Performance Shell-and-Tube Flooded Evaporators

McQuay packaged centrifugal chillers are equipped with new high performance heat exchangers. The unique design greatly increases heat transfer and reduces unit footprint and refrigerant charge compared to previous designs. In many cases vessel length has been reduced by 40 percent. Chillers are designed, constructed and tested in accordance with ASME Section VIII, ASHRAE Standard 15 requirements and TEMA recommendations.

The replaceable water tubes are integral internally and externally enhanced copper and are mechanically bonded to steel tube sheets. Standard tubes are 0.025 inch wall copper in the evaporator and 0.028 inch wall copper in the condenser. Optional tubes include 0.028 inch evaporator and 0.035 inch on either vessels and 90/10 cupro-nickel, 304 stainless steel or titanium material. Clad tube sheets and epoxy coated heads are included when other than copper tubes are specified.

Vessels are available for 1, 2 or 3 pass water flow. A 3/4" thick vinyl/nitrate polymer evaporator insulation is standard. All seams are glued to form an effective vapor barrier. The entire chiller barrel including non-connection heads and tube sheets are factory insulated. Detailed information on the insulation can be found under “Physical Data” in this catalog.

Lubrication System

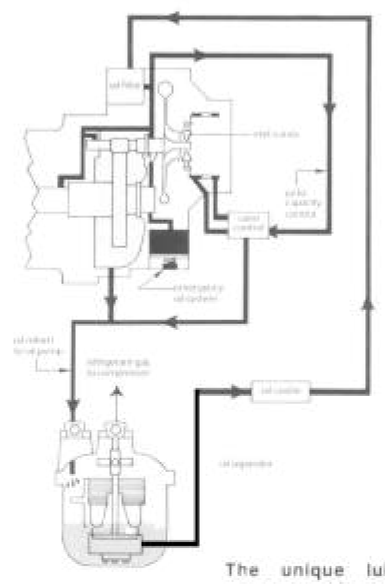
A separately driven electric oil pump assembly supplies lubrication at controlled temperature and pressure to all bearing surfaces and is the source of hydraulic pressure for the capacity control system.

The control system will not allow the compressor to start until oil pressure at the proper temperature is established, and also allows the oil pump to operate after compressor shutdown to assure lubrication during coast down.

Lubricant from the pump is supplied to the compressor through an external brazed-plate heat exchanger and internal single or dual 5 micron oil filter. All bearing surfaces are pressure lubricated. Drive gears are operated in a controlled lubricated mist atmosphere that efficiently cools and lubricates them.

Lubricant is made available under pressure from the compressor oil filter to the unit capacity control system and is used to position the inlet guide vanes in response to changes in leaving chiller water temperature.

Should a power failure occur an emergency oil reservoir guarantees adequate lubrication flow under pressure and prevents damage that could occur during the spin down period with the oil pump stopped.



The unique lubrication system provides forced feed lubrication to all bearing surfaces as well as full coast-down protection.

Since the McQuay chillers are positive pressure there is no need to change lubricant or filter on a regular basis. An annual oil check is recommended to evaluate the lubricant condition.

SurgeGardÒ

Protects The Compressor From Surge Damage

As centrifugal compressors operate at part load, the volume of refrigerant gas entering the impeller is reduced. At the reduced flow, the impeller's capacity to develop the peak load head is also reduced. When inadequate maintenance of condenser tube cleanliness or a cooling tower or control malfunction occurs, artificially elevating the compressor head, a rotating stall or surge condition can occur. Under normal operating conditions, all WSC chillers will operate to 10% capacity without surge and WDC dual compressor chillers to 5% capacity without surge. For abnormal conditions, McQuay compressor designers have developed a protective control system that senses the occurrence of a surge and stops the compressor before any damage is sustained. This protection, called SurgeGard, is provided as a standard on all McQuay centrifugal compressors.

Quiet, stable capacity from 10% to 100% without hot gas bypass

Compressor capacity on McQuay chillers is maximized at full load and modulated to 10% load by interlocked inlet guide vanes and the movable discharge diffuser. This seemingly esoteric and unimportant design detail, like many other McQuay innovations, has real owner benefits. Compressors that do not unload this well, and most don't, waste energy at low load conditions by unnecessary cycling or use of hot gas bypass.

No leakage at the capacity control mechanism

An oil pressure operated guide vane activating piston is internally mounted and powered to eliminate external linkage and seals. The vanes are positioned in response to variation in leaving chiller water temperature. A built-in compensating control allows automatic override of normal operation to close the vanes for low suction pressure or current limiting duty.

Pumpdown

Pumpout systems provide a means to collect and contain the refrigerant charge without loss, when the access to internal chiller components is required for service.

McQuay condensers are sized to hold the entire unit refrigerant charge when not more than 90% full at 90°F (32°C) ambient temperature. They are equipped with a tight-seating check valve at the hot gas inlet and a manual shutoff valve in the liquid outlet. These valves, coupled with the condenser design, satisfy the stringent requirements of the U.S. Department of Transportation for refrigerant shipping containers, as well as ASME vessel codes. When service is required, the refrigerant charge may be pumped down into the condenser by compressor operation and use of a refrigerant transfer unit. All dual compressor units and single compressor units equipped with an optional suction shutoff valve can also be pumped down to the evaporator. **Elimination of the cost and space requirements of an external pumpout system is a major McQuay advantage**.

Thermal Expansion Valves

Controlled refrigerant flow over the entire capacity range saves energy and dollars

Cooling loads and condenser water temperatures change daily. Refrigerant float valves and orifices on competitive chillers are selected for peak load and peak condenser water temperatures and offer only partial control of refrigerant flow at operating conditions experienced over 95% of the time.

On McQuay chillers a pilot operated thermostatic expansion valve meters refrigerant flow in direct response to the suction superheat, regardless of changing load or condensing temperatures. In doing so, full utilization of compressor, evaporator, and condenser efficiency over the entire operating range is achieved. Intermittent refrigerant flood-back and excessive superheat characteristic of orifices and floats are eliminated.

Factory Performance Test

Fast and trouble free startup and operation.

All WSC and WDC chillers are factory tested on ARI certified microprocessor based test stands. The test stand microprocessors interface with the chiller MicroTech controls, allowing monitoring of all aspects of the test stand and chiller operation.

The test procedure starts with dehydration and evacuation of the refrigerant circuit and charging with refrigerant and lubricant. This is followed by a run test at job conditions of flow and temperature. Compressors must meet a stringent 0.14 in/sec vibration limit and the entire unit must pass a moisture limit of 30 ppm. The testing ensures correct operation prior to shipment, and allows factory calibration of chiller operating controls.

Optional Certified Test

A McQuay engineer oversees the testing, certifies the accuracy of the computerized results, and translates the test data onto an easy-to-read spreadsheet. The tests can be run at ARI load points between 10% and 100% and are run to ARI tolerance of capacity and power. 50 Hz units are run tested at 60 Hz to their motor maximum power.

Optional Witness Test

A McQuay engineer oversees the testing in the presence of the customer or their designate and translates the test data onto an easy-to-read spread sheet. The tests can be run at ARI load points between 10% and 100%. It takes two to three hours of test time per load point specified. Tests are run to ARI tolerances of capacity and power. 50 Hz units are run tested at 60 Hz to their motor maximum power.

McQuayService Startup

All McQuay centrifugal chillers are commissioned by McQuayService personnel or by authorized McQuay startup technicians. This procedure assures proper starting and checkout procedures and results in a trouble-free initial startup.

WDC Design Features

WDC Dual Compressor Chiller

One WDC Dual Compressor Chiller = Two Single Compressor Chillers

1^2 is greater than 2 when it means:

Lower equipment costs than 2 separate units

Lower installation cost than 2 separate units

Lower annual operating cost than either 1 large or 2 small units

Less equipment room space required than for 2 separate units

Capacity reduction to 5% of design cooling tons

Standby redundancy for 80% of the cooling season

The Redundancy Feature

The McQuay Dual Centrifugal Chillers *have two of everything* connected to a common evaporator and condenser. Two compressors, two lubrication systems, two control systems, two starters.

Should a failure occur to any component on a compressor system, the component can be removed or repaired without shutting down the other compressor; an automatic back-up with 60 percent of the chiller design capacity available.

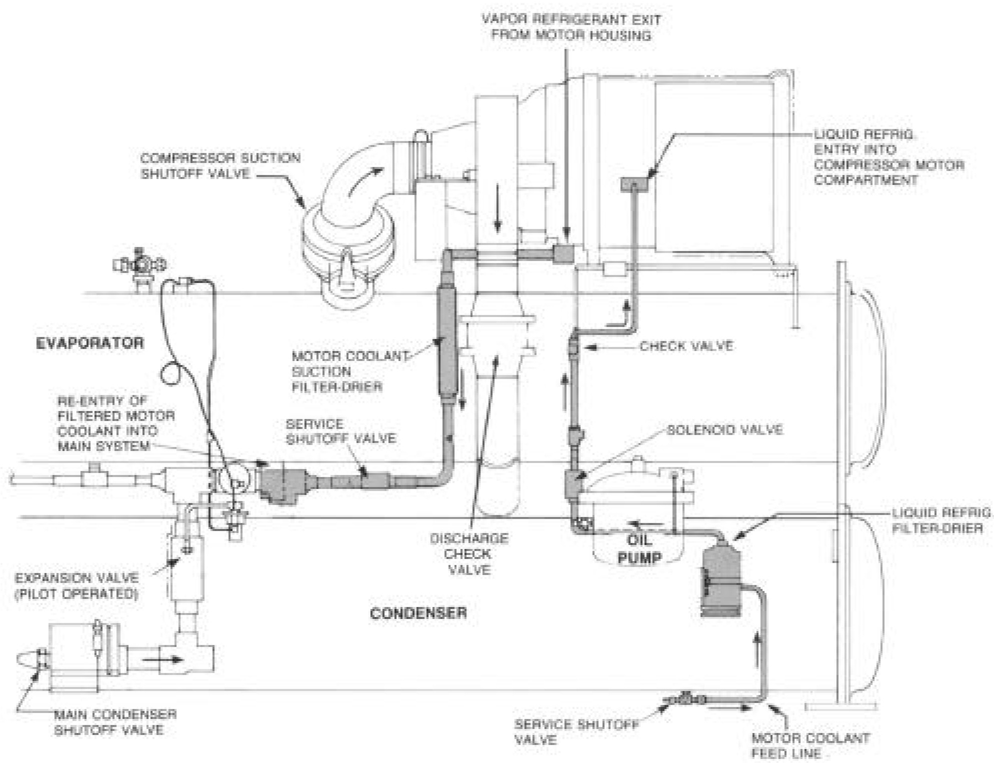
In the unlikely event of a motor burn-out from a lightening strike or any other cause, the chiller refrigerant charge *will not be contaminated.* This is so well proven that it is *guaranteed for five years.* In areas supported by McQuayService, should a motor burnout contaminate the refrigerant in the chiller, the charge will be replaced free for a period of five years from start-up.

Why a Compressor Motor Failure Will Not Contaminate the Common Refrigerant Circuit

The compressor motor is isolated from the main refrigerant flow circuit so that any contaminants generated by a motor fault will not pass into the main refrigerant circuit. Moisture, acid and/or carbon particles would be automatically trapped within the dedicated coolant feed and exit lines.

Internally, the compressor motor compartment is separated and sealed from the main refrigerant compression chamber. A double shaft seal on the motor side of the gear housing prevents cross flow of refrigerant within the compressor. The motor coolant feed line is equipped with both a solenoid valve and a check valve. These mechanical components, plus the higher pressure of the liquid refrigerant, prevent backfeed into the main refrigerant system. Refrigerant vapor exiting the motor compartment must pass through an undersized combination filter-drier. The filter-drier is sized to immediately plug up and seal off the motor compartment in case of a motor burnout. Both the coolant feed and return lines are equipped with manual shutoff valves to permit component service.

Over 30 years of field experience have proven the reliability of these compressor motors. Despite the reliability intended by the motor design and the protective control, electrical distribution system faults and lightning strikes may occur that are beyond the control of the most conscientious designer. The motor coolant's protective system protects the system. A motor failure will not contaminate the common refrigerant circuit or prevent normal operation of the second compressor.



Part Load Efficiency

Chillers usually spend 99% of their operating hours under part load conditions, and as illustrated on page 4, most of this time at less that 60% of design capacity. One compressor of a dual chiller operates with the full heat transfer surface of the entire unit, for example, one 500 ton (1,750 kW) compressor on a 1,000 ton (3,500 kW) chiller utilizes 1,000 tons (3500 kW) of evaporator and condenser surface. This increases its capacity and also results in very high efficiency.

Typical efficiencies for a dual compressor chiller, taken from a computer run, look like this:

- Full load efficiency 0.550 kW per ton (6.5 COP)
- 60% load, one compressor 0.364 kW per ton (9.6 COP)
- IPLV 0.415 kW per ton (8.5COP)

Lower Installed Costs

The redundancy feature pays off in lower installed costs

An example of how to incorporate dual compressor chillers into a system requiring redundancy:

Job requirement: 1,200 tons (4200 kW), 50% Backup

Obsolete Single Compressor Method	Dual Compressor Method
(2) 600 ton (2100 kW) On Line Units	(2) 750 ton (2100 kW) Units with
+ (1) 600 (2100 kW) ton Standby Unit	________ 1,200 (4200 kW) Standby tons *
(3) @ 1,800 ton (6300 kW)Installed Capacity	(2) @ 1500 ton (5250 kW)Installed Capacity

***** One 750 ton (2100 kW) chiller running on two compressors for 750 tons (2100 kW), plus one 750 ton (2100 kW) chiller running on one compressor for 60% of 750 tons (2100 kW) = 450 tons (1575 kW) for a total of 1200 tons (4200 kW) on 3 of 4 compressors.

The elimination of the extra pumps, valves, piping, controls, rigging, and floor space can result in as much as a 35% reduction in the installation cost for a chiller plant, plus the savings on the chillers themselves.

Bolt Together Construction

The Replacement Market Advantage

- Put 20% or more tons in the same footprint
- Add dual compressor redundancy
- Greatly reduce chiller energy consumption
- Install an unregulated refrigerant
- Opens many options for multiple chiller plants

WDC Chiller Controls

Each model WDC dual compressor chiller comes complete with two compressor-dedicated factory mounted and wired MicroTech control panels. Individual control panels allow the monitoring of each compressor independently from the other. Elapsed time, number of starts, percent RLA ; are all monitored separately by each MicroTech control panel. Also individual compressor fault history, setpoint control, loading functions, time of day starts, etc., can be controlled and monitored.

The lead-lag/load balance function is a standard feature of each MicroTech panel and, therefore, of the WDC chiller. Smart scheduling by the lead-lag/load balance function assigns the compressor with the fewest starts as lead, and will only start the lag compressor when proof of sufficient load has been established. The lead-lag function will stop the compressor with the most hours when the load decreases to single compressor range. During two compressor operation, the load balance function will equalize the load between each compressor, providing optimum unit efficiency.

25% or greater annual kWh savings over the range of 5% to 60% design tons

The majority of comfort cooling systems operate at 60% or less of building design tons for most of the year. A great number of those operating hours occur between 50% and 60% design cooling capacity.

For that reason, the Model WDC chiller was designed to produce up to 60% unit capacity with a single operating compressor, efficiently and reliably.

That performance is achieved by a combination of individual component features that include compressor design, operating control, double heat transfer surface, refrigerant and refrigerant flow control.

Control Features

All McQuay Chillers Feature MicroTech Controls

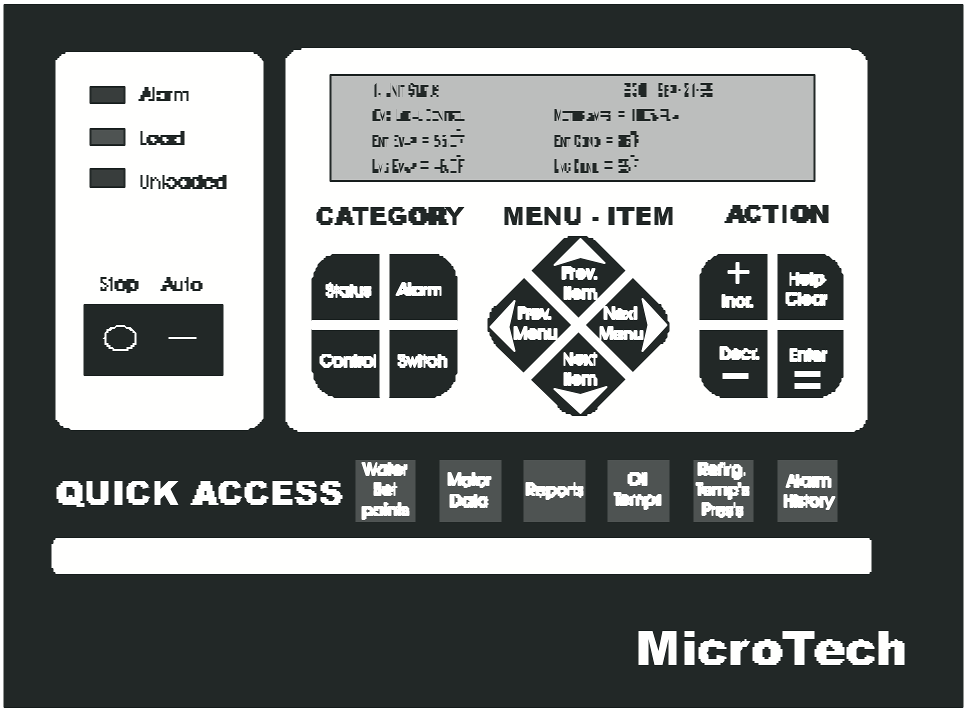
McQuay has incorporated the latest microprocessor technology into the MicroTech control system to give you the ultimate in centrifugal chiller control. The control includes many energy-saving features not found in any other microprocessor system on the market today. MicroTech's innovative design will keep your chiller running efficiently. . . day in, day out, for years to come.

FEATURE	BENEFIT
Easy integration into Building Management System via OPEN PROTOCOL.	Designer open to select any BMS supplier and MicroTech will interface with it.
Remote PC monitoring available via direct connection or modem	Provides central remote control and monitoring of any MicroTech panel
Easy to read 4 line by 40 character backlit display in plain English (metric)	Operators can observe operation at a glance and easily select various menus
Precise $\pm$ 0.2 °F chilled water control	Provides stability in chilled water system
Proactive pre-alarm correction of "off-condition" upset-chiller stays online	Activates alarm and modifies chiller operation to provide maximum cooling
Automatic control of chilled water and condenser water pumps	Integrated lead/lag and automatic engagement of backup pump
Controls up to four stages of tower fans and modulation of tower fan or bypass valve	Optimum integrated control of cooling tower water based on system conditions
Internal 7-day,14-holiday clock with programmable duration	Enables unattended starting and stopping of entire chiller plant
Eight previous alarms and attendant operating conditions in memory	Invaluable assist in trouble shooting

Designed with the system operator in mind

Reliable, economic use of centrifugal chillers depends on easy operator interface. That's why operation simplicity was one of the main considerations in the development of MicroTech. For example, all the system's status messages are shown in plain English on a 4-line by 40-character liquid crystal display (LCD). The display is backlit for easy viewing in all light conditions. Metric units are available at no extra cost.

In addition to the display, 18 individual, touch sensitive membrane key switches provide easy access to data. MicroTech's keypad is separated into four distinct functional areas; Category, Menu Item, Action, and Quick Access.



By constantly monitoring chiller status, MicroTech will automatically take proactive measures to relieve abnormal conditions or shut the unit down should a fault occur. For example, should a problem occur in the cooling tower and discharge pressure start to rise, MicroTech will automatically hold the load point and activate an alarm signal. A further rise in pressure will initiate compressor unloading to maintain the setpoint pressure. Should the pressure continue to rise, the unit will shut off at the cutout pressure setting.

MicroTech's memory retains a snapshot of any fault, all the operating conditions at the time of the shutdown, and the time/date stamp. The MicroTech memory (no batteries required) can retain and display the cause of the current fault and the last eight fault conditions. This method for retaining the fault, *and* operating conditions at the time of the fault, is extremely useful for trouble shooting and maintaining an accurate record of unit performance and history.

To complete the local interface, MicroTech features a two level password security system to provide protection against unauthorized use.

MicroTech increases chiller operating economy

Many standard features have been incorporated into MicroTech in order to improve the operating economy of McQuay centrifugal chillers. In addition to replacing normal relay logic circuits, we've enhanced MicroTech's energy saving capabilities with the following features:

- Direct control of water pumps. Optically isolated digital output relays provide automatic lead-lag of the evaporator and condenser pumps, permitting pump operation only when required.
- User-programmable compressor soft loading. Prevents excessive power draw during pull down from high chilled water temperature conditions.
- Chilled water reset. Can be accomplished directly on the unit by controlling from return water temperature or from a remote 4-20ma or 1-5 VDC EMS signal.
- Demand limit control. Maximum motor current draw can be set on the panel or can be adjusted from a remote 4-20ma or 1-5 VDC EMS signal. This feature controls maximum demand charges during high usage periods.

- Condenser water temperature control. Capable of four stages of tower fan control plus an optional analog control of either a three-way tower bypass valve or variable speed tower fan motor. Stages are controlled from condenser water temperature. The three way valve can be controlled to a different water temperature or track the current tower stage. This allows optimum system performance based upon specific job requirements.
- Lead-lag and load balance. The standard MicroTech is capable of compressor lead-lag decisions and balancing compressor loads between two McQuay compressors, whether on separate chillers or mounted on a WDC Dual Compressor unit. This feature assures optimum efficiency under any load condition.
- Auto-logging. This feature takes a snapshot of the operating conditions at the peak conditions each week and retains this data in memory.

Nonvolatile Memory

Since MicroTech's memory is nonvolatile, battery backup to protect the programs and settings in case of power loss is unnecessary.

Versatile Communications Capabilities Give You Even More Control

For complete flexibility there are four ways to interface with the MicroTech controller:

1. Direct entry and readout locally at the panel on the unit
2. (1) plus digital and analog input/output signals for certain functions such as:
    - Enable run input
    - Alarm signal output
    - 4-20ma or 0-5 VDC input for reset and load limiting
    - Pump and tower fan control.
    - Analog output for variable speed fan or tower bypass
3. Remote monitoring by PC-hard wired or via modem-local control still in effect
4. Interfaced with Building Management System, open protocol, with full read and write capability

PC Communications

Not only can you operate MicroTech from the keypad/display or via interconnection to the BMS, but an optional software package lets you control it from any IBM MS/DOS compatible personal computer. Communicating with the MicroTech is accomplished using a single twisted pair RS-232 or RS-422/485 communications protocol. Operators can monitor chiller information remotely on a personal computer. By adding an optional modem interface, all chiller operations can be controlled from a remote location through standard telephone lines. The modem communication can be added to the unit control at any time.

MicroTech can also handle multiple unit installations with the optional Chiller System Control (CSC) panel. This feature allows communications with the individual unit controllers to permit sophisticated sequencing control strategies. In addition, the System Controller can control and access all information available at the unit controllers. The end result is optimum operating efficiency.

Building Management Systems

All MicroTech unit controllers and system controllers are capable of Open Protocol communications providing seamless integration and comprehensive monitoring, control and two-way data exchange with virtually all Building Management Systems.

Here are just a few of the 220 points on a WDC chiller that are available remotely through one simple, low cost twisted-pair interface.

Operating Parameters	Safety/Cycling Conditions
Entering/leaving water temperatures	High and low refrigerant pressures
Refrigerant temperatures and pressures	Oil pressure differential
Motor amps as a percent of FLA	Motor condition from embedded sensors
Hours of operation and number of starts	System water pump failures
Chilled water and demand limit setpoints	High discharge temperatures
Cause and conditions for last eight shutdowns	Starter fault

Multiple Machine Control

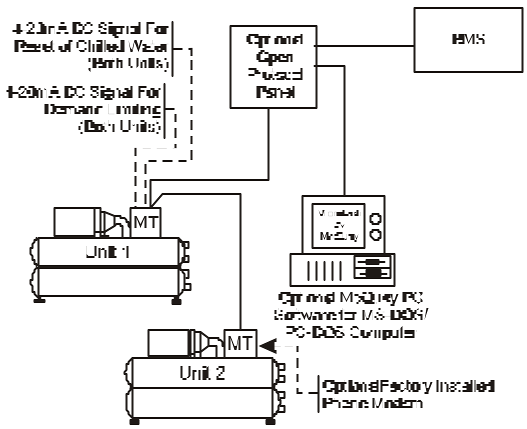
Two WSC Units or One WDC Dual Compressor Unit

The lead-lag/load balance function is a *standard feature* of each MicroTech panel. It provides sequencing control, load balancing and single point control for BMS interface for reset or demand limiting of either compressor.

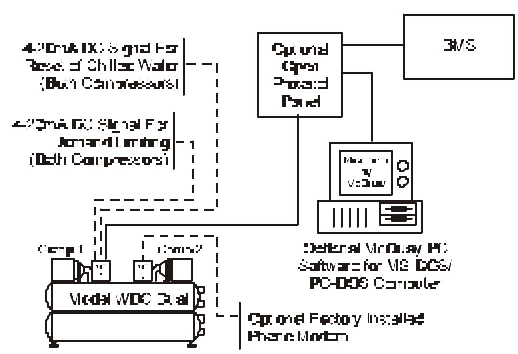
Lead-lag can be selected as manual or automatic. In automatic, the compressor with the least starts will start first and the compressor with the most hours will stop first.

Load balance equalizes the load between the two compressors providing optimum efficiency and preventing short cycling of the lag compressor.

Two-Unit Model WSC Control



Dual Compressor Model WDC



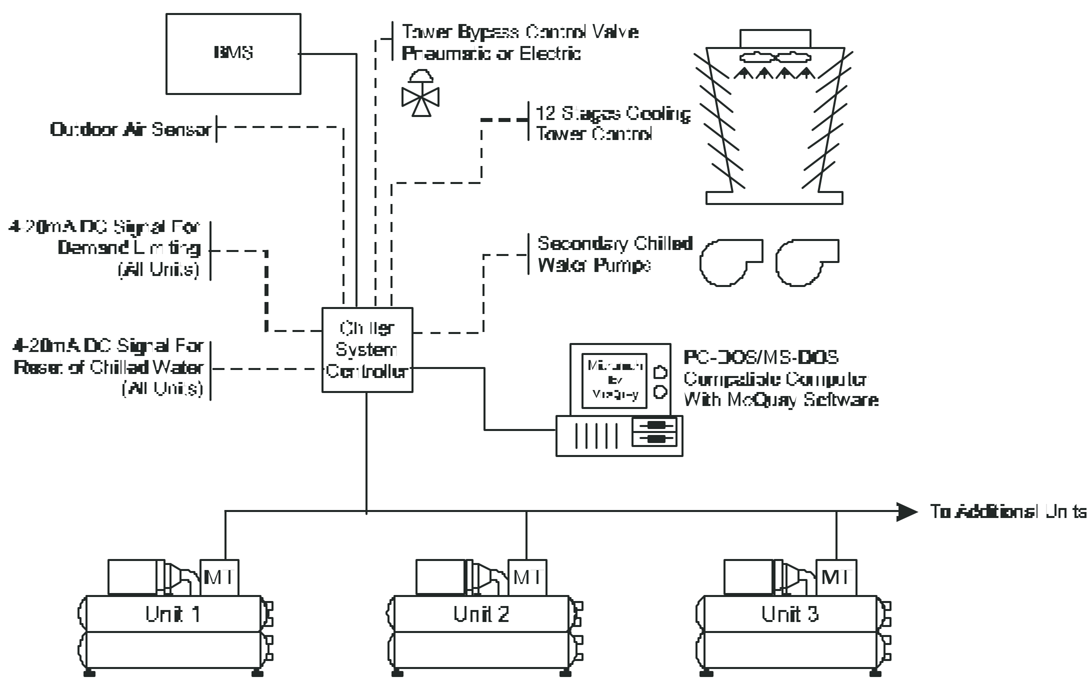
Three or More Units

In the past, it has been difficult to control multiple machines for optimum operating economy and comfort. MicroTech Chiller System Controllers (CSC) allow coordinated control of multiple machines, from load balancing and sequencing, to control of the cooling tower and water pumps. All this is accomplished via twisted pair communications between the Chiller System Control panel and the chillers, and via standard control wiring between the chillers and auxiliary control points.

The optional Chiller System Controller is a separate panel that controls up to12 MicroTech panels, optimizing the entire central plant operation. All CSC panels have the following features:

- Multiple compressor programmable sequencing.
- 12 stages of tower control.
- Pneumatic or electric control of a three-way tower bypass valve.
- Secondary pump control including lead-lag and sequencing.
- Single point BMS interface for reset and demand limiting of all machines.
- Expanded time clock for multiple machine control.
- Temperature monitoring of primary and secondary chilled water loop, outside air temperature and tower water supply and return temperature.
- Central on/off control point for all machines.
- Optimized morning start-up to insure full cooling at a specified time.

Multiple Machine Control



Condenser water pump control relay

Water flow through the condenser should be discontinued when the chiller is inoperative. Continuous flow through a cooling tower, without inclusion of building heat in the water, will overcool condenser water if tower bypass is not employed and will unnecessarily depress the chiller's refrigerant pressure. Where energy conservation is desirable, cessation of condenser water flow when the chiller is not operating provides a practical, inexpensive method of saving power.

Alarm circuit

Terminals are provided in each unit control panel to supply 24 volt AC power to an external alarm circuit. A 25 VA relay coil may be connected to these terminals. The coil will be deenergized when any of the unit's or system's protective controls function. The alarm is not included.

Operating Sequence

With the control panel "Stop-Auto" switch in the "Auto" position, the unit will start, provided that:

1. The chilled water sensor is calling for cooling.
2. No time delay is restraining operation.
3. A remote start-stop switch is not open, preventing unit operation.
4. No safety switch has been tripped and not reset.
5. Compressor is unloaded and lubricant temperature and pressure are within prescribed limits.

The statement "Waiting to load", and the countdown period in seconds assigned to it, assumes that the water temperature sensed by the chilled water temperature sensor may not represent the entire chilled water system temperature if the chilled water pump has been shut off. This delay interval provides time for the chilled water pump to circulate system water and impart a valid system water temperature to the chilled water sensor.

Temperature control operation

Temperature sensors are negative coefficient thermistors selected for extended accuracy and close control. During compressor operation from 10% to 100% capacity, chilled water temperature will be held to within ±0.2 degrees F (0.12 degrees C). As building cooling load is decreased, the compressor inlet vanes will close as required to match building load down to 10% of full capacity. A further decrease in the cooling load will lower the leaving chilled water temperature. The control system will permit a total of 3 to 10 degrees F (1.6 to 5.5 degrees C) (user adjustable) overcooling of the chilled water, preventing rapid restarting and/or elevation of the chilled water temperature above the setpoint. When the chilled water temperature is depressed to the shutoff differential setpoint, the compressor motor is de-energized. The oil pump motor continues to run during the compressor coast-down period and is timed off automatically.

If there is still some load on the chilled water, its temperature will rise until it reaches the cycle-on temperature setting. At this point the compressor will initiate its start cycle and commence operation.

Sound

Sound Levels -- One Of The Quietest Centrifugal Chillers In The Industry

McQuay centrifugal chillers are one of the quietest units available in the marketplace. It is easy to make this type of claim!! For us, it is just as easy to support!!

Unique!! --- Quiet full load sound levels and QUIETER part load sound levels.

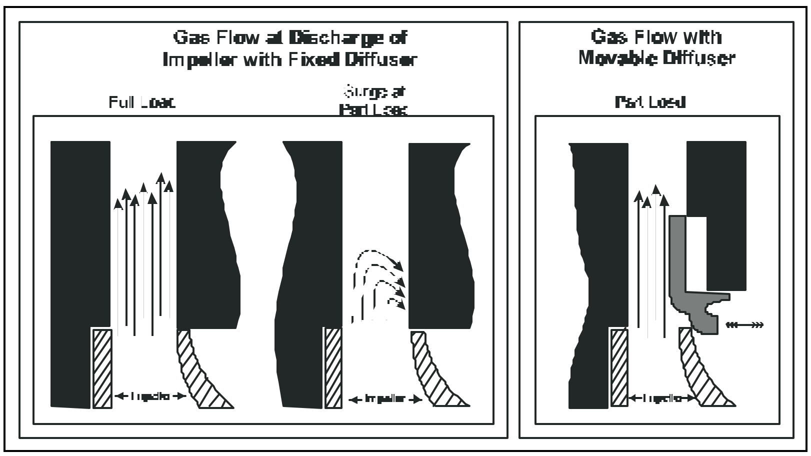
The highest noise levels for McQuay chillers are at FULL load. As McQuay chillers unload, noise levels reduce. Other chillers on the market are typically the opposite, with higher sound levels at part load. Be certain to compare noise levels at several load conditions.

Unique!! --- Liquid refrigerant injection into compressor discharge

Although this sounds complex, this feature is quite simple. Most of the noise in all centrifugal compressors results from high gas velocity in the discharge line.

The McQuay liquid injection system injects liquid refrigerant into the discharge gas through a radial array of ports. This refrigerant mist absorbs sound energy (much like a foggy day) and the flash gas cools the discharge gas leaving the compressor. The net result is significant noise reduction.

ADDITIONALLY !! By removing superheat from the discharge gas, the condenser becomes more efficient, improving unit efficiency.



Unique!! --- Moveable Discharge Diffuser
The other unique feature to reduce noise and increase stability at low loads is the unique moveable discharge diffuser. Less refrigerant is circulated as the chiller capacity reduces. The left drawing shows the operation at full load of a unit with a fixed compressor discharge section. At full load, a large quantity of gas is discharged with a fairly uniform discharge velocity as indicated by the arrows.

The middle drawing shows a fixed compressor discharge at low capacity. Note that the velocity is not uniform and the refrigerant tends to reenter the impeller. This is caused by low velocity in the discharge area and the high pressure in the condenser, resulting in unstable surge operation and with noise and vibration generated.

The right side drawing shows the unique McQuay moveable discharge diffuser. As the capacity reduces, the moveable diffuser travels inward, maintaining the refrigerant velocity, and allowing reduction to 10% load.

Discharge Line Sound Packages

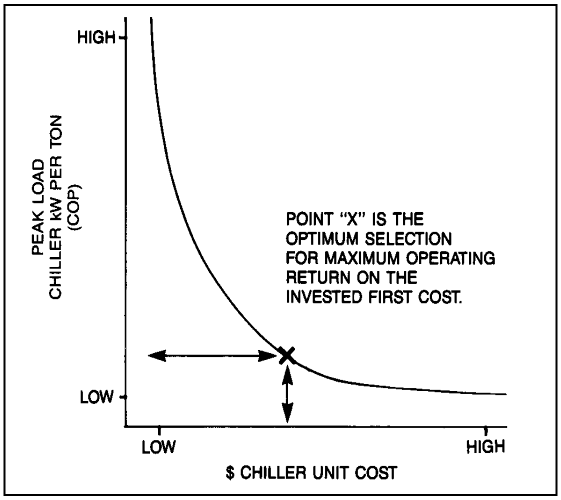
For the extremely sensitive projects, an optional discharge line sound package is offered consisting of sound insulation installed on the unit's discharge line. An additional 2 to 4 dbA reductions normally occurs.

ARI Standard 575 Sound Ratings

Sound data in accordance with ARI 575 for individual units are available from your local McQuay representative. These ratings are in accordance with ARI Standard 575. Due to the large number of component combinations and variety of applications, sound data is not published in this catalog.

Unit Selection

Many combinations of compressor configuration and condensers and evaporators are available for a given capacity. The units range from low first cost and relatively high kW per ton (COP) to high first cost and low kW per ton (COP). A graphic display of the optional performance available is shown at the right. The COP curve would be mirrored and is not shown for clarity. Optimum unit selection for maximum operating return on the invested first cost is identified as point X.



Actual optimum unit selection will vary with building application and system design. Applications with minimal hours of operation may not justify a very low kW per ton (COP) unit. Applications with high hours of operation will justify high part load as well as full load efficiency units. For optimum selection an energy analysis is recommended through your local McQuay Sales Representative.

Basic unit selections

All McQuay centrifugal chillers are computer selected to optimize the cooling output and total kW. Computer selection allows for the specification of leaving chilled water temperature, entering condenser water temperature, evaporator and condenser flow rates, number of passes, and fouling factors. Glycol applications may also be specified.

Glycol operation

The addition of glycol to the chilled water system for freeze protection may be required for special applications. Glycol solutions are required where the evaporating temperatures are below 33°F (1°C).

ARI Certification

McQuay International has an on-going commitment to supply chillers that perform as specified. To this extent, McQuay centrifugal chillers are part of the ARI Certification. On-going performance verification of chiller capacity and power input plus ARI certified computerized selection output assure the owner of specified performance in accordance with ARI Standard 550/590.

All chillers that fall within the scope of the certification program have an ARI certification label at no cost to the owner. Equipment covered by the ARI certification program include all water-cooled centrifugal and screw water chilling packages rated up to 2000 tons at ARI standard rating conditions, hermetic or open drive, 60 Hz, with electric driven motor below 5000 volts, cooling water (not glycol).

Published certified ratings verified through testing by ARI include:

- Capacity, tons (kW)
- Power, kW/ton (COP)
- Pressure drops, ft. of water (kPa)
- Integrated Part Load Value (IPLV) or Non-Standard Part Load Value (NPLV)

As part of the ARI certification program, ARI has approved the McQuay computer selection program used to select and rate chillers. The certified computer program version number and issue date for all manufacturers is listed in the ARI Directory of Certified Applied Air-Conditioning Products published biannually.

ARI Standard 550/590-98 for Centrifugal or Screw Water -Chilling Packages and associated manuals define certification and testing procedures and tolerances of all units that fall within the application rating conditions.

Leaving chilled water temperature ....40°F to 48°F

Entering condenser water temperature ....60°F to 95°F

Rating outside the range of the certification program may be listed or published but must include a statement describing such. The standard rating conditions are:

Leaving chilled water temperature ....44°F

Evaporator waterside field fouling allowance........................0.0001

Chilled water flow rate ....2.4 gpm/ton

Entering condenser water temperature ....85°F

Condenser waterside field fouling allowance 0.00025

Condenser water flow rate ....3.0 gpm/ton

IPLV/NPLV Defined

Part load performance can be presented in terms of Integrated Part Load Value (IPLV), which is based on ARI standard rating conditions (listed above), or Non-Standard Part Load Values (NPLV), which is based on specified or job site conditions. IPLV and NPLV are based on the following equation from ARI 550/590.

$$IPLV \text{ or } NPLV = \frac{1}{\frac{0.01}{A} + \frac{0.42}{B} + \frac{0.45}{C} + \frac{0.12}{D}} \quad \textbf{or} \quad 0.01A + 0.42B + 0.45C + 0.12D$$

Where: A = kW/ton at 100%

B = kW/ton at 75%

C = kW/ton at 50%

D = kW/ton at 25%

Where: A = COP at 100%

B = COP at 75%

C = COP at 50%

D = COP at 25%

Tolerances

The ARI test tolerance, per ARI Standard 550/590-98, for capacity (tons), power input per ton (kW/ton), and heat balance is:

$$\%Tolerance = 10.5 - (0.07x\%FL) + \left(\frac{1500}{DTFLx\%FL}\right)$$

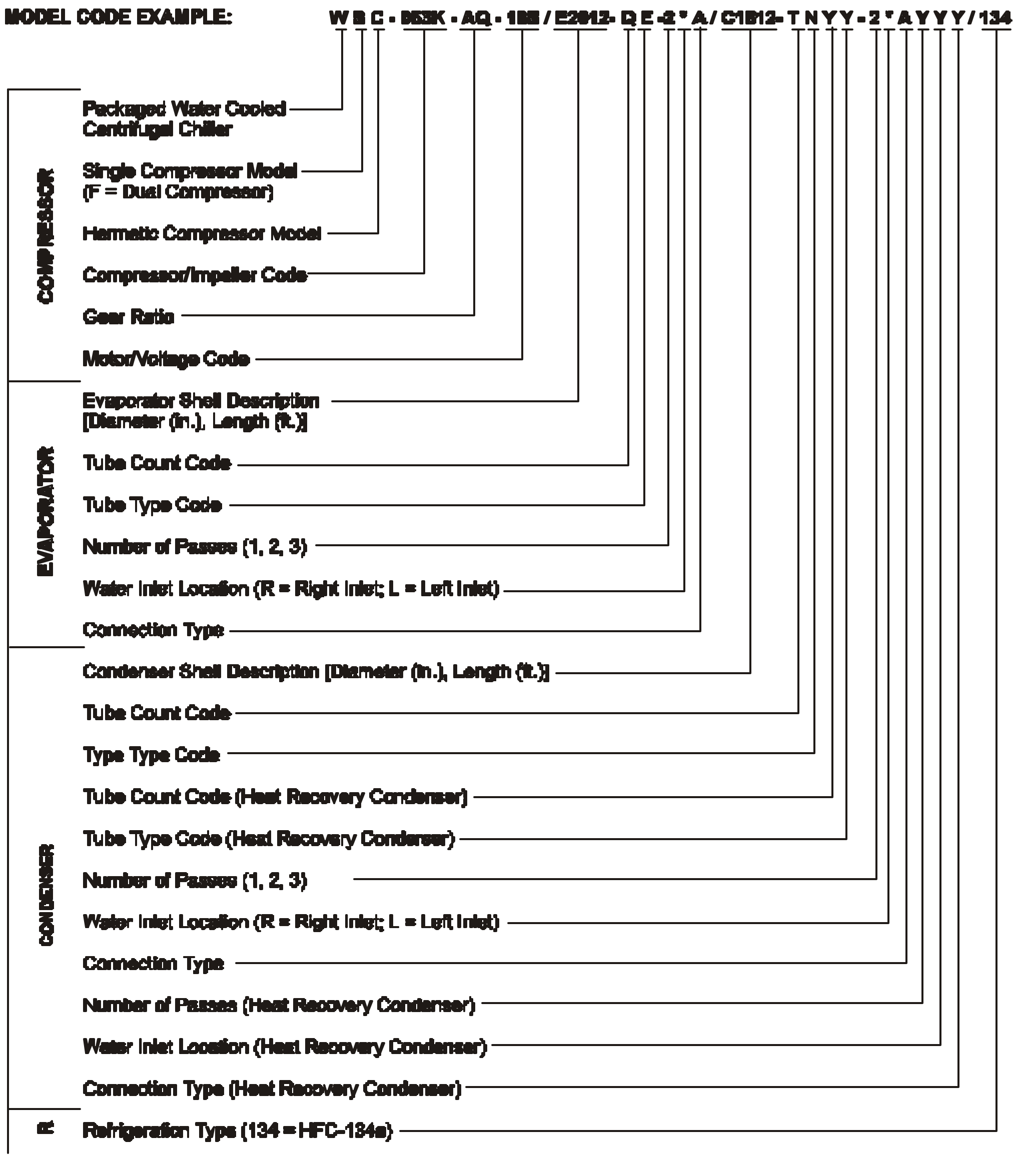
Where: FL = Full Load

DTFL = Chilled Water Delta-T at Full Load

Chiller Identification

To provide a wide range of components to match job requirements of capacity, efficiency and competitive initial cost, McQuay WSC and WDC centrifugal chillers are selected by computer and identified by their components.

The variations of compressor, impeller, gear ratio, evaporator and condenser tube surface and configuration provide over 1,000,000 combinations of standard components within the range of 70 to 2,500 tons. It is impractical to catalog all of these combinations. Therefore, computer selection for specific application conditions is required. The complete unit model code is then established as follows:



Physical Data and Weights

Condenser

With positive pressure systems, the pressure variance with temperature is always predictable, and the vessel design and relief protection are based upon pure refrigerant characteristics. HCFC-123 systems are not ASME designed, inspected and stamped. HFC-134a requires ASME vessel design, inspection and testing and uses spring-loaded pressure relief valves. Negative pressure units use rupture disks. When an over pressure condition occurs the rupture disk is permanently destroyed. Spring-loaded relief valves purge only that refrigerant required to reduce system pressure to a safe level and then close.

Refrigerant side design pressure is 200 psi (1380 kPa), water side design is 150 psi (1034 kPa).

Pumpdown

To facilitate non-routine compressor service, all McQuay centrifugal chillers are designed to permit pumpdown and isolation of the entire refrigerant charge in the unit's condenser. Dual compressor units and single compressor units equipped with the optional suction shutoff valve can also be pumped down into the evaporator. **No separate pumpout receiver is required.**

Condenser Physical Data

Condenser Code	WSC	WDC	Pumpdown Capacity lb (kg)	Water Capacity gal (L)	Vessel Weight lb (kg)
C1609	X		468 (213)	33 (125)	1645 (746)
C1612	X		677 (307)	33 (123)	1753 (795)
C1612		X	631 (286)	40 (152)	1897 (860)
C1809	X		597 (271)	43 (162)	1887 (856)
C1812	X		845 (384)	44 (166)	2050 (930)
C1812		X	806 (366)	52 (196)	2201 (998)
C1816		X	1081 (490)	66 (250)	2726 (1236)
C2009	X		728 (330)	47 (147)	1896 (860)
C2012	X		971 (440)	62 (236)	2528 (1147)
C2209	X		822 (372)	73 (278)	2596 (1169)
C2212	X		1183 (537)	76 (290)	2838 (1287)
C2212		X	1110 (504)	89 (337)	3075 (1395)
C2216		X	1489 (676)	114 (430)	3861 (1751)
C2416		X	1760 (799)	143 (540)	4647 (2188)
C2609	X		1242 (563)	83 (314)	2737 (1245)
C2612	X		1656 (751)	111 (419)	3650 (1660)
C2616		X	2083 (945)	159 (603)	5346 (2425)
C3009	X		1611 (731)	108 (409)	3775 (2537)
C3012	X		2148 (975)	144 (545)	5033 (3383)
C3016		X	2789 (1265)	207 (782)	6752 (3063)
C3612	X		2963 (1344)	234 (884)	7095 (3219)
C3616		X	3703 (1725)	331 (1251)	9575 (4343)
C4212	X		3796 (1722)	344 (1302)	9984 (4529)
C4216		X	5010 (2273)	475 (1797)	12662 (5743)
C4220		X	5499 (2494)	634 (2401)	17164 (7785)
C4224		X	6630 (3007)	745 (2821)	20225 (9174)
C4812	X		4912 (2228)	488 (1848)	12843 (5826)
C4816		X	5581 (2532)	717 (2715)	18807 (8530)
C4820		X	7034 (3191)	862 (3265)	23106 (10481)
C4824		X	8488 (3850)	1008 (3814)	27239 (12355)

Notes:
1. Condenser pumpdown capacity based on 90% full at 90°F.
2. Water capacity based on standard configuration and standard heads and may be less with lower tube counts.

Evaporator

The insulation of cold surfaces includes the evaporator and *non-connection* water head, suction piping, compressor inlet, motor housing, and motor coolant suction line.

The insulation used is UL recognized (Card No. E61978). It is 3/4" thick vinyl nitrate polymer having a K factor of 0.28 at 75°F. The sheet insulation is fitted and cemented in place forming a vapor barrier, then painted with a resilient epoxy finish that resists cracking.

The insulation complies to appropriate requirements or has been tested in accordance with the following:

HH-I-573 (GSA-FSS)	ASTM-D-1149	ASTM-C-177
ASTM-C-534	ASTM-D-1056	UL 94-5V
ASTM-C-355		

Refrigerant side design pressure is 200 psi (1380 kPa), water side is 150 psi (1034 kPa).

In the event insulation is to be field installed, none of the cold surfaces identified above will be factory insulated. Approximate total square footage of insulation surface required for individual packaged chillers is tabulated by evaporator code and may be found below.

Evaporator Physical Data

Evaporator Code	WSC	WDC	Refrigerant Charge lb (kg)	Evaporator Water Capacity, gal (L)	Insulation Area Sq Ft (m^2)	Vessel Weight lb (kg)
E1809	X		434 (197)	37 (138)	75 (7.0)	2734 (1239)
E1812	X		347 (158)	27 (103)	78 (7.2)	2370 (1075)
E1812		X	578 (262)	44 (165)	85 (7.9)	2920 (1323)
E1816		X	771 (349)	59 (220)	113 (10.5)	3893 (1764)
E2009	X		561 (254)	34 (164)	82 (7.6)	3026 (1371)
E2012	X		420 (190)	37 9139)	84 (7.8)	2713 (1231)
E2012		X	585 (265)	51 (193)	84 (7.8)	3245 (1471)
E2209	X		729 (331)	54 (206)	66 (6.1)	3285 (1488)
E2212	X		500 (227)	45 (170)	90 (8.3)	2877 (1305)
E2212		X	645 (291)	63 (240)	90 (8.3)	3550 (1609)
E2216		X	1312 (595)	79 (301)	144 (13.4)	4200 (1903)
E2412		X	1005 (456)	88 (335)	131 (12.1)	4410 (1999)
E2416		X	1424 (646)	110 (415)	157 (14.6)	5170 (2343)
E2609	X		531 (249)	54 (295)	76 (7.1)	2730 (1238)
E2612	X		708 (321)	72 (273)	102 (9.4)	3640 (1651)
E2612		X	925 (418)	101 (381)	102 (9.4)	4745 (2150)
E2616		X	1542 (700)	126 (478)	162 (15.0)	5645 (2558)
E3009	X		676 (307)	67 (252)	86 (8.0)	3582 (1625)
E3012	X		901 (409)	89 (336)	115 (10.6)	4776 (2166)
E3016		X	2117 (960)	157 (594)	207 (19.2)	7085 (3211)
E3609	X		988 (720)	118 (445)	155 14.4)	5314 (2408)
E3612	X		1317 (597)	152 (574)	129 (11.9)	6427 (2915)
E3616		X	3320 (1506)	243 (918)	239 (22.2)	9600 (4351)
E4212	X		1757 (797)	222 (841)	148 (13.7)	8679 (3937)
E4216		X	4422 (2006)	347 (1313)	264 (24.5)	12215 (5536)
E4220		X	4713 (2138)	481 (1819)	330 (30.6)	15045 (6819)
E4224		X	5656 (2565)	561 (2123)	396 (36.7)	17880 (8103)
E4812	X		2278 (1033)	327 (1237)	169 (15.6)	10943 (4964)
E4816		X	4690 (2128)	556 (2106)	302 (281)	16377 (7429)
E4820		X	5886 (2670)	661 (2503)	377 (35.0)	17190 (7791)
E4824		X	7063 (3204)	766 (2900)	452 (41.9)	20430 (9259)

Notes:

1. Refrigerant charge is approximate since the actual charge will depend on other variables. It will be shown on the unit name tag.
2. Water capacity is based on standard tube configuration and standard heads.
3. The evaporator charge includes the maximum condenser charge available with that evaporator and is therefore the maximum charge for a unit with the evaporator. Actual charge for a specific selection can vary with tube count and can be obtained from MS-85 Selection Program. The program will not allow a selection where the unit charge exceeds the condenser pumpdown capacity.

Compressor

Compressor Weights

Compressor Size ⇒	050	063	079	087	100	126
Weight lb (kg) ⇒	870 (390)	3200 (1440)	3200 (1440)	3200 (1440)	6000 (2700)	6000 (2700)

Relief Valves

Vessel Relief Valves

Evaporator Code	Relief Valve	
	Connection	Number
E1608 Thru E2616	1" FPT	1
E3016 Thru E4216	1" FPT	1
E4816 Thru E4824	1" FPT	2
Condenser Code		
C1608 thru C3016	1" FPT	2
C3616 Thru C4216	1" FPT	2
C4816 Thru C4824	1" FPT	4

Relief valve connection sizes and quantity are shown to the right. Relief valves must be piped to the outside of the building in accordance with ANSI/ASHRAE 15. Twin relief valves mounted on a transfer valve are used on the condenser so that one relief valve can be shut off and removed leaving the other in operation. Where 4 valves are shown, they consist of two valves mounted on two transfer valves. Only two relief valves of the four are active at any time.

Vent piping is sized for only one valve of the set since only one can be in operation at a time. In no case would a combination of evaporator and condenser sizes require more refrigerant than the pumpdown capacity of the condenser. Condenser pumpdown capacities are based upon ANSI/ASHRAE Standard 15-1992 recommendations of 90% full at 90°F (32°C). To convert values to the older ARI standard, multiply pumpdown capacity by 0.888.

Relief Valve Pipe Sizing

Relief valve pipe sizing is based on the discharge capacity for the given evaporator or condenser and the length of piping to be run. Discharge capacity for HFC-134a vessels is calculated as follows:

$$C = 0.133xDxL$$

Where: C=Minimum discharge capacity, lbs of air/min

D=Vessel diameter, in.

L=Vessel length, ft.

Example: E3016 Evaporator, HFC-134a Refrigerant, 75 equivalent feet of piping

$$C = 0.133x30x16 = 63.8\ Lbs\ of\ air\ /\ \text{min}$$

From the table below, 75 feet of piping for 63.8 lb. of air/min. at 180 psig valve setting requires a 2" diameter pipe.

Discharge Capacity, lbs of Air/Min

EQUIVALENT LENGTH OF DISCHARGE PIPING, FT. (m)	DIAMETER STANDARD WALL IRON PIPE											
	1" (25mm)		1.25" (32mm)		1.5" (38mm)		2" (50mm)		2.5" (64mm)		3" (76mm)	
	RELIEF VALVE PRESSURE SETTNG											
	180	225	180	225	180	225	180	225	180	225	180	225
50 (15.2)	21.4	26.8	42.8	53.6	62.7	78.4	117.0	146.3	182.2	227.7	315.4	393.7
75 (22.9)	17.5	21.9	35.0	43.8	51.5	64.4	95.4	119.3	150.5	188.1	257.4	321.8
100 (30.5)	15.2	19.1	30.2	27.8	44.3	55.4	82.6	103.3	129.6	162.0	222.5	278.1
150 (45.7)	12.4	15.6	24.7	30.9	36.0	45.0	67.3	84.2	105.1	131.9	182.2	227.7
200 (61.0)	10.6	13.6	21.4	26.8	31.4	39.3	58.4	73.1	91.1	113.9	157.7	197.1
300 (91.4)	8.8	11.1	17.5	21.9	25.5	32.0	47.6	59.6	75.6	94.5	128.5	160.7

Note: Standard relief valve settings; R-134a, evaporator=180 psig, condenser=225 psig

Note: Per ASHRAE Standard 15, the pipe size may not be less than the relief device, meaning a minimum 1" diameter pipe is required. The discharge from more than one relief valve may be run into a common header, the area of which shall not be less than the sum of the areas of the connected pipes. For further details, refer to ASHRAE Standard 15. The common header can be calculated by the formula:

$$D_{Common} = \left(D_1^2 + D_2^2 \ldots. D_n^2\right)^{0.5}$$

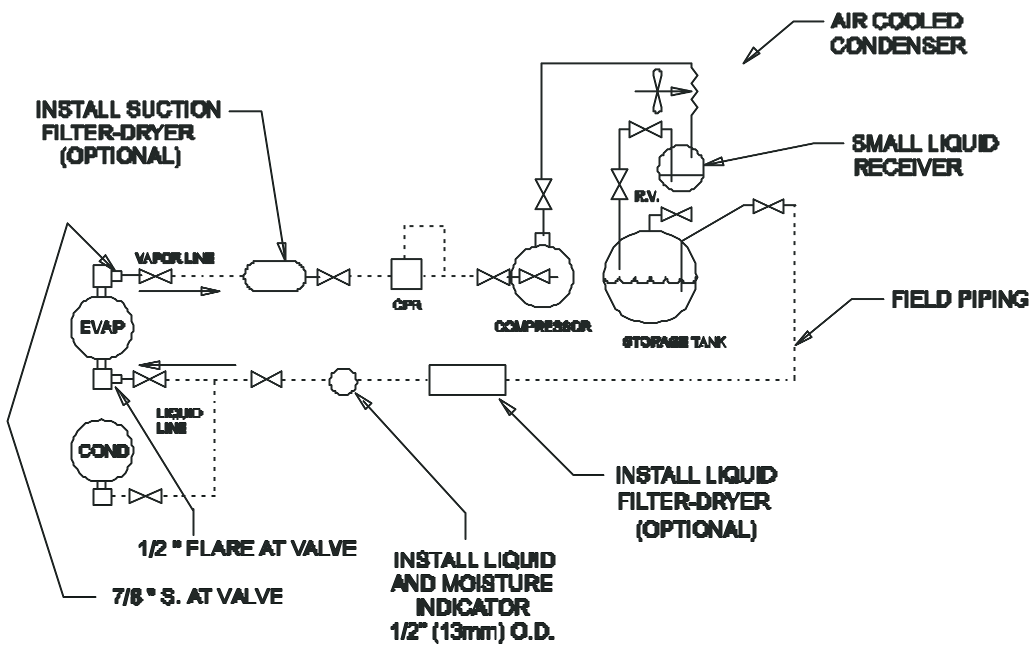
WARNING: The above information is a guide only. Consult local codes and/or latest version of ASHRAE Standard 15 for sizing data.

Pumpout Units

Although McQuay chillers can pump the entire refrigerant charge into the condenser and valve it off, there are occasions when pumpout units are required due purely to specification requirements or unusual job considerations. The McQuay Model LSA units consist of an ASME storage tank, a top mounted air-cooled condensing unit with a 1 HP compressor to provide motive power, and necessary valves and fittings to constitute a complete system. Optional casters are available. Storage tank capacities range from 1078 pounds to 4570 pounds of R-134a. Very large dual compressor units may require an additional storage tank.

The schematic piping arrangement shown below is the normal method of installation. Transfer from the chiller is accomplished by liquid refrigerant flow from the condenser into the storage tank. When liquid transfer is completed, valving changes are made to draw out the chiller's remaining refrigerant vapor through the suction of the pumpout compressor, condense the vapor in the air-cooled condenser and transfer it to the storage tank.

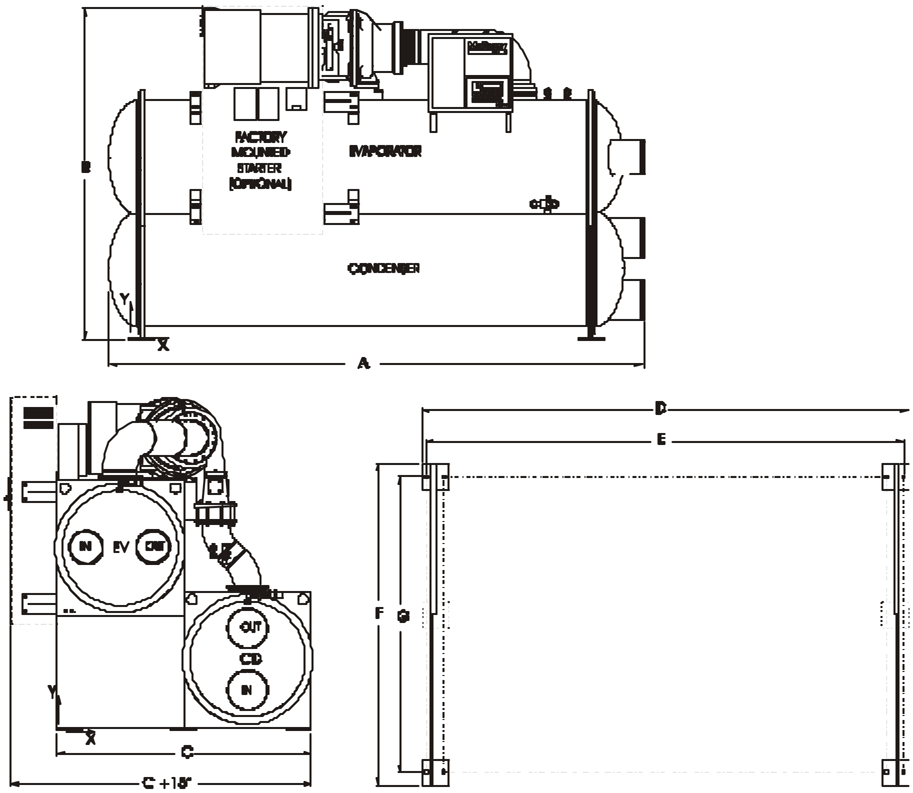
Transfer from the storage tank to the chiller is initially by liquid/vapor flow until enough refrigerant is in the chiller unit to start it. The chiller compressor will then draw refrigerant directly from the tank.



Dimensions

Chillers

WSC 048/WSC 050, 80 to 150 tons

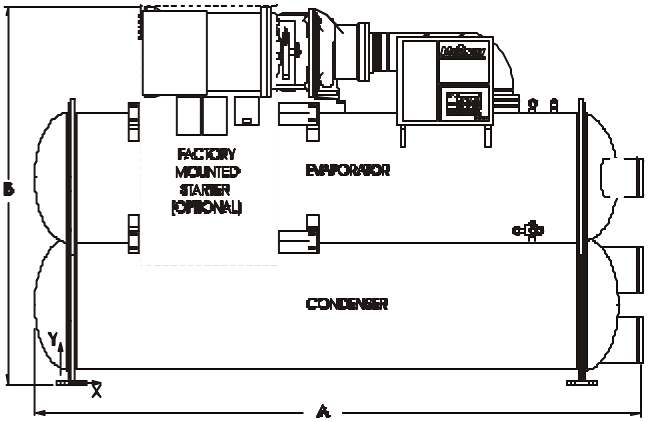


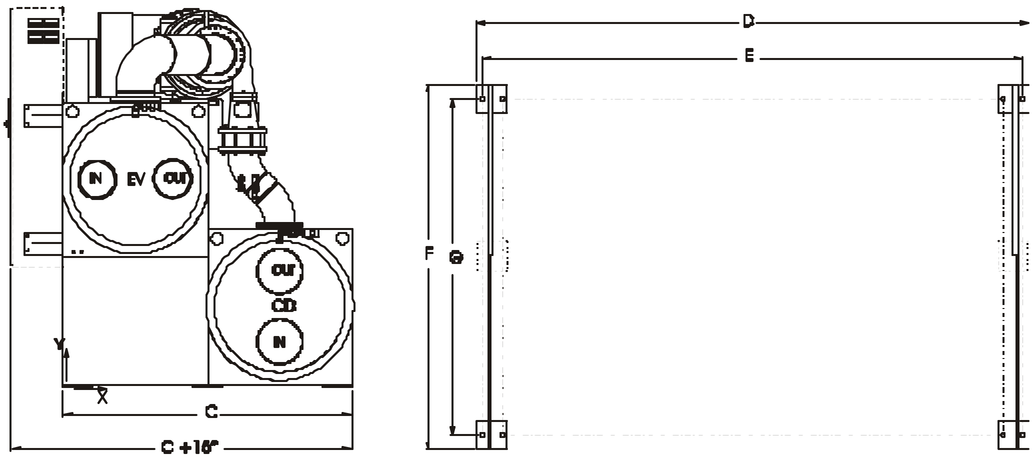
VESSEL CODE		OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
1809	1609	134 (3404)	128 (3251)	134 (3404)	71 (1803)	42 (1067)	55 (1397)	31 (787)	17 (432)	113 (2870)	111 (2819)	42 (1067)	34 (864)	6	5
1812	1612	169 (4293)	163 (4140)	169 (4293)	71 (1803)	42 (1067)	72 (1829)	30 (762)	16 (406)	148 (3759)	145 (3683)	42 (1067)	34 (864)	6	5
2009	1609	134 (3404)	128 (3251)	134 (3404)	71 (1803)	42 (1067)	55 (1397)	31 (787)	16 (406)	113 (2870)	111 (2819)	42 (1067)	34 (864)	6	5
2012	1612	169 (4293)	163 (4140)	169 (4293)	71 (1803)	42 (1067)	72 (1829)	30 (762)	16 (406)	148 (3759)	145 (3683)	42 (1067)	34 (864)	6	5
2009	1809	134 (3404)	128 (3251)	134 (3404)	71 (1803)	42 (1067)	55 (1397)	31 (787)	17 (432)	113 (2870)	111 (2819)	42 (1067)	34 (864)	6	6
2012	1812	169 (4293)	163 (4140)	169 (4293)	71 (1803)	42 (1067)	73 (1854)	30 (762)	17 (432)	148 (3759)	145 (3683)	42 (1067)	34 (864)	6	6
2209	2009	134 (3404)	129 (3277)	134 (3404)	71 (1803)	42 (1067)	55 (1397)	30 (762)	17 (432)	113 (2870)	111 (2819)	42 (1067)	34 (864)	8	6
2212	2012	169 (4293)	164 (4166)	169 (4293)	71 (1803)	42 (1067)	73 (1854)	29 (737)	17 (432)	148 (3759)	145 (3683)	42 (1067)	34 (864)	8	6

Notes:

1. Dimensions in inches (mm).
2. See Physical Data and Weights section for component and unit weights.
3. Allow three feet of service access on all four sides.
4. Allow the length of the tubes plus two feet on one end for tube removal. The last two numbers in the vessel code are the tube length in feet.
5. Mounting holes are 1 1/8 in. (2.9 cm) diameter.
6. Approximate thickness of waffle pad when compressed: ¼ in. (.63 cm).

WSC 063, 160 to 300 tons

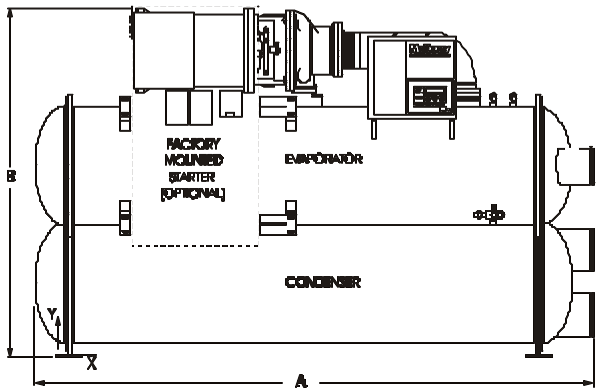


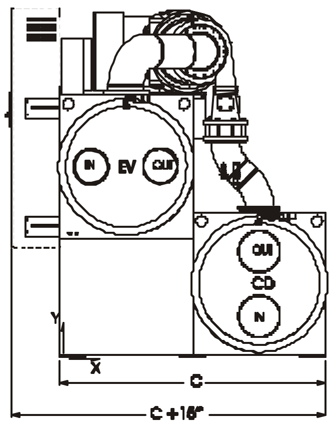


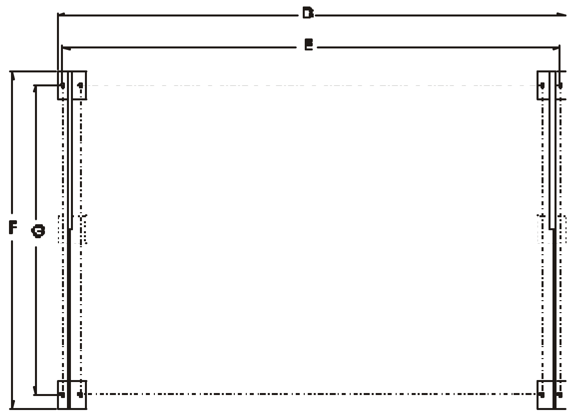
VESSEL CODE		OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN. BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
2009	1809	134 (3404)	128 (3251)	134 (3404)	76 (1930)	42 (1067)	50 (1270)	37 (940)	16 (406)	113 (2870)	111 (2819)	42 (1067)	34 (864)	6	6
2012	1812	169 (4293)	163 (4140)	169 (4293)	76 (1930)	42 (1067)	68 (1727)	36 (914)	17 (432)	148 (3759)	145 (3683)	42 (1067)	34 (864)	6	6
2209	2009	134 (3404)	129 (3277)	134 (3404)	76 (1930)	42 (1067)	50 (1270)	36 (914)	17 (432)	113 (2870)	111 (2819)	42 (1067)	34 (864)	8	6
2212	2012	169 (4293)	164 (4166)	169 (4293)	76 (1930)	42 (1067)	68 (1727)	34 (864)	17 (432)	148 (3759)	145 (3683)	42 (1067)	34 (864)	8	6
2209	2209	134 (3404)	129 (3277)	134 (3404)	76 (1930)	42 (1067)	51 (1295)	35 (889)	17 (432)	113 (2870)	111 (2819)	42 (1067)	34 (864)	8	8
2212	2212	169 (4293)	164 (4166)	169 (4293)	76 (1930)	42 (1067)	68 (1727)	34 (864)	17 (432)	148 (3759)	145 (3683)	42 (1067)	34 (864)	8	8
2609	2209	134 (3404)	129 (3277)	134 (3404)	80 (2032)	46 (1168)	51 (1295)	37 (940)	20 (508)	113 (2870)	111 (2819)	46 (1168)	38 (965)	8	8
2612	2212	169 (4293)	164 (4166)	169 (4293)	80 (2032)	46 (1168)	69 (1753)	35 (889)	20 (508)	148 (3759)	145 (3683)	46 (1168)	38 (965)	8	8
2609	2609	134 (3404)	129 (3277)	134 (3404)	86 (2184)	48 (1219)	51 (1295)	40 (1016)	20 (508)	113 (2870)	111 (2819)	48 (1219)	40 (1016)	8	8
2612	2612	169 (4293)	164 (4166)	169 (4293)	86 (2184)	48 (1219)	69 (1753)	38 (965)	21 (533)	148 (3759)	145 (3683)	48 (1219)	40 (1016)	8	8
3012	2612	175 (4445)	167 (4242)	175 (4445)	90 (2286)	53 (1346)	67 (1702)	41 (1041)	21 (533)	148 (3759)	145 (3683)	53 (1646)	45 (1143)	10	8

Note: See notes on page 33.

WSC 079/087, 300 to 550 tons



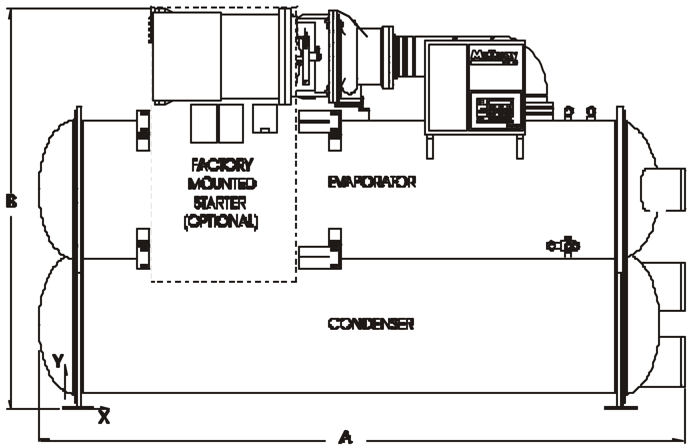


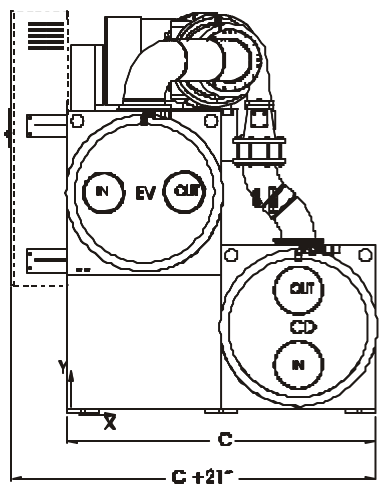


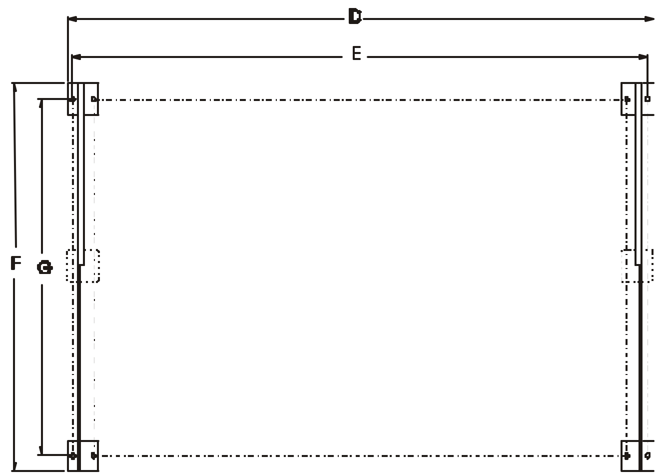
VESSEL CODE		"A" OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN. BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
2209	2209	134 (3404)	129 (3277)	134 (3404)	74 (1880)	45 (1143)	50 (1270)	35 (889)	18 (457)	113 (2870)	111 (2819)	45 (1173)	37 (9398)	8	8
2212	2212	169 (4293)	164 (4166)	169 (4293)	74 (1880)	45 (1143)	68 (1727)	34 (864)	18 (457)	148 (3759)	145 (3683)	45 (1173)	37 (9398)	8	8
2609	2209	134 (3404)	129 (3277)	134 (3404)	78 (1981)	49 (1245)	51 (1295)	40 (1016)	22 (559)	113 (2870)	111 (2819)	49 (1245)	41 (1041)	8	8
2612	2212	169 (4293)	164 (4166)	169 (4293)	78 (1981)	49 (1245)	69 (1753)	35 (889)	21 (533)	148 (3759)	145 (3683)	49 (1245)	41 (1041)	8	8
2609	2609	134 (3404)	129 (3277)	134 (3404)	83 (2108)	52 (1321)	51 (1295)	37 (940)	21 (533)	113 (2870)	111 (2819)	52 (1321)	44 1118)	8	8
2612	2612	169 (4293)	164 (4166)	169 (4293)	83 (2108)	52 (1321)	69 (1753)	38 (965)	22 (559)	148 (3759)	145 (3683)	52 (1321)	44 1118)	8	8
3009	2609	140 (3556)	132 (3353)	140 (3556)	88 2235)	56 (1422)	52 (1321)	41 (1041)	25 (635)	113 (2870)	111 (2819)	56 (1422)	48 (1219)	10	8
3009	3009	140 (3556)	132 (3353)	140 (3556)	93 (2362)	58 (1473)	52 (1321)	43 (1092)	26 (660)	113 (2870)	111 (2819)	58 (1473)	50 (1270)	10	10
3012	2612	175 (4445)	167 (4242)	175 (4445)	88 (2235)	56 (1422)	69 (1753)	40 (1016)	25 (635)	148 (3759)	145 (3683)	56 (1422)	48 (1219)	10	8
3012	3012	175 (4445)	167 (4242)	175 (4445)	93 (2362)	58 (1473)	70 (1778)	41 (1041)	26 (660)	148 (3759)	145 (3683)	58 (1473)	50 (1270)	10	10
3609	3009	140 (3556)	133 (3378)	140 (3556)	94 (2388)	74 (1880)	52 (1321)	43 (1092)	34 (864)	113 (2870)	111 (2819)	74 (1880)	66 (1676)	12	10
3612	3012	175 (4445)	168 (4267)	175 (4445)	94 (2388)	74 (1880)	70 (1778)	41 (1041)	34 (864)	148 (3759)	145 (3683)	74 (1879)	66 (1676)	12	10
3612	3612	175 (4445)	168 (4267)	175 (4445)	105 (2667)	80 (2032)	70 (1778)	46 (1168)	38 (965)	148 (3759)	145 (3683)	80 (2032)	72 (1829)	12	12

Note: See notes on page 33.

WSC 100-126, 600 to 1300 tons



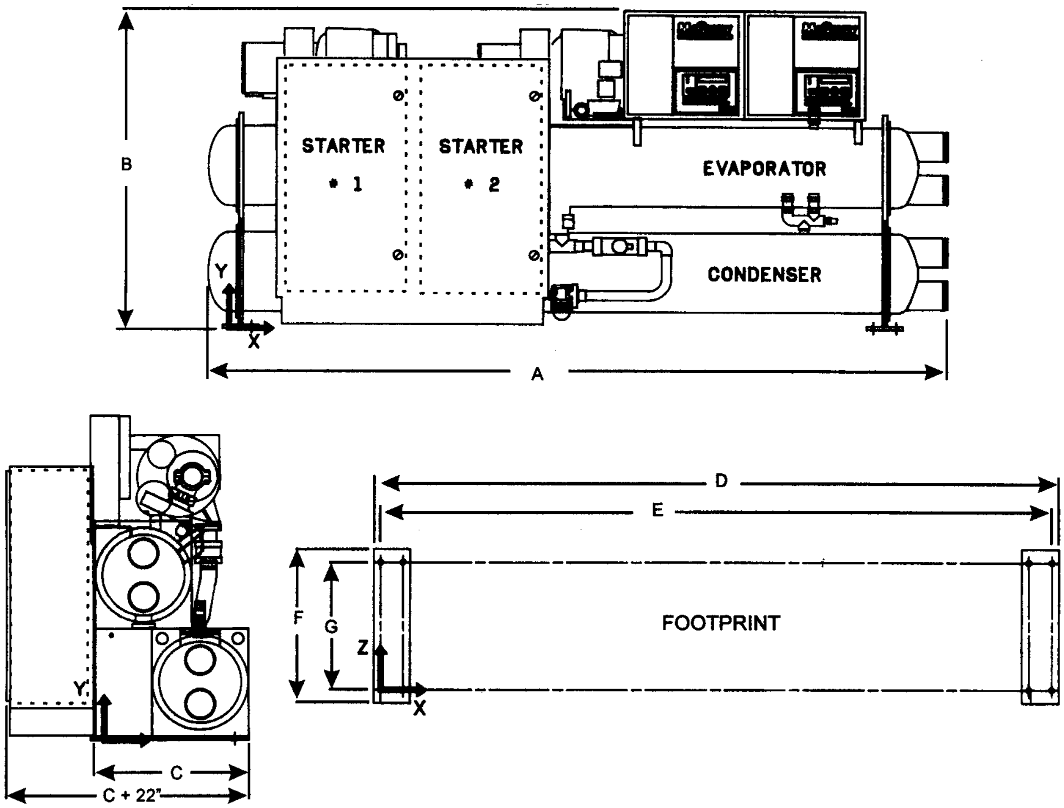




VESSEL CODE		OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
3012	3012	175 (4445)	167 (4242)	175 (4445)	97 (2464)	61 (1549)	65 (1651)	47 (1194)	21 (553)	148 (3759)	145 (3683)	61 (1549)	53 (1346)	10	10
3612	3012	175 (4445)	168 (4267)	175 (4445)	99 (2515)	74 (1880)	68 (1727)	47 (1194)	27 (686)	148 (3759)	145 (3683)	74 (1880)	66 (1676)	12	10
3612	3612	175 (4445)	168 (4267)	175 (4445)	99 (2515)	80 (2032)	68 (1727)	46 (1168)	31 (787)	148 (3759)	145 (3683)	80 (2032)	72 (1829)	12	12
4212	3612	175 (4445)	170 (4318)	175 (4445)	99 (2515)	86 (2184)	69 (1753)	45 (1143)	35 (889)	148 (3759)	145 (3683)	86 (2184)	78 (1981)	14	12
4212	4212	175 (4445)	170 (4318)	175 (4445)	102 (2591)	92 (2337)	69 (1753)	45 (1143)	37 (940)	148 (3759)	145 (3683)	92 2337)	84 (2134)	14	14
4812	4212	181 (4597)	175 (4445)	181 (4597)	106 (2692)	98 (2489)	69 (1753)	46 (1168)	42 1067)	148 (3759)	145 (3683)	98 2489)	90 (2286)	18	14
4812	4812	181 (4597)	175 (4445)	181 (4597)	106 (2692)	104 (2642)	70 (1778)	46 (1168)	46 (1168)	145 (3683)	145 (3683)	104 (2642)	96 (2438)	18	18

Note: See notes on page 33.

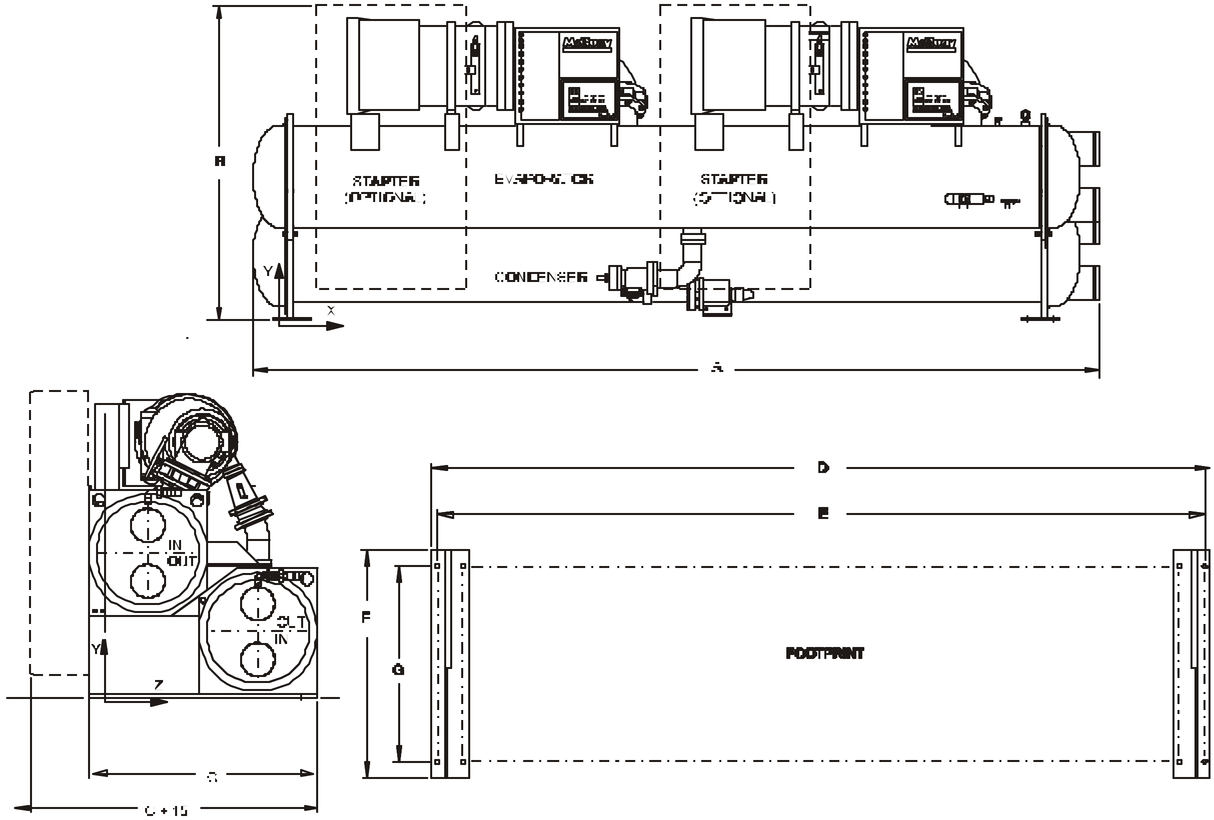
WDC 048/050, 180 to 320 tons



VESSEL CODE		OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
E1812	C1612	169 (4298)	170 (4134)	169 (4298)	74 (1883)	34 (876)	66 (1608)	34 (857)	14 (352)	150 (3802)	147 (3726	35 (876)	29 (724)	6	5
E1812	C1812	169 (4299)	163 (4132)	169 (4299)	76 (1934)	34 (876)	65 (165)	33 (875)	14 (362)	150 (3802)	147 (3726	35 (876)	29 (724)	6	6
E1816	C1816	218 (5544)	212 (5380)	218 (5544)	76 (1934)	34 (876)	97 (2458)	31 (781)	14 (368)	199 (5050)	196 (4974)	35 (876)	29 (724)	6	6
E2012	C1812	169 (4299)	163 (4147)	169 (4299)	78 (1984)	34 (876)	67 (1705)	34 (873)	14 (359)	150 (3802)	147 (3726	35 (876)	29 (724)	6	6
E2016	C1816	218 (5544)	212 (5393)	218 (5544)	78 (1994)	34 (876)	93 (2359)	32 (813)	14 (365)	199 (5050)	196 (4974)	35 (876)	29 (724)	6	6
E2212	C2212	169 (4299)	164 (4158)	169 (4299)	79 (2020)	40 (1024)	72 (1838)	29 (733)	15 (384)	150 (3802)	147 (3726	41 (1024)	35 (872)	8	8
E2216	C2216	218 (5544)	213 (5404)	218 (5544)	79 (2020)	40 (1024)	93 (2367)	31 (800)	20 (498)	199 (5050)	196 (4974)	41 (1024)	35 (872)	8	8
E2612	C2212	169 (4299)	165 (4180)	169 (4299)	85 (2149)	44 (1131)	75 (1918)	35 (902)	20 (505)	150 (3802)	147 (3726	45 (1131)	39 (979)	8	8
E2616	C2216	218 (5544)	214 (5428)	218 (5544)	85 (2149)	44 (1131)	97 (2467)	36 (921)	19 (492)	199 (5050)	196 (4974)	45 (1131)	39 (979)	8	8

Note: See notes on page 33.

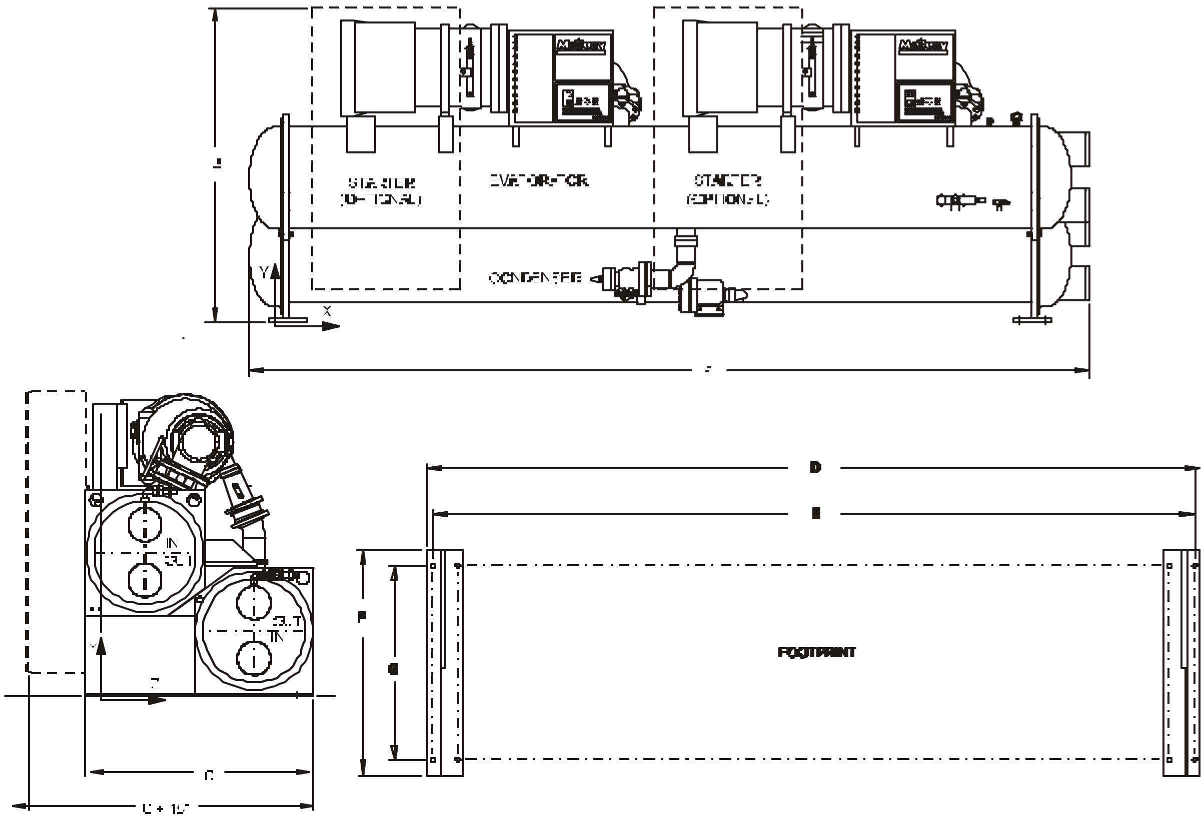
WDC 063, 320 to 600 tons



VESSEL CODE		OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN .BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
E2416	C2416	218 (5544)	214 (5426)	218 (5544)	80 (2032)	58 (1470)	91 (2318)	36 (911)	17 (425)	199 (5048)	196 (4972)	58 (1470)	50 (1267)	8	8
E2416	C2616	218 (5544)	214 (5426)	218 (5544)	80 (2032)	58 (1470)	91 (2324)	35 (895)	17¼ (438)	199 (5048)	196 (4972)	58 (1470)	50 (1267)	8	8
E2616	C2416	218 (5544)	214 (5426)	218 (5544)	80 (2032)	58 (1470)	91 (2324)	36 (911)	16 (419)	199 (5048)	196 (4972)	58 (1470)	50 (1267)	8	8
E2616	C2616	218 (5544)	214 (5426)	218 (5544)	80 (2032)	58 (1470)	92 (2340)	35 (899)	17 (435)	199 (5048)	196 (4972)	58 (1470)	50 (1267)	8	8
E3016	C3016	221 (5623)	214 (5445)	221 (5623)	90 (2280)	64 (1619)	95 (2410)	40 (1029)	21 (537)	199 (5048)	196 (4972)	64 (1619)	56 (1416)	10	10

Note: See notes on page 33.

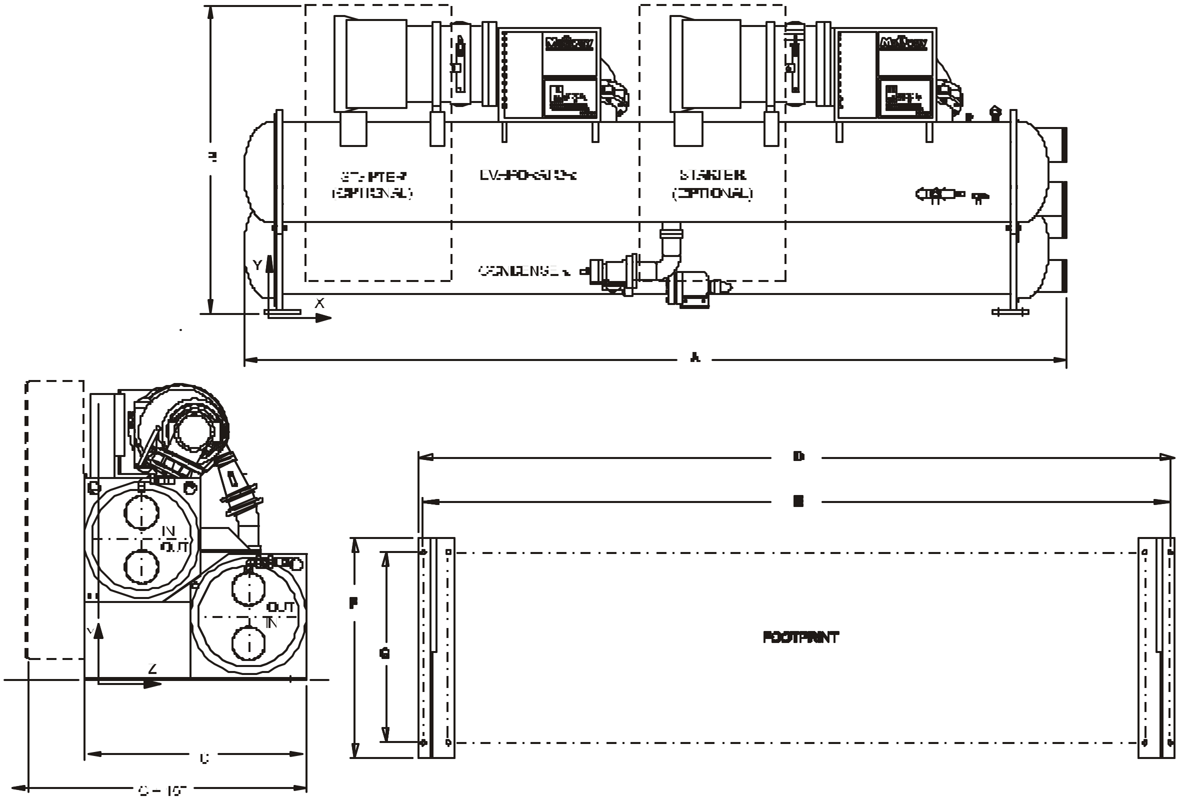
WDC 079, 600 to 700 tons



VESSEL CODE		OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
E3016	C3016	221 (5620)	214 (5442)	221 (5620)	94 (2407)	57 (1454)	93 (2369)	44 (1127)	19 (492)	199 (5050)	196 (4974)	57 (1453)	49 (1250)	10	10
E3616	C3016	224 (5696)	218 (5531)	224 (5696)	100 (2530)	71 (1808)	94 (2388)	45 (1149)	32 (803)	199 (5050)	196 (4974)	57 (1453)	49 (1250)	12	10
E3616	C3616	224 (5698)	218 (5531)	224 (5698)	106 (2686)	74 (1886)	94 (2392)	48 (1232)	32 (822)	199 (5050)	196 (4974)	74 (1886)	66 (1682)	12	12

Note: See notes on page 33.

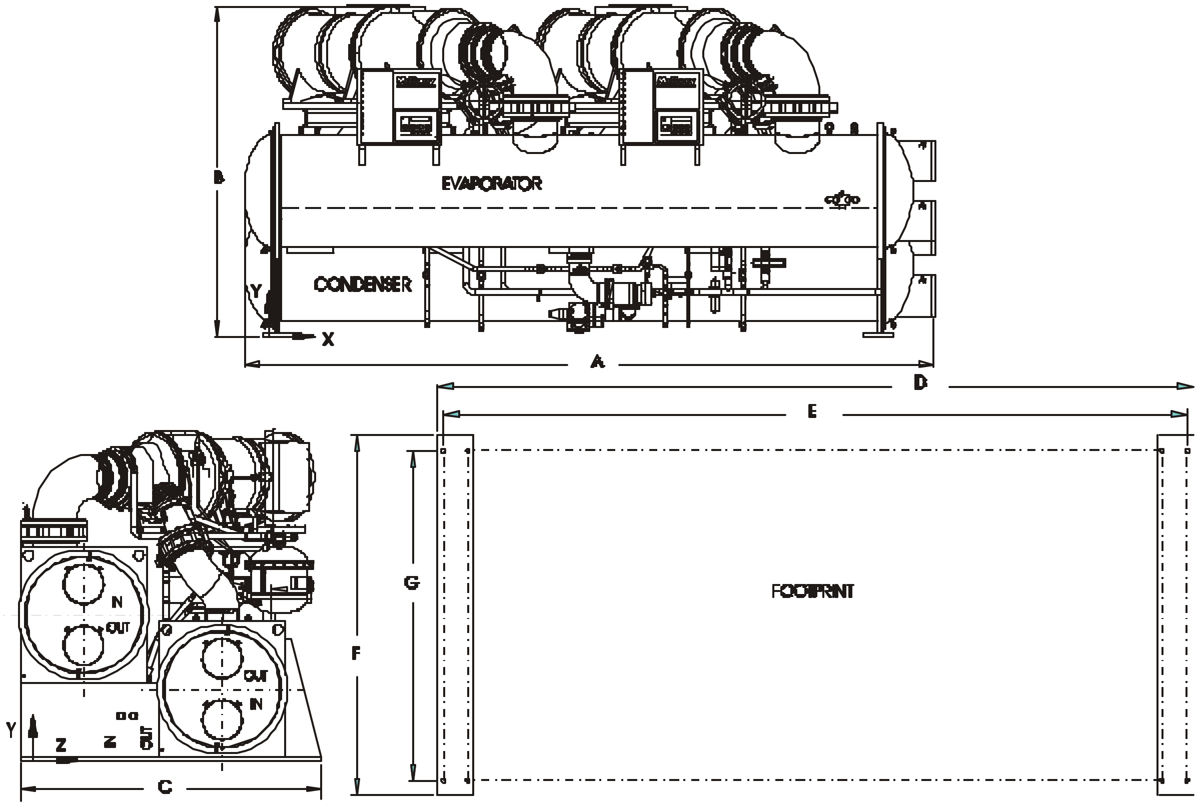
WDC 087, 700 to 1200 tons



VESSEL CODE EVAP	VESSEL CODE COND	OVERALL LENGTH 1&3 PASS A	OVERALL LENGTH 2 PASS A	OVERALL LENGTH HEAD CONN .BOTH ENDS A	OVERALL HEIGHT B	OVERALL WIDTH W/O STARTER C	CENTER OF GRAVITY X	CENTER OF GRAVITY Y	CENTER OF GRAVITY Z	FOOTPRINT D	FOOTPRINT E	FOOTPRINT F	FOOTPRINT G	CONNECTIONS EVAP 2 PASS	CONNECTIONS COND 2 PASS
E3016	C3016	221 (5620)	214 (5442)	221 (5620)	95 (2410)	57 (1454)	93 (2353)	46 (1172)	18 (467)	199 (5050)	196 (4974)	57 (1453)	49 (1250)	10	10
E3616	C3016	224 (5698)	218 (5531)	224 (5698)	100 (2530)	72 (1808)	93 (224)	47 (1187)	32 (806)	199 (5050)	196 (4974)	57 (1453)	49 (1250)	12	10
E3616	3616	224 (5698)	218 (5531)	224 (5698)	106 (2686)	74 (1886)	94 (2384)	50 (1273)	32 (822)	199 (5050)	196 (4974)	74 (1886)	66 (1682)	12	12

Note: See notes on page 33.

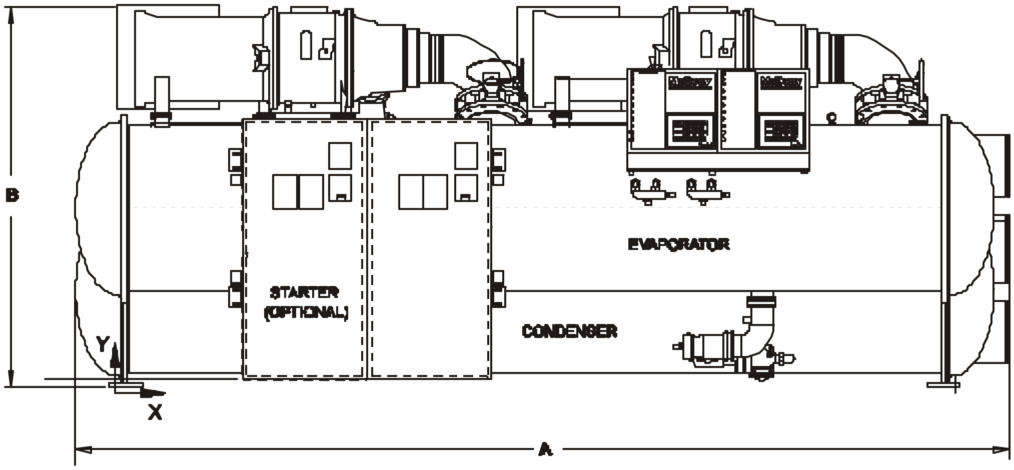
WDC 100, 1200 to 1700 tons

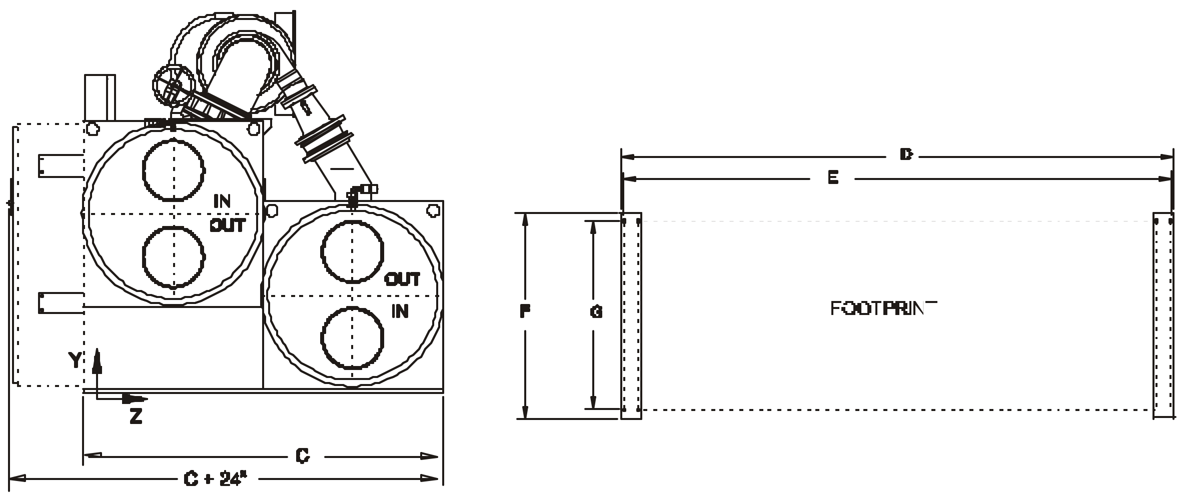


VESSEL CODE		OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY W/O STARTER			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
E3616	C3616	224 (5692)	218 (5528)	224 (5692)	104 (2652)	95 (2419)	93 (2353)	51 (1292)	40 (1003)	199 (5050)	196 (4974)	95 (2419)	87 (2216)	12	12
E4216	C4216	224 (5692)	219 (5554)	224 (5692)	107 (2722)	100 (2545)	94 (2381)	50 (1254)	44 (1105)	199 (5050)	196 (4974)	100 (2545)	92 (2342)	14	16
E4816	C4816	230 (5848)	224 (5703)	230 (5848)	116 (2956)	110 (2792)	95 (2400)	52 (1318)	51 (1292)	199 (5050)	196 (4974)	110 (2792)	102 (2589)	18	18
E4220	C4220	272 (6909)	267 (6772)	272 (6909)	102 (2591)	92 (2343)	117 (2991)	46 (1165)	36 (921)	247 (6269)	244 (6193)	92 (2343)	84 (2140)	14	16
E4820	C4820	276 (7010)	271 (6890)	276 (7010)	111 (2810)	104 (2648)	118 (3007)	49 (1238)	43 (1105)	247 (6269)	244 (6193)	104 (2648)	96 (2444)	18	18

Note: See notes on page 33.

WDC 126, 1600 to 2700 tons



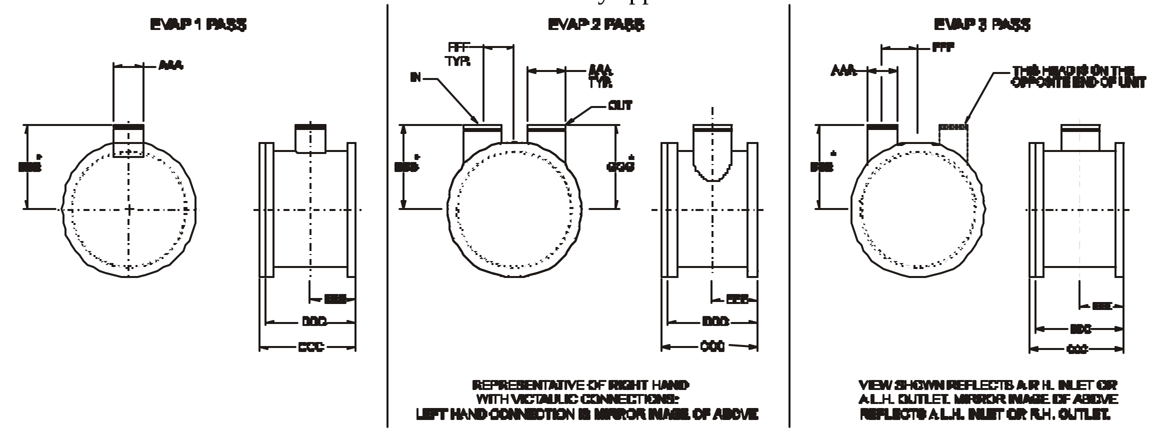


VESSEL CODE		OVERALL LENGTH			OVERALL HEIGHT	OVERALL WIDTH W/O STARTER	CENTER OF GRAVITY			FOOTPRINT				CONNECTIONS	
EVAP	COND	1&3 PASS	2 PASS	HEAD CONN BOTH ENDS										EVAP 2 PASS	COND 2 PASS
		A	A	A	B	C	X	Y	Z	D	E	F	G		
E3616	C3616	224 (5692)	218 (5528)	224 (5692)	104 (2652)	95 (2419)	93 (2353)	51 (1292)	40 (1003)	199 (5050)	196 (4974)	95 (2419)	87 (2216)	12	12
E4216	C4216	224 (5692)	219 (5554)	224 (5692)	107 (2722)	100 (2545)	94 (2381)	50 (1254)	44 (1105)	199 (5050)	196 (4974)	100 (2545)	92 (2342)	14	16
E4816	C4816	230 (5848)	224 (5703)	230 (5848)	116 (2956)	110 (2792)	95 (2400)	52 (1318)	51 (1292)	199 (5050)	196 (4974)	110 (2792)	102 (2589)	18	18
E4220	C4220	272 (6909)	267 (6772)	272 (6909)	102 (2591)	92 (2343)	117 (2991)	46 (1165)	36 (921)	247 (6269)	244 (6193)	92 (2343)	84 (2140)	14	16
E4224	C4224	320 (8128)	315 (7991)	320 (8128)	102 (2591)	92 (2343)	136 (3457)	44 (1121)	37 (946)	295 (7487)	292 (7412)	92 (2343)	84 (2140)	14	16
E4820	C4820	276 (7010)	271 (6890)	276 (7010)	111 (2810)	104 (2648)	118 (3007)	49 (1238)	43 (1105)	247 (6269)	244 (6193)	104 (2648)	96 (2444)	18	18
E4824	C4824	324 (8230)	319 (8109)	324 (8230)	111 (2810)	104 (2648)	138 (3496)	47 (1194)	45 (1133)	295 (7487)	292 (7412)	104 (2648)	96 (2444)	18	18

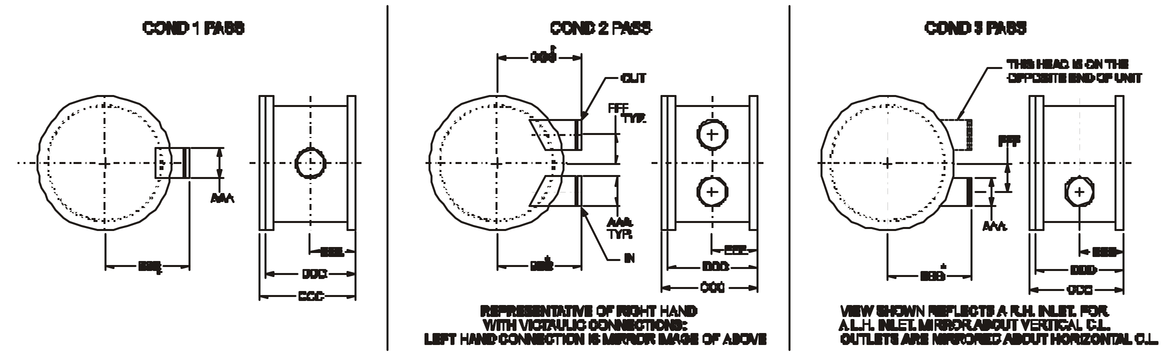
Note: See notes on page 33.

Marine Water Boxes

Marine water boxes are an available option on all evaporator and condenser sizes. Epoxy coating of the water boxes and clad tube sheets are available for extreme duty applications.



NOTE: * ADD .400 INCH FOR FLANGED CONNECTION.



Dimensions with Victaulic or Flanged Connections

150 PSI Non-ASME - Victaulic Connection

Evap. Dia.	1 PASS					2 PASS							3 PASS						Return Head
	'AAA'	'BBB'	'CCC	'DDD'	'EEE'	'AAA'	'BBB'	'CCC'	'DDD'	'EEE'	'FFF'	'GGG'	'AAA'	'BBB'	'CCC'	'DDD'	'EEE'	'FFF'	'UU'
E18	8.625	15.00	19.25	18.00	9.00	6.625	15.00	19.25	18.00	9.00	4.78	15.00	4.500	15.00	19.25	18.00	9.00	5.85	6.50
E20	8.625	16.00	19.25	18.00	9.00	6.625	16.00	19.25	18.00	9.00	5.63	16.00	4.500	16.00	19.25	18.00	9.00	6.69	7.00
E22	10.750	17.00	21.25	20.00	10.00	8.625	17.00	21.25	20.00	10.00	5.59	23.00	5.563	17.00	21.25	20.00	10.00	7.12	7.50
E26	10.750	19.00	21.25	20.00	10.00	8.625	19.00	21.25	20.00	10.00	7.07	19.00	6.625	19.00	21.25	20.00	10.00	8.07	8.38
E30	14.000	21.00	28.50	26.50	13.25	10.750	21.00	28.50	26.50	13.25	8.13	21.00	6.625	21.00	28.50	26.50	13.25	10.19	7.50
E36	16.000	24.00	30.25	28.00	14.00	12.750	24.00	30.25	28.00	14.00	9.75	24.00	8.625	24.00	30.25	28.00	14.00	11.81	9.44
E42	20.000	27.00	32.50	30.00	15.00	14.000	27.00	32.50	30.00	15.00	11.63	27.00	10.750	27.00	32.50	30.00	15.00	13.25	10.50
E48	24.000	30.00	39.50	36.50	18.25	18.000	30.00	39.50	36.50	18.25	12.50	30.00	12.750	30.00	39.50	36.50	18.25	15.13	13.22

Cond. Dia.	1 PASS					2 PASS							3 PASS						Return Head
	'AAA'	'BBB'	'CCC	'DDD'	'EEE'	'AAA'	'BBB'	'CCC'	'DDD'	'EEE'	'FFF'	'GGG'	'AAA'	'BBB'	'CCC'	'DDD'	'EEE'	'FFF'	'UU'
C16	8.625	14.00	15.25	14.00	7.00	5.563	14.00	15.25	14.00	7.00	4.35	14.00	Consult Factory						6.00
C18	8.625	15.00	19.25	18.00	9.00	6.625	15.00	19.25	18.00	9.00	4.78	15.00							6.50
C20	8.625	16.00	19.25	18.00	9.00	6.625	16.00	19.25	18.00	9.00	5.63	16.00							7.00
C22	10.750	17.00	21.25	20.00	10.00	8.625	17.00	21.25	20.00	10.00	5.59	23.00							7.50
C26	10.750	19.00	21.25	20.00	10.00	8.625	19.00	21.25	20.00	10.00	7.07	19.00							8.38
C30	14.000	21.00	28.50	26.50	13.25	10.750	21.00	28.50	26.50	13.25	8.13	21.00							7.50
C36	16.000	24.00	30.25	28.00	14.00	12.750	24.00	30.25	28.00	14.00	9.75	24.00							9.44
C42	20.000	27.00	32.50	30.00	15.00	14.000	27.00	32.50	30.00	15.00	11.63	27.00							10.50
C48	24.000	30.00	39.50	36.50	18.25	18.000	30.00	39.50	36.50	18.25	12.50	30.00							13.22

Note:
1. Dimensions in inches (mm).
2. Flanges are ANSI raised face. Mating flanges by others.
3. Some condensers with flanges may have staggered connections due to flange interference. Consult factory.
4. When built with flange connections instead of victaulic, the distance from the vertical centerline to the flange face is 0.5 inches more than shown with victaulic (dimension D).

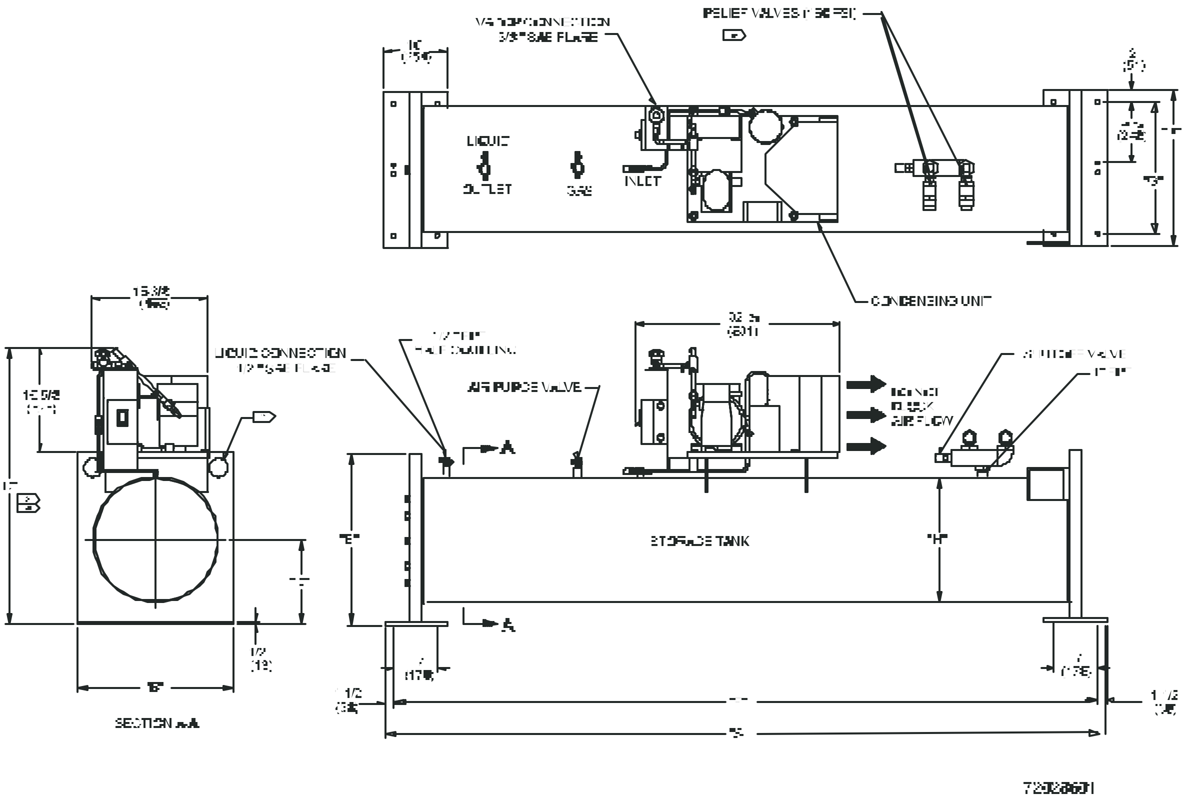
Weights

Unit	Evaporator / Condenser Size	Certified Drawing Number	Max. Unit Weight Without Starter		Max. Unit Weight With Starter	
			Shipping lbs. (kg)	Operating lbs. (kg)	Shipping lbs. (kg)	Operating lbs. (kg)
WSC050	1809 / 1609	WSC 050	5771 (2618)	6168 (2798)	6972 (3162)	7368 (3342)
WSC050	1812 / 1612	WSC 050	6504 (2950)	7004 (3177)	7704 (3495)	8204 (3721)
WSC050	2009 / 1609	WSC 050	6130 (2781)	6591 (2990)	7330 (3326)	7791 (3534)
WSC050	2012 / 1612	WSC 050	6933 (3145)	7510 (3407)	8133 (3689)	8711 (3951)
WSC050	2009 / 1809	WSC 050	6395 (2901)	6932 (3144)	7595 (3445)	8132 (3689)
WSC050	2012 / 1812	WSC 050	7267 (3296)	7938 (3601)	8467 (3841)	9138 (4145)
WSC050	2209 / 2009	WSC 050	7038 (3192)	7760 (3520)	8238 (3737)	8960 (4064)
WSC050	2212 / 2012	WSC 050	8077 (3664)	8972 (4070)	9277 (4208)	10172 (4614)
WSC063	2009 / 1809	WSC 063/087	8412(3816)	8949 (4059)	9612 (4360)	10149 (4604)
WSC063	2012 / 1812	WSC 063/087	9284 (4211)	9955 (4516)	10484 (4756)	11155 (5060)
WSC063	2209 / 2009	WSC 063/087	9119 (4136)	9841 (4464)	10319 (4681)	11040 (5008)
WSC063	2212 / 2012	WSC 063/087	10182 (4619)	11077 (5025)	11382 (5163)	12277 (5569)
WSC063	2209 / 2209	WSC 063/087	9416 (4271)	10235 (4643)	10616 (4815)	11435 (5187)
WSC063	2212 / 2212	WSC 063/087	10557 (4789)	11570 (5248)	11757 (5333)	12770 (5792)
WSC063	2609 / 2209	WSC 063/087	10248 (4648)	11258 (5107)	11448 (5193)	12458 (5651)
WSC063	2612 / 2212	WSC 063/087	11577 (5251)	12517 (5678)	12777 (5796)	14017 (6358)
WSC063	2609 / 2609	WSC 063/087	10984 (4982)	12228 (5547)	12184 (5527)	13428 (6091)
WSC063	2612 / 2612	WSC 063/087	12494 (5667)	14020 (6359)	13394 (6076)	15220 (6904)
WSC063	3012 / 2612	WSC 063/087	13903 (6306)	15569 (7062)	15103 (6851)	16769 (7606)
WSC079	2209 / 2209	WSC 063/087	10140 (4600)	10959 (4971)	11340 (5144)	12159 (5515)
WSC079	2212 / 2212	WSC 063/087	11281 (5117)	12294 (5577)	12481 (5661)	13494 (6121)
WSC079	2609 / 2209	WSC 063/087	10980 (4981)	11990 (5439)	12180 (5525)	13190 (5983)
WSC079	2612 / 2212	WSC 063/087	12309 (5592)	13548 (6145)	13509 (6128)	14749 (6690)
WSC079	2609 / 2609	WSC 063/087	11716 (5314)	12960 (5879)	12916 (5859)	14160 (6423)
WSC079	2612 / 2612	WSC 063/087	13226 (5999)	14752 (6692)	14426 (6544)	15952 (7236)
WSC079	3012 / 2612	WSC 063/087	14635 (6638)	16301 (7394)	15835 (7183)	17501 (7938)
WSC079	3012 / 3012	WSC 063/087	16119 (7312)	18061 (8192)	17319 (7856)	19261 (8737)
WSC079	3612 / 3012	WSC 063/087	18340 (8319)	20807 (9438)	19540 (8863)	22007 (9982)
WSC087	2609 / 2209	WSC 063/087	10980 (4981)	11990 (5439)	12180 (5525)	13190 (5983)
WSC087	2612 / 2212	WSC 063/087	12309 (5583)	13549 (6146)	13509 (6128)	14749 (6690)
WSC087	2609 / 2609	WSC 063/087	11716 (5314)	12960 (5879)	12916 (5859)	14160 (6423)
WSC087	2612 / 2612	WSC 063/087	13226 (5999)	14752 (6692)	14426 (6544)	15592 (7073)
WSC087	3009 / 2609	WSC 063/087	12892 (5848)	14246 (6462)	14092 (6392)	15446 (7006)
WSC087	3012 / 2612	WSC 063/087	14635 (6638)	16301 (7394)	15835 (7183)	17501 (7938)
WSC087	3009 / 3009	WSC 063/087	14076 (6385)	15644 (7096)	15276 (6929)	16844 (7640)
WSC087	3012 / 3012	WSC 063/087	16118 (7311)	18060 (8192)	17318 (7855)	19260 (8736)
WSC087	3609 / 3009	WSC 063/087	15913 (7218)	17929 (8133)	17113 (7762)	19129 (8677)
WSC087	3612 / 3012	WSC 063/087	18339 (8319)	20806 (9438)	19539 (8863)	22006 (9982)
WSC087	3612 / 3612	WSC 063/087	20584 (9337)	23799 (10795)	21784 (9881)	24999 (11340)
WSC100	3012 / 3012	WSC 100/126	19397 (8798)	21339 (9679)	20597 (9343)	22539 (10224)
WSC100	3612 / 3012	WSC 100/126	21578 (9788)	24045 (10907)	22778 (10332)	25245 (11451)
WSC100	3612 / 3612	WSC 100/126	23826 (10807)	27041 (12266)	25026 (11352)	28241 (12810)
WSC100	4212 / 3612	WSC 100/126	26457 (12001)	30260 (13726)	27657 (13545)	31460 (14270)
WSC100	4212 / 4212	WSC 100/126	29298 (13290)	34024 (15433)	30498 (13834)	35224 (15978)
WSC100	4812 / 4212	WSC 100/126	32024 (14526)	37623 (17066)	33224 (15070)	38823 (17610)
WSC126	3612 / 3012	WSC 100/126	21680 (9834)	24147 (10953)	22880 (10378)	25347 (11497)
WSC126	3612 / 3612	WSC 100/126	23928 (10854)	27143 (12312)	25128 (11398)	28343 (12856)
WSC126	4212 / 3612	WSC 100/126	26457 (12001)	30260 (13726)	27657 (12545)	31460 (14270)
WSC126	4212 / 4212	WSC 100/126	29298 (13290)	34024 (15433)	30498 (13834)	35224 (15978)
WSC126	4812 / 4212	WSC 100/126	32024 (14526)	37623 (17066)	33224 (15070)	38823 (17610)
WSC126	4812 / 4812	WSC 100/126	35016 (15883)	41817 (18968)	36216 (16427)	43017 (19513)

Unit	Evaporator / Condenser Size	Certified Drawing Number	Max. Unit Weight Without Starter		Max. Unit Weight With Starter	
			Shipping lbs. (kg)	Operating lbs. (kg)	Shipping lbs. (kg)	Operating lbs. (kg)
WDC050	1812 / 1612	F5182162	8861 (4019)	9564 (4338)	11261 (5108)	11964 (5427)
WDC050	1812 / 1812	F5182182	9217 (4181)	10018 (4544)	11617 (5269)	12418 (5633)
WDC050	1816 / 1816	F5186186	10468 (4748)	11268 (5111)	12868 (5837)	13668 (6200)
WDC050	2012 / 1812	F5202182	9671 (4387)	10534 (4778)	12071 (5475)	12934 (5867)
WDC050	2016 / 1816	F5206186	11024 (5000)	12110 (5493)	13424 (6089)	14510 (6582)
WDC050	2212 / 2212	F5222222	11123 (5045)	12403 (5626)	13523 (6134)	14803 (6715)
WDC050	2216 / 2216	F5226226	12874 (5840)	14485 (6470)	15274 (6928)	16885 (7659)
WDC050	2412 / 2212	F5242222	12348 (5601)	13836 (6276)	14748 (6690)	16236 (7365)
WDC050	2416 / 2216	F5246226	13957 (6331)	15820 (7176)	16357 (7419)	18220 (8264)
WDC050	2612 / 2212	F5262222	12836 (5822)	14428 (6544)	15236 (6911)	16828 (7633)
WDC050	2616 / 2216	F5266226	14642 (6642)	16643 (7549)	17042 (7730)	19043 (8638)
WDC063	2416 / 2416	F6246246	18673 (8470)	20422 (9263)	21407 (9710)	23156 (10503)
WDC063	2416 / 2616	F6246266	19365 (8784)	21294 (9577)	22099 (10024)	23848 (10817)
WDC063	2616 / 2416	F6266246	19282 (8746)	21207 (9639)	22016 (9986)	23763 (10779)
WDC063	2616 / 2616	F6266266	20025 (9083)	22091 (9939)	22759 (10323)	24646 (11179)
WDC063	3016 / 3016	F6306306	23545 (10680)	26405 (11830)	26279 (11920)	28815 (13070)
WDC079	3016 / 3016	F7306306	25131 (11399)	27671 (12551)	27531 (12488)	30071 (13640)
WDC079	3616 / 3016	F7366306	28763 (13047)	32018 (14523)	31163 (14135)	34418 (15612)
WDC079	3616 / 3616	F7366366	32027 (14527)	36115 (16382)	34427 (15616)	38515 (17470)
WDC087	3016 / 3016	F8306306	26157 (11865)	28697 (13017)	28891 (13105)	31431 (14257)
WDC087	3616 / 3016	F8366306	29789 (13512)	33044 (14989)	32523 (14752)	35778 (15322)
WDC087	3616 / 3616	F8366366	33053 (14993)	37141 (16847)	35787 (16233)	39875 (18087)
WDC100	3616 / 3616	F0366366	41816 (18967)	46513 (21098)	See Note	See Note
WDC100	4216 / 4216	F0426426	50470 (22893)	57463 (26065)	See Note	See Note
WDC100	4816 / 4816	F0486486	59185 (26846)	68996 (31296)	See Note	See Note
WDC100	4220 / 4220	F0420420	54802 (24858)	63248 (28689)	57202 (25946)	65648 (29777)
WDC100	4820 / 4820	F0480480	65964 (29921)	77698 (35243)	68364 (31009)	80098 (36332)
WDC126	3616 / 3616	F0366366	41816 (18967)	46513 (21098)	See Note	See Note
WDC126	4216 / 4216	F0426426	50470 (22893)	57463 (26065)	See Note	See Note
WDC126	4816 / 4816	F0486486	59185 (26846)	68996 (31296)	See Note	See Note
WDC126	4220 / 4220	F2420420	54802 (24858)	63248 (28689)	57202 (25946)	65648 (29777)
WDC126	4224 / 4224	F2424424	62519 (28358)	72345 (32815)	64919 (29447)	74745 (33904)
WDC126	4820 / 4820	F2480480	65964 (29921)	77698 (35243)	68364 (31009)	80098 (36332)
WDC126	4824 / 4824	F2484484	75831 (34396)	89410 (40556)	78231 (35485)	91810 (41644)

Note: Unit not available with factory mounted starters.

Pumpout Units



Model Number	Overall Unit Length "A"	Overall Unit Width "B"	Overall Unit Height "C"	"D"	"E"	"F"	"G"	"H"	Storage Capacity at 90°F lbs (kg)	Weight Empty lbs (kg)
LSA 5000	204 1/2 (5194)	35 (889)	54 5/8 (1387)	18 1/2 (470)	37 1/2 (953)	201 1/2 (5118)	31 (787)	30 3/4 (781)	4570 (2073) At 80% Full	4889 (2218)
LSA 3600	152 1/8 (3854)	35 (889)	54 1/8 (1377)	18 1/2 (470)	37 1/2 (953)	149 1/8 (3788)	31 (787)	30 (762)	3202 (1195) At 80% Full	3483 (1301)
LSA 2200	108 1/8 (2746)	35 (889)	54 1/8 (1377)	18 1/2 (470)	37 1/2 (953)	105 1/8 (2670)	31 (787)	30 (762)	2199 (821) At 80% Full	3043 (1137)
LSA 1600	167 3/4 (4261)	35 (635)	44 1/8 (1123)	13 1/2 (343)	27 ½ (699)	164 3/4 (4185)	21 (533)	20 (508)	1586 (592) At 80% Full	2015 (753)
LSA 1200	118 1/4 (3004)	25 (635)	44 1/8 (1123)	13 1/2 (343)	27 1/2 (699)	115 1/4 (2927)	21 (533)	20 (508)	1078 (403) At 80% Full	1797 (672)

Notes:
1. All dimensions in inches (mm).
2. 3 in. lifting holes are provided.
3. The shipping skid adds 6 in. to overall height.
4. The optional casters are field installed and add 11 in. to unit height.
5. I in. liquid receiver valves must be piped per ANSI 15 for each storage tank.
6. Refer to evaporator physical data on page 30 for unit refrigerant charge.
7. Use certified drawings from local sales office for more dimensional detail and for construction.

Electrical Data

Centrifugal compressor motors have been redesigned to increase efficiencies well into the 90% range. This design change is particularly important since it represents a motor characteristic that directly impacts the system's watt-hour meter. In addition, the motor efficiency, unlike power factor, is a design characteristic that cannot be improved on the job.

Motor and Voltage Code

The typical unit model number below displays the three digits used to identify the motor and voltage codes:

WSC 126K BS 72 R

Motor Code — 72; Voltage Code — R

The motor described by motor and voltage code letters will determine the maximum kW, locked rotor amperes, power factor and voltage found in the Motor Data Tables.

Wiring and Conduit

Wire sizes should comply with local and state electrical codes. Where total amperes require larger conductors than a single conduit would permit (limited by dimensions of motor terminal box), two or more conduits may be used. Where multiple conduits are used, all three phases must be balanced in each conduit. Failure to balance each conduit will result in excessive heating of the conductors and unbalanced voltage.

An interposing relay may be required on remote mounted starter applications when the length of the conductors run between the chiller and starter is excessive.

Note: On WDC dual compressor units, dual power leads are standard, requiring separate power leads properly sized and protected to each compressor starter. Separate disconnects must be used.

Motor Data

10⇒	Motor nominal horsepower ÷ 10
A⇒	Compressor that motor is used on; A = 050, B = 063 to 087, C = 100 to 126

60 Hertz

Motor Code	Nameplate Volts	200	208	220	230	240	380	440	460	480	575	2400	3300	4160	6600
	Voltage Code	N	B	P	V	W	U	A	R	S	D	M	C	L	2
	Min/Max Volts	180/ 220	187/ 229	198/ 242	208/ 253	216/ 264	342/ 418	396/ 484	414/ 506	432/ 528	518/ 633	2160/ 2640	2970/ 3630	3744/ 4575	5940/ 7260
10 A	Max kW	87	87	87	86	86	86	87	86	86	86				
	Locked Rotor Amps	1104	1148	947	990	1033	613	473	495	517	405				
	Power Factor	.90	.90	.90	.90	.89	.90	.90	.90	.89	.89				
13 A	Max kW	111	111	111	111	110	111	111	111	110	111				
	Locked Rotor Amps	1548	1610	1291	1350	1409	832	646	675	704	544				
	Power Factor	.89	.88	.89	.89	.87	.88	.89	.89	.87	.88				
15 A	Max kW	124	123	124	124	124	124	124	124	123	123				
	Locked Rotor Amps	1813	1886	1469	1536	1603	890	735	768	801	610				
	Power Factor	.87	.86	.88	.87	.86	.88	.88	.87	.86	.87				
18 B	Max kW	145	145	146	145	145	145	146	145	145	145				
	Locked Rotor Amps	2850	2975	2294	2402	2517	1617	1147	1201	1259	1022				
	Power Factor	.89	.87	.90	.89	.87	.87	.90	.89	.87	.88				
19 B	Max kW												141	141	142
	Locked Rotor Amps												179	223	83
	Power Factor												.88	.80	.87

(Continued next page)

Compressor Motor Data, 60 Hz. (continued)

Motor Code	Nameplate Volts	200	208	220	230	240	380	440	460	480	575	2400	3300	4160	6600
	Voltage Code	N	B	P	V	W	U	A	R	S	D	M	C	L	2
	Min/Max Volts	180/ 220	187/ 229	198/ 242	208/ 253	216/ 264	342/ 418	396/ 484	414/ 506	432/ 528	518/ 633	2160/ 2640	2970/ 3630	3744/ 4575	5940/ 7260
20 B	Max kW	155	155	155	155	155	155	155	155		155	141			
	Locked Rotor Amps	2833	2954	2472	2591	2712	1516	1289	1352		1020	203			
	Power Factor	.91	.90	.91	.90	.90	.91	.91	.90		.90	.90			
21 B	Max kW											165	165	165	167
	Locked Rotor Amps											242	179	223	94
	Power Factor											.89	.89	.83	.87
23 B	Max kW	180	180	181	180	180	180	181	180	180	180				
	Locked Rotor Amps	3885	4063	2964	3112	3238	1849	1482	1556	1619	1244				
	Power Factor	.86	.83	.90	.88	.86	.89	.90	.88	.86	.88				
25 B	Max kW	194	194	194	194	194	194	194	194	194	194	196	197	196	198
	Locked Rotor Amps	3429	3576	3133	3287	3443	1863	1535	1610	1686	1302	295	206	223	105
	Power Factor	.90	.90	.90	.90	.88	.90	.90	.90	.89	.90	.88	.89	.86	.88
29 B	Max kW	228	228	228	228	228		228	228	227	228				
	Locked Rotor Amps	3678	3839	3643	3832	4023		1672	1742	1828	1392				
	Power Factor	.90	.90	.90	.88	.86		.90	.89	.88	.90				
31 B	Max kW	233	233	233	233	233	233	233	233	233	233				
	Locked Rotor Amps	4988	5195	3547	3726	3924	2388	1901	2008	2099	1576				
	Power Factor	.87	.84	.90	.89	.88	.88	.89	.88	.86	.88				
32 B	Max kW											251	251	251	254
	Locked Rotor Amps											357	276	223	117
	Power Factor											.89	.88	.88	.90
34 B	Max kW	272	272	272	272	272	272	272	272	272	272				
	Locked Rotor Amps	5156	5370	4055	4279	4472	2762	2125	2225	2325	1787				
	Power Factor	.89	.88	.90	.90	.89	.89	.90	.89	.88	.89				
35 B	Max kW	276	276	276	275	275	275	276	275	275	276				
	Locked Rotor Amps	4280	4482	3828	4024	4226	2610	1914	2012	2113	1479				
	Power Factor	.90	.90	.91	.90	.88	.89	.91	.90	.88	.90				
40 B	Max kW	314	314	316	315	315	315	315	314	314	314				
	Locked Rotor Amps	5377	6045	4640	5255	5494	2536	2329	2638	2758	2210				
	Power Factor	.89	.87	.90	.88	.86	.90	.90	.88	.86	.87				
41 B	Max kW	311	311	311	311	311	311	311	311	311	311	322	322	323	324
	Locked Rotor Amps	5569	5801	5102	5344	5585	3018	2408	2521	2635	1991	435	316	245	160
	Power Factor	.91	.90	.91	.90	.88	.90	.91	.90	.89	.90	.90	.90	.90	.89
45 B	Max kW						355	355	355	355	355				
	Locked Rotor Amps						2965	2443	2559	2675	2223				
	Power Factor						.88	.89	.88	.86	.86				
47 B	Max kW	350	350	350	350	350	350	350	350	350	350				
	Locked Rotor Amps	6876	7162	5451	5709	5968	3482	2725	2854	2983	2193				
	Power Factor	.89	.87	.90	.89	.88	.89	.90	.89	.88	.90				
49 B	Max kW	388	388	388	388	388	388	388	388	388	38				
	Locked Rotor Amps	7045	7339	5898	6177	6456	3589	2957	3097	3238	2753				
	Power Factor	.91	.90	.91	.90	.89	.91	.91	.90	.89	.89				
50 B	Max kW						393	393	393	393	393	392	392	392	395
	Locked Rotor Amps						3660	2951	3091	3232	2500	548	409	323	184
	Power Factor						.88	.89	.87	.86	.87	.90	.89	.89	.90
55 C	Max kW							419	436	449	428	452		455	
	Locked Rotor Amps							3335	3494	3654	2511	610		352	
	Power Factor							.90	.90	.88	.90	.88		.90	
57 B	Max kW	447	447	447	447	447	447	447	447	447	447				
	Locked Rotor Amps	8412	8763	7286	7632	7979	4279	3642	3815	3989	3053				
	Power Factor	.89	.87	.90	.88	.86	.89	.90	.88	.86	.88				
58 B	Max kW											452	452	452	453
	Locked Rotor Amps											636	457	362	220
	Power Factor											.89	.89	.89	.90
61 C	Max kW											470	470	470	472
	Locked Rotor Amps											632	442	365	249
	Power Factor											.85	.85	.85	.84
62 C	Max kW						466	466	465	465	466				
	Locked Rotor Amps						4304	3665	3839	4013	2736				
	Power Factor						.91	.91	.90	.89	.91				
65 B	Max kW											510	510	510	
	Locked Rotor Amps											792	548	416	
	Power Factor											.89	.89	.90	
66 B	Max kW	505	505	505	505	505	505	505	505	505	505				
	Locked Rotor Amps	8069	8406	8069	8452	8836	4778	3737	3914	4092	3131				
	Power Factor	.91	.91	.90	.89	.87	.90	.91	.90	.89	.90				

(Continued next page)

Compressor Motor Data, 60 Hz. (continued)

Motor Code	Nameplate Volts	200	208	220	230	240	380	440	460	480	575	2400	3300	4160	6600
	Voltage Code	N	B	P	V	W	U	A	R	S	D	M	C	L	2
	Min/Max Volts	180/ 220	187/ 229	198/ 242	208/ 253	216/ 264	342/ 418	396/ 484	414/ 506	432/ 528	518/ 633	2160/ 2640	2970/ 3630	3744/ 4575	5940/ 7260
72 C	Max kW											567	567	567	569
	Locked Rotor Amps											819	540	473	314
	Power Factor											.85	.86	.85	.84
73 C	Max kW						563	565	564	563	563				
	Locked Rotor Amps						4965	3792	3973	4153	3552				
	Power Factor						.91	..92	.91	.91	.91				
84 C	Max kW											664	665	664	667
	Locked Rotor Amps											884	648	511	372
	Power Factor											.87	.87	.87	.85
85 C	Max kW						660	662	660	660	660				
	Locked Rotor Amps						5692	4572	4790	5008	3830				
	Power Factor						.92	.92	.92	.91	.92				
K0 C	Max kW						777	777	775	774	775				
	Locked Rotor Amps						6612	5618	5885	6155	4811				
	Power Factor						.92	.92	.92	.91	.92				
N0 C	Max kW											781	780	781	782
	Locked Rotor Amps											1077	772	622	457
	Power Factor											.87	.87	.87	.85
N1 C	Max kW														860
	Locked Rotor Amps														535
	Power Factor														.84
K2 C	Max kW						931	932	931	930	930				
	Locked Rotor Amps						7806	6446	6753	7061	5736				
	Power Factor						.92	.92	.91	.91	.91				
N2 C	Max kW											937	938	937	
	Locked Rotor Amps											1304	872	756	
	Power Factor											.88	.88	.88	
N3 C	Max kW						1011	1012	1012	1011	1011	1014	1014	1014	
	Locked Rotor Amps						8343	7519	7090	6748	5613	1428	1022	825	
	Power Factor						.88	.88	.88	.88	.88	.88	.88	.88	
M4 C	Max kW						990	998	1045	1092	1044	1098		1098	
	Locked Rotor Amps						7860	7317	7663	8009	6022	1339		773	
	Power Factor						.92	.92	.91	.91	.91	.90		.90	

50 Hertz

Motor Code	Nameplate Volts	220	346	380	400	415	440	3300	6000	6600
	Voltage Code	E	Y	F	G	K	H	J	8	9
	Min/Max Volts	198/242	311/381	342/418	360/440	374/457	396/484	2970/3630	5400/6600	5940/7260
8 A	Max kW	73	73	73	73	73	73			
	Locked Rotor Amps	912	625	462	505	524	456			
	Power Factor	.89	.89	.90	.90	89	.89			
10 A	Max kW	94	93	94	94	94	93			
	Locked Rotor Amps	1278	850	656	690	716	639			
	Power Factor	.88	.86	.89	.88	.87	.88			
13 A	Max kW	114	114	114	113	112	113			
	Locked Rotor Amps	1434	910	746	785	814	717			
	Power Factor	.87	.86	.88	.87	.85	.87			
17 B	Max kW	130	130	130	130	130	130			
	Locked Rotor Amps	2349	1647	1324	1399	1455	1175			
	Power Factor	.90	.89	.90	.89	.89	.90			
18 B	Max kW	152	151	152	151	151	152			
	Locked Rotor Amps	2544	1965	1498	1585	1638	1272			
	Power Factor	.89	.84	.89	.86	.84	.89			
19 B	Max kW							142	144	143
	Locked Rotor Amps							209	89	95
	Power Factor							.86	.86	.85
20 B	Max kW	162	162	162	162	162	162			
	Locked Rotor Amps	2740	2027	1577	1666	1735	1423			
	Power Factor	.90	.88	.90	.90	.88	.90			
21 B	Max kW							165	168	167
	Locked Rotor Amps							209	98	95
	Power Factor							.88	.88	.87

(Continued next page)

Compressor Motor Data, 50 Hz. (continued)

Motor Code	Nameplate Volts	220	346	380	400	415	440	3300	6000	6600
	Voltage Code	E	Y	F	G	K	H	J	8	9
	Min/Max Volts	198/242	311/381	342/418	360/440	374/457	396/484	2970/3630	5400/6600	5940/7260
23 B	Max kW	191	191	192	191	191	191			
	Locked Rotor Amps	3281	2311	1688	1771	1849	1640			
	Power Factor	.88	.85	.90	.88	.86	.88			
25 B	Max kW	195	195	195	195	195	195	210	212	211
	Locked Rotor Amps	3485	2588	1956	2075	2156	1859	209	108	121
	Power Factor	.88	.85	.89	.87	.85	.87	.89	.90	.87
31 B	Max kW	228	228	228	228	228	228			
	Locked Rotor Amps	3666	2993	2179	2298	2388	1921			
	Power Factor	.90	.85	.90	.88	.87	.89			
32 B	Max kW							271	271	271
	Locked Rotor Amps							230	144	135
	Power Factor							.91	.89	.89
34 B	Max kW	260	260	260	260	260	260			
	Locked Rotor Amps	4366	3267	2468	2603	2704	2429			
	Power Factor	.90	.88	.90	.89	.88	.89			
35 B	Max kW	263	263	264	263	263	263			
	Locked Rotor Amps	4753	2718	2349	2669	2775	2376			
	Power Factor	.87	.88	.89	.86	.84	.87			
41 B	Max kW	293	293	293	293	293	293	328	329	329
	Locked Rotor Amps	4664	3771	2793	2946	3061	2429	303	198	180
	Power Factor	.90	.85	.90	.88	.86	.90	.90	.89	.89
45 C	Max kW		355	355	355	355		363		
	Locked Rotor Amps		3901	2979	3143	3267		334		
	Power Factor		.85	.88	.86	.84		.91		
47 B	Max kW	325	325	325	325	325	325			
	Locked Rotor Amps	5839	3885	3030	3196	3321	2758			
	Power Factor	.89	.89	.91	.90	.88	.90			
49 B	Max kW	374	374	374	374	374	374			
	Locked Rotor Amps	6238	4632	3732	3937	4092	3118			
	Power Factor	.89	.86	.89	.86	.84	.89			
50 B	Max kW							380	380	381
	Locked Rotor Amps							339	212	191
	Power Factor							.90	.90	.90
52 C	Max kW							395	397	395
	Locked Rotor Amps							343	212	224
	Power Factor							.86	.86	.85
53 C	Max kW		389	390	389	389	389			
	Locked Rotor Amps		4655	3752	3958	4113	3547			
	Power Factor		.89	.91	.89	.88	.90			
57 B	Max kW	424	424	424	424	424	424			
	Locked Rotor Amps	6754	5170	3827	4037	4195	3619			
	Power Factor	.90	.87	.90	.89	.88	.89			
58 B	Max kW							426		
	Locked Rotor Amps							390		
	Power Factor							.91		
59 C	Max kW							472	474	473
	Locked Rotor Amps							445	294	268
	Power Factor							.86	.83	.86
62 C	Max kW		467	470	468	468	468			
	Locked Rotor Amps		5370	3880	4093	4255	3920			
	Power Factor		.89	.92	.91	.90	.91			
65 B	Max kW							482		
	Locked Rotor Amps							443		
	Power Factor							0.91		
71 C	Max kW							551	551	551
	Locked Rotor Amps							480	319	306
	Power Factor							.88	.86	.85
73 C	Max kW		545	547	545	545	546			
	Locked Rotor Amps		6151	4676	4933	5126	4280			
	Power Factor		.90	.92	.91	.90	.91			
83 C	Max kW							653	654	654
	Locked Rotor Amps							584	412	333
	Power Factor							.88	.85	.87
85 C	Max kW		646	647	646	645	646			
	Locked Rotor Amps		7143	5743	6059	6297	5541			
	Power Factor		.91	.92	.91	.90	.91			

(Continued next page)

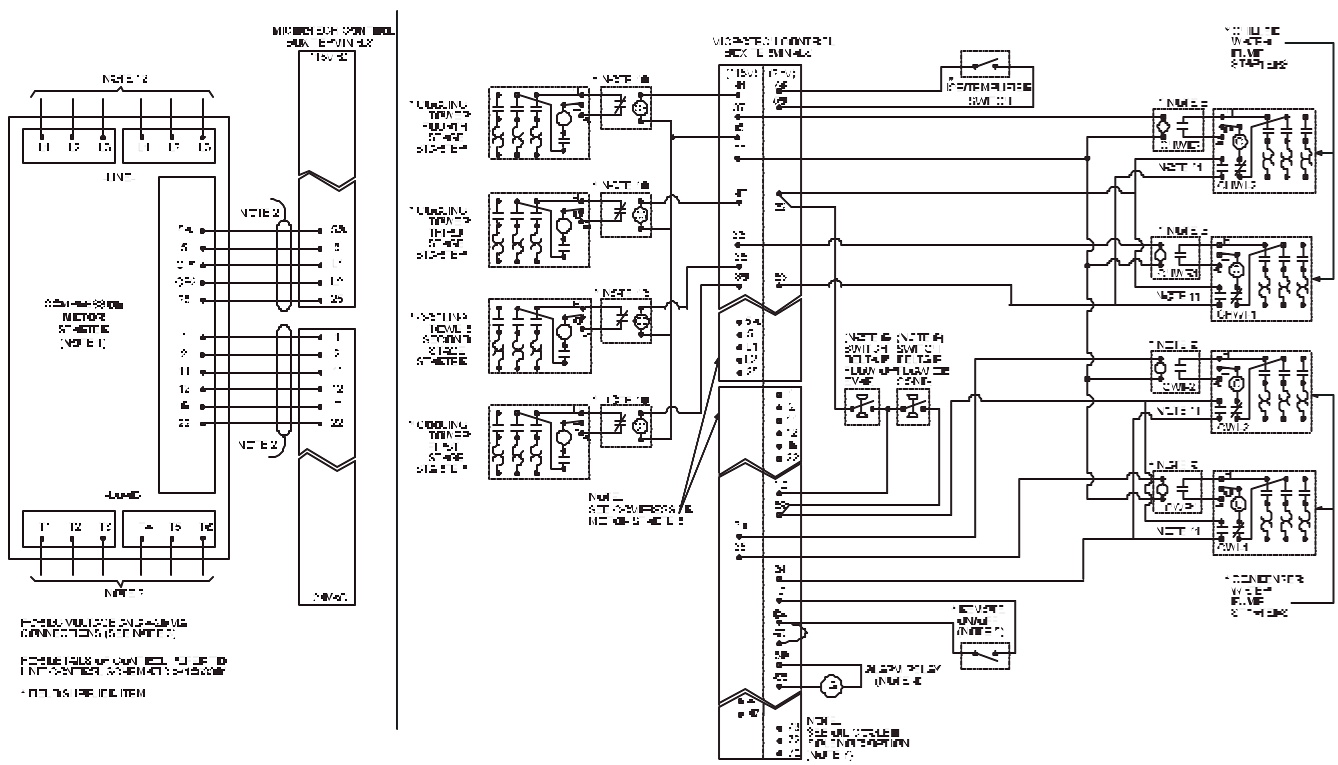
Compressor Motor Data, 50 Hz. (continued)

Motor Code	Nameplate Volts	220	346	380	400	415	440	3300	6000	6600
	Voltage Code	E	Y	F	G	K	H	J	8	9
	Min/Max Volts	198/242	311/381	342/418	360/440	374/457	396/484	2970/3630	5400/6600	5940/7260
91 C	Max kW									721
	Locked Rotor Amps									439
	Power Factor									.84
K0 C	Max kW		778	780	778	778	780			
	Locked Rotor Amps		8440	6590	6956	7231	5685			
	Power Factor		.90	.91	.91	.89	.91			
N0 C	Max kW							785	784	785
	Locked Rotor Amps							738	548	498
	Power Factor							.88	.84	.84
N1 C	Max kW		842	845	843	844	846	849		
	Locked Rotor Amps		7795	6930	6658	5975	5565	774		
	Power Factor		.88	.88	.88	.89	.89	.89		
N2 C	Max kW		937	935	940	940	938	940		
	Locked Rotor Amps		8522	8125	6898	6532	6003	867		
	Power Factor		.89	.88	.90	.90	.90	.89		

Field Wiring

Model WSC/WDC centrifugal chillers require field connected power and interlock wiring to complete their integration into an operating system.

Typical Field Connection Diagram, WSC Unit



Notes:

1. Compressor motor starters are either factory mounted and wired or shipped separate for field wiring. If provided by others, starters must comply with McQuay specification 359A999. All line and load side power conductors must be copper.
2. If starters are free standing then field wiring between the starter and the control panel is required. Minimum wire size for 115 VAC is 12GA for maximum length of 50 feet. If greater than 50 feet, refer to McQuay for recommended wire size minimum. Wire size for 24 VAC is 18 GA. All wiring to be installed as NEC class 1 wiring system. All 24 VAC wiring must run in separate conduit from 115 VAC wiring. Main power wiring between starter and motor terminal is factory installed when units are supplied with mounted starters. Wiring of free standing starter must be done in accordance with NEC, and connection to compressor motor terminals must be made with copper wire and copper lugs only.
3. For optional sensor wiring see unit control diagram - Terminals AH1 through AH6. It is recommended that DC wires be run separately from 115 VAC wiring.
4. A customer furnished 24 volt alarm relay coil may be connected between terminals 50 and 68 of the control panel. The alarm is operator programmable. Maximum rating of the alarm relay coil is 25 VA.
5. Remote On/Off control unit can be accomplished by installing a set of dry contacts between terminals 9 and 64. If an additional point of On/Off control is required remove jumper from terminals 64 and 65 and install the additional set of dry contacts.
6. Evaporator and condenser paddle type flow switches or pressure differential switches are required and must be wired as shown. Field supplied pressure differential switches must be installed across the vessel and not the pump.
7. A 115 VAC oil cooler solenoid (OC1) or a two solenoid 24 VAC oil cooler motorized valve. (OC1, OC2) are two options required on some models. Refer to the installation manual and wire as shown.
8. Optional customer supplied 115 VAC 25VA maximum coil rated chilled water pump relay (CHWR 1 and 2) may be wired as shown. This option will cycle the chilled water pump in response to building load.
9. The condenser water pump must cycle with the unit. A customer supplied 115VAC 25VA maximum coil rated condenser water pump relay (CWR 1 and 2) is to be wired as shown.
10. Optional customer supplied 115 VAC 25 VA maximum coil rated cooling tower fan relays (C1 - C4) may be wired as shown. This option will cycle the cooling tower fans in order to maintain unit head pressure.
11. Auxiliary 24 VAC rated contacts in both the chilled water and condenser water pump starters must be wired as shown.
12. All wiring to be NEC Class 1.

Control Power

The 115 volt control power may be supplied from the starter or a 2 KVA transformer separate from the starter. Either source should be properly fused with 20 amp dual element fuses or with a circuit breaker selected for motor duty. If the control transformer or other power source for the control panel is remote from the unit, conductors must be sized for a maximum voltage drop of 3%. Required circuit ampacity is 20 amps at 115 volts. Conductor size for long runs between the control panel and power source, based upon National Electrical Code limitations for 3% voltage drop, may be determined from the table below.

Control Power Line Sizing

Maximum Length, FT (M)	Wire Size (AWG)	Maximum Length, FT (M)	Wire Size (AWG)
0 (0) to 50 (15.2)	12	120 (36.6) to 200 (61.0)	6
50 (15.2) to 75 (22.9)	10	200 (61.0) to 275 (83.8)	4
75 (22.9) to 120 (36.6)	8	275 (83.8) to 350 (106.7)	3

Notes:

1. Maximum length is the distance a conductor will traverse between the control power source and the unit control panel.
2. Panel terminal connectors will accommodate up to number 10 AWG wire. Larger conductors will require an intermediate junction box.

Motor Starters

McQuay has a wide variety of starter types and options to fit virtually all applications. The specifics of the final selection of size and enclosure are covered in the product manual *PM Starters*. Please consult the local McQuay sales office or this manual for starter details. This section contains a general overview only.

Mounting Options

Factory furnished, factory mounted; on vessel stacks larger than E3616/C3016, the starters are shipped loose with cable kits and mounting brackets for field installation on the units by others.

Factory furnished, floor mounted; drop shipped to job site for setting and wiring by others.

Furnished by others; must meet McQuay Starter Specification and be approved by McQuay Engineering.

Low Voltage Starters (200 through 600 volts)

Standard equipment

Low voltage starters are continuous duty AC magnetic type with air break contactors. Enclosures are NEMA 1A, gasketed door, with top cable entry (bottom entry optional). Main control relays are redundant with coils in parallel and contacts in series. Included are overload protection, phase failure and reversal protection, stall protection, undervoltage protection and control transformer.

Wye-Delta closed transition

This starter (sometimes called "Star-Delta") is the most popular type for centrifugal chiller applications. It reduces inrush current by first connecting six motor terminals in a "Wye" configuration to reduce the maximum inrush current to 33.3% of locked rotor amps and producing 33.3% of normal starting torque. After a brief delay, the electrical load is momentarily transferred to resistors while the motor terminal connections are changed to the delta configuration. The resistors minimize the second inrush current when the Delta leads becomes active. Open transition starters (without resistors) are not recommended.

Autotransformer

This starter type uses a transformer with 50%, 65%, and 80% taps. The taps determine the initial voltage and resulting inrush amps that will reach the motor. For centrifugal compressors, the 65% tap is used allowing 42% of normal inrush current and generating 42% of starting torque. The 50% tap will usually not generate enough starting torque and the 80% tap allows unnecessary inrush (64% of LRA). After a designated time period, a bypass contactor closes allowing normal current to flow to the motor and removes the transformers from service. There is little reason to use autotransformer type starters with centrifugal compressors, except for applications where it is desirable to have the same type of starter throughout a facility.

Solid state starters

The solid state starters are another excellent type of starter for centrifugal compressors. This starter uses solid state switching devices called SCRs (Silicon Controlled Rectifiers) that control the flow of current to the motor during start up.

The SCR's control the amount of voltage that reaches the motor which in turn controls the motor's acceleration and current inrush. Eventually, full voltage is applied and a bypass contactor is energized. The bypass contactor, which is standard in the McQuay solid state starters, removes the SCR's from service and eliminates SCR losses and heat buildup while the unit is operating. Although setpoints are determined by the compressor size, motor characteristics and starting torque, requirements usually are a minimum of three times the RLA for the compressor's specific application.

Solid state starters are generally used in applications where it is desirable to provide precise control of motor starting characteristics. The inrush current can sometimes be reduced below Wye-Delta starters in severely limited utility electrical distribution systems.

Options for Low Voltage Starters

Canadian Standards Association (CSA) certification and label

Circuit breaker as a control disconnect

Fuse block (fuses by others) with disconnect

Ground fault protection

Medium Voltage Starters (2300 to 6900 Volts)

Standard Equipment

Medium voltage starters are NEMA Class E2 continuous duty AC and include isolated vertical line contactors; drawout three-pole; gang operated line isolating switch; current limiting fuse block with fuses; drawout three-pole; vacuum break contactor; control transformer; control circuit primary and secondary fuse block; current transformers, and phase failure and reversal relay.

Across-the-line starter

Across-the-line starters are very simple and consist of a primary contactor that allows locked rotor amps to reach the motor when energized. These starters are low cost, provide the highest starting torque, require the least maintenance and can be used with any standard motor. However, they have the highest starting inrush current.

Autotransformer starter

In addition to the standard equipment listed above are: drawout magnetic, three-pole, vacuum break shorting assembly, drawout three-pole, vacuum break starting contactor, and starting auto-transformer. The autotransformer starter operation was discussed in the low voltage starter section.   As with low voltage starters, the 65% tap is used for centrifugal compressors providing 42% starting torque with 45% inrush current. The time for the starter to transition from reduced current to full voltage as the motor reaches the proper speed is critical to get a relatively shock free transition.

Once the starting sequence begins, the motor is not disconnected from the line which prevents a second inrush "spike" from occurring. Autotransformer starters are a good choice because of their efficiency and flexibility. All power taken from the line is transmitted to the motor except for some transformer losses during starting. They are not smooth starting, they may shock machinery if the timing cycle for the motor and starter are not closely matched.

Primary reactor starter

In addition to the standard equipment listed above: drawout magnetic, three-pole vacuum break shorting assembly and three-phase starting reactor factory set at 65% tap. These starters are similar in operation to the autotransformer, however they provide 42% starting torque with 65% inrush of locked rotor current.

Additional Options for Medium Voltage Starters

Certifications and Approvals

- UL certification for full voltage starters
- UL certification for reduced voltage starters
- CSA certification for full voltage starters
- CSA certification for reduced voltage starters

Options for Low and Medium Voltage Starters

Metering devices

Ammeters, voltmeters

Deluxe motor protection system

The deluxe motor protection system is the IQ-DP-4000 which includes an ammeter, voltmeter, watt-hour meter, wattmeter, power factor meter, frequency meter, undervoltage protection, overvoltage protection, phase loss, phase reversal and phase unbalance in a single device.

Protection device options

Overvoltage relay and lightning arrestors.

Pilot devices

Indicating lights, additional electrical interlocks and control relays.

NEMA modifications

- NEMA 1A -- adds a gasket to the starter door of NEMA 1 construction (option on medium voltage starters, standard on low voltage starters)
- NEMA 3R -- Rain resistant construction
- NEMA 4 -- Rain tight construction *****
- NEMA 4/4X with stainless steel construction for both non combustion and combustion use *****
- NEMA 12 -- Dust tight construction *****

*** Low voltage starters only**

Pumps

Model WSC and WDC chiller compressor motors operate at 3600 rpm at 60 Hz (3000 rpm at 50 Hz). To avoid the possibility of objectionable harmonics in the system piping, the use of 3600 (3000) rpm system pumps should be avoided. The condenser water pump(s) must be cycled off when the last chiller of the system cycles off. This will help to maintain proper separation of oil and refrigerant within the chiller. In addition, turning off the condenser water pump(s) when the chillers are not operating will conserve energy.

Evaporator Water Temperature

If used as chilled water, the temperature of system heating water should not exceed 110°F (43.3°C) when introduced into the evaporator.

System Water Volume

All chillers need adequate time to recognize a load change, respond to the load change and stabilize without short-cycling the compressor. There is a distinct relationship between the minimum capacity of the chiller plant, the system minimum expected capacity, system water volume, the desired interval between starts, and the dead band of the chiller controller-the number of degrees between shut off and turn on. McQuay centrifugal chillers unload to 10% (5% for dual compressor units), have as little as 20 minutes between starts (adjustable from 60 to 20 minutes), and a factory default value of 6 degrees F of chilled water temperature between shut off and restart (adjustable 2 to 20°F). There must be sufficient time/volume when the compressor is running with more capacity than system load, plus sufficient time/volume for the compressor to be off during the required anti-cycle time. These relationships are expressed in the following formula:

$$V = \frac{TS}{500\left(\frac{TD}{H1 - H2} + \frac{TD}{H2}\right)}$$

Where: *V* = Total system U.S. gallons

TS = Time between starts (min)

TD = Dead band range of controller (°F)

H1 = Chiller minimum capacity (btu/hr)

H2 = Minimum system capacity (btu/hr)

Condenser Water Temperature

When ambient wet bulb temperature are lower than design, the entering condenser water temperature may be allowed to fall. Lower temperatures, to a predetermined minimum, improve chiller performance.

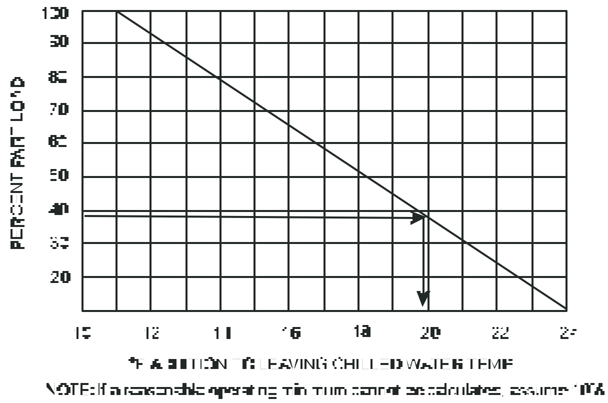
Normally, McQuay centrifugal chillers will start with entering condenser water temperature of 55°F (42.8°C).

During normal operation the minimum entering condenser water temperature (assuming 3 gpm per ton flow) is a function of the leaving chilled water temperature and load. The table below gives the approximate minimum condenser water temperatures as a function of these variables. These values may be lower in mild climates and low wet bulb areas.

Depending on local climatic conditions, using the lowest possible entering condenser water temperature may be more costly in total system power consumed than the expected savings in chiller power would suggest due to the excessive fan power required.

To obtain 55°F (12.8°C) entering condenser water temperature with a tower selected to produce 85°F (29.4°C) water temperature at design ambient air temperatures, cooling tower fans must continue to operate at 100% capacity at low wet bulb temperatures. As chillers are selected for lower kW per ton, the cooling tower fan motor power becomes a higher percentage of the peak load chiller power. On the other hand, the low condenser water temperatures may be easy to achieve in mild climates with low wet bulb temperatures.

Even with tower fan control, some form of water flow control such as tower bypass is recommended.



Oil Coolers

WSC-048/050 and WDC-048/050 units are equipped with internal self-contained refrigerant-cooled oil coolers and require no field piping for the coolers.

WSC 063, 079, 087, 100 and 126 single compressor units have a factory mounted water-cooled oil cooler, temperature controlled water regulating valve and solenoid valve, all as standard. Connection location is inboard of the compressor location. Accessories must be installed as shown in the following piping diagrams.

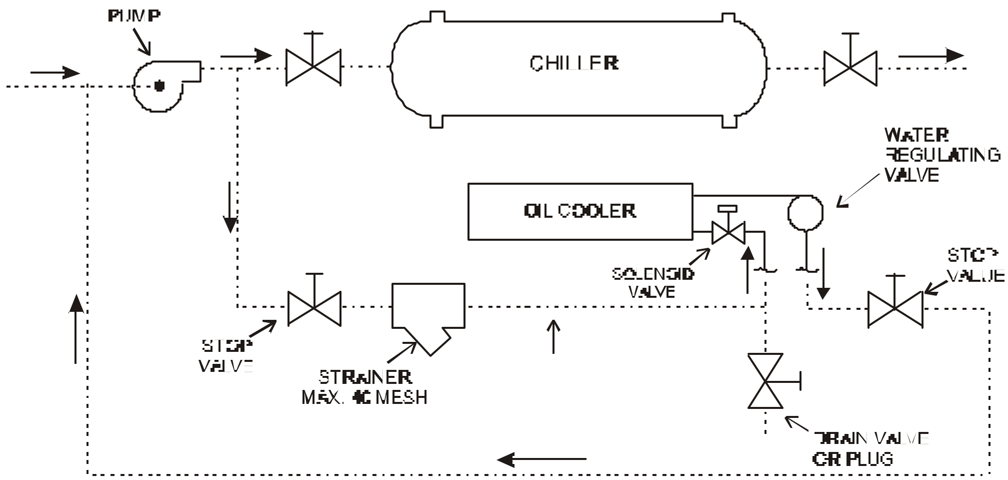
WDC 063, 079, 087, 100 and 126 dual compressor units are equipped as above but the water piping for the two oil coolers cooling is factory piped to a common connection at the tube sheet.

Field water piping to the inlet and outlet connections must be installed according to good piping practices and should include stop valves to isolate the cooler for servicing. A 1" minimum cleanable filter (40 mesh maximum), a solenoid stop valve wired in accordance with the field connection control diagram (also available as a factory installed option,), and drain valve or plug should also be field installed. The water supply for the oil cooler may be either from the chilled water circuit (preferred and recommended) or from an independent source such as city water. When using chilled water it is important that the water pressure drop through the oil cooler be less than the drop across the evaporator or insufficient oil cooler flow will result. This is normally no problem except on single pass evaporators in which case the oil cooler water should be piped across the chilled water pump to provide the maximum possible head and flow.

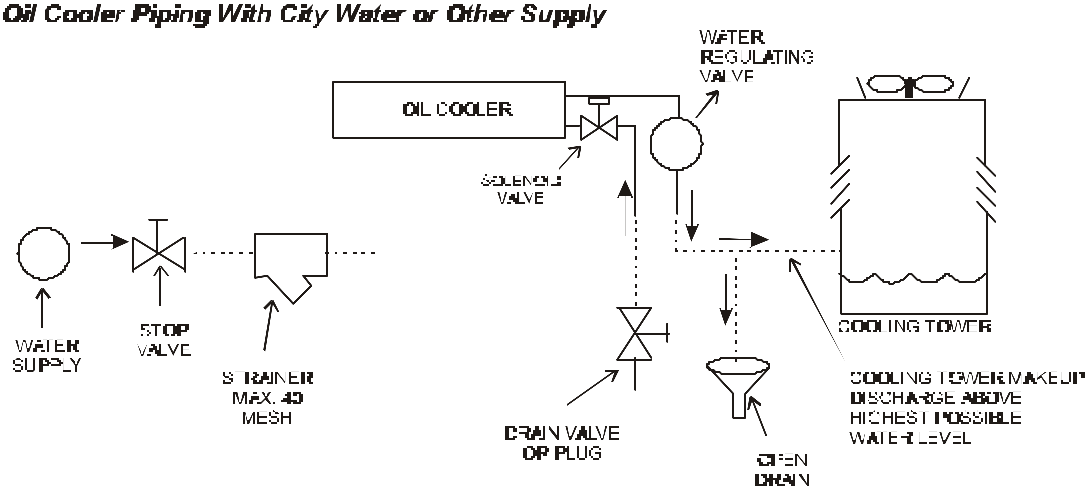
The water flow through the oil cooler will be adjusted by the regulating valve so that the temperature of oil supplied to the compressor bearings (leaving the oil cooler) is between 80°F and 110°F (27°C and 43°C).

When supplied with city water, the oil piping should discharge through a trap into an open drain to prevent draining the cooler by siphoning. The city water may also be used for cooling tower makeup by discharging it into the tower sump from a point above the highest possible water level.

Recommended Oil Cooler Water Piping Across Chilled Water Pump



Oil Cooler Piping With City Water or Other Supply



Machine Room Ventilation

In the market today centrifugal chillers are available with either hermetic or open type motors. Hermetic motors are cooled with refrigerant and dissipate their heat through the cooling tower. On the other hand, open motors circulate equipment room air across themselves for cooling and reject the heat to the equipment room. McQuay chillers have hermetic motors and DO NOT require additional ventilation.

For chillers with air-cooled motors, good engineering practice dictates that the motor heat be removed to prevent high equipment room temperatures. In many applications this requires a large volume of ventilation air or mechanical cooling to properly remove this motor heat.

EXAMPLE: 1000 tons x 0.6 kW/Ton x 0.04 motor heat loss x 0.284 Tons/kW = 7 tons (24 kW) cooling

The energy and installation costs of ventilation or mechanical cooling equipment must be considered when evaluating various chillers. For a fair comparison, the kW used for the ventilation fans or if mechanical cooling is required, the additional cooling and fan energy, must be added to the open motor compressor energy when comparing hermetic drives. Additionally, significant costs occur for the purchase, installation, and maintenance of the ventilation or air handling units.

Equipment room ventilation and safety requirements for various refrigerants is a complex subject and is updated from time to time. The latest edition of ASHRAE 15 should be consulted.

Thermal Storage

McQuay chillers are designed for use in thermal storage systems. The chillers have two operating conditions that must be considered. The first is normal air conditioning duty where leaving evaporator fluid temperatures range from 40°F to 45°F (4.4°C to 7.2°C). The second condition occurs during the ice making process when leaving fluid temperatures are in the 22°F to 26°F (-5.6°C to -3.3°C) range.

The MicroTech control system will accommodate both operating points. The ice mode can be started or stopped by a digital input signal to the microprocessor, through an Open Protocol Module (OPM) panel or through a chilled water reset signal. When a signal is received to change from the ice mode to the normal operating mode, the chiller will shut down until the system fluid temperature rises to the higher setpoint. The chiller will then restart and continue operation at the higher leaving fluid temperature. When changing from normal cooling to the ice mode, the chiller will load to maximum capacity until the lower set point is reached.

Computer selections must be made to insure that the chiller will operate at both conditions. If the “ice mode” is at night, the pressure differentials between the evaporator and condenser are usually similar to normal cooling applications. The leaving fluid temperature is lower, but the condensing temperature is also lower because the cooling tower water is colder. If the ice mode can also operate during the day when cooling tower water temperatures are high, a proper selection becomes more difficult because the two refrigerant pressure differentials are significantly different.

A three-way condenser water control valve is always required.

Variable Speed Pumping

Variable speed pumping involves changing system water flow relative to cooling load changes. McQuay centrifugal chillers are designed for this duty with two limitations. First, the rate of change in the water flow needs to be slow, not greater than 2% per minute. The chiller needs time to sense a load change and respond. Second, the water velocity in the vessels must remain between 3 and 10 fps (0.91 and 3.0 m/sec). Below 3 fps (0.91 m/sec), laminar flow occurs which reduces heat transfer. Above 10 fps (3.0 m/sec), excessively high pressure drops and tube erosion occur. These flow limits can be determined from the McQuay MS-85 selection program.

We recommend variable flow only in the evaporator because there is virtually no change in chiller efficiency compared to constant flow. Although variable speed pumping can be done in the condenser loop, it is usually unwise. The intent of variable flow is to reduce pump horsepower. However, reducing condenser water flow increases the chiller’s condensing pressure, increasing the lift that the compressor must overcome which, in turn, increases energy use. Consequently, pump energy savings can be lost because the chiller operating power is significantly increased.

Variable Frequency Drives

(Versus Dual Compressor Units)

Variable frequency drives improve chiller part load performance by varying the compressor speed from 100% to approximately 70%. Most of the energy savings results from the reduced condenser water temperatures that prevail at part load. At all load points, there are additional drive losses which increase the system energy use. The initial cost for VFD is high.

WDC dual compressor chillers should be considered instead. They offer comparable part load performance and have the “two chillers in one” benefit of system redundancy. System reliability is greatly enhanced by having the two compressors for redundancy (parallel equipment-one fails the other runs) rather than the dependent VFD (series equipment-one fails, neither runs).

Free Cooling

There are several systems available to achieve "free cooling" when ambient air temperatures are low enough to reject building heat to the atmosphere without compressor operation. The use of a plate and frame heat exchanger to exchange heat from the chilled water to the cooling tower water and ultimately to atmosphere is the most common today.

McQuay chillers are well suited to this application and, as with all chillers, attention must be paid to the system design, particularly to the switching from the economizer (free cooling) cycle to normal compressor operation.

Vibration Mounting

Every McQuay chiller is run tested and compressor vibration is measured and limited to a maximum rate of 0.14 inches per second which is considerably more stringent than other available compressors. Consequently, floor mounted spring isolators are not required. Rubber mounting pads are shipped with each unit. It is wise to continue to use piping flexible connectors to reduce sound transmitted into the pipe and to allow for expansion and contraction.

Options and Accessories

Vessels

Marine water boxes
Provides tube access for inspection, cleaning, and removal without dismantling water piping.

Flanges (victaulic standard)
ANSI raised face flanges on either the evaporator or condenser. Mating flanges are by others.

0.028 (evaporator) or 0.035 in. tube wall thickness
For applications with aggressive water conditions requiring thicker tube walls.

Cupro-nickel or titanium tube material
For use with corrosive water conditions, only available with clad tube sheets.

Water side vessel construction of 300 psi (150 psi is standard)
For high pressure water systems, typically high-rise building construction.

Water flow or differential pressure switches
A proof of flow device is mandatory in the water system. They can be field supplied, mounted and wired. This option provides them as a factory mounted and wired option.

Double insulation, 1 ½ inch, on evaporator, suction piping, and motor barrel
For high humidity locations and ice making applications.

No Insulation
This option for cases where insulation will be applied in the field. Chiller and suction line are not insulated.

Electrical

Optional starters for factory or field mounting
See details in the Motor Starter section of this manual.

NEMA 4 watertight enclosure
For use where there is a possibility of water intrusion into the control panel.

NEMA 12 Dust tight enclosure
For use in dusty areas.

Controls

English or Metric Display
Either English or metric units for operator ease of use.

Modem for remote monitoring
Includes the modem required for remote monitoring one or more units. Requires Monitor software.

Monitor software
Required for installation in a PC to complete remote monitoring capability.

Chiller System Controller
Details described in the Control Section of this manual.

Unit

Export packaging

Can be either slat or full crate for additional protection during shipment. Units normally shipped in containers.

Pumpout Unit, with or without casters

Available in 1100 to 4900 pound sizes. Details under the Pumpout section of this manual.

Refrigerant monitor

For remote mounting including accessories such as 4-20ma signal, strobe light, audible horn, air pick-up filter.

Hot Gas Bypass

For operation below 10% on WSC and 5% on WDC units. Reduces cycling and its attendant water temperature swings. Standard on TEH and TFH Templifiers.

Sound attenuation package

Consists of acoustical insulation on the discharge line.

Extended warranties

Extended 1, 2, 3, or 4 year warranties for parts only or for parts and labor are available for the entire unit or compressor/motor only.

Witness performance test

The standard full load run test is performed in the presence of the customer under the supervision of a McQuay engineer, includes compilation of the test data. Travel and local expenses are not included.

Certified performance test

The standard run test is performed under the supervision of a McQuay engineer, data is compiled and certified.

SECTION 15XXX
CENTRIFUGAL CHILLERS
SINGLE COMPRESSOR

PART 1 — GENERAL

1.1 SUMMARY

Section includes design, performance criteria, refrigerants, controls, and installation requirements for water-cooled centrifugal chillers.

1.2 REFERENCES

Comply with the following codes and standards

ARI 550/590	NEC
ANSI/ASHRAE 15	OSHA as adopted by the State
	ASME Section VIII

1.3 SUBMITTALS

Submittals shall include the following:

A. Dimensioned plan and elevation view drawings, including motor starter cabinet, required clearances, and location of all field piping and electrical connections.

B. Summaries of all auxiliary utility requirements such as: electricity, water, air, etc. Summary shall indicate quality and quantity of each required utility.

C. Diagram of control system indicating points for field interface and field connection. Diagram shall fully depict field and factory wiring.

D. Manufacturer's certified performance data at full load plus IPLV or NPLV.

E Before shipment, submit a certification of satisfactory completion of factory run test signed by a company officer. The test shall be performed on an ARI Certified test stand and conducted according to ARI Standard 550.

F Installation and Operating Manuals.

1.4 QUALITY ASSURANCE

A. Qualifications: Equipment manufacturer must specialize in the manufacture of the products specified and have five years experience with the equipment and refrigerant offered.

B. Regulatory Requirements: Comply with the codes and standards in Section 1.2.

C. Chiller manufacturer plant shall be ISO 9002 Registered.

1.5 DELIVERY AND HANDLING

A. Chillers shall be delivered to the job site completely assembled and charged with refrigerant and oil.

B. Comply with the manufacturer's instructions for rigging and transporting units. Leave protective covers in place until installation.

1.6 WARRANTY

The refrigeration equipment manufacturer's warranty shall be for a period of (one) -- **Or** -- (two) --**Or**-- (five) years from date of equipment start up or 18 months from shipment whichever occurs first. The warranty shall include parts and labor costs for the repair or replacement of defects in material or workmanship.

1.7 MAINTENANCE

Chiller maintenance shall be the responsibility of the owner with the following exceptions:

A. The manufacturer shall provide the first year scheduled oil and filter change if required.

B. The manufacturer shall provide first year purge unit maintenance if required.

PART 2 — PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. McQuay International

B. (Approved Equal)

2.2 UNIT DESCRIPTION

Provide and install as shown on the plans a factory assembled, factory charged, and factory run-tested water-cooled packaged chiller. Each unit shall be complete with a single-stage hermetic centrifugal compressor with lubrication and control system, factory mounted starter, evaporator, condenser, refrigerant control device and any other components necessary for a complete and operable chiller package.

2.3 DESIGN REQUIREMENTS

A. General: Provide a complete water-cooled hermetic centrifugal compressor water-chilling package as specified herein. Machine shall be provided according to referenced standards Section 1.2. In general, unit shall consist of a compressor, condenser, evaporator, lubrication system, starter and control system.

Note: Chillers shall be charged with a refrigerant such as HCFC-134a, not subject to the Montreal Protocol and the U. S. Clean Air Act.

B. Performance: Refer to schedule on the drawings. The chiller shall be capable of stable operation to ten percent of full load with standard ARI entering condensing water relief without the use of hot gas bypass.

C. Acoustics: Sound pressure levels for the complete unit shall not exceed the following specified levels. Provide the necessary acoustic treatment to chiller as required. Sound data shall be measured according to ARI Standard 575-87. Data shall be in dB. Data shall be the highest levels recorded at all load points. Test shall be in accordance with ARI Standard 575.

Octave Band

63	125	250	500	1000	2000	4000	8000	dba
_____	_____	_____	_____	_____	_____	_____	_____	

2.4 CHILLER COMPONENTS

A. Compressor:

1. Unit shall have a single-stage hermetic centrifugal compressor. Casing design shall ensure major wearing parts, main bearings, and thrust bearings are accessible for maintenance and replacement. The lubrication system shall protect machine during coast down period resulting from a loss of electrical power.
2. The impeller shall be statically and dynamically balanced. The compressor shall be vibration tested and not exceed a level of 0.14 IPS.
3. Movable inlet guide vanes actuated by an internal oil pressure driven piston shall accomplish unloading. Compressors using an unloading system that requires penetrations through the compressor housing or linkages, or both that must be lubricated and adjusted are acceptable provided the manufacturer provides a five-year inspection agreement consisting of semi-annual inspection, lubrication, and annual change out of any compressor seals. A statement of inclusion must accompany any quotations.
4. If the compressor is not equipped with guide vanes for each stage and movable discharge diffusers, then furnish hot gas bypass and select chillers at 5% lower kW/ton than specified to compensate for bypass inefficiency at low loads.

B. Lubrication System: The compressor shall have an independent lubrication system to provide lubrication to all parts requiring oil. Provide a heater in the oil sump to maintain oil at sufficient temperature to minimize affinity of refrigerant, and a thermostatically controlled water-cooled oil cooler. Coolers located inside the evaporator or condenser are not acceptable due to inaccessibility. A positive displacement oil pump shall be powered through the unit control transformer.

C. Refrigerant Evaporator and Condenser:

1. Evaporator and condenser shall be of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME Code, Section VIII. Regardless of the operating pressure, the refrigerant side of each vessel will bear the ASME stamp indicating compliance with the code and indicating a test pressure of 1.3 times the working pressure but not less than 100 psig. Provide intermediate tube supports at a maximum of 18 inch spacing.
2. Tubes shall be enhanced for maximum heat transfer, rolled into steel tube sheets and sealed with Locktite or equal sealer. The tubes shall be individually replaceable.
3. Provide isolation valves and sufficient volume to hold the full refrigerant charge in the condenser or provide a separate pumpout system with storage tank..
4. The water sides shall be designed for a minimum of 150 psig or as specified elsewhere. Vents and drains shall be provided.
5. Chilled water minimum refrigerant temperature shall be 33°F.

6. A self-metering and adjustable thermal expansion valve shall control refrigerant flow to the evaporator. Fixed orifice devices or float controls with hot gas bypass are not acceptable because of inefficient control at low load conditions. The liquid line shall have a moisture indicating sight glass.
7. The evaporator and condenser shall be separate shells. A single shell containing both vessel functions is not acceptable because of the possibility of internal leaks.
8. Interstage economizers shall be used between each compressor stage for increased efficiency.
9. Reseating type spring loaded pressure relief valves according to ASHRAE-15 safety code shall be furnished. The evaporator shall be provided with single or multiple valves. The condenser shall be provided with dual relief valves equipped with a transfer valve so one valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the vessel. Rupture disks are not acceptable.
10. The evaporator, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized 3/4 inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.
11. Provide water pressure differential switches on each vessel to prevent unit operation with no flow. Furnished, mounted and wired by the contractor.

D. Prime Mover: Squirrel cage induction motor of the hermetic type of sufficient size to efficiently fulfill compressor horsepower requirements. Motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase. Motor shall be compatible with the starting method specified hereinafter. If the Contractor chooses to provided an open drive motor or compressor, verify in the submittal that the scheduled chiller room ventilation system will accommodate the additional heat and maintain the equipment room at design indoor temperature based on 95°F outdoor ambient ventilation air available.

If additional cooling is required, manufacturer shall be responsible for the installation, wiring and controls of a cooling system. Chiller selection shall compensate for tonnage and efficiency loss to make certain the owner is not penalized.

E. Motor Starter:

1. The main motor starter is to be factory mounted and fully wired to the chiller components and factory tested during the run test of the unit.

-- Or --

The main motor starter is to be furnished by the chiller manufacturer and shipped loose for floor mounting and field wiring to the chiller package. It shall be free-standing with NEMA-1 enclosure designed for top entry and bottom exit and with front access.

2. For air-cooled motors the chiller manufacturer shall be responsible for providing the cooling of the refrigeration machinery room. The sensible cooling load shall be based on the total heat rejection to the atmosphere from the refrigeration units.
3. For open motor unit, an oil reservoir shall collect any oil and refrigerant that leaks past the seal. A float device shall be provided to open when the reservoir is full, directing the refrigerant/oil mixture back into the compressor housing. Manufacturer shall warrant the shaft seal, reservoir, and float valve system against leakage of oil and refrigerant to the outside of the refrigerating unit for a period of 5 years from the initial start-up including parts and labor to replace a defective seal and any refrigerant required to trim the charge original specifications.
4. The starter must comply with the requirements of Section 1.2.
5. All controllers are to be continuous duty AC magnetic type constructed according to NEMA standards for Industrial Controls and Systems (ICS) and capable of carrying the specified current on a continuous basis. The starter shall be:

Autotransformer - The autotransformer starter shall be of the closed transition type and equipped with multiple taps for 80%, 65%, 50%, and set up for the 65% tap. A clearly marked timer shall be adjustable from 0 to 30 seconds.

-- Or --

Wye-Delta Closed Transition - The wye contactor shall be capable of handling 33% of the delta locked rotor current and be equipped with properly sized resistors to provide a smooth transition. The resistors shall be protected with a transition resistor protector, tripping in a maximum of two seconds, locking out the starter, and shall be manually reset. A clearly marked transition timer shall be adjustable from 0 to 30 seconds.

-- Or --

Solid-State Reduced Voltage - Starter shall be furnished with silicon controlled rectifiers (SCR) connected for starting and include a bypass contactor. When operating speed is reached, the bypass contactor shall be energized removing the SCRs from the circuit during normal running. The starter shall be capable of across-the-line starting in an emergency.

6. The starter shall be coordinated with the chiller package(s) making certain all terminals are properly marked according to the chiller manufacturer's wiring diagrams.
7. The starters shall be equipped with redundant motor control relays (MCR) with coils in parallel. The relays interconnect the starters with the unit control panels and

directly operate the main motor contactors. The MCRs shall constitute the only means of energizing the motor contacts.

8. The main contactors shall have a normally open and a normally closed auxiliary contact rated at 125VA pilot duty at 115 VAC. An additional set of normally open contacts shall be provided for each MCR.

9. There shall be electronic overloads in each phase set at 107% of the rated load amps of each motor. Overloads shall be manual reset and shall de-energize the main contactors when the overcurrent occurs. The overloads shall be adjustable and selected for mid-range. Overloads shall be adjusted for a locked rotor trip time of 8 seconds at full voltage and must trip in 60 seconds or less at reduced voltage (33% of delta LRA).

10. Each starter shall have a current transformer and adjustable voltage dropping resistor(s) to supply a 5.0 VAC signal at full load to the unit control panels.

11. Each starter shall be equipped with a line-to-115 VAC control transformer, fused in both the primary and secondary, to supply power to the control panels, oil heaters and oil pumps.

12. Each starter shall include the following protective devices:

    a) Phase failure and reversal protection

F. CONTROL PANEL

A microprocessor based control panel shall be fully wired and factory-mounted on the chiller and have the following features:

1. The display shall have a minimum of 160-character liquid crystal display and be backlit with a light emitting diode. Messages shall be in plain English. Coded two or three character displays are not acceptable.
2. The following information shall be available on the display with simple entry on the keypad:
   a) Entering and leaving chilled and condenser water temperatures
   b) Evaporator, suction, discharge, condenser, and liquid temperatures
   c) Suction and discharge superheat
   d) Liquid subcooling, evaporator and condenser approach temperatures
   e) Evaporator, condenser, and compressor lift pressures
   f) Oil feed and sump temperatures
   g) Oil pump discharge and oil differential pressure
   h) Motor amps and amps as a percent of rated load amps
   i) Hours of operation and number of starts, time of last start and stop
   j) Chilled water setpoint and reset temperature setpoint
   k) Amp limit for manual and remote
   l) History for last 8 faults with date and time plus critical sensor values
   m) Unit status; start-up and shutdown sequence, operational status
3. The microprocessor shall either unload or shut down the compressor during an abnormal condition. At a minimum the following safeties shall be incorporated in the control system:
   a) High and low discharge pressure
   b) Low evaporator pressure
   c) High discharge temperature
   d) Chilled or condenser water pump failure
   e) No evaporator or condenser water flow
   f) High or low oil feed temperature
   g) Low oil differential pressure
   h) High motor temperature, low motor current
   i) Surge-high suction superheat
   j) Starter fault, no starter transition
   k) Vanes open during start sequence
   l) Sensor failure, specific to sensor
4. Controller shall hold leaving chilled water temperature to within 0.2°F. without hunting, droop, or overshooting.

5. Controller shall be able to limit motor amps from 30% to 100 % of RLA based on a keypad entry or by a remote 4-20mA DC signal.
6. The controller shall be able to reset chilled water temperature by controlling return chilled water temperature or from a remote 4-20 mA DC signal. The amount of reset shall be adjustable.
7. Soft loading shall be provided to prevent the unit from operating at full load during pulldown if desired.
8. A time clock shall be incorporated to allow daily timed starts and stops and to allow for holidays and weekends.
9. The control system shall have automatic restart after a power failure and not require a battery backup for memory continuity. A battery shall be provided for the time clock only.
10. The controller shall be capable of starting and stopping chilled and condenser water pumps. It shall also be capable of four-step control of cooling tower fans and provide an analog output for a tower bypass valve.
11. The microprocessor shall be capable of communicating to other units or a PC using a twisted pair communication interface of RS-232 (100 feet) or RS-422/485 (5000 feet) or with a 9600 baud modem.

2.5. MISCELLANEOUS ITEMS

A. Pumpout System: The unit shall be equipped with a pumpout system complete with a transfer pump, condensing unit, and storage vessel constructed according to ASME Code for Unfired Pressure Vessels and shall bear the National Board stamp. If the design of the unit allows the charge to be transferred to and isolated in the main condenser, then a pumpout system is not required. Transfer of refrigerant charge shall be accomplished by either main compressor operation, migration, or gravity flow. Isolation shall be accomplished with valves located at the inlet and outlet of the condenser. The main condenser shall be sized to contain the refrigerant charge at 90°F according to ANSI-ASHRAE 15.A.

B. Purge System (HCFC-123 Chillers Only):

1. The chiller manufacturer shall provide a separate high efficiency purge system that operates independently of the unit and can be operated while the unit is off. The system shall consist of an air-cooled condensing unit, purge condensing tank, pumpout compressor and control system.
2. A dedicated condensing unit shall be provided with the purge system to provide a cooling source whether or not the chiller is running. The condensing unit shall provide a low purge coil temperature to result in a maximum loss of 0.1 pounds of refrigerant per pound of purged air.

3. The purge tank shall consist of a cooling coil, filter-drier cores, water separation tube, sight glass, drain, and air discharge port. Air and water are separated from the refrigerant vapor and accumulated in the purge tank.
4. The pumpout system shall consist of a small compressor and a restriction device located at the pumpout compressor suction connection.
5. The purge unit shall be connected to a 100% reclaim device.

C. Vacuum Prevention System (HCFC-123 Chillers Only): Chiller manufacturer shall supply and install a vacuum prevention system for each chiller. The system shall constantly maintain 0.05 psig inside the vessel during non-operational periods. The system shall consist of a precision pressure controller, two silicon blanket heaters, a pressure transducer, and solid-state safety circuit.

D. Refrigerant Detection Device (HCFC-123 Chillers Only): Chiller manufacturer shall supply and install a refrigerant detection device and alarm capable of monitoring refrigerant at a level of 10 ppm. Due to the critical nature of this device and possible owner liability, the chiller manufacturer shall guarantee and maintain the detection monitor for five years after owner acceptance of the system.

E. Waffle type vibration pads for field mounting under unit feet.

PART 3 — EXECUTION

3.1 INSTALLATION

A. Install according to manufacturer's requirements, shop drawings, and Contract Documents.

B. Adjust chiller alignment on concrete foundations, sole plates or subbases as called for on drawings.

C. Arrange the piping on each vessel to allow for dismantling the pipe to permit head removal and tube cleaning.

D. Furnish and install necessary auxiliary water piping for oil cooler.

E. Coordinate electrical installation with electrical contractor.

F. Coordinate controls with control contractor.

G. Provide all materiel required to ensure a fully operational and functional chiller.

3.2 START-UP

A. Units shall be factory charged with the proper refrigerant and oil.

B. Factory Start-Up Services: Provide for as long a time as is necessary to ensure proper operation of the unit, but in no case for less than two full working days. During the period of start-up, the Start-up Technician shall instruct the Owner's representative in proper care and operation of the unit.

SECTION 15XXX
CENTRIFUGAL CHILLERS
DUAL COMPRESSOR

PART 1 — GENERAL

1.1 SUMMARY

Section includes design, performance criteria, refrigerants, controls, and installation requirements for water-cooled centrifugal chillers.

1.02 REFERENCES

Comply with the following codes and standards

ARI 550/590	NEC
ANSI/ASHRAE 15	OSHA as adopted by the State
	ASME Section VIII

1.3 SUBMITTALS

Submittals shall include the following:

A. Dimensioned plan and elevation view Drawings, including motor starter cabinet, required clearances, and location of all field piping and electrical connections.

B. Summaries of all auxiliary utility requirements such as: electricity, water, air, etc. Summary shall indicate quality and quantity of each required utility.

C. Diagram of control system indicating points for field interface and field connection. Diagram shall fully depict field and factory wiring.

D. Manufacturer's certified performance data at full load plus IPLV or NPLV.

E Installation and Operating Manuals.

1.4 QUALITY ASSURANCE

A. Qualifications: Equipment manufacturer must specialize in the manufacture of the products specified and have five years experience with the equipment and refrigerant offered.

B. Regulatory Requirements: Comply with the codes and standards in Section 1.2.

C. Chiller manufacturer plant shall be ISO 9002 Registered.

1.5 DELIVERY AND HANDLING

A. Chillers shall be delivered to the job site completely assembled and charged with refrigerant and oil.

B. Comply with the manufacturer's instructions for rigging and transporting units. Leave protective covers in place until installation.

1.6 WARRANTY

The refrigeration equipment manufacturer's warranty shall be for a period of (one) -- **Or** -- (two) --**Or**-- (five) years from date of equipment start or 18 months from shipment whichever occurs first. The warranty shall include parts and labor costs for the repair or replacement of defects in material or workmanship. The refrigerant charge shall be warranted against contamination from a motor burnout for five years.

1.7 MAINTENANCE

Maintenance of the chillers shall be the responsibility of the owner with the following exceptions:

A. The manufacturer shall provide the first year scheduled oil and filter change if required.

B. The manufacturer shall provide first year purge unit maintenance if required.

PART 2 — PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. McQuay International

B. (Approved Equal)

2.2 UNIT DESCRIPTION

Provide and install as shown on the plans a factory assembled, charged, and run-tested water-cooled packaged chiller. Each unit shall be complete with two single-stage hermetic centrifugal compressors each having independent lubrication and control systems, factory mounted starters, and isolation valves. The evaporator, condenser, and refrigerant control device of each unit shall be common to the compressors. The chiller unit shall be capable of running on one compressor with the other compressor or any of its auxiliaries removed.

2.3 DESIGN REQUIREMENTS

A. General: Provide a complete water-cooled dual hermetic compressor centrifugal water chiller as specified herein. Machine shall be provided according to standards, Section 1.2. In general, unit shall consist of two compressors, refrigerant condenser and evaporator, two lubrication systems, two starters and two control systems.

Note: Chillers shall be charged with a refrigerant such as HCFC-134a, not subject to the Montreal Protocol and the U. S. Clean Air Act.

B. Performance: Refer to schedule on the drawings. The chiller shall be capable of stable operation to five percent of full load with standard ARI entering condensing water relief without hot gas bypass.

C. Acoustics: Sound pressure levels for the unit shall not exceed the following specified levels. Provide the necessary acoustic treatment to chiller as required. Sound data shall be measured according to ARI Standard 575-87. Data shall be in dB. Data shall be the highest levels recorded at all load points. Test shall be in accordance with ARI Standard 575.

Octave Band								
63	125	250	500	1000	2000	4000	8000	dba
____	____	____	____	____	____	____	____	

2.4 CHILLER COMPONENTS

A. Compressors:

1. Unit shall have two single-stage hermetic centrifugal compressors. Casing design shall ensure major wearing parts, main bearings and thrust bearings are accessible for maintenance and replacement. Lubrication system shall protect machine during coast down resulting from a loss of power.

2. Impeller shall be statically and dynamically balanced. The compressor shall be vibration tested and not exceed 0.14 IPS.

3. Movable inlet guide vanes actuated by an internal oil pressure driven piston shall accomplish unloading. Compressors using an unloading system that requires penetrations of the compressor housing or linkages, or both, that must be lubricated and adjusted are acceptable provided the manufacturer provides a five-year inspection agreement consisting of semi-annual inspection, lubrication, and annual changeout of compressor seals. A statement of inclusion must accompany any quotations.

4. If compressors are not equipped with guide vanes for each stage and movable discharge diffusers, then furnish hot gas bypass and select chillers at 5% lower kW/ton than specified to compensate for bypass inefficiency at low loads.

B. Lubrication System: Each compressor shall have an independent lubrication system to provide lubrication to all parts requiring oil. Provide a heater in the oil sump to maintain oil at sufficient temperature to minimize affinity of refrigerant, and a thermostatically controlled water-cooled oil cooler. Coolers located inside the evaporator or condenser are not acceptable due to inaccessibility. A positive displacement submerged oil pump shall be powered through the unit control transformer.

C. Refrigerant Evaporator and Condenser:

1. Evaporator and condenser shall be of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME Code, Section VIII. Regardless of the operating pressure, the refrigerant side of each vessel will bear the ASME stamp indicating compliance with the code and indicating a test pressure of 1.3 times the working pressure but not less than 100 psig. Provide intermediate tube supports at a maximum of 18 inch spacing.

2. Tubes shall be enhanced for maximum heat transfer, rolled into steel tube sheets and sealed with Locktite or equal sealer. The tubes shall be individually replaceable and secured to the intermediate supports without rolling.

3. Provide sufficient isolation valves and condenser volume to hold full refrigerant charge in the condenser during servicing or provide a separate pumpout system and storage tank sufficient to hold the charge of the largest unit being furnished.

4. The water sides shall be designed for a minimum of 150 psig or as specified elsewhere. Vents and drains shall be provided.

5. Chilled water minimum refrigerant temperature shall be 33°F.

6. A self-metering and adjustable thermal expansion valve shall control refrigerant flow to the evaporator. Fixed orifice devices or float controls with hot gas bypass are not acceptable because of inefficient control at low load conditions. The liquid line shall have a moisture indicating sight glass.

7. The evaporator and condenser shall be separate shells. A single shell containing both vessel functions is not acceptable because of the possibility of internal leaks.
8. Interstage economizers shall be used between each compressor stage for increased efficiency.
9. Reseating type spring loaded pressure relief valves according to ASHRAE-15 safety code shall be furnished. The evaporator shall be provided with single or multiple valves. The condenser shall be provided with dual relief valves equipped with a transfer valve so one valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the vessel. Rupture disks are not acceptable.
10. The evaporator, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized 3/4 inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.
11. Provide water pressure differential switches on each vessel to prevent unit operation with no flow, furnished, installed and wired by the contractor.

D. Prime Mover: Squirrel cage induction motor of the hermetic type of sufficient size to efficiently fulfill compressor horsepower requirements. Motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase. Motor shall be compatible with the starting method specified hereinafter. If the Contractor chooses to provided an open drive motor or compressor, verify in the submittal that the scheduled chiller room ventilation system will accommodate the additional heat and maintain the equipment room at design indoor temperature based on 95°F outdoor ambient ventilation air available.

If additional cooling is required, manufacturer shall be responsible for the installation, wiring and controls of a cooling system. Chiller selection shall compensate for tons and efficiency loss to make certain the owner is not penalized.

E. Motor Starters:

1. The main motor starters are to be factory mounted and fully wired to the chiller components and factory tested during the run test of the unit.

-- Or --

The main motor starters are to be furnished by the chiller manufacturer and shipped loose for floor mounting and field wiring to the chiller package. They shall be free-standing with NEMA-1 enclosure designed for top entry and bottom exit and with front access.

2. For air-cooled motors the chiller manufacturer shall be responsible for providing the cooling of the refrigeration machinery room. The sensible cooling load shall be based on the total heat rejection to the atmosphere from tow refrigeration units.

3. For open motor unit, an oil reservoir shall collect any oil and refrigerant that leaks past the seal. A float device shall be provided to open when the reservoir is full, directing the refrigerant/oil mixture back into the compressor housing. Manufacturer shall warrant the shaft seal, reservoir, and float valve system against leakage of oil and refrigerant to the outside of the refrigerating unit for a period of 5 years from the initial start-up including parts and labor to replace a defective seal and any refrigerant required to trim the charge original specifications.
4. The starters must comply with Section 1.2 as required.
5. All controllers are to be continuous duty AC magnetic type constructed according to NEMA standards for Industrial Controls and Systems (ICS) and capable of carrying the specified current on a continuous basis. The starters shall be:

Autotransformer - The autotransformer starters shall be of the closed transition type and equipped with multiple taps for 80%, 65%, 50%, and set up for the 65% tap. A clearly marked timer shall be adjustable from 0 to 30 seconds.

-- Or --

Wye-Delta Closed Transition - The wye contactor shall be capable of handling 33% of the delta locked rotor current and be equipped with properly sized resistors to provide a smooth transition. The resistors shall be protected with a transition resistor protector, tripping in a maximum of two seconds, locking out the starter, and shall be manually reset. A clearly marked transition timer shall be adjustable from 0 to 30 seconds.

-- Or --

Solid-State Reduced Voltage - Starter shall be furnished with silicon controlled rectifiers (SCR) connected for starting and include a bypass contactor. When operating speed is reached, the bypass contactor shall be energized removing the SCRs from the circuit during normal running. The starter shall be capable of across-the-line starting in an emergency.

6. Starters shall be coordinated with the chiller package(s) making certain all terminals are properly marked according to the chiller manufacturer's wiring diagrams.
7. The starters shall be equipped with redundant motor control relays (MCR) with coils in parallel. The relays interconnect the starters with the unit control panels and directly operate the main motor contactors. The MCRs shall constitute the only means of energizing the motor contacts.

8. The main contactors shall have a normally open and a normally closed auxiliary contact rated at 125VA pilot duty at 115 VAC. An additional set of normally open contacts shall be provided for each MCR.
9. There shall be electronic overloads in each phase set at 107% of the rated load amps of each motor. Overloads shall be manual reset and shall de-energize the main contactors when the overcurrent occurs. The overloads shall be adjustable and selected for mid-range. Overloads shall be adjusted for a locked rotor trip time of 8 seconds at full voltage and must trip in 60 seconds or less at reduced voltage (33% of delta LRA).
10. Each starter shall have a current transformer and adjustable voltage dropping resistor(s) to supply a 5.0 VAC signal at full load to the unit control panels.
11. Each starter shall be equipped with a line to 115 VAC control transformer, fused in both the primary and secondary, to supply power to the control panels, oil heaters and oil pumps.
12. Each starter shall include the following protective devices:
    a) Phase failure and reversal protection
    b) Stall protection

F. CONTROL PANELS

A microprocessor based control panel shall be furnished for each compressor and shall be fully wired and factory-mounted on the chiller. The control panels shall be independent allowing one compressor to operate with the other panel removed. The control panels shall also be interconnected to provide lead and lag control as well as load balancing when two compressors are running. The compressor with fewest starts will start first and the unit with the most hours will shut off first. Each panel shall have the following features:

1. The display shall have a minimum of 160-character liquid crystal display and be backlit with a light emitting diode. Messages shall be in plain English. Coded two or three character displays are not acceptable.
2. The following information shall be available on the display with simple entry on the keypad:
    a) Entering and leaving chilled and condenser water temperatures
    b) Evaporator, suction, discharge, condenser, and liquid temperatures
    c) Suction and discharge superheat
    d) Liquid subcooling, evaporator and condenser approach temperatures
    e) Evaporator, condenser, and lift pressures
    f) Oil feed and sump temperatures
    g) Oil pump discharge and oil differential pressure
    h) Motor amps and amps as a percent of rated load amps
    i) Hours of operation and number of starts, time of last start and stop

j) Chilled water setpoint and reset temperature setpoint

k) Amp limit for manual and remote

l) History of last 8 failures with date and time plus critical sensor values

m) Unit status; start-up and shutdown sequence, operational status

3. The microprocessor shall either unload or shut down one or both compressors during an abnormal condition. At a minimum the following safeties shall be incorporated in the control system:

a) High and low discharge pressure

b) Low evaporator pressure

c) High discharge temperature

d) Chilled or condenser water pump failure

e) No evaporator or condenser water flow

f) High or low oil feed temperature

g) Low oil differential pressure

h) High motor temperature, low motor current

i) Surge-high suction superheat

j) Starter fault, no starter transition

k) Vanes open during start sequence

l) Sensor failure, specific to sensor

4. Controller shall hold leaving chilled water temperature to within 0.2°F. without hunting, droop, or overshooting.

5. Controller shall be able to limit motor amps from 30 to 100 % of RLA based on a keypad entry or by a remote 4-20mA DC signal.

6. The controller shall be able to reset chilled water temperature by controlling return chilled water temperature or from a remote 4-20 mA DC signal.

7. Soft loading shall be provided to prevent the unit from operating at full load during pulldown if desired.

8. A time clock shall be incorporated to allow daily timed starts and stops and to allow for holiday and weekend schedule changes.

9. The control system shall have automatic restart after a power failure and not require a battery backup for memory continuity. A battery shall be provided for the time clock only.

10. The controller shall be capable of starting and stopping chilled water and condenser water pumps. It shall also be capable of four-step control of cooling tower fans and analog control of a tower bypass valve.

11. The microprocessor shall be capable of communicating to other units or a PC using a twisted pair communication interface of RS-232 (100 feet) or RS-422/485 (5000 feet) or with a 9600 baud modem.

2.5. MISCELLANEOUS ITEMS

A. Pumpout System: The unit shall be equipped with a pumpout system complete with a transfer pump, condensing unit, and storage vessel constructed according to ASME Code for Unfired Pressure Vessels and shall bear the National Boards stamp. If the design of the unit allows the charge to be transferred to and isolated in the main condenser, then a pumpout system is not required. Transfer of refrigerant charge shall be accomplished by either main compressor operation, migration, or gravity flow. Isolation shall be accomplished with valves located at the inlet and exit of the condenser. The main condenser shall be sized to contain the refrigerant charge at 90°F according to ANSI-ASHRAE 15.A.

B. Purge System (HCFC-123 Chillers Only):

1. The chiller manufacturer shall provide a separate high efficiency purge system that operates independently of the unit and can be operated while the unit is off. The system shall consist of an air-cooled condensing unit, purge condensing tank, pumpout compressor and control system.
2. A dedicated condensing unit shall be provided with the purge system to provide a cooling source whether or not the chiller is running. The condensing unit shall provide a low purge coil temperature to result in a maximum loss of 0.1 pounds of refrigerant per pound of purged air.
3. The purge tank shall consist of a cooling coil, filter-drier, water separation tube, sight glass, drain, and air discharge port. Air and water are separated from the refrigerant vapor and accumulated in the purge tank.
4. The pumpout system shall consist of a small compressor and a restriction device located at the pumpout compressor suction connection.
5. The purge unit shall be connected to a 100% reclaim device.

C. Vacuum Prevention System (HCFC-123 Chillers Only): Chiller manufacturer shall supply and install a vacuum prevention system for each chiller. The system shall constantly maintain 0.05 psig inside the vessel during non-operational periods. The system shall consist of a precision pressure controller, two silicon blanket heaters, a pressure transducer, and solid-state safety circuit.

D. Refrigerant Detection Device (HCFC-123 Chillers Only): Chiller manufacturer shall supply and install a refrigerant detection device and alarm capable of monitoring refrigerant at a level of 10 ppm. Due to the critical nature of this device and possible owner liability, the chiller manufacturer shall guarantee and maintain the detection monitor for five years after owner acceptance of the system.

E. Waffle type vibration pads for field mounting under unit feet.

PART 3 — EXECUTION

3.1 INSTALLATION

A. Install per manufacturer's requirements, shop drawings, and Contract Documents.

B. Adjust chiller alignment on foundations, or subbases as called for on drawings.

C. Arrange piping to allow for dismantling to permit head removal and tube cleaning.

D. Furnish and install necessary auxiliary water piping for oil cooler.

E. Coordinate electrical installation with electrical contractor.

F. Coordinate controls with control contractor.

G. Provide all materiel required to ensure a fully operational and functional chiller.

3.2 START-UP

A. Units shall be factory charged with the proper refrigerant and oil.

B. Factory Start-Up Services: Provide for as long a time as is necessary to ensure proper operation of the unit, but in no case for less than two full working days. During the period of start-up, The Start-up Technician shall instruct the Owner's representative in proper care and operation of the unit.

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