DB

HERCULES

Water Cooled Centrifugal Chillers

DCLC, DCLCD & DCLCT Series 50/60Hz

Cooling Capacity: 300 to 4000 TR (1055 to 14068 kW)

R134a

AHRI CERTIFIED®

ASHRAE 90.1 COMPLIANT

DUNHAM-BUSH®

Products that perform...By people who care

GENERAL

From the beginning of 20th Century, DB has been providing innovative solutions for the heating, air conditioning and refrigeration needs of its customers. Today's global company has a proud heritage that began over a 100 years' ago.

Customers demand high efficiency products with exceptional value and DB's new range of DCLC centrifugal chillers satisfy modern market requirements with outstanding energy efficiency and proven technology, designed specifically for environmentally safe refrigerants. This combination ensures the most cost-effective, reliable solution for comfort cooling and process cooling applications.

DB continues to deliver performance with reliability packaged in the most energy efficient way with the introduction of the DCLC range of centrifugal water chillers.

The major advantages of the DCLC:

- High reliability
- Simple operation and maintenance
- Low sound levels
- Simplified structure and compact size
- High efficiency at a competitive market price
- Designed to use with environmentally friendly R134a refrigerant

The DCLC range of chillers is ideal for offices, hospitals, hotels and retail stores as well as industrial applications. The chiller offers a full range of Evaporator/Condenser/Compressor combinations, permitting precise matching of the machine capacity to system requirements. With such a wide range of available combinations, DCLC units can be configured to provide lowest first cost, lowest operating cost or choice of several criteria important for a particular application. The centrifugal chiller selection software is certified in accordance with the latest AHRI standard 550/ 590.

DB Sales Engineers are available to assist in selecting the optimum machine needed to satisfy the particular project requirements.

The DCLC centrifugal chiller from DB offers superior value and application flexibility, a wide range of options and accessories and the peace of mind that more than 100 years of industry experience is behind this product can be ideally configured to suit your project.

TABLE OF CONTENTS

NOMENCLATURE

DCLC D V 1000

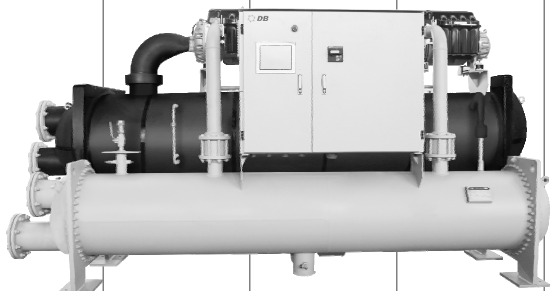
Dunham-Bush Centrifugal Liquid Chiller

Product Series
Blank - Single Stage Centrifugal Chiller
D - Dual Stage Centrifugal Chiller
T - Twin Compressors Centrifugal Chillers

VFD Operation
Blank - Constant Speed Operation
V - Variable Speed Operation

Nominal Cooling Capacity TR

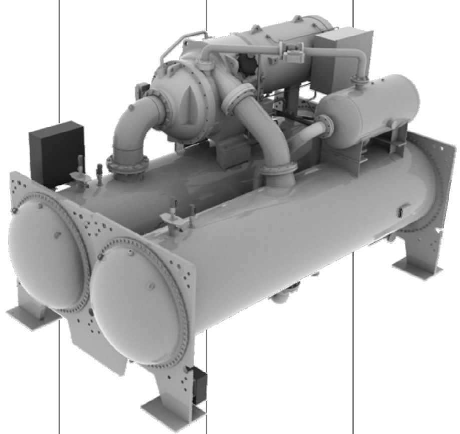
PRODUCT LINE UP



PROmetheus
DCLC-M Series
Magnetic Bearing Oil Free Centrifugal Chillers

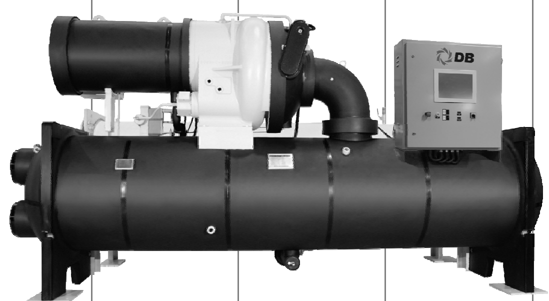
90 ~ 680TR (315 ~ 2390kW)

Note: PROmetheus DCLC-M series is not included in this product catalogue. Please refer to PROmetheus DCLC-M series catalogue for more information.



DCLCD Series
Dual Stage Centrifugal Chillers

500 ~ 1600TR (1760 ~ 5627 kW)



DCLC Series
Single Stage Centrifugal Chillers

300 ~ 2000TR (1055 ~ 7034 kW)

DCLCT Series
Twin Compressors Centrifugal Chillers

2000 ~ 4000TR (7034 ~ 14068 kW)

0 500 1000 1500 2000 2500 3000 3500 4000
TR

FEATURES & BENEFITS

COMPLIANCES

- Unit design to meets/ exceeds AHSRAE 90.1 requirements
- Performance of DCLC chillers are certified in accordance with AHRI Standard 550/590
- Refrigerant safety of DCLC series is designed in accordance with ASHRAE Standard 15

COMPUTER PERFORMANCE RATINGS

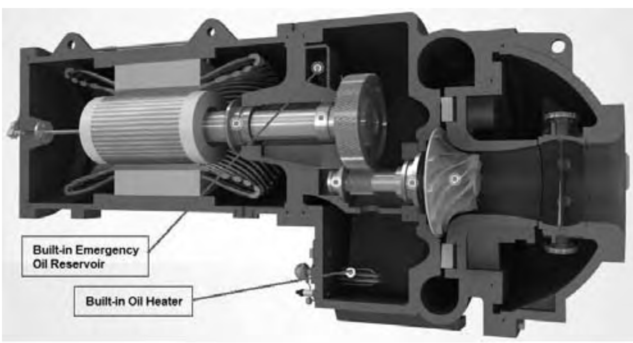
Dunham-Bush DCLC Chillers are available from 300 to 4000 TR [1055 to 14068 kW]. The vast number of combinations of heat exchangers, compressors and motors make it impractical to publish tabular ratings for each combination. A chiller may be custom matched to certain building requirements by your Dunham-Bush Sales Representatives utilizing the DCLC Computer Selection Program. Data which can be provided to you will include:

- Chiller Capacity
- kW Input
- Evaporator and Condenser Fluid Temperature
- Evaporator and Condenser Pressure Drop
- Evaporator and Condenser Tube Water Velocities
- Electrical Data
- Part-Load Performance

Contact our local Dunham-Bush Sales Representative to discuss what Custom Solutions Dunham-Bush can offer to solve your chiller selection questions.

COMPRESSOR

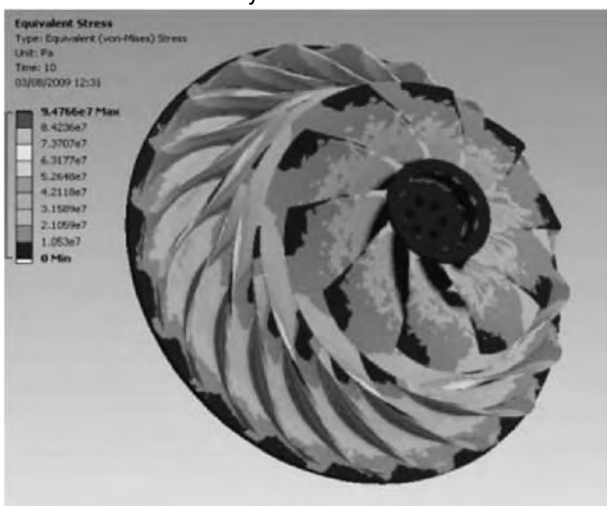
- Semi-hermetic compressor for reliable operation; compressor and motor are direct gear driven. Shaft alignment, refrigerant and oil leaking at shaft seals are not applicable with this design



- Refrigerant cooled motor is hermetically sealed in compressor; motor heat generated is concealed in refrigerant system; no motor heat is rejected into chiller plantroom
- Motor shaft is supported with Babbitt bearings to reduce friction losses. High speed impeller shaft is supported by thrust bearings (rolling-element bearings) for reliable and efficient operation
- Built-in emergency oil reservoir to ensure continuous oil supply for compressor safe operation at coast-down period in the event of power interruption
- Built-in oil pump (gear type) reduces leaking possibility, improve operation reliability
- Built-in oil heater to maintain the oil at 100~120°F [40~50℃] even when the compressor is shut down. This prevents oil dilution, which may causes a decrease in viscosity and hence change lubrication properties

IMPELLER

- The impeller is precision cast from special super high density aluminum alloy cast using the Integer mold technique, resulting in light weight and high anti-corrosion ability

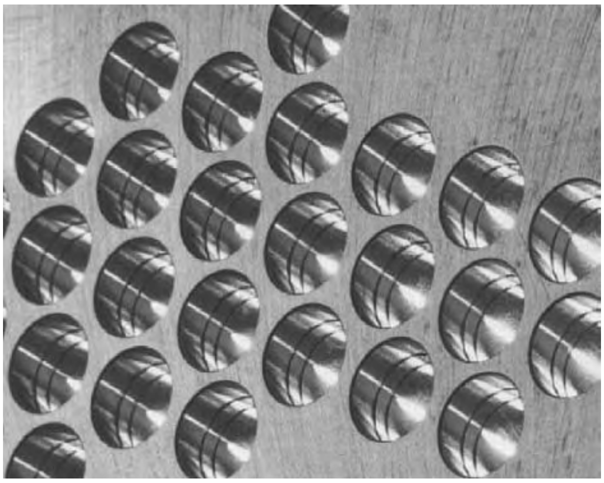


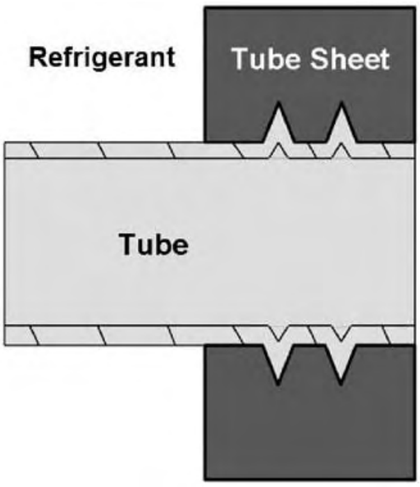
- Each impeller has succeeded in stringent balancing test and over-speed test up to 125% of rated value; to ensure stable and reliability operation
- Impellers design are aerodynamically contoured with CFD software to improve compressor full load and part load operating efficiency. Compressor efficiency is improved by 5~7%, with improve sound level, as well as anti-surge capability

EVAPORATOR AND CONDENSER

- The vessels are designed in accordance with ASME Boiler and Pressure Vessel Code
- Refrigerant side design pressure of 200PSIG [13.8BAR]; water side design pressure of 150PSIG [10.3BAR]
- Pressure test up to 220PSIG [15.2BAR] for refrigerant side; and 195PSIG [13.4BAR] for water side
- Waterboxes are fabricated using nozzle-in-head arrangement and are supplied with vent and drain connections on the dome head
- "Dual Lock" design on vessel's tube sheets ensure better sealing and minimizes the possibility of leaks between the water and refrigerant system, increasing product reliability

FEATURES & BENEFITS





- Copper tubes with enhanced profile and grooves for best heat transfer efficiency
- Intermediate tube support sheets are provided in all heat exchangers to prevent tube sagging and vibration, which could otherwise result in premature failure
- 1, 2 or 3-passes to suite the design requirements.
- Victaulic groove water connection comply with ANSI/AWWA C-606. Flanged water connection is available on request
- Condenser is designed with full pumpdown capacity

SUB-COOLER

- The sub-cooler is located in the bottom of the condenser
- It increases the overall refrigeration effect of the chiller by sub-cooling the condensed liquid refrigerant which results in a combination of increased cooling capacity and reduced compressor power consumption

CAPACITY CONTROL & ANTI-SURGE

- Capacity control with inlet guide vane and adjustable diffuser visualized precise control and energy saving operation, with enhanced anti-surge capability, permits stable operation at low load condition
- The guide vanes are connected with aircraft- quality cable and controlled by a precise electronic actuator
- The adjustable diffuser with adjustable discharge geometry enabling the surge point of DB centrifugal compressors to be lowered
- Models with VFD (Variable Frequency Drive) gains further energy saving with VFD unloading during partial load operation

ENVIRONMENTAL FRIENDLY REFRIGERANT

- Use environmental friendly HFC-134a refrigerant, with **ZERO** ODP (Ozone Depletion Potential)
- Non-toxide refrigerant with no phasing out date set by Montreal Protocol
- Positive pressure operations eliminates need of purging system, which cause additional energy to unit operation

FACTORY TESTING

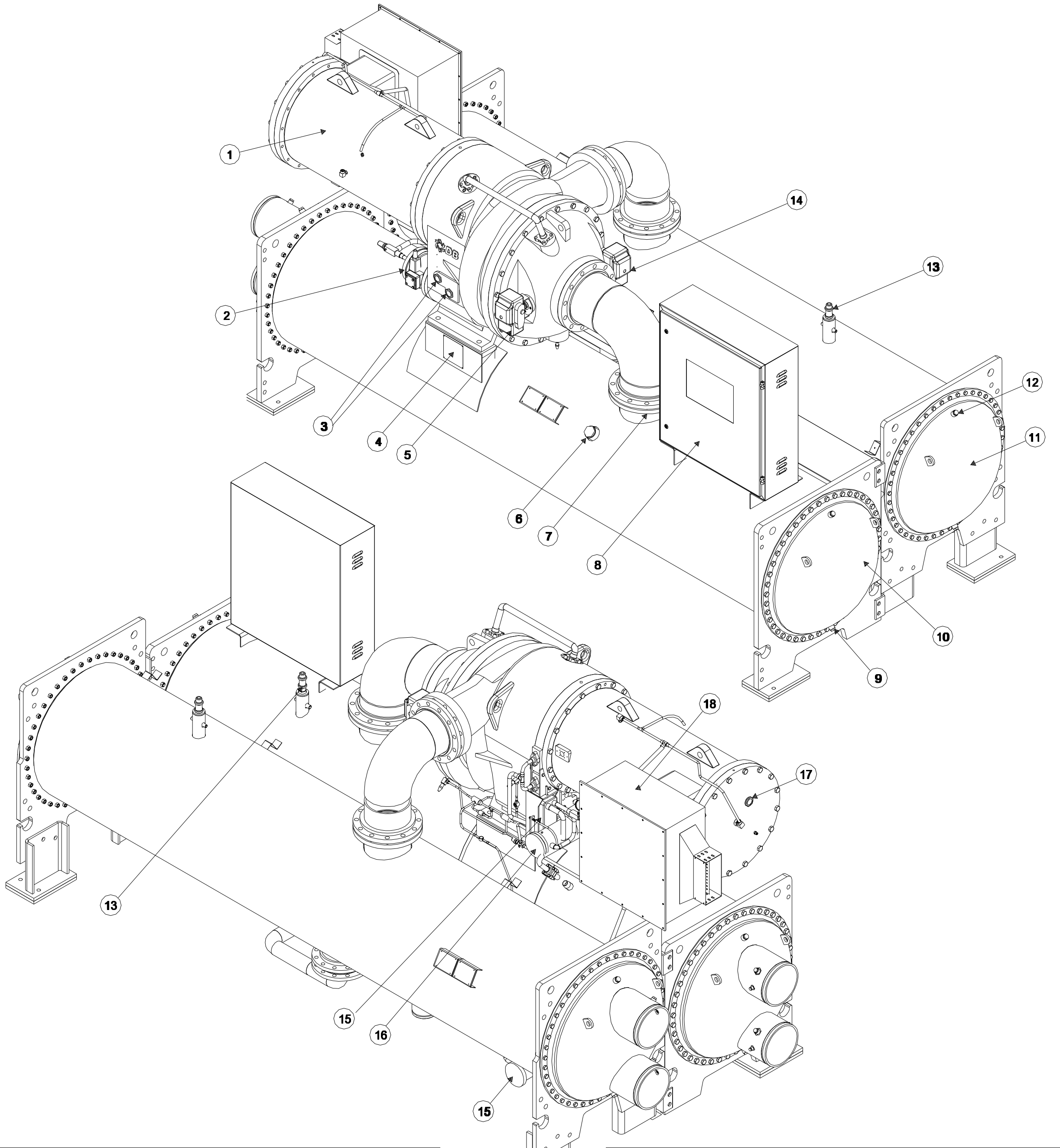
- All DB DCLC chillers are thoroughly run tested at the factory prior to shipment
- This ensured proper operation of all components in the system, including compression, power transmission, vibration & sound, oil lubrication system, and electrical & control system

INTELLEGENT CONTROL SYSTEM

- DB DCLC chillers are equipped with ***DB DIRECTOR*** control system. The state-of-art controller which specifically designed to operate DCLC at optimum efficiency with proactive control logics
- 15.4” touch screen colour display panel is furnished for user friendly operation

CHILLER COMPONENTS

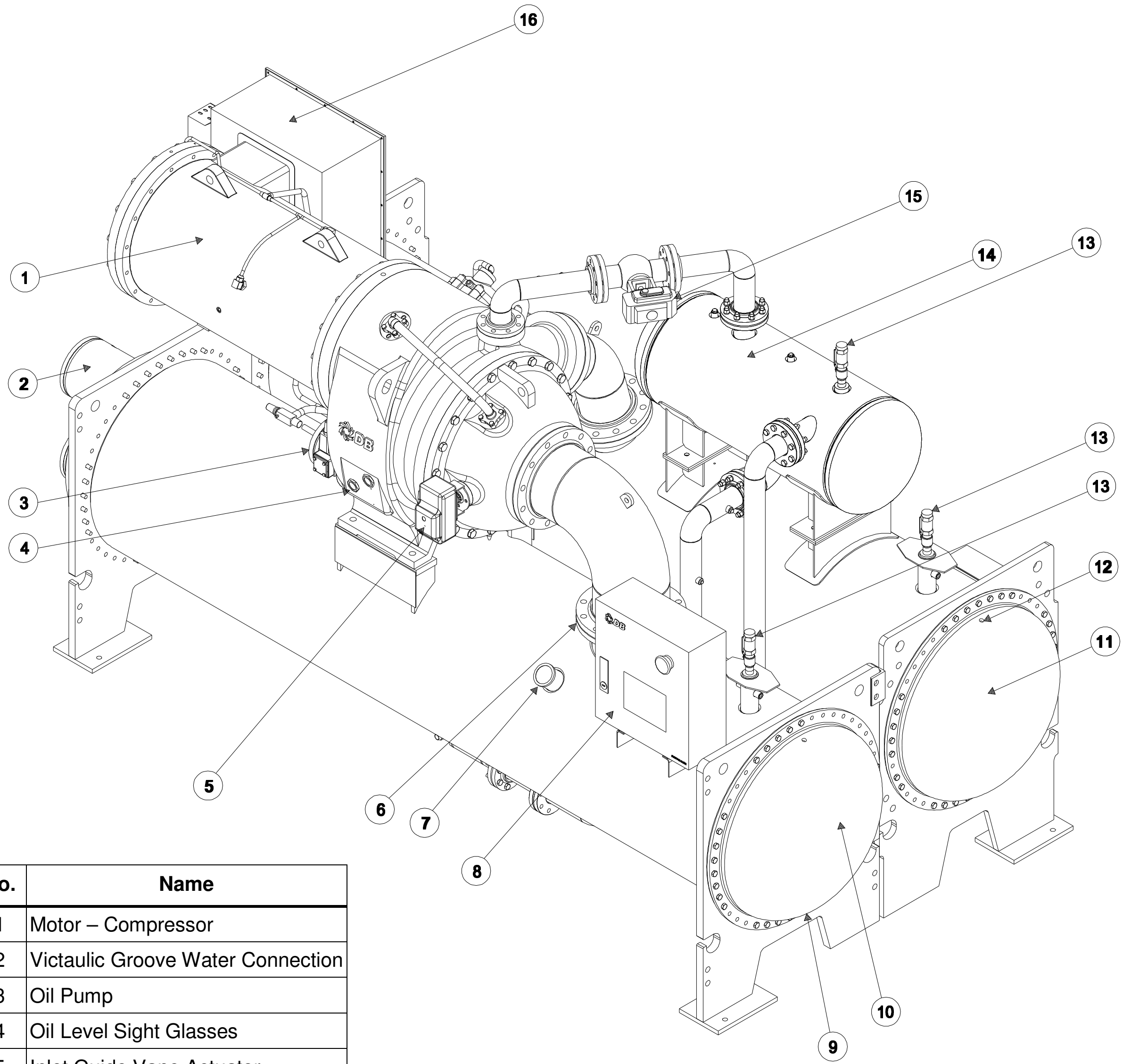
DCLC Series (Single Stage Centrifugal Chillers)



No.	Name	No.	Name
1	Motor – Compressor	10	End Water Box Cover (Evaporator)
2	Oil Pump	11	End Water Box Cover (Condenser)
3	Oil Level Sight Glasses	12	Typical Water Box Vent Port
4	Unit Name Plate	13	Safety Valve (PRV)
5	Inlet Guide Vane Actuator	14	Adjustable Diffuser Actuator
6	Evaporator Sight Glass	15	Oil Cooler
7	Typical Flanged Connection	16	Replaceable Oil Filter
8	Control Panel	17	Motor Rotation Sight Glass
9	Typical Water Box Drain Port	18	Motor Terminal Box

CHILLER COMPONENTS

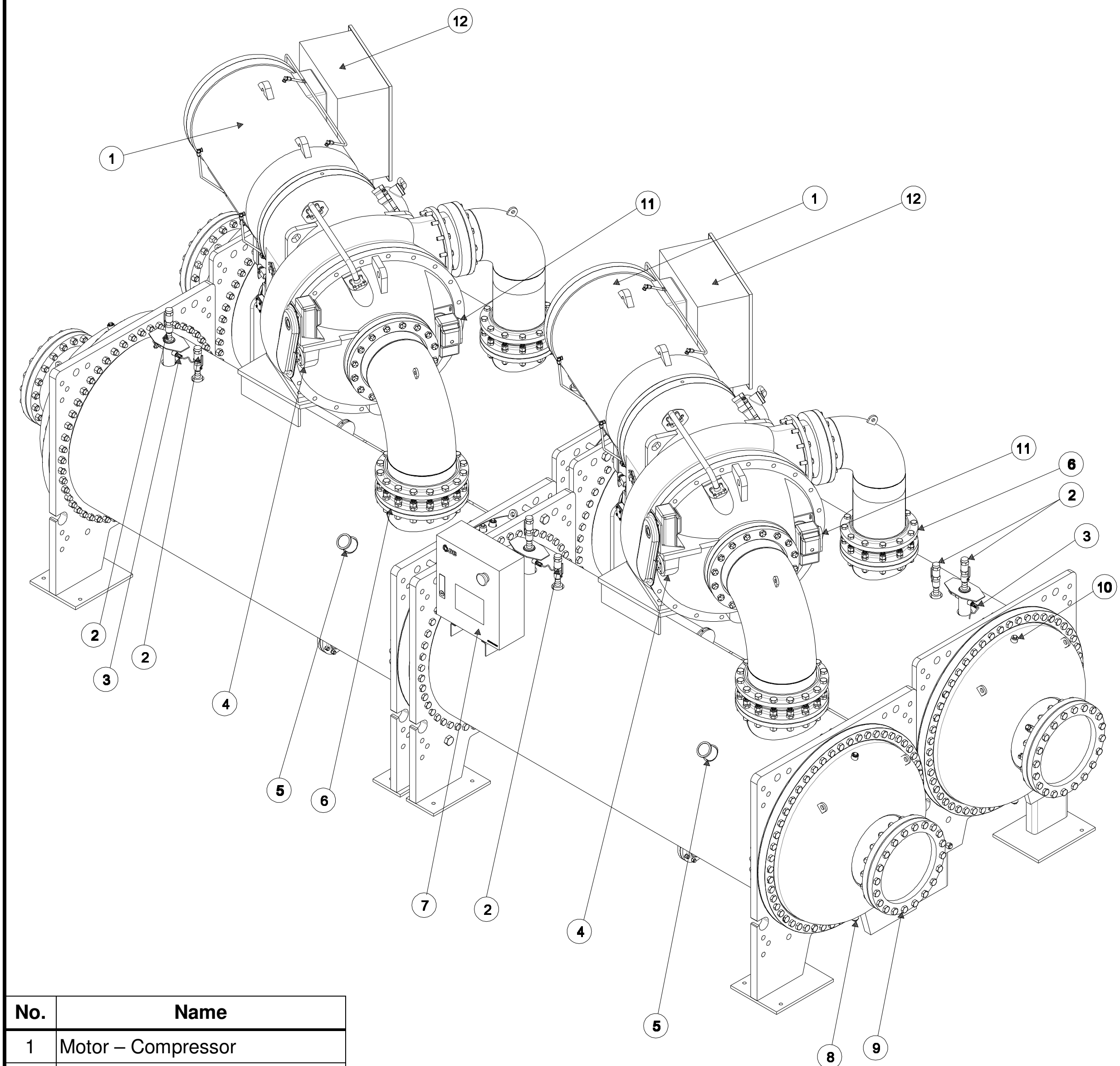
DCLCD Series (Dual Stage Centrifugal Chillers)



No.	Name
1	Motor – Compressor
2	Victaulic Groove Water Connection
3	Oil Pump
4	Oil Level Sight Glasses
5	Inlet Guide Vane Actuator
6	Typical Flanged Connection
7	Evaporator Sight Glass
8	Control Panel
9	Typical Water Box Drain Port
10	End Water Box Cover (Evaporator)
11	End Water Box Cover (Condenser)
12	Typical Water Box Vent Port
13	Safety Valve (PRV)
14	Flash Economizer
15	Economizer Regulating Valve
16	Motor Terminal Box

CHILLER COMPONENTS

DCLCT (Twin Compressors Centrifugal Chillers)



No.	Name
1	Motor – Compressor
2	Safety Valve (PRV)
3	Pressure Transducer
4	Inlet Guide Vane Actuator
5	Evaporator Sight Glass
6	Typical Flanged Connection
7	Control Panel
8	Typical Water Box Drain Port
9	Flanged Water Connection (Optional)
10	Typical Water Box Vent Port
11	Adjustable Diffuser Actuator
12	Motor Terminal Box

WORKING PRINCIPLE AND STRUCTURE

REFRIGERATION CYCLE

DCLC Series

The compressor on a centrifugal chiller utilizes the Vapour Compression cycle in much the same way as any positive displacement compressor. The Vapour compression cycle uses a medium such as refrigerant to absorb heat at one part of the cycle and reject that heat at a different part of the cycle. The centrifugal compressor is a dynamic machine which raises the pressure and temperature of the circulating refrigerant by imparting velocity or dynamic energy through an electric motor driven impeller discharging into a volute or diffuser plate to convert this velocity energy to pressure energy. As with all vapour compression systems, there are four major components: compressor, condenser, expansion device and evaporator. The evaporator absorbs heat from its surrounding and the condenser rejects the heat collected plus any system losses to its surroundings. The cycle will continue to operate all the time the compressor is operating and a system load exists.

The following is the principle in details:

Compressor:
The refrigerant vapour enters the compressor in a low pressure, low temperature but superheated state. The compression process increases the pressure and the temperature and the now high pressure, high temperature superheated gas is discharged into a condenser, a heat exchanger where due to its high temperature the refrigerant can be condensed using cooling tower water or ambient air.

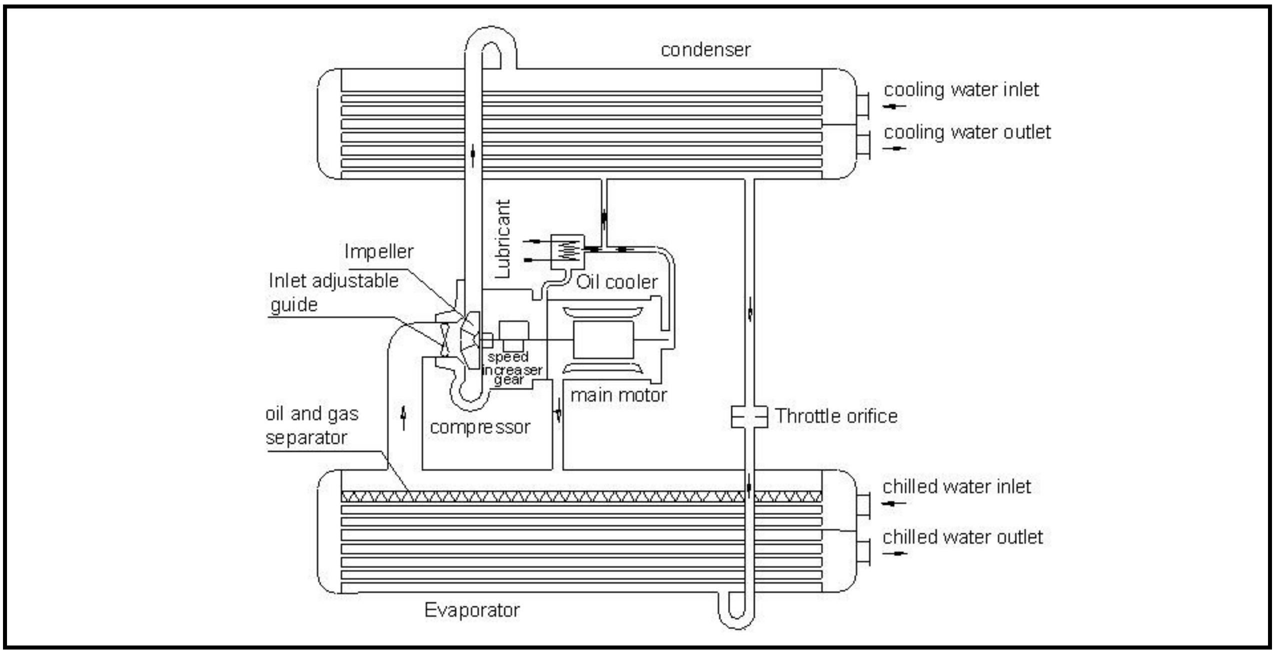
Condenser:
The high pressure hot vapour is condensed into a high pressure hot liquid, or saturated liquid at its pressure corresponds to its condensing temperature. This high pressure liquid refrigerant discharges from the bottom of the condenser and is passed through an expansion valve or some other restrictive device.

Expansion device:
The downstream side of this expansion device is exposed to the low pressure part of the system which causes the refrigerant to expand rapidly as it passes through the device, as it expands; adiabatic cooling of the gas/liquid mixture occurs at this point where it then becomes colder than the water (or other liquid to be cooled) in the evaporator.

Evaporator:
This is a second heat exchanger where the medium (water) ultimately to be cooled by this process, the 'chilled water', is circulated on one side and the cold refrigerant mixture is circulated through the other side where it absorbs heat, thereby cooling down the chilled water. Cooling the chilled water is the fundamental purpose of the equipment. The refrigerant then continues to circulate in the system and after going through the compression process again the heat absorbed will be rejected by the condenser to the tower water or ambient air.

The cooling capacity of the system is directly proportional to refrigerant gas flow through the compressor. An adjustable guide vane regulating device can be installed at the inlet of centrifugal compressors to control the suction flow of compressor, matching the system cooling capacity to that of the building cooling load in a regulated and step less manner across a defined range.

Single-Stage Compression Circulating Diagram



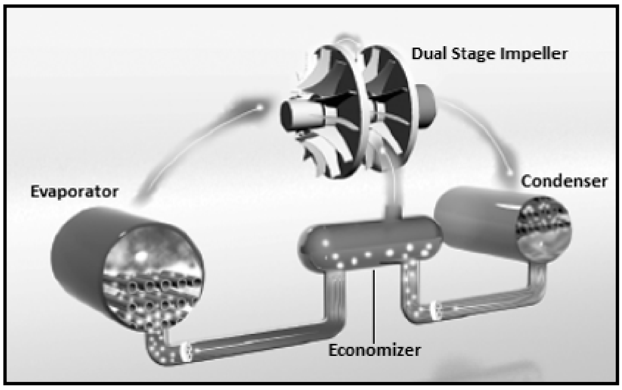
WORKING PRINCIPLE AND STRUCTURE

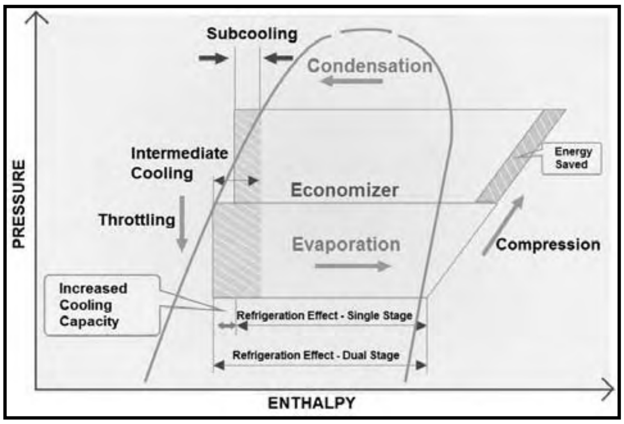
DCLCD Series (Dual Stage Centrifugal Chillers)

The refrigerant cycle of DCLCD chillers with dual-stage impellers are similar to the DCLC chillers with single stage impeller, except for below.

Liquid refrigerant from condenser flows through first throttling device and then flow into the economizer instead of flowing directly to the evaporator. Vapor refrigerant is separated from liquid refrigerant in the economizer. Flash vapor refrigerant exits economizer, flows and enters compressor at second stage of the compression; while remaining liquid refrigerant is further subcooled, flows through second throttling device and then flows in to evaporator. Two benefits as below are visualized by refrigeration effect with dual stage compression, which contribute to the energy saving operation of DCLCD chillers.

a. Power saving operation as flash vapor refrigerant need to pass through only half of the compression cycle to reach the condenser pressure
b. Further subcooled liquid refrigerant able to absorb more heat in the evaporator which benefits the cooling cycle



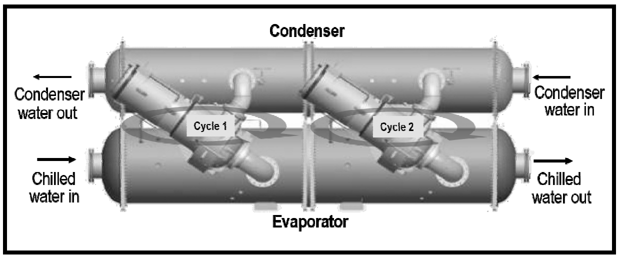


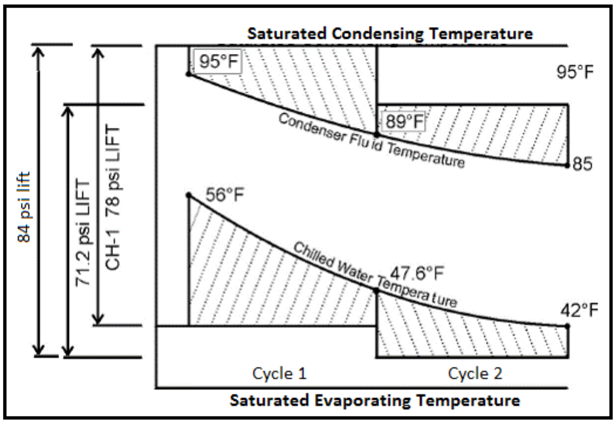
Besides energy saving operations, DCLCD also visualized stable operation in high lift conditions, as well as better resistance to surging.

DCLCT Series (Twin Compressors Centrifugal Chillers)

Dunham-Bush DCLCT chillers are designed with two compressors, with independent refrigerant system.

Evaporators and condensers of DCLCT chillers are with series counter flow design to reduce and balance the total lift of both compressors. Total lift of each compressor of DCLCT chiller is less than single compressor model.





Referring to the above diagram, total refrigerant system lift is 84PSID. With DCLCT design and operation, total lift of Cycle #1 is reduced to 71.2PSID and for Cycle #2, it is reduced to 78PSID.

DCLCT chillers introduce dramatic savings on initial installation cost, as well as the precious installation space compared to installation with two chillers in series connection. DCLCT chillers are also better on control and operation stability as both compressors work as one unit with single control system.

WORKING PRINCIPLE AND STRUCTURE

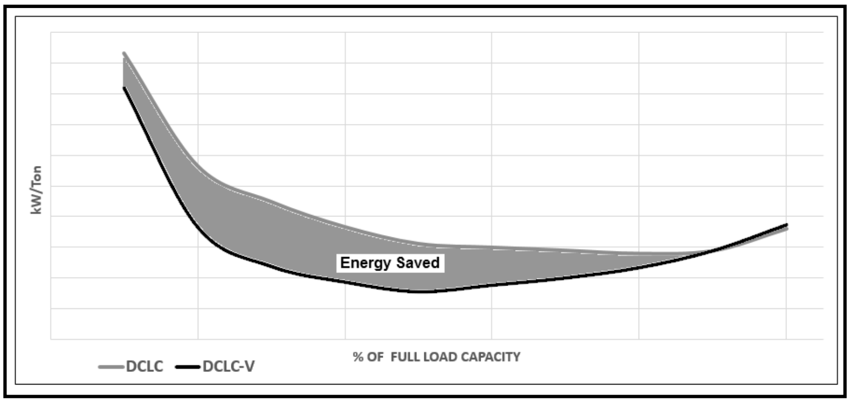
VARIABLE SPEED OPERATION
(DCLCV, DCLCDV & DCLCTV Series)

With increasing demand on high efficiency chillers and energy saving operation, Variable Speed Drive (VSD) is coupled with centrifugal compressor to extend potential of energy saving in the chiller operation. DCLC-V chillers are equipped with inverter duty compressor motor, and remote mounted floor standing VSD panel.

DCLC-V chillers with variable speed operation visualized outstanding part load efficiency, thanks to capability to unload chiller capacity by reducing the motor speed. During partial load operation with reduced compressor lift, VSD slows down compressor motor speed to reduce impeller tip speed, to retain just sufficient tip speed to meet the discharge pressure requirement. This generates great energy saving as compared to capacity unloading by inlet guide vane of the compressor.

In actual operations where the compressor lift reduction is not substantial, unit capacity control is done by combination actions of VSD and inlet guide vane. VSD will slows down the motor speed as much as possible to retain sufficient tip speed, while inlet guide vane will do the remaining capacity reduction. This advanced control provides optimized performance with stable operation under all operating conditions.

Below graph shows typical performance comparison of DCLC chiller versus DCLC-V chiller, and illustrate the potential savings with variable speed operation at AHRI part load operating conditions.



Besides benefits on energy saving as described above, VSD chillers enjoy below benefits too:-

a. No inrush current – Starting current of the compressor motor is **MUCH LESS THAN** motor FLA (Full Load Amps)
b. High displacement power factor – **Minimum** 0.95 displacement power factor for entire operation range

With the above features, sizing and selection of transformers, generators, and switchgears can be optimized. Capacitor bank for displacement power factor correction can be omitted.

IEEE STANDARD 519

IEEE Standard 519 – *"IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems"* recommends harmonic distortion limits for power utilities, as well as the customer. IEEE 519 recommends limits on Total Demand Distortion (TDD) at the Point of Common Coupling (PCC).

TDD, Total Demand Distortion is defined as "harmonic current distortion in % of maximum demand load current".

While PCC, Point of Common Coupling is defined as the point where the building mains is connected to the public power grid.

Thus, IEEE 519 does not specify requirements for internal electrical loads, or any points in the building facility. To comply with the TDD limits as stated in IEEE 519, a power-distribution system analysis on the building's electrical system design shall be conducted to determine degree of harmonics attenuation required.

OIL LUBRICATION AND COOLING SYSTEM

The compressor motor assembly is internally lubricated by an oil system driven by a motor independent to that of the main compressor. The system delivers filtered oil to the compressor and motor bearings at the required temperature and pressure; the drive gears operate in a controlled lubricant mist atmosphere that efficiently cools and lubricates them.

The temperature of the lubricating oil is maintained between 95 to 130°F [35 to 55°C], by passing it through a refrigerant cooled plate heat exchanger mounted on the compressor. Refrigerant cooled oil cooler benefits the owner by eliminating the requirement for field water piping and the associated installation expenses.

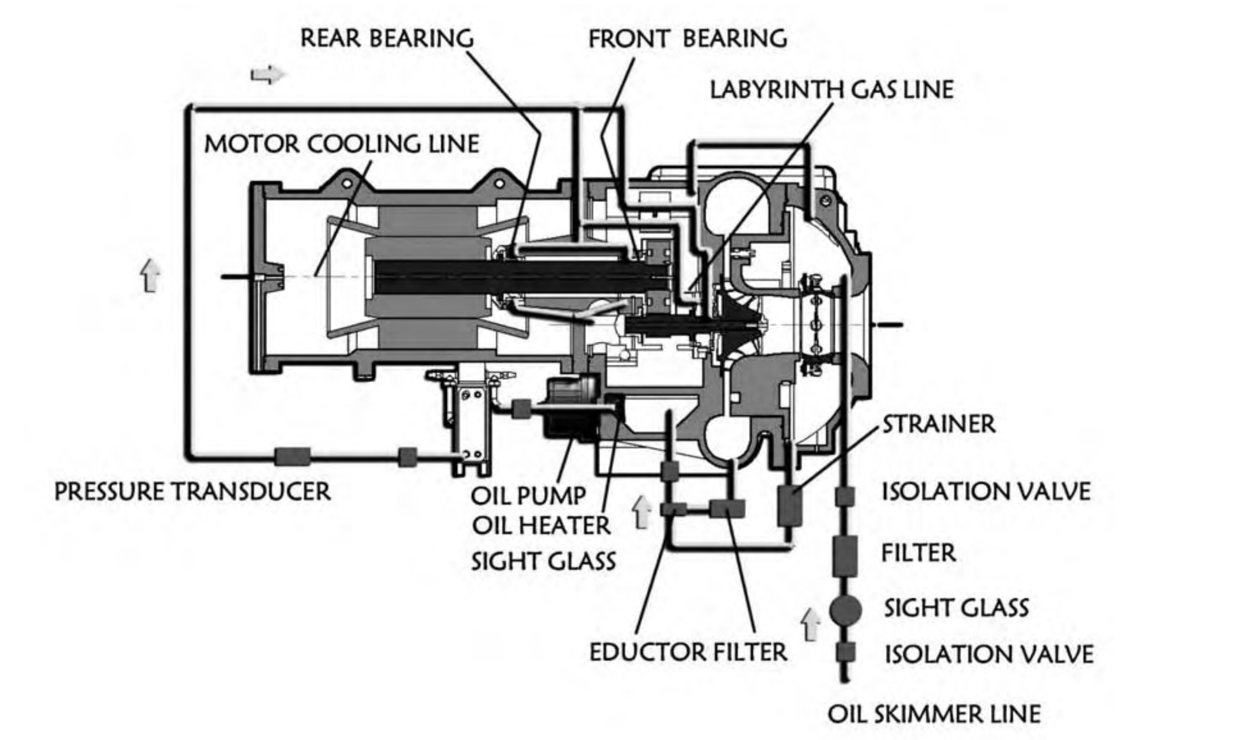
To minimize the quantity of lubricating oil entering and mixing with the refrigerant, comb (labyrinth) seals are installed at inner side of motor bearings at both ends.

Lubricant from the pump is supplied to the compressor through 10 micron oil filter(s) internal to the compressor. An external oil filter is also supplied. The external oil filter is replaceable oil filter which contained in a flanged housing providing easy and convenient access for normal inspection and maintenance of the filter

The control system will not allow the compressor to start until proper oil pressure, 18~25PSID (1.24~1.72BAR), and the proper temperature is established. It also ensures the oil pump to operate after compressor shutdown to provide lubrication during coast-down.

WORKING PRINCIPLE AND STRUCTURE

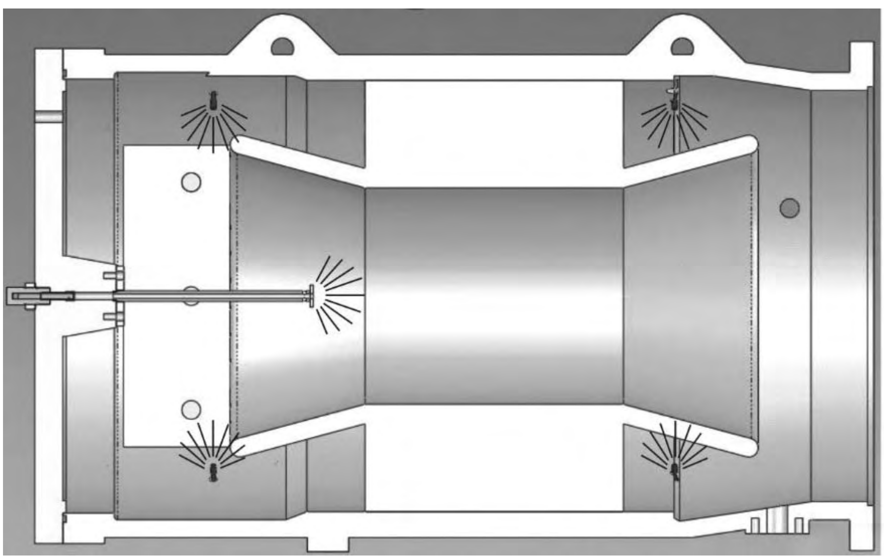
Oil Lubrication And Cooling System



MOTOR REFRIGERANT-COOLED SYSTEM

The DCLC compressor motor is cooled by an efficient refrigerant spray cooling system. Refrigerant spray cooling method is more efficient than other methods.

The motor and the lubricating oil are cooled by liquid refrigerant taken from the bottom of the condenser vessel. Flow of refrigerant is maintained by the pressure difference during compressor operation. After the refrigerant passes through a control valve and filter, it is distributed by the motor cooling system.



The refrigerant flows through an orifice into the motor housing. Once past the orifice, the refrigerant is directed over the motor by a spray nozzle. The refrigerant collects in the bottom of the motor casing and is then drained back to the evaporator through the motor refrigerant drain line.

The motor is protected by the temperature sensors imbedded in the stator windings. If the temperature rises above the safety limit 230°F [110℃], the compressor will shut down automatically.

WORKING PRINCIPLE AND STRUCTURE

INSULATION

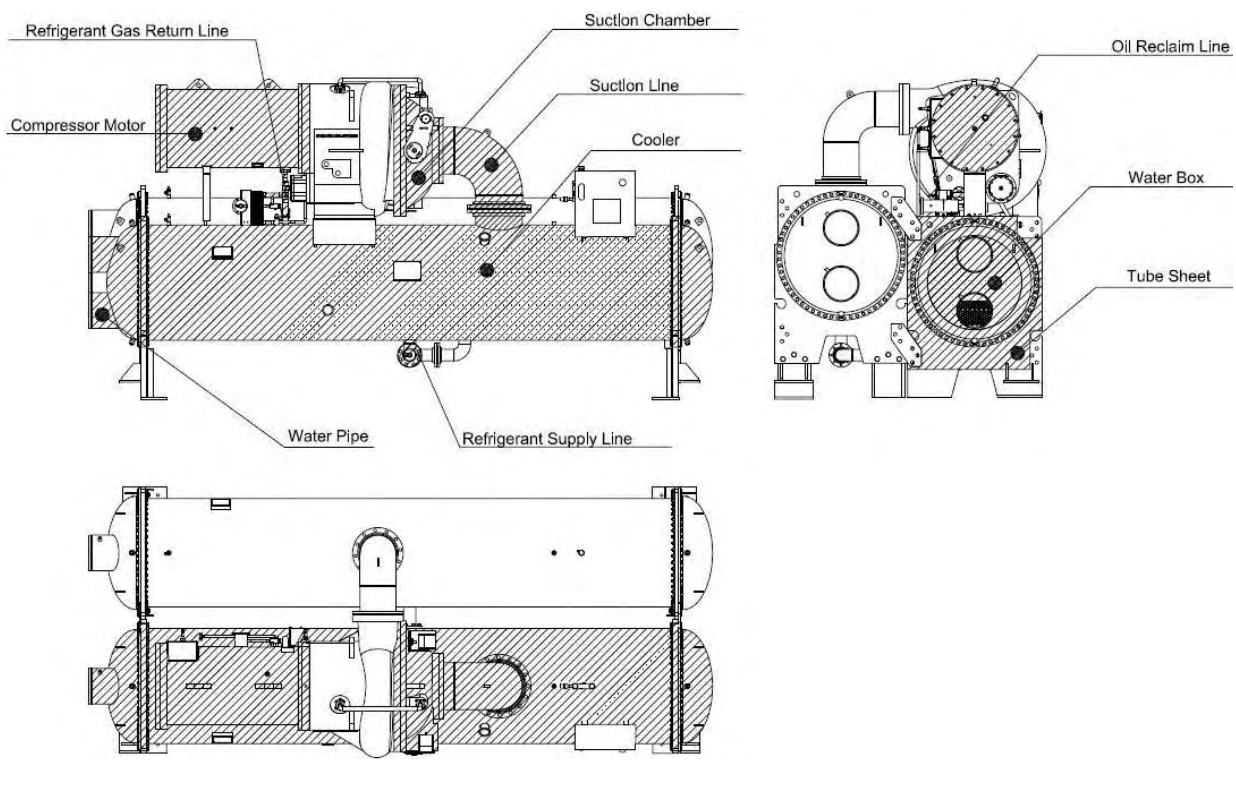
Factory insulation on DCLC chillers with 19mm closed cell insulation are standard supply. The factory insulation for the DCLCs includes the following areas:

- The evaporator shell and tube sheets
- Suction line up to the compressor suction housing
- Compressor motor and motor cooling return lines
- Several small oil cooling and oil return system lines, the liquid line

For unit installation at high humidity job site may require ***Double Thick Insulation*** option to prevent possibility of condensation.

Note: In the case that factory insulation is excluded and unit insulation to be carry out at job site. Thermal insulation shall be fitted in a way that will not interfere with the normal operation of the unit and that will also allow removal of the water boxes to enable cleaning of the heat exchanger tubes. Access to fasteners and nameplate shall be maintained at all times.

Typical Insulated Area By Factory Insulation



ELECTRICAL AND CONTROL SYSTEM

Main Power Supply Voltage and Starter Cabinet

Various main power supply voltages for compressor motor are available in all DCLC series, as below.

Low Voltage (LV)

50Hz– 380V; 400V; 415V

60Hz– 200V; 230V; 380V; 416V; 460V; 575V

Medium Voltage (MV)

50Hz– 3000V; 3300V; 6000V; 6600V; 10000V; 11000V

60Hz– 2400V; 3300V; 4160V; 6900V; 11000V; 13800V

Optional floor Standing NEMA 1 starter cabinet can be supplied and shipped loose for site installation.

Refer to ***Options and Accessories*** for various type of starter cabinet offered by DB.

WORKING PRINCIPLE AND STRUCTURE

Control Power Supply and Unit Electrical Enclosure

The DCLC unit electrical panel is designed to contain oil pump starter together with the control system in single enclosure for the ease of installation. The enclosure is NEMA 1 rated for indoor installation.

Design with single power termination point (3-phase power supply) to provide power supply for oil pump, oil heater(s) and controls. Step down transformer is built-in to step down the main voltage to the required control voltage.

Power consumption of oil heater and oil pump are as below.

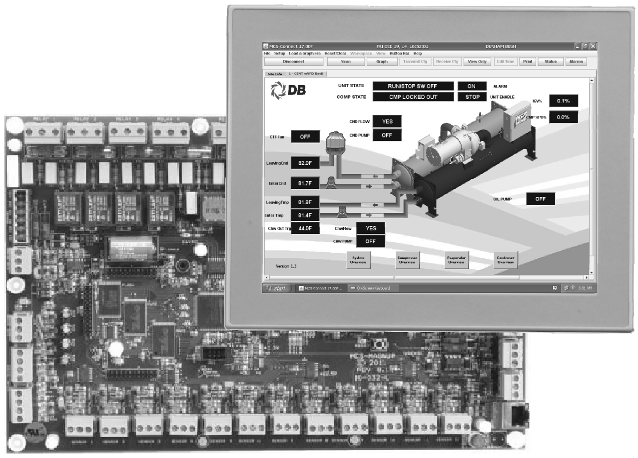
Item	Input power kW
Oil heater	1.0
Oil Pump	1.5

The 3-phase power supply to the control panel can be any of below.

Frequency of power supply	Voltage of Power Supply
50Hz	380V; 400V; 415V
60Hz	208V; 230V; 380V; 460V; 575V

DB Director Control System

DCLC series adopt the state of art ***DB DIRECTOR*** DDC (Direct Digital Control) control system which is proven for its reliability. '***Smart logic***' control theory is used in the DDC control system, through measurement of key parameters and the rate at which they change, the control system will anticipate operation trend and ensure the accurate stable and optimal control of the chiller.



DB DIRECTOR in the DCLC chiller is complete with RS485 communications port and all hardware and software necessary to remotely monitor and control the packaged chiller up to 1500m away (hard wired).

This valuable enhancement to the chiller system allows the ultimate in serviceability. ***DB DIRECTOR*** as standard is additionally equipped with history files which may be used to take logs which would be retrievable. This feature provides owners of multiple buildings with a simple and inexpensive method of investigating potential problems quickly and in a highly effective manner.

DB DIRECTOR is equipped with RS485 and Ethernet communication ports as standard. This user friendly design allows Building Management System (BMS) to interface directly with the chiller via either of Modbus RTU, Modbus IP, or BACnet IP communication protocol. LONworks or BACnet MSTP communication protocol can be established with installation of external adapter

DB DIRECTOR is equipped with 15.4" Touch Screen Color Display Panel as the user interface. This user friendly graphical interface providing following:

- Adjustment of chiller operation set point
- Real time inspection and supervising of chiller operation status
- Real time failure inspection
- Historical operation data storage

The screen displays parameters of chiller operation and to achieve constant monitoring. The start-stop and automatic control procedures can be adjusted, user can access the unit status and reliable start, stop, adjustable operation automatically through simply click on the button.

In addition, user can switch automatic and manual control mode easily. System has protection and malfunction used to ensure safe chiller operation, and it can retain record of up to 99 items of failure parameters for investigation. If the unit operation failed, the control system can carry out an initial diagnosis, indicating the possible cause of the malfunction automatically.

WORKING PRINCIPLE AND STRUCTURE

DB DIRECTOR on each DB centrifugal system is factory mounted, wired, and tested to ensure unit protection and efficient capacity control. In addition, the program logic ensures proper starting, stopping, and anti-recycling of the chiller.

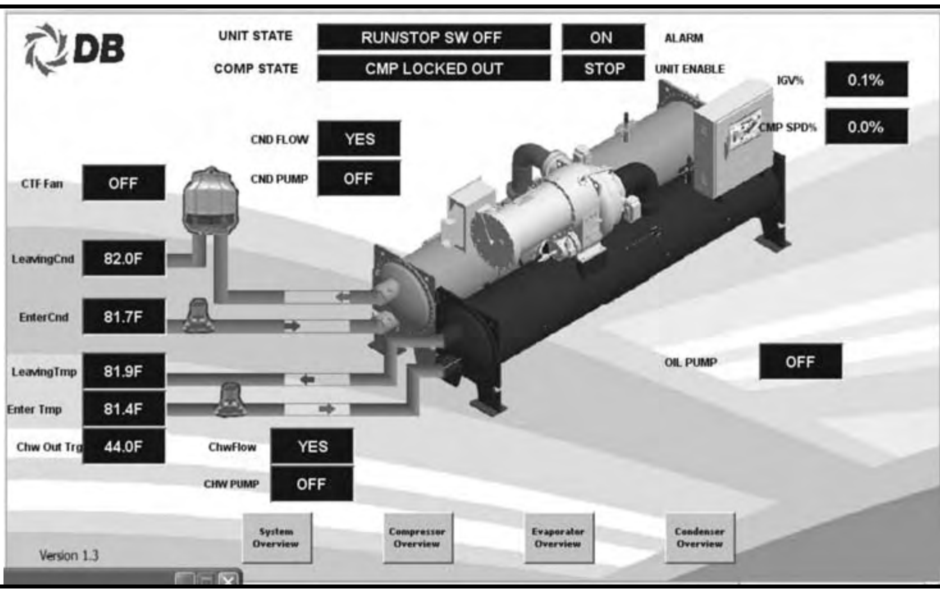
Below readouts are available on the display panel.

- Leaving chilled water temperature
- Evaporator and condenser saturation pressure
- In/out chilled water temperature
- In/out cooling water temperature
- Evaporation saturation pressure
- Condensation saturation pressure
- Percentage of the full load Amps
- Guide vane open degree
- Diffuser open degree
- Water temperature set value
- Oil sump temperature
- Oil sump pressure
- Oil pressure difference
- Total chiller running time
- Elapsed compressor run time
- Motor status
- Oil pump status
- Oil heater status
- Pressure difference flow device status
- Temp/pressure sensor status
- External stop/start command status

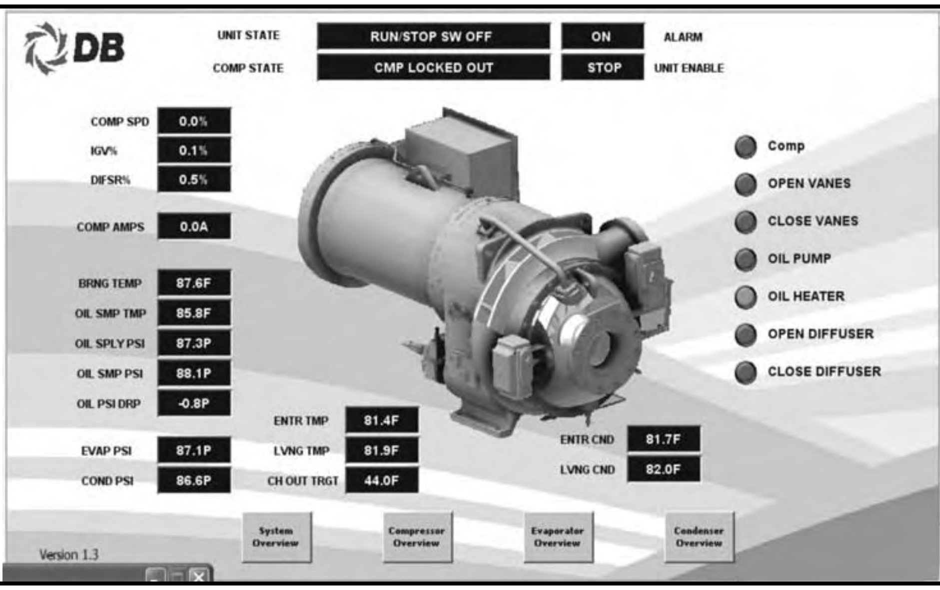
Below are user accessible setpoints available on the display panel.

- Leaving chilled water temperature setpoint
- Leaving chiled water temperature control band
- Weekly operating schedule
- Chilled water temperature reset
- Demand limiting

The Unit Operating Parameters

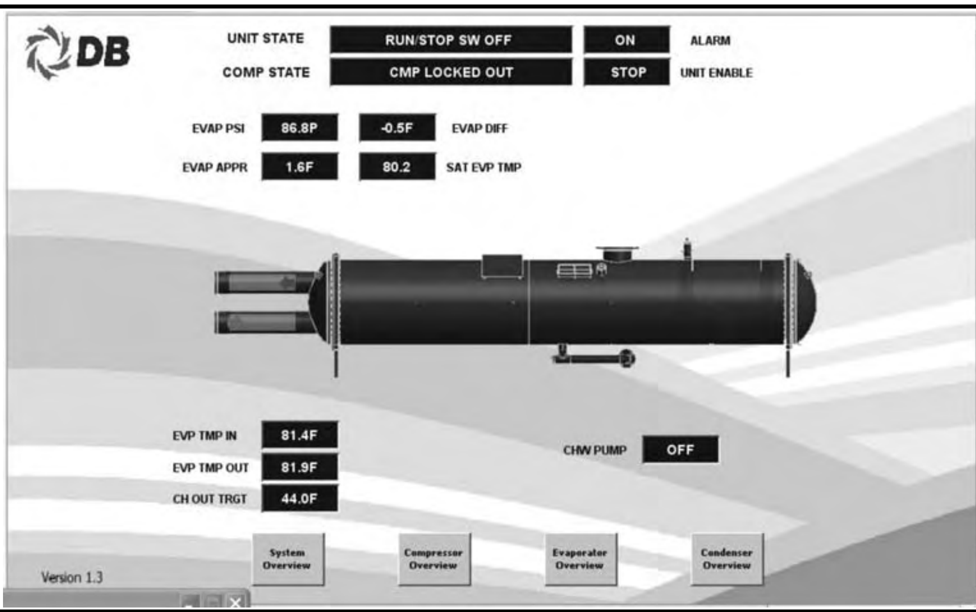


The Compressor Operating Parameters

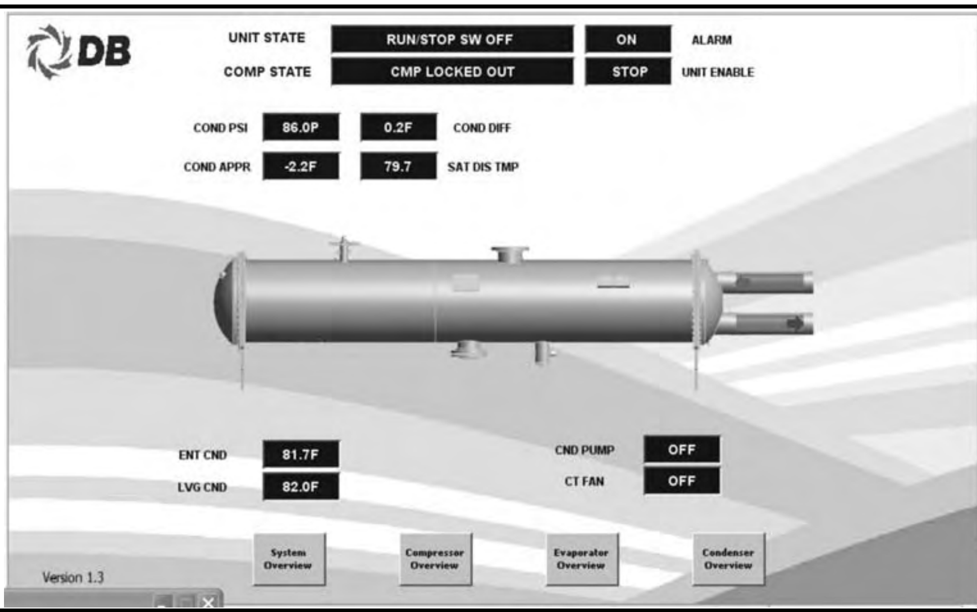


WORKING PRINCIPLE AND STRUCTURE

The Condenser Operating Parameters



The Evaporator Operating Parameters



SYSTEM PROTECTIONS

The chiller controller uses proportional integral-derivative (PID) control for all limits. This removes oscillation above and below setpoints and extends the capabilities of the chiller.

Some of the standard protection features of the chiller controller are described in this section. There are additional protection features not listed here.

High Condenser-Pressure Protection: The condenser limit controller keeps the condenser pressure under a specified maximum pressure. The chiller runs all the way up to 100 percent of the setpoint before reducing capacity using its adaptive control mode.

Starter Failure Protection: The chiller will protect itself from a starter failure that prevents the compressor motor from disconnecting from the line, to the limits of its capabilities. The controller starts and stops the chiller through the starter. If the starter malfunctions and does not disconnect the compressor motor from the line when requested, the controller will recognize the fault and attempt to protect the chiller by operating the evaporator-and condenser-water pumps and attempting to unload the compressor.

WORKING PRINCIPLE AND STRUCTURE

Loss of Water-Flow Protection: DCLC control system has an input that will accept a contact closure from a proof-of-flow device. These are the pressure differential switch and the flow switch for alternative. Customer wiring diagrams also suggest that the flow switch be wired in series with the cooling-water (condenser-water) pump starter's auxiliary contacts. When this input does not prove flow within a fixed time during the transition from Stop to Auto modes of the chiller, or if the flow is lost while the chiller is in the Auto mode of operation, the chiller will be prohibited from running by a non-latching diagnostic.

Anti-freezing Protection: Low evaporator-water temperature protection, also known as Anti-freezing protection, avoids water freezing in the evaporator by immediately shutting down the chiller and attempting to operate the chilled-water pump. This protection prevents freezing in the event of extreme errors in the evaporator- refrigerant temperature sensor.

The cutout setting should be based on the percentage of antifreeze used in the customer's water loop. The chiller's operation and maintenance documentation provides the necessary information for percent antifreeze and suggests leaving-water temperature cutout settings for a given chilled-water temperature set point.

Oil-Temperature Protection: Low oil temperature when the oil pump and/or compressor are running may be an indication of refrigerant diluting the oil. If the oil temperature is at or below the low oil-temperature set point, the compressor is shut down on a latching diagnostic and cannot be started. The diagnostic is reported at the user interface. The oil heater is energized in an attempt to raise the oil temperature above the low oil-temperature set point. High oil-temperature protection is used to avoid overheating the oil and the bearings.

Low Differential Oil-Pressure Protection: Oil pressure is indicative of oil flow and active oil-pump operation. A significant drop in oil pressure indicates a failure of the oil pump, oil leakage, or other blockage in the oil-circuit. During oil pump and compressor prelude mode the differential pressure should not fall below 20PSID [1.4BAR]. A shutdown diagnostic will occur within 3 seconds of the differential pressure falling below 2/3 of the low differential oil pressure cutout. When the compressor is running the shutdown diagnostic will occur when the differential pressure falls below the differential oil pressure cutout for more than (cutout x 3) seconds. This allows for a relatively high cutout to be violated longer before triggering shutdown, as compared to a low cutout.

Current Overload Protection: The control panel will monitor the current drawn by each line of the motor and shut the chiller off when the highest of the three line currents exceeds the trip curve. A manual reset diagnostic describing the failure will be displayed. The current overload protection does not prohibit the chiller from reaching its full load amperage. The chiller protects itself from damage due to current overload during starting and running modes, but is allowed to reach full-load amps.

High Motor-Winding Temperature Protection: This function monitors the motor temperature and terminates chiller operation when the temperature is excessive. The controller monitors each of the three winding-temperature sensors any time the controller is powered up. Immediately prior to start, and while running, the controller will generate a latching diagnostic if the winding temperature exceeds 110℃.

There are some other system protection controls which will automatically act to insure system reliability:-

- High gear temperature
- Sensor error
- Anti-recycle
- Oil pump overload
- [Optional] Oil pump starter failure
- Low pressure difference of oil
- Power loss

DB DIRECTOR retains the latest 99 alarm conditions complete with time of failure in its alarm history. This tool aids service technicians in troubleshooting tasks enabling downtime and nuisance trip-outs to be minimized.

Chilled water pump, condenser water pump and cooling tower can be control by the chiller controller. ***DB DIRECTOR*** gives start/stop command to these equipment through the volt-free contacts to work as a standalone system. For best energy saving and optimized chiller system operation, ***DB-CPM*** (Chiller Plant Manager) is the recommended solution. Refer ***Options & Accessories*** for detail explanations.

OPTIONS & ACCESSORIES

Starter Panel

The factory supplied main motor starter panel are rated with NEMA-1 protection and includes below:

- Main incoming power terminal block for wires termination
- Circuit breaker for the compressor
- Solid state compressor motor over Current protection module for each phase
- Compressor motor overheat protection module
- Main power supply monitoring module to give protection on:
  - Under or over voltage
  - Phase reversal
  - Phase loss
  - Phase imbalance
- (Optional) Ground fault interrupter

Direct-On-Line (DOL) Starter – DOL starter is full voltage starter with simplest design and lowest cost. Full starting torque is applied to motor during start-up, thus, starting current is equivalent to motor LRA (lock rotor amps), in another words, about 7 times of rated full load current (FLA). DOL starter is recommended for MV applications only and subject to local rules, regulation and authorities' approval.

Star-Delta Starter – Star-Delta starter is a reduced voltage starter where the starting voltage is reduced to 1/3 of full voltage start. Thus, starting torque applied to the motor is 1/3 of full voltage starting torque, resulting 2/3 decrement in starting current as compared to DOL

WORKING PRINCIPLE AND STRUCTURE

starter. Generally the starting current is about 2~3 times of rated FLA. Star-Delta starter with just 1/3 of full load torque is good enough to start the centrifugal compressor as centrifugal compressor is always started at "No Load" condition with inlet guide vane fully closed.

Auto-transformer Starter – This type of closed transition reduced voltage starter uses transformer to step down the voltage to the motor during startup. Auto-transformer starter reduced starting torque to 42% of full load torque when 65% voltage tap is used. In such, starting current is reduced to 42% of LRA, which is about 3 times of rated FLA.

Softstarter (Solid State Starter) – Softstarter, or solid state starter is an electronic controlled starter with controllable starting characteristic. Softstarter uses SCRs (silicon Controlled Rectifier) to control current flow to the motor during start-up, thus, the motor starting current can be controlled. Maximum starting current by softstarter can be preset, and usually is about 2~2.5 times of rated FLA. SCRs or softstarter will be bypass after motor has reached rated motor rpm to minimize heat loss generated by softstarter, as well as to extend the life span of the softstarter.

VSD (Variable Speed Drive) – VSD is motor controller which appear to be best motor starter for now. Besides enjoying no inrush motor startup by VSD starter, part load performance of DCLC chillers can be further improved, as describe in Section ***Variable Speed Operation*.**

VSD utilize IGBT (Insulated-Gate Bipolar Transistor) technology to generate PWM (Pulse Width Modulating) signal to control the motor speed. Thus, motor starting torque can be applied precisely without over-stress the motor. Therefore, integration of VSD to DCLC chillers not only benefits the chiller operation, it also helps on power grid and generator as it eliminates current surging during motor startup. Besides, displacement power factor is also improved to minimum level of 0.95 for entire operation range.

Harmonic filter option – Harmonic distortion occurs when there is VSD in the electrical distribution system. Harmonic distortion level can be treated at PCC (Point of Common Coupling) as specify by IEEE Standard 519. However, DB can provide option to include additional harmonic filter to lower the total harmonic distortion level. Harmonic filter with maximum 5% or 10% total harmonic distortion is available on customer request to suite the applications.

Refrigerant Isolation Valves

Isolation valves are installed at refrigerant liquid line and compressor discharge line to isolate the condenser for refrigerant storage during servicing. This saves precious time on servicing as it eliminates the needs to transfer refrigerant into external refrigerant storage vessels.

1-pass Evaporator and Condenser

1-pass evaporator or condenser is suitable for applications with low temperature different (delta T) or high fluid flow, where the evaporators or condensers are piped in series. This is available for DCLC and DCLCD series only, DCLCT series is with 1-pass evaporator and condenser as standard.

3-pass Evaporator and Condenser

3-pass evaporator or condenser is suitable for applications with high delta T and low fluid flow. This is available for DCLC and DCLCD series only, and not applicable for DCLCT series.

Flange Water Connection

Flanged water connection for evaporator and condenser water connections in lieu of standard Victaulic groove connection.

Marine Water Box

Marine water box for condenser, for ease of condenser tube cleaning without interfere with field water piping.

250 / 300psig Evaporator and Condenser

Evaporator and condenser vessels with 250 / 300psig working pressure at water side is available to suite site installation.

Double Thick Insulation

Evaporator with double thick 1 ¾" [38mm] closed cell insulation, for extra resistance to condensation.

Vibration Isolator

Spring isolators with 1" [25mm] deflection is supplied for field installation. These housed spring assemblies have a neoprene friction pad at the bottom to prevent the passage of noise, and a spring locking levering bolt at the top. Neoprene inserts prevent contact between the steel upper and lower housings.

ASME / PED Stamp, JKKP Compliance

Evaporator and condenser with ASME / PED Stamp, or with JKKP approval are available on request.

DB-CPM (Chiller Plant Manager)

DB Chiller Plant Manager (***CPM***) is a trustworthy and headache-free solution for building owners and users on chiller plant control and automation system. ***CPM***s advanced controllers monitor and control equipment in chiller plant such as chillers, primary and secondary chilled water pumps, condenser water pumps, cooling towers, variable frequency drives (VFD), motorized valves, bypass modulating valves, and etc. Field devices such as flow meters, BTU meters, digital power meters, sensors & transducers can be interfaced with ***CPM*** via HLI or LLI. ***CPM*** controls chillers, pumps and cooling towers sequencing, as well as lead-lag, duty-standby and alarm changeover operations.

NetVisorPRO – Monitoring software of ***CPM*** system which allows system monitoring, historical trending, and alarm logging to be carry out at a PC terminal. Graphical animations on system operation, temperature and flow rate trend graphs, historical data and alarm history logs, settings changes are all available with ***NetVisorPRO***.

Chiller plantroom control and automation by Dunham-Bush ***DB-CPM*** provides the owners with a chiller system in stable operation, optimized performance and energy efficiency.

PRODUCT SPECIFICATIONS

DCLC Chiller Specifications (Typical)

MODEL DCLC		300	350	400	450	500	550	600	650	700	750	800	850	900
UNIT PERFORMANCE														
Nominal Cooling Capacity	TR	300	350	400	450	500	550	600	650	700	750	800	850	900
	kW	1055	1231	1407	1583	1759	1934	2110	2286	2462	2638	2814	2989	3165
Nominal Power Input	kW	178.87	203.82	232.00	261.00	288.66	311.99	340.00	364.49	388.55	422.00	449.00	470.00	500.01
Energy Efficiency	kW/TR	0.596	0.582	0.580	0.580	0.577	0.567	0.566	0.561	0.555	0.563	0.561	0.553	0.555
	COP	5.90	6.04	6.06	6.06	6.10	6.20	6.21	6.27	6.34	6.25	6.27	6.36	6.34
IPLV	kW/TR	0.53	0.52	0.49	0.50	0.50	0.48	0.48	0.52	0.49	0.50	0.50	0.48	0.49
	COP	6.64	6.76	7.18	7.03	7.03	7.33	7.33	6.76	7.18	7.03	7.03	7.33	7.18
EVAPORATOR														
Flow Rate	Usgpm	717.4	837.0	956.6	1076.2	1195.7	1315.3	1434.9	1554.5	1674.0	1793.6	1913.2	2032.8	2152.3
	L/S	45.20	52.73	60.27	67.80	75.33	82.86	90.40	97.93	105.46	113.00	120.53	128.07	135.59
Pressure Drop	ft.wg	4.7	6.2	10.9	11.7	16.1	19.0	22.1	20.7	20.9	20.9	20.6	20.1	22.3
	kPa	14.0	18.5	32.6	35.0	48.1	56.8	66.0	61.9	62.4	62.4	61.6	60.1	66.6
Water Connection	Victaulic (inch)	8	8	8	8	8	8	8	8	8	10	10	10	10
	Flange	DN200	DN200	DN200	DN200	DN200	DN200	DN200	DN200	DN200	DN250	DN250	DN250	DN250
Number of Passes		2	2	2	2	2	2	2	2	2	2	2	2	2
CONDENSER														
Flow Rate	Usgpm	900.0	1050.0	1200.0	1350.0	1500.0	1650.0	1800.0	1950.0	2100.0	2250.0	2400.0	2550.0	2700.0
	L/S	56.70	66.15	75.60	85.05	94.50	103.95	113.40	122.85	132.30	141.75	151.20	160.65	170.10
Pressure Drop	ft.wg	6.0	7.9	11.4	10.7	14.7	23.4	23.2	23.2	26.4	26.3	26.0	19.5	21.6
	kPa	17.9	23.6	34.1	32.0	43.9	69.9	69.3	69.3	78.9	78.6	77.7	58.3	64.5
Water Connection	Victaulic (inch)	8	8	8	8	8	8	10	10	10	10	10	10	10
	Flange	DN200	DN200	DN200	DN200	DN200	DN200	DN250	DN250	DN250	DN250	DN250	DN250	DN250
Number of Passes		2	2	2	2	2	2	2	2	2	2	2	2	2
GENERAL														
Length (L)	inch	194.65	194.65	194.65	174.13	194.65	194.65	194.65	194.65	194.65	195.24	195.24	199.41	199.41
	mm	4944	4944	4944	4423	4944	4944	4944	4944	4944	4959	4959	5065	5065
Width (W)	inch	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	82.52	82.52	95.51	95.51
	mm	1994	1994	1994	1994	1994	1994	1994	1994	1994	2096	2096	2426	2426
Height (H)	inch	83.9	83.9	83.9	83.9	83.9	83.9	83.9	88.19	88.19	90.75	90.75	109.45	109.45
	mm	2131	2131	2131	2131	2131	2131	2131	2240	2240	2305	2305	2780	2780
Shipping Weight	lbs	20915	20951	20338	19403	20657	20243	20507	24725	24945	25717	26164	31493	31497
	kg	9487	9503	9225	8801	9370	9182	9302	11215	11315	11665	11868	14285	14287
Operating Weight	lbs	24668	24703	23731	22432	24134	23543	23900	28371	28698	29778	30433	36882	36826
	kg	11189	11205	10764	10175	10947	10679	10841	12869	13017	13507	13804	16730	16704
R134a Charge (Approx.)	lbs	1173	1173	1065	853	1065	1065	1065	1133	1173	1254	1296	1556	1556
	kg	532	532	483	387	483	483	483	514	532	569	588	706	706

MODEL DCLC		950	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
UNIT PERFORMANCE													
Nominal Cooling Capacity	TR	950	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
	kW	3341	3517	3869	4220	4572	4924	5276	5627	5979	6331	6682	7034
Nominal Power Input	kW	547.51	570.00	623.00	687.00	729.01	784.05	833.03	909.00	959.05	1016.04	1068.95	1126.99
Energy Efficiency	kW/TR	0.576	0.570	0.566	0.573	0.561	0.560	0.555	0.568	0.564	0.564	0.563	0.563
	COP	6.11	6.17	6.21	6.14	6.27	6.28	6.34	6.19	6.24	6.24	6.25	6.25
IPLV	kW/TR	0.57	0.52	0.51	0.50	0.48	0.48	0.49	0.49	0.49	0.49	0.49	0.49
	COP	6.17	6.76	6.90	7.03	7.33	7.33	7.18	7.18	7.18	7.18	7.18	7.18
EVAPORATOR													
Flow Rate	Usgpm	2271.9	2391.5	2630.6	2869.8	3108.9	3348.1	3587.2	3826.4	4065.5	4304.7	4543.8	4783.0
	L/S	143.13	150.66	165.73	180.80	195.86	210.93	225.99	241.06	256.13	271.20	286.26	301.33
Pressure Drop	ft.wg	22.7	24.8	25.3	29.4	31.1	30.6	30.0	24.7	27.4	24.4	26.9	24.3
	kPa	67.8	74.1	75.6	87.8	92.9	91.4	89.6	73.8	81.9	72.9	80.4	72.6
Water Connection	Victaulic (inch)	10	12	12	12	14	14	14	16	16	16	16	16
	Flange	DN250	DN300	DN300	DN300	DN350	DN350	DN350	DN400	DN400	DN400	DN400	DN400
Number of Passes		2	2	2	2	2	2	2	2	2	2	2	2
CONDENSER													
Flow Rate	Usgpm	2850.0	3000.0	3300.0	3600.0	3900.0	4200.0	4500.0	4800.0	5100.0	5400.0	5700.0	6000.0
	L/S	179.55	189.00	207.90	226.80	245.70	264.60	283.50	302.40	321.30	340.20	359.10	378.00
Pressure Drop	ft.wg	22.9	25.1	29.6	34.5	32.1	31.7	35.8	29.2	26.2	29.0	27.5	30.0
	kPa	68.4	75.0	88.4	103.1	95.9	94.7	107.0	87.2	78.3	86.7	82.2	89.6
Water Connection	Victaulic (inch)	10	12	12	12	14	14	14	16	16	16	16	16
	Flange	DN250	DN300	DN300	DN300	DN350	DN350	DN350	DN400	DN400	DN400	DN400	DN400
Number of Passes		2	2	2	2	2	2	2	2	2	2	2	2
GENERAL													
Length (L)	inch	223.43	223.43	223.43	223.43	225.87	225.87	225.87	209.06	209.06	209.06	209.06	209.06
	mm	5675	5675	5675	5675	5737	5737	5737	5310	5310	5310	5310	5310
Width (W)	inch	95.51	95.51	95.51	95.51	110.24	110.24	110.24	122.05	122.05	122.05	122.05	122.05
	mm	2426	2426	2426	2426	2800	2800	2800	3100	3100	3100	3100	3100
Height (H)	inch	109.45	109.45	116.14	116.14	116.34	116.34	116.34	125	125	125	125	125
	mm	2780	2780	2950	2950	2955	2955	2955	3175	3175	3175	3175	3175
Shipping Weight	lbs	34072	34077	37881	37860	41277	42208	42657	45503	46165	47851	48513	49042
	kg	15455	15457	17183	17173	18723	19146	19349	20640	20940	21705	22005	22245
Operating Weight	lbs	40558	40563	44555	44604	48671	50078	50812	53899	54750	56824	57686	58656
	kg	18397	18399	20210	20232	22077	22715	23048	24449	24835	25775	26166	26606
R134a Charge (Approx.)	lbs	1951	1951	2070	2070	2141	2271	2392	2255	2255	2509	2509	2762
	kg	885	885	939	939	971	1030	1085	1023	1023	1138	1138	1253

Notes:

1. The units are rated in accordance with AHRI Standard 550/590. The above data are rated with following conditions: Chilled Water Inlet/Outlet Temperature 54/44℉ [12.2/6.7°C]; Cooling Water Inlet Temperature 85℉ [29.4°C]; Cooling Water Flow Rate 3Usgpm/ton; Evaporator fouling factor 0.0001hr.ft2.℉/Btu [0.000018 m^2.°C/W]; condenser fouling factor 0.00025 hr.ft2.℉/Btu [0.0000144 m^2.°C/W]; 2-pass evaporator and condenser
2. The Sample Specification above is for reference only. With variety of main components combination, the same cooling capacity can have many different models. Contact local DB office to choose the appropriate chiller for the User's practical requirements.

PRODUCT SPECIFICATIONS

DCLCD Chiller Specifications (Typical)

MODEL DCLCD		500	550	600	650	700	750	800	850
UNIT PERFORMANCE									
Nominal Cooling Capacity	TR	500	550	600	650	700	750	800	850
	kW	1759	1934	2110	2286	2462	2638	2814	2989
Nominal Power Input	kW	266.80	288.20	315.30	335.00	366.90	393.10	420.30	441.70
Energy Efficiency	kW/TR	0.534	0.524	0.526	0.516	0.524	0.524	0.526	0.519
	COP	6.59	6.71	6.69	6.82	6.71	6.71	6.69	6.78
IPLV	kW/TR	0.50	0.50	0.50	0.49	0.49	0.49	0.49	0.48
	COP	7.03	7.03	7.03	7.18	7.18	7.18	7.18	7.33
EVAPORATOR									
Flow Rate	Usgpm	1195.7	1315.3	1434.9	1554.5	1674.0	1793.6	1913.2	2032.8
	L/S	75.33	82.86	90.40	97.93	105.46	113.00	120.53	128.07
Pressure Drop	ft.wg	19.0	22.4	15.8	16.1	18.4	16.1	16.4	22.9
	kPa	56.8	66.9	47.2	48.1	55.0	48.1	49.0	68.4
Water Connection	Victaulic (inch)	8	8	8	8	8	10	10	10
	Flange	DN200	DN200	DN200	DN200	DN200	DN250	DN250	DN250
Number of Passes		2	2	2	2	2	2	2	2
CONDENSER									
Flow Rate	Usgpm	1500.0	1650.0	1800.0	1950.0	2100.0	2250.0	2400.0	2550.0
	L/S	94.50	103.95	113.40	122.85	132.30	141.75	151.20	160.65
Pressure Drop	ft.wg	24.8	24.1	20.4	20.4	23.2	20.4	20.5	25.9
	kPa	74.1	72.0	61.0	61.0	69.3	61.0	61.3	77.4
Water Connection	Victaulic (inch)	10	10	10	10	10	10	10	10
	Flange	DN250	DN250	DN250	DN250	DN250	DN250	DN250	DN250
Number of Passes		2	2	2	2	2	2	2	2
GENERAL									
Length (L)	inch	174.14	174.13	174.13	174.13	174.13	174.72	174.72	195.24
	mm	4423	4423	4423	4423	4423	4438	4438	4959
Width (W)	inch	78.5	78.5	78.5	78.5	78.5	82.52	82.52	82.52
	mm	1994	1994	1994	1994	1994	2096	2096	2096
Height (H)	inch	100	100	100	100	100	101.97	101.97	101.97
	mm	2540	2540	2540	2540	2540	2590	2590	2590
Shipping Weight	lbs	16876	17097	18089	18420	21363	22851	23182	24291
	kg	7655	7755	8205	8355	9690	10365	10515	11018
Operating Weight	lbs	20430	20739	22271	22847	25790	27886	28431	30075
	kg	9267	9407	10102	10363	11698	12649	12896	13642
R134a Charge (Approx.)	lbs	1451	1451	1605	1706	1706	1874	1942	2205
	kg	658	658	728	774	774	850	881	1000

MODEL DCLCD		900	950	1000	1100	1200	1300	1400	1500
UNIT PERFORMANCE									
Nominal Cooling Capacity	TR	900	950	1000	1100	1200	1300	1400	1500
	kW	3165	3341	3517	3869	4220	4572	4924	5276
Nominal Power Input	kW	467.10	496.40	517.80	578.50	628.30	669.30	725.10	769.80
Energy Efficiency	kW/TR	0.519	0.522	0.518	0.526	0.523	0.515	0.518	0.513
	COP	6.78	6.74	6.79	6.69	6.72	6.83	6.79	6.86
IPLV	kW/TR	0.49	0.49	0.49	0.50	0.50	0.49	0.49	0.49
	COP	7.18	7.18	7.18	7.03	7.03	7.18	7.18	7.18
EVAPORATOR									
Flow Rate	Usgpm	2152.3	2271.9	2391.5	2630.6	2869.8	3108.9	3348.1	3587.2
	L/S	135.59	143.13	150.66	165.73	180.80	195.86	210.93	225.99
Pressure Drop	ft.wg	22.9	25.2	26.8	25.7	25.8	23.5	26.8	26.3
	kPa	68.4	75.3	80.1	76.8	77.1	70.2	80.1	78.6
Water Connection	Victaulic (inch)	10	10	12	12	12	14	14	14
	Flange	DN250	DN250	DN300	DN300	DN300	DN350	DN350	DN350
Number of Passes		2	2	2	2	2	2	2	2
CONDENSER									
Flow Rate	Usgpm	2700.0	2850.0	3000.0	3300.0	3600.0	3900.0	4200.0	4500.0
	L/S	170.10	179.55	189.00	207.90	226.80	245.70	264.60	283.50
Pressure Drop	ft.wg	28.6	31.4	25.9	30.6	30.3	28.1	27.8	31.4
	kPa	85.5	93.8	77.4	91.4	90.5	84.0	83.1	93.8
Water Connection	Victaulic (inch)	10	10	12	12	12	14	14	14
	Flange	DN250	DN250	DN300	DN300	DN300	DN350	DN350	DN350
Number of Passes		2	2	2	2	2	2	2	2
GENERAL									
Length (L)	inch	195.24	195.24	199.41	199.41	199.41	201.85	201.85	201.85
	mm	4959	4959	5065	5065	5065	5127	5127	5127
Width (W)	inch	82.52	82.52	95.51	95.51	95.51	110.24	110.24	110.24
	mm	2096	2096	2426	2426	2426	2800	2800	2800
Height (H)	inch	101.97	101.97	115.35	116.93	116.93	118.5	118.5	118.5
	mm	2590	2590	2930	2970	2970	3010	3010	3010
Shipping Weight	lbs	24548	24553	29315	32534	33830	38797	39238	39727
	kg	11135	11137	13297	14757	15345	17598	17798	18020
Operating Weight	lbs	30450	30455	36387	39919	41692	48387	49011	49842
	kg	13812	13814	16505	18107	18911	21948	22231	22608
R134a Charge (Approx.)	lbs	2253	2253	1578	2789	2959	3287	3287	3474
	kg	1022	1022	716	1265	1342	1491	1491	1576

Notes:

1. The units are rated in accordance with AHRI Standard 550/590. The above data are rated with following conditions:
   Chilled Water Inlet/Outlet Temperature 54/44℉ [12.2/6.7ºC]; Cooling Water Inlet Temperature 85℉ [29.4ºC]; Cooling Water Flow Rate 3Usgpm/ton; Evaporator fouling factor 0.0001hr.ft2.℉/Btu [0.000018 m^2.ºC/W]; condenser fouling factor 0.00025 hr.ft2.℉/Btu [0.0000144 m^2.ºC/W]; 2-pass evaporator and condenser
2. The Sample Specification above is for reference only. With variety of main components combination, the same cooling capacity can have many different models. Contact local DB office to choose the appropriate chiller for the User's practical requirements.

PRODUCT SPECIFICATIONS

DCLCT Chiller Specifications (Typical)

MODEL DCLCT		2200	2400	2600	2800	3000
UNIT PERFORMANCE						
Nominal Cooling Capacity	TR	2200	2400	2600	2800	3000
	kW	7737	8441	9144	9848	10551
Nominal Power Input	kW	1252.6	1366.7	1477.9	1583.8	1690.5
Energy Efficiency	kW/TR	0.569	0.569	0.568	0.565	0.563
	COP	6.18	6.18	6.19	6.22	6.25
IPLV	kW/TR	0.45	0.45	0.45	0.45	0.45
	COP	7.82	7.82	7.82	7.82	7.82
EVAPORATOR						
Flow Rate	Usgpm	5257.4	5735.4	6213.3	6691.3	7169.2
	L/S	331.22	361.33	391.44	421.55	451.66
Pressure Drop	ft.wg	18.3	19.6	19.5	19.3	18.2
	kPa	54.7	58.6	58.3	57.7	54.4
Number of Passes		1	1	1	1	1
CONDENSER						
Flow Rate	Usgpm	6600.0	7200.0	7800.0	8400.0	9000.0
	L/S	415.80	453.60	491.40	529.20	567.00
Pressure Drop	ft.wg	20.1	20.1	20.1	19.0	21.4
	kPa	60.1	60.1	60.1	56.8	63.9
Number of Passes		1	1	1	1	1
GENERAL						
Length (L)	inch	318.9	318.9	318.9	322.83	322.83
	mm	8100	8100	8100	8200	8200
Width (W)	inch	110.24	110.24	110.24	122.05	122.05
	mm	2800	2800	2800	3100	3100
Height (H)	inch	121.26	121.26	121.26	123.03	123.03
	mm	3080	3080	3080	3125	3125
Shipping Weight	lbs	54306	55387	56868	68112	69554
	kg	24633	25124	25795	30896	31550
Operating Weight	lbs	66176	67838	70092	83410	85449
	kg	30017	30771	31794	37835	38760
R134a Charge (Approx.)	lbs	3893	4061	4310	5093	5355
	kg	1766	1842	1955	2310	2429

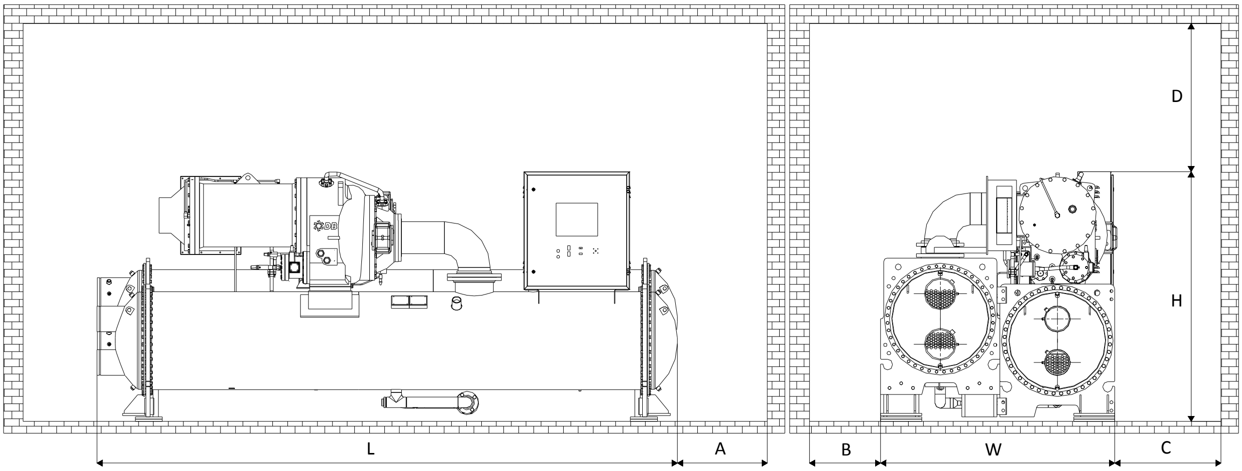
MODEL DCLCT		3200	3400	3600	3800	4000
UNIT PERFORMANCE						
Nominal Cooling Capacity	TR	3200	3400	3600	3800	4000
	kW	11254	11958	12661	13365	14068
Nominal Power Input	kW	1805.0	1916.3	2026.5	2137.0	2241.3
Energy Efficiency	kW/TR	0.564	0.563	0.563	0.563	0.560
	COP	6.24	6.25	6.25	6.25	6.28
IPLV	kW/TR	0.45	0.45	0.45	0.45	0.44
	COP	7.82	7.82	7.82	7.82	7.99
EVAPORATOR						
Flow Rate	Usgpm	7647.2	8125.1	8603.1	9081.0	9559.0
	L/S	481.77	511.88	542.00	572.10	602.22
Pressure Drop	ft.wg	16.5	18.3	16.7	18.4	15.7
	kPa	49.3	54.7	49.9	55.0	46.9
Number of Passes		1	1	1	1	1
CONDENSER						
Flow Rate	Usgpm	9600.0	10200.0	10800.0	11400.0	12000.0
	L/S	604.80	642.60	680.40	718.20	756.00
Pressure Drop	ft.wg	19.4	18.6	20.5	19.4	21.2
	kPa	58.0	55.6	61.3	58.0	63.3
Number of Passes		1	1	1	1	1
GENERAL						
Length (L)	inch	322.83	322.83	322.83	326.77	326.77
	mm	8200	8200	8200	8300	8300
Width (W)	inch	122.05	122.05	122.05	134.65	134.65
	mm	3100	3100	3100	3420	3420
Height (H)	inch	125.20	125.20	125.20	133.27	133.27
	mm	3180	3180	3180	3385	3385
Shipping Weight	lbs	70993	72199	73116	93399	94942
	kg	32202	32749	33165	42366	43066
Operating Weight	lbs	88372	90099	91814	113867	116587
	kg	40086	40869	41647	51650	52884
R134a Charge (Approx.)	lbs	5838	5939	6290	6733	7249
	kg	2648	2694	2853	3054	3288

Notes:

1. The units are rated in accordance with AHRI Standard 550/590. The above data are rated with following conditions: Chilled Water Inlet/Outlet Temperature 54/44℉ [12.2/6.7°C]; Cooling Water Inlet Temperature 85℉ [29.4°C]; Cooling Water Flow Rate 3Usgpm/ton; Evaporator fouling factor 0.0001hr.ft2.℉/Btu [0.000018 m^2.°C/W]; condenser fouling factor 0.00025 hr.ft2.℉/Btu [0.0000144 m^2.°C/W]; 1-pass evaporator and condenser, with series counter flow connection.
2. The Sample Specification above is for reference only. With variety of main components combination, the same cooling capacity can have many different models. Contact local DB office to choose the appropriate chiller for the User's practical requirements.

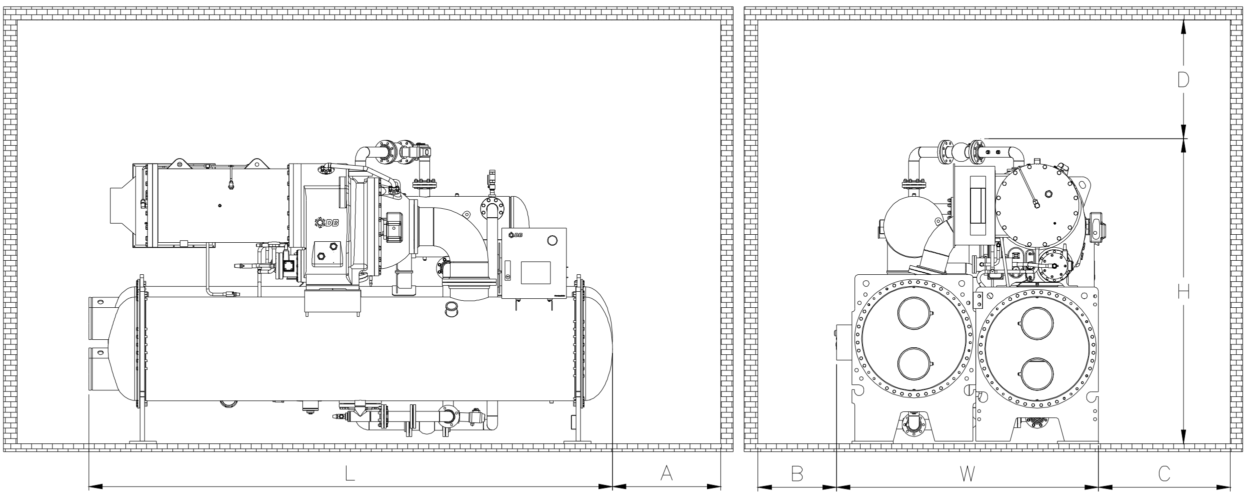
CHILLER DIMENSIONS

DCLC Dimensions And Service Clearance



Notes:
1. The above drawings show general construction of a DCLC chiller with reference to chiller configuration published in PRODUCT SPECIFICATIONS – *DCLC Chiller Selection Sample.*
2. Chiller dimensions (W- width, L – Length, H – Height) can be refer from the same section with reference to unit dimensions as per selection sample published.
3. Recommended service clearance:
   Maintenance space (A) – 3800mm [150''] (DCLC800 and below); 4300mm [169''] (DCLC850 and above)
   Maintenance space (B) – 375mm [15'']
   Maintenance space (C) – 635mm [25'']
   Overhead service clearance (D) – 1350mm [53'']
4. The above constructions and dimensions are based on standard water side design pressure of 150PSIG [10.3BAR], with 2-pass evaporator and condenser.
5. Service access should be provided in accordance with American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) 15, latest edition, National Fire Protection Association (NFPA) 70, and local safety code.
6. Compressor motor starter panel is not shown in this drawing.
7. Certified drawings available upon request. Drawings included in this section are for preliminary layout purposes only. Detailed certified drawings are available from the local DB sales office. Do not use these input for final construction drawings.

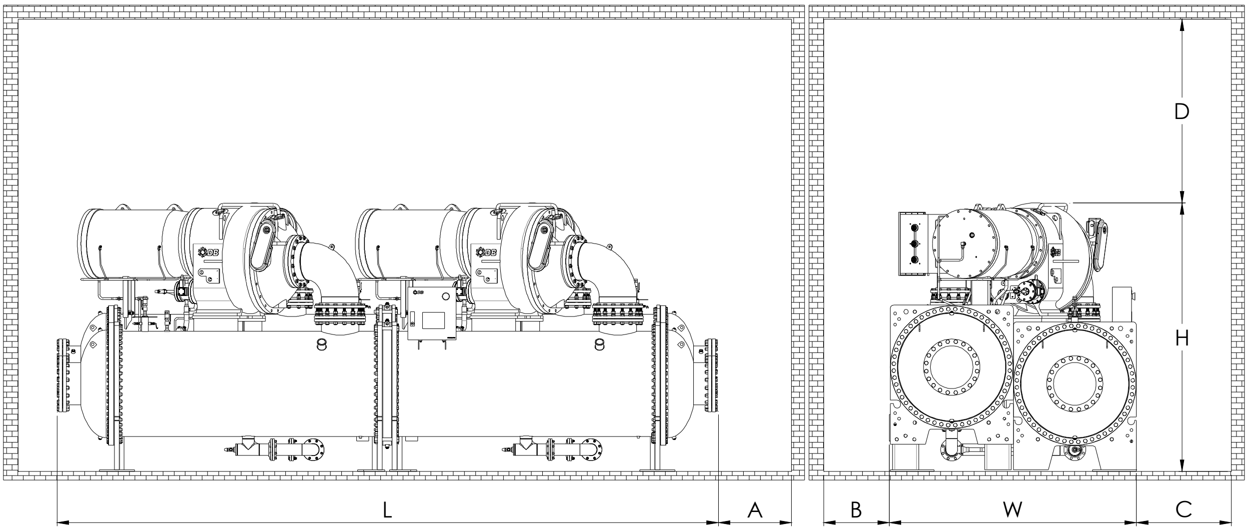
DCLCD Dimensions And Service Clearance



Notes:
1. The above drawings show general construction of a DCLCD chiller with reference to chiller configuration published in PRODUCT SPECIFICATIONS – *DCLCD Chiller Selection Sample*.
2. Chiller dimensions (W- width, L – Length, H – Height) can be refer from the same section with reference to unit dimensions as per selection sample published.
3. Recommended service clearance:
   Maintenance space (A) – 3400mm [134''] (DCLCD850 and below); 3800mm [150''] (DCLC900 and above)
   Maintenance space (B) – 375mm [15'']
   Maintenance space (C) – 635mm [25'']
   Overhead service clearance (D) – 1350mm [53'']
4. The above constructions and dimensions are based on standard water side design pressure of 150PSIG [10.3BAR], with 2-pass evaporator and condenser.
5. Service access should be provided in accordance with American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) 15, latest edition, National Fire Protection Association (NFPA) 70, and local safety code.
6. Compressor motor starter panel is not shown in this drawing.
7. Certified drawings available upon request. Drawings included in this section are for preliminary layout purposes only. Detailed certified drawings are available from the local DB sales office. Do not use these input for final construction drawings.

CHILLER DIMENSIONS

DCLCT Dimensions And Service Clearance



Notes:
1. The above drawings show general construction of a DCLCT chiller with reference to chiller configuration published in PRODUCT SPECIFICATIONS – *DCLCT Chiller Selection Sample*
2. Chiller dimensions (W- width, L – Length, H – Height) can be refer from the same section with reference to unit dimensions as per selection sample published.
3. Recommended service clearance:
   Maintenance space (A) – 3400mm [134''] x 2
   Maintenance space (B) – 375mm [15'']
   Maintenance space (C) – 635mm [25'']
   Overhead service clearance (D) – 1350mm [53'']
4. The above constructions and dimensions are based on standard water side design pressure of 150PSIG [10.3BAR], with 1-pass evaporator and condenser.
5. Service access should be provided in accordance with American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) 15, latest edition, National Fire Protection Association (NFPA) 70, and local safety code.
6. Compressor motor starter panel is not shown in this drawing.
7. Certified drawings available upon request. Drawings included in this section are for preliminary layout purposes only. Detailed certified drawings are available from the local DB sales office. Do not use these input for final construction drawings.

APPLICATION DATA

LOCATION

DCLC chillers are design with NEMA 1 rated on chillers, control enclosure and main motor starter enclosure. This is suitable for installation in an indoor or weather protected area only. The temperature of storage area and operating plantroom shall be within below specified limits. Chiller plantroom shall have good ventilation and low humidity, maximum humidity allowed is 95%rH non-condensing.

	Minimum	Maximum
Storage and Transportation	-4°F [-20°C]	122°F [50°C]
Chiller room ambient	32°F [0°C]	104°F [40°C]

OPERATING LIMITS

The DCLC, DCLCD and DCLCT chillers series shall be operated within below temperature limits.

	Minimum	Maximum
Evaporator Inlet Water Temperature	46°F [8°C]	77°F [25°C]
Evaporator Outlet Water Temperature	39°F [4°C]	59°F [15°C]
Condenser Inlet Water Temperature	60°F [15.6°C]	93°F [34°C]
Condenser Outlet Water Temperature	71.5°F [22°C]	105.8°F [41°C]

SOUND AND VIBRATION

Sound level of the DCLC is not published in this catalogue. However, it is available on the performance summary printout. Please contact your local DB representative for the information.

DCLC series is designed and run tested to have maximum vibration less than 3mm/second, which is significantly better than the industry norm.

Vibration isolators such as rubber pads and spring isolators are offered as optional accessories to suite dedicated site installation.

WATER QUALITY

The cooling water quality is an important part of the centrifugal unit maintenance. If the quality is poor, there will be scaling, mud sediment, corrosion as well as micro-organism reproduction etc. Scale and mud heavily affects the normal operation of the unit, will decrease the heat transfer coefficient of copper tubes and refrigerating capacity and increase the energy

APPLICATION DATA

consumption. It also decreases the flowing area andincreases the water resistance. The corrosion could lead to pipe perforation and water leakage in the unit possibly resulting in shut down of the unit for tube repair. Regular and reliable monitoring of the cooling water quality is recommended for the long term reliable operation of the unit. It is also advised that comprehensive consideration for water treatment is required by referring to water treatment for circulating cooling water treatment method or by consulting your local DB Sales and Service personnel.

EVAPORATOR FLUID CIRCUIT

The evaporator fluid circuit requires a minimum system fluid volume of 3 US gallons per Ton [3.3 liters/ cooling kW] for stable operation. The minimum system fluid volume may increasing up to 10 US gallons per Ton [11 liters/ cooling kW] for process cooling, low load applications with small temperature range and/or vastly fluctuating load conditions.

Variable Evaporator Flow

Dunham-Bush chillers are capable for variable evaporator flow system. The chiller may operate to maintain constant leaving fluid temperature with evaporator flow rate changes, with below conditions fulfilled.

- Evaporator fluid flow rate is within minimum and maximum flow rate of the unit at all time during the operation
- Rate of flow changed shall not exceeded 10% per minute

Failure to comply with the above conditions will cause problem to the chiller operation and may cause the chiller to shutdown.

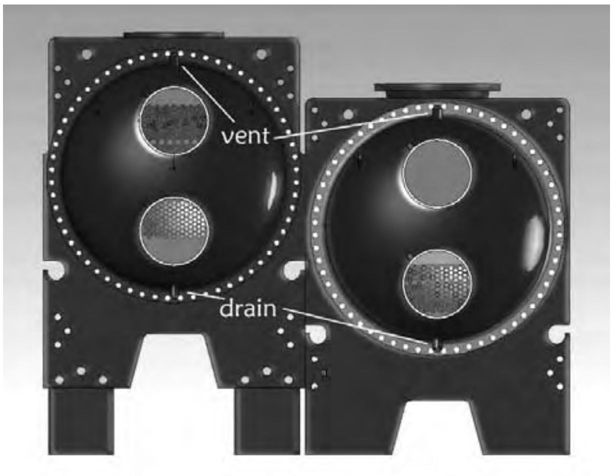
CONDENSER FLUID CIRCUIT

The unit shall works with constant condenser flow, variable condenser flow is not recommended. Variable condenser flow will keep condenser pressure high at the chiller, and thus, decreases chiller's efficiency and increase power consumption of the system. In addition, variable condenser flow increases rate of fouling of condenser, which will de-rating chiller performance and increases unit maintenance cost.

VENT AND DRAIN CONNECTIONS

Waterboxes are fabricated using the nozzle-in-head arrangement and are supplied with vent and drain connections on the dome head. Marine waterboxes are supplied with vent and drain connections on the waterbox shells.

Vents should be provided on the chilled water as high as possible in the system and drains should be located as low as possible to ensure ease of servicing and maintenance. Where shutoff valves are provided in the main water pipes near the unit, only minimal amount of system water will be lost when the heat exchangers are drained. This reduces the time required for drainage and saves on the cost of re-treating the system water.



REFRIGERANT SAFETY VALVE / PRESSURE RELIEF VALVE (PRV)

Pressure relief or safety valve connection sizes are NPT1 (DN25) for the DCLC evaporator and condenser. The relief setting is 12.8 bar.

All Safety Valves must be piped to the outside of the building in accordance with ANSI/ASHRAE Standard 15.

Twin pressure relief valves mounted on a changeover valve, are used on the condenser so that one PRV can be shut off and removed for testing or replacement, leaving the other in operation. Only one of the two valves is in operation at any time. Where 4 valves are shown, on some large vessels, they consist of two PRV's mounted on each of two transfer valves.

Only two PRV's 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.

Per ASHRAE Standard 15, the pipe size cannot be less than the relief device. The discharge from more than one Safety Valve can be run into a common header, the area of which shall not be less than the sum of the areas of the connected pipes.

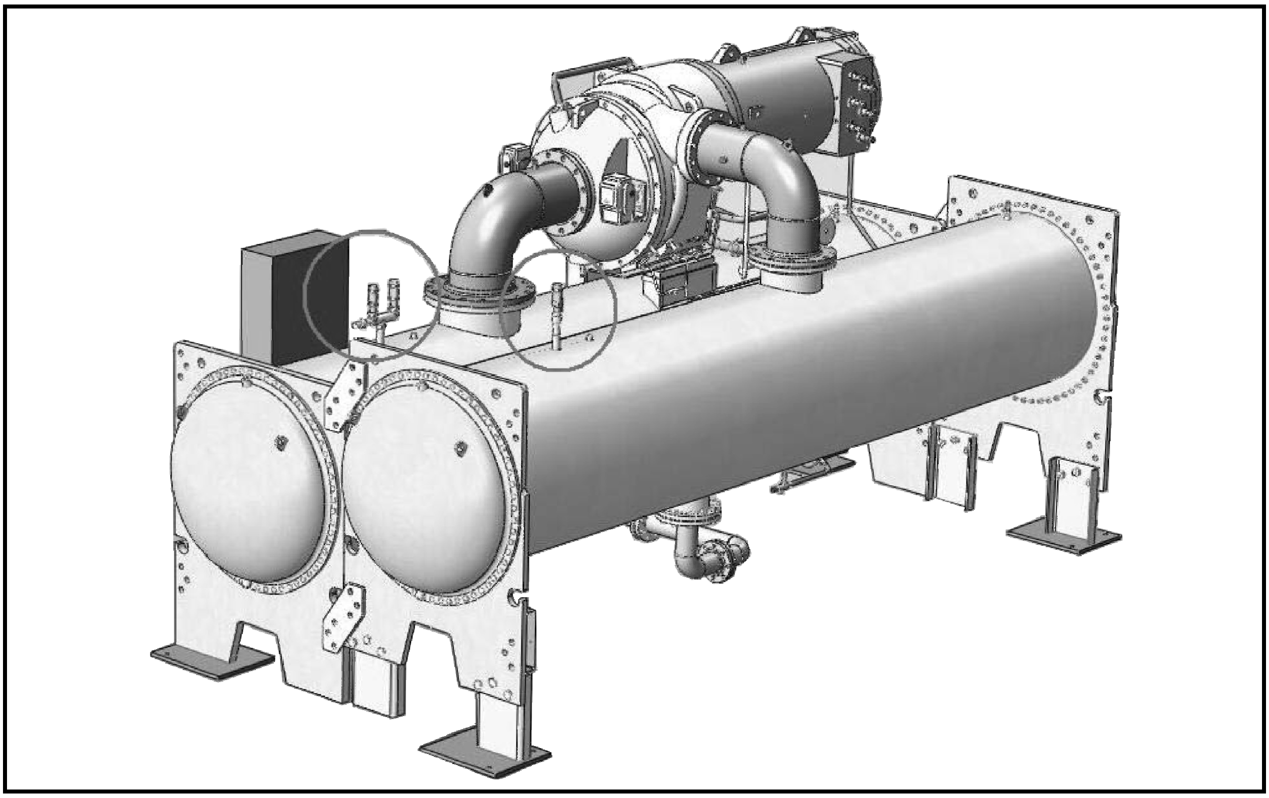
For further details, refer to ASHRAE Standard 15. The common header can be calculated by the formula:

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

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

APPLICATION DATA

The Safety Valve Locations



Condenser Pressure Control

Cooling tower control is increasingly becoming an overlooked subject, and it causes problems. The following is a general recommendation that is applicable to all standard packaged chillers.

Most chiller manufacturers recommend that condenser water be controlled so that its temperature never goes below 55℉ [12.8℃] (even when the machine is off) and that its rate of change is not rapid. Rapid can be defined as not exceeding 2℉ [1.1℃] per minute. This is necessary because a chiller operates in a dynamic environment and is designed to maintain a precise leaving chilled water temperature under varying entering chilled water conditions. The additional dynamic of rapidly varying condenser water temperature subjects the machine to fluctuating pressure on differentials across the evaporator and condenser. This varies the refrigerant flow and, therefore, the capacity. If this occurs faster than the machine can accommodate it, the condenser pressure or evaporator pressure will soon exceed their safety setpoints and the machine will shut down.

The necessary control can sometimes be attained via fan cycling if the tower is rated at the same capacity as the chiller's heat rejection. On multiple chiller jobs, a single tower is oversized relative to the chiller. On other jobs the tower/chiller might be oversized to the design load and the chiller and tower frequently cycle under light load. Under these conditions, fan cycling might result in very rapid temperature swings, which creates a dynamic situation to condenser, which potentially cause unstable operation. Thus, in this case, either variable speed fans or modulating valve control should be used to regain control of the condenser water. Either type of control provides precise modulating control of the condenser water rather than on-off step control. The control can be initiated either by a condenser water temperature sensor or controller.

It is further recommended that the condenser water pump be cycled by the chiller. This is to eliminate potentially very cold water from going through the condenser while the chiller is shut down. At the same time it is probable that relatively warmer chilled water is in the evaporator (an inversion). Refrigerant tends to migrate if there is a difference in pressures within the components of the chiller. It will seek the lowest pressure area of the packaged chiller which, in this case, would be the condenser. Starting of a chiller where the refrigerant has migrated to the condenser is not desirable. The presence of highly subcooled liquid refrigerant in the condenser will cause low suction pressures and possibly liquid slugging of the compressor. If the condenser water pump is off until prior to the chiller starts, the water in the condenser is at the chiller room ambient, which is usually much closer to the evaporator water temperature.

Thus, even though there has been a trend toward fan cycling control of cooling towers, it is not a device that is suitable to every installation. We recommend that the designer carefully evaluate the system to determine if a more precise method of control is indicated. If there is any doubt, the more precise control is required.

GUIDE SPECIFICATIONS

SCOPE

Supply and commissioning of complete factory assembled water cooled centrifugal compressor chiller (s). The centrifugal chiller(s) shall contain centrifugal compressor(s), evaporator, condenser, interconnecting refrigerant piping, expansion device(s), inlet guide vanes, diffusers, control panel, chilled liquid connections, and condenser water connections. The control panel shall be fully wired by the manufacturer connecting & interlocking controller, starter, electrical protection devices with electrical power and control connections. The starter may be supplied separate for field installation. Packaged chiller shall be factory assembled, charged and tested with a full operating refrigerant and oil charge. Upon successful completion the testing, the refrigerant shall be recovered from the chiller and leaving sufficient holding refrigerant charge above atmospheric pressure prior to the shipment. The refrigerant type shall be R134a and shall not have phasing out schedule.

Capacity of each chiller shall be not less than _________________ refrigerant tons (kW output) cooling at _____________ USGPM (liters/min.) of water from __________ °F[°C] to _________ °F[°C]. Power input requirements for the unit(s), incorporating all appurtenances necessary for unit operation, including but not limited to the control accessories and pumps, if required, shall not exceed ___________kW input at design conditions. The unit shall be able to unload to 20% of cooling (refrigeration) capacity when operating with leaving chilled water temperature and at condenser water entering temperatures as per AHRI relief. The unit shall be capable of continuous operation at this point, with stable compressor operation, without the use of hot gas bypass.

Heat transfer surfaces shall be selected to reflect the incorporation of a fouling factor of 0.00025 hr.sq.ft.°F/BTU [0.000044m².°C/W] for the water condenser and 0.0001 hr.sq.ft.°F/BTU [0.0000176m².°C/W] for evaporator. Water pressure drop at design conditions shall not exceed ___________ feet of water through the condenser, and ____________ feet of water through the evaporator.

QUALITY ASSURANCE

- Chiller performance shall be certified by AHRI as per AHRI 550/590 standard latest edition
- ASHRAE Standard 15 safety code for mechanical refrigeration
- ASME standard B31.5 for Refrigerant piping
- Vessels shall be fabricated and pressure tested in accordance with ASME Boiler and Pressure vessel code, Section VIII, Division 1 “Unfired Pressure Vessels”
- [Optional] ASME stamp on pressure vessels
- [Optional] JKKP approval for pressure vessels required in Malaysia market place
- [Optional] PED certification required in Europe market place
- Unit shall be manufactured in ISO9001 registered manufacturing facility
- Factory run test: Chiller shall be pressure tested, evacuated and fully charged with refrigerant and oil. The chiller shall be run tested with water flowing through the vessels. The chiller needs to be tested either with the starter if the chiller is supplied with them
- Manufacturer shall have a strong service organization with trained service personal

DELIVERY, STORAGE AND HANDLING

Unit shall be delivered to job site fully assembled with all interconnecting refrigerant piping and internal wiring ready for field installation and with refrigerant holding charge and oil by manufacturer. When delivered, machine shall be stored indoors, away from construction dirt, dust, moisture or any other hazardous material that would harm the chillers. Inspect under shipping tarps, bags, or crates to be sure there is no water collected during transit. Protective shipping covers shall be kept with the unit until machine is ready for installation.

WARRANTY

Chiller manufacturer’s warranty shall cover for 12 months from the date of start-up or 18 months from the date of shipment whichever is first. The start-up shall be carried out by an authorized service personnel and the warranty is limited to part replacement excluding labor and consumables such as refrigerant, oil & filter driers etc.

MAINTENANCE

Maintenance of the chillers will be responsibility of the owner and performed in accordance with the manufacturer’s instructions.

OPERATING REQUIREMENT

The unit shall be capable of starting up with entering fluid temperature to the cooler at 93°F [34°C].

Minimum and maximum transportation and storage temperature of the chiller shall be -4°F [-20°C] and 122°F [50°C].

Unit shall be able to operate with 3-ph ______Hz with unit rated voltage +/- 10%.

Control Voltage shall be 230V/1ph/50Hz or 230V/1ph/60Hz.

COMPRESSOR AND MOTOR

The packaged chiller shall be furnished with single-stage or dual stage semi-hermetic dynamic centrifugal compressor(s) to suit the desired design requirement. The compressor shall be driven by a 2 pole motor (2900 RPM @ 50Hz; 3600 RPM @ 60Hz).

The impeller shall be statically and dynamically balanced. The compressor shall be vibration tested and shall not exceed 4mm/s.

The impeller shall be cast from special super high density aluminum alloy, light weight, high anti-corrosion ability. It shall have high efficient, back sweep main blades and low profile intermediate splitter blades, contoured aerodynamically to improve compressor full load and part load operating efficiency. Compressor shall complete with a backward inclined impeller and the compressor speed shall be increased to meet the required capacity and lift by using a single set of helical gears. The gears shall be especially engineered helical, crowned teeth, shall ensure that more than one tooth is in contact at all times for even distribution of load and for quieter operation. Gear tooth surfaces are case hardened and precision ground to AGMA class 11. Gears are integrally assembled in the compressor rotor support and are film lubricated. Each gear is individually mounted in its own journal and thrust bearings to isolate it from impeller and motor forces. The double layer compressor case design reduce the gear contacting noise. The drive gears shall operate in a controlled lubricant mist atmosphere that shall effectively cools and lubricate them.

The bearings shall be consisting of steel-backed babbitt-lined sleeve bearings, and special composite bearings ensure smooth, reliable operation over the life time of the chiller.

Non-contact labyrinth shaft seal shall be used for reducing the flow of gas from an area of high to low pressure. It shall involve a stationary labyrinth in close proximity to a rotating shaft.

Compressor shall have a reliable lubrication system which shall include integral oil pump, changeable oil filter, oil sump, oil heater, educator- jet pump and sight glass. A reliable compact, lightweight oil pump with lower pressure fluctuations and higher volumetric efficiency shall be used for maintaining required oil pressure and flow throughout the lubrication system to maintain the bearing lubrication in the compressor and motor. The lubrication system shall complete with reliable oil recovery system to bring back the oil accumulated in the cooler and other locations to the oil sump. Oil sump shall be provided with an integral electric oil heater with the compressor to maintain oil temperature of 95°F ~ 131°F [35℃ ~ 55℃] during shutdown period in order to prevent oil dilution which may causes decrease in viscosity. The heater shall be energized by a sensor whenever the oil temperature in the sump is lower than the set value. Power to the oil heater/controls shall be on circuits that can provide continuous power supply when the compressor is disconnected and the chiller is switched off. In case of power interruption for longer period oil heater shall be energized for at least 24hrs to raise the oil temperature. Oil shall also be cooled during operation to the required temperature by sub cooled liquid refrigerant expansion. A plate type heat exchanger shall be used for this purpose.

An emergency oil reservoir shall be provided in order to maintain adequate lubrication flow under gravity, and prevent bearing damage that could occur during the coast down period, in the event of power failure or pump malfunction.

The control system shall prevent compressor starting until proper oil pressure and proper oil temperature is achieved.

Capacity control shall be achieved by adjusting the degree of opening of the inlet guide vanes, thereby adjusting the volume flow rate. The guide vanes shall be connected with aircraft-quality cable and controlled by precise electronic actuator. It shall be able to maintain chilled fluid leaving temperature within a narrow dead band of the desired set point without surging or undue vibration. The vanes shall be able to regulate refrigerant flow through a wide stable operating range.

For unit equipped with Variable Speed Drive (VSD), compressor motor speed shall be reduce to minimum possible speed before inlet guide vane to starts closing. The controller shall be capable to perform combined action of both VSD and inlet guide vane to deliver stable operation with optimized efficiency.

An adjustable diffuser shall be used on the discharge passage in order to increase the discharge refrigerant gas velocity by adjusting the discharge geometry thereby enabling the surge point of the compressor to be lowered.

The compressor motor shall be closed-coupled hermetic, 2 pole, squirrel cage induction type. The motor shall have efficient refrigerant cooling system with spray nozzles, eliminating the need for additional equipment for motor cooling in the machine room. Motor winding shall have reliable corrosion resistant insulation which shall compatible with refrigerant and oil. The motor shall be protected by a temperature sensor imbedded in the stator windings.

EVAPORATOR

Evaporator vessel shall be cleanable shell and tube, flooded type. Shell shall be fabricated from rolled carbon steel sheet with fusion welded seams or carbon steel standard pipes. End plates shall be of carbon steel with precision drilling, reamed in order to accommodate tubes. Intermediate tube support shall be in place to provide required tube support between tube sheets. Tubes shall be of copper, seamless, high efficient, internally enhanced and externally finned, mechanically expanded into fixed steel tube sheets. Tube diameter shall be ¾ inch [19mm] and thickness shall be 0.025 inch [0.635mm]. The flooded evaporator shall have a built in distributor for feeding refrigerant evenly under the tube bundle to produce a uniform boiling action and baffle plates shall be provided to ensure vapor separation. Water box shall be removable for tube cleaning, shall have stub-out water connections with Victaulic grooves in compliance to ANSI/ AWWAC-606. They are to be available in single, two or three pass design as required on the drawings. Vent and drain plugs are to be provided in water box. The shell side of the evaporator shall have pressure relief valve with provision for refrigerant venting. Evaporators refrigerant side shall be designed, constructed in accordance with the ASME Code for Unfired Pressure Vessels. Evaporator shell side shall undergo pneumatic pressure test at 220psig [15.2Bar],

GUIDE SPECIFICATIONS

shall be designed for working pressure up to 200psig [13.8Bar]. Tube side shall undergo hydrostatic pressure test at 195psig [13.4Bar], shall be designed for 150psig [10.3BAR] working pressure.

The flooded evaporator shall have an efficient and reliable oil recovery system. The oil recovery system shall insure the evaporator is operating at peak efficiency at all times and provide optimal energy efficiency during extended periods of part load. Units without such oil recovery systems will not be acceptable.

All low temperature surfaces shall be factory insulated with ¾ inch [19mm] thick closed cell insulation.

[OPTIONAL]

A. Evaporator Flanged Water Connection – Flanged water connection shall be provided in lieu of Victaulic groove connection
B. Double Thick Insulation – Evaporator shall be provided with 1¾ inch [38mm] thick closed cell insulation for extra resistance to condensation
C. 250/300PSIG Working Pressure Vessel – Evaporator with 250/300PSIG [1.72/2.07MPa] working pressure on shell side shall be provided
D. Marine Water Box – Marine type water box shall be provided for removal of the end covers of the vessel without dismantling the piping to facilitate tube cleaning
E. JKKP Compliance – Evaporator with JKKP approval shall be provided for installation in Malaysia
F. PED Compliance – Evaporator with PED approval shall be provided for installation in European countries

CONDENSER

Condenser vessel shall be cleanable shell and tube. Shell shall be fabricated from rolled carbon steel sheet with fusion welded seams or carbon steel standard pipes. End plates shall be of carbon steel with precision drilling, reamed in order to accommodate tubes. Intermediate tube support shall be in place to provide required tube support between tube sheets. Tubes shall be of copper, seamless, high efficient, internally enhanced and externally finned, mechanically expanded into fixed steel tube sheets. Tube diameter shall be ¾ inch [19mm] and thickness shall be 0.025 inch [0.635mm]. Water box shall be removable for tube cleaning, shall have stubout water connections with Victaulic grooves in compliance to ANSI / AWWAC-606. They are to be available in single, two pass or three pass design as required on the drawings. Vent and drain plugs are to be provided in water box. The shell side of the condenser shall have pressure relief valve with provision for refrigerant venting. Condenser refrigerant side shall be designed, constructed in accordance with the ASME Code for Unfired Pressure Vessels. Condenser shell side shall undergo pneumatic pressure at 220psig [15.2Bar], shall be designed for working pressure up to 200psig [13.8Bar]. Tube side shall undergo hydrostatic pressure test at 195psig [13.4Bar], shall be designed for 150psig [10.3BAR] working pressure.

The condenser shall have baffle that prevent direct impingement of high velocity refrigerant gas flow from the compressor onto condenser tubes. It shall also eliminates the related vibration and wear of the tubes and distributes the refrigerant flow evenly over the length of the vessel for improved efficiency.

The condenser shall have sub-cooler located in the bottom of the condenser; increase the overall refrigerant effect of the chiller by sub-cooling the condensed liquid refrigerant which results in a combination of increasing capacity and improving the efficiency.

The condenser shall be sized for full pump down capacity.

[OPTIONAL]

A. Evaporator Flanged Water Connection – Flanged water connection shall be provided in lieu of Victaulic groove connection
B. 250/300PSIG Working Pressure Vessel – Evaporator with 250/300PSIG [1.72/2.07MPa] working pressure on shell side shall be provided
C. Marine Water Box – Marine type water box shall be provided for removal of the end covers of the vessel without dismantling the piping to facilitate tube cleaning
D. JKKP Compliance – Evaporator with JKKP approval shall be provided for installation in Malaysia
E. PED Compliance – Evaporator with PED approval shall be provided for installation in European countries
F. Refrigeration Isolation Valves – Refrigerant isolation valve shall be provided to enable the entire unit refrigerant charge to be storage in the condenser enabling service and maintenance activities to be completed in less time and lower cost

REFRIGERANT CIRCUIT

The refrigerant circuit shall include (OPTION) liquid and discharge line isolation valves (which facilitate full pump down capacity in the condenser), oil filter, replaceable filter drier on oil line, sight glass on oil line, pressure relief valves on the cooler and condenser, liquid line angle valve for refrigerant charging. The packaged chiller shall be furnished with a simple reliable fixed orifice expansion device with no moving parts for refrigerant flow control.

OIL MANAGEMENT

The compressor shall have an independent lubrication system to provide lubrication to all parts requiring oil. The lubricating system shall have a positive displacement, compact light weight oil pump that shall be powered through the unit control transformer. The oil sump shall complete with oil heater to maintain sufficient oil temperature to minimize the oil dilution. It shall also include a plate type heat exchanger as oil cooler. An efficient oil recovery system shall be in place with interconnecting oil pipes together with required educator-jet-pump to recover oil from cooler and other locations in the chiller back to the oil sump.

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TWIN COMPRESSOR SYSTEM DESIGN

Chiller with twin compressors design shall be designed with independent refrigerant system for best refrigerant isolation. The heat exchangers of each refrigerant system shall be connected in series counter flow arrangement to optimized the compressor lift of each refrigerant system.

ELECTRICAL AND CONTROL PANEL

The electrical switch gears, controller, control sensors and relays shall be housed in NEMA-1 panel. The panel casing shall be of galvanized steel with powder coating for corrosion resistance. The panel shall be divided into two separate compartments or shall have two separate panels to house power and control devices separately.

OPTIONAL COMPRESSOR MOTOR STARTER PANEL

The chiller manufacturer shall provide suitable starter for the compressor motor in order to minimize the starting current. The starter shall be factory built fully wired as stipulated under starter section elsewhere in this specification. The starter shall be able to provide adequate starting torque and the required acceleration for the compressor during starting.

NEMA-1 electrical panel compartment shall include:

- Main incoming power terminal block suitable to receive single entry of three phase 3-wire power supply with specified voltage
- Circuit breakers for the compressor
- Solid state compressor motor over Current protection module for each phase
- Compressor motor overheat protection module
- Under/over voltage phase reversal and imbalance relay
- [Optional] Ground fault interrupter

The main motor starter shall be factory built to the chiller component and factory tested during the run test of the unit. The main motor starter is shipped loose for floor mounting and field wiring to the chiller package. It shall be free standing designed for top entry and bottom exit and with front access.

The compressor starter and circuit breakers shall be wired securely to the main incoming terminal block. External compressor over load protector, over heating protection modules, over/under voltage phase relay shall be interlocked with the compressor starter contactors to provide adequate protection to the compressor motor.

Low Voltage Starter (up to 575Vac)

A) Star-Delta Starter (Closed Transition)

Star-Delta Starter with open transition shall not be accepted due to high changeover inrush current.

Contactors and resistors shall be properly sized to ensure smooth transition. Transition timer should be selected with adjustable 30 seconds range for proper changeover setting.

B) Solid State Starter (Softstarter)

The starter shall be furnished with SCRs (silicon controlled rectifier), or also known as thyristors to limit the current flow during motor starting. The starter shall be furnished together with bypass contactor. When the motor starting cycle is completed (motor has reached operating speed), the bypass contactor shall be energized and disconnect SCRs from the power circuit during normal motor operation.

C) Variable Speed Drive (VSD)

The chiller shall be capable for variable speed operation if VSD starter is supplied.

The VSD shall be constant torque type and able to deliver 110% torque for 60 seconds during normal operation. Displacement power factor of motor shall be improved to minimum level of 0.95 at all operating conditions.

VSD shall meets EMC product standard EN61800-3, and harmonic requirement as per IEC/EN 61000-3-12.

VSD shall have inbuilt protection mode which automatically reduce the frequency and the modulation process adjusted when it detects critical status such as over current or over voltage etc.

VSD shall have inbuilt Electronic thermal motor protection against overload. The VSD shall be protected against short-circuits on motor terminals U, V, W. It shall also Protection against mains phase loss.

The VSD shall have built-in LCD keypad display with below information available:

- Motor current
- Voltage / frequency output
- Output kW
- Output frequency
- Fault log

Medium Voltage Starter (3kV up to 13.8kV)

A) Direct-On-Line Starter (DOL)

Contactor shall be properly sized to allow Lock Rotor Current (LRA) flows to motor during start-up.

B) Auto-Transformer Starter

Auto-transformer shall be supplied with properly sized contactors and transformer with factory wired to 65% tapping.

GUIDE SPECIFICATIONS

C) Solid State Starter (Softstarter)

The starter shall be furnished with SCRs (silicon controlled rectifier), or also known as thyristors to limit the current flow during motor starting. The starter shall be furnished together with bypass contactor. When the motor starting cycle is completed (motor has reached operating speed), the bypass contactor shall be energized and disconnect SCRs from the power circuit during normal motor operation.

D) Variable Speed Drive (VSD)

The chiller shall be capable for variable speed operation if VSD starter is supplied.

The VSD shall be constant torque type and able to deliver 110% torque for 60 seconds during normal operation. Displacement power factor of motor shall be improved to minimum level of 0.95 at all operating conditions.

VSD shall meets EMC product standard EN61800-3, and harmonic requirement as per IEC/EN 61000-3-12.

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VSD shall have inbuilt Electronic thermal motor protection against overload. The VSD shall be protected against short-circuits on motor terminals U, V, W. It shall also Protection against mains phase loss.

The VSD shall have built-in LCD keypad display with below information available:

- Motor current
- Voltage / frequency output
- Output kW
- Output frequency
- Fault log

CONTROL SYSTEM

The packaged chiller shall be equipped with stand along proactive advance Microprocessor based DDC controller which adapts to abnormal operation conditions. It shall have built in Input/Output, PC interface, BMS communication port. The unit algorithm program and operating parameters shall be stored in non-volatile memory. Battery back-up is not acceptable. 230V Power supply to the controller shall be provided by a control transformer provided with the panel. External power source to the controller is not acceptable. The controller shall be equipped with a user friendly terminal with color touch screen display preferably with 15.4" TFT screen for larger operating and viewing with 1024× 768 pixel VGA screen resolution and dedicated touch keys that provides easy access to the unit operating parameters, control set points and alarm history, based on security level of password. There shall be password protection for operator, service personnel and for the critical manufacturer settings in order to protect the chiller controller from unauthorized access.

The controller board shall be provided with a set of terminals that connected to various devices such as temperature sensors, pressure transducers, current transducers, solenoid valves, compressor starter, control relays.

The controller shall be able to carry out its own diagnose test on the controller and the connected devices and alarm messages shall be displayed automatically on faulty devices.

All messages shall be displayed in English language, and shall be displayed either in Imperial or SI units.

Leaving chilled water temperature control shall be accomplished by entering the water temperature set point with accuracy to 0.54°F and placing the controller automatic control mode. The controller shall monitor all control functions and move the compressor IGV or VFD (if supplied) or both to the calibrated position. The compressor loading cycle shall be programmable and shall be adjusted to the building load requirement. The loading IGV adjustable range shall be from 1% to 3% per increment to prevent excessive demand hike at start up.

The controller shall continuously monitor evaporator leaving water temperature, evaporator entering temperature, evaporator and condenser pressure; compressor amp draw; oil temp; oil pressure; motor temp and discharge refrigerant temperature. The controller shall complete with all hardware and software necessary to enable remote monitoring of all data through the Building Management Systems with open protocol Bacnet Over IP, Modbus RTU & Modbus TCP/IP), and [Optional BMS links: LonTalk, BACnet MSTP, or Johnson Control N2]. The controller shall be complete with a RS485 long distance differential communications port, the remote connection shall be established by a twisted pair of wire. The controller shall also accept a remote start and stop signal, 0 to 5VDC (optional), chilled water temperature reset signal (optional) and 0 to 5VDC compressor current limit reset signal (optional).

The electrical control panel shall be wired to permit fully automatic operation during - initial start-up, normal operation, and shutdown conditions. The control system shall contain the following control, displays and safety devices:

Manual/Auto Controls

- Auto/Local/Remote switch
- Control circuit stop and start switches
- Compressor enable switch
- Compressor over current
- Compressor anti-recycle
- Programmable with Seven day operation cycle
- Chilled liquid pump on/off control
- Condenser water pump on/off control
- Oil pump starter
- Start delay timer
- Anti-recycle timer
- Oil sump heater interlock relays

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Refrigerant Flow Controls
- Compressor loading and unloading shall be carried out by inlet guide vanes actuator
- For unit with Variable Speed Drive (VFD), compressor capacity control shall be carried out by VFD and Inlet Guide Vane actuators

Indicator Lights
- Control power
- Compressor power
- System common alarm
- VFD alarm (if supplied)

Soft Indicators On Touch Screen
- Compressor
- Open vanes
- Close vanes
- Oil pump
- Oil heater
- Open diffuser
- Close diffuser

The control system shall be provided with an anti-recycle device. The control shall limit compressor starting to a minimum of 15 minutes between starts.

System Operation Information
The chiller display shall provide following operating information.

Analog readings
- Leaving chilled water temperature
- Entering chilled water temperature
- Leaving condenser water temperature
- Entering Condenser water temperature
- Evaporator approach temp
- Evaporator entering and leaving temp difference
- Evaporator pressure
- Condenser pressure
- Saturated suction temp
- Saturated discharge temp
- Compressor amps drawn
- Operating supply Voltage
- Compressor elapsed run time
- Guide vane open degree in %
- Guide Vane adjusting range % (min-max)
- Diffuser open degree in %
- Water temperature set value
- Water temperature control zone (band)
- Bearing temperature
- Oil sump temperature
- Oil supply pressure
- Oil sump pressure
- Oil pressure difference
- [Optional] Water temperature re-set value
- Percentage of compressor capacity
- Motor temperature
- Comp lift
- Compressor speed
- Power up delay time

Status and set points
- Chilled water flow
- Condenser water flow
- Unit enable
- Oil pump over load
- BMS run
- IGV Open/closed
- Comp on/off
- Oil pump on/off
- Oil heater on/off
- Diffuser on/off
- Control power on
- Chilled water pump of/off
- Alarm on/off
- Condenser pump on/off
- External start/stop command status
- Cooling tower fan on/off

Safety Protections
- Short circuit protection
- Compressor motor over load protection (3 phase)
- Compressor motor overheat protection
- High discharge temperature protection
- Under voltage phase failure relay
- Low oil level protection via optical sensor
- High condenser pressure
- Low evaporator pressure
- Freeze protection (low chilled liquid leaving temperature)
- Chilled water flow loss
- Low differential pressure
- Compressor run error
- Power loss
- Sensor error
- Refrigerant loss
- Reverse rotation
- VFD fault (if VFD is supplied)
- Emergency stop

Controller shall be able to retain up to 10 alarm conditions complete with time of failure and all critical sensor readings. This aids service technicians in their trouble shooting task enabling downtime and nuisance trip-outs to be minimized.

EXECUTION

INSTALLATION
Chiller shall be installed strictly according to manufacturer's recommendations as stipulated in the installation manual, drawings and tender documents. Care should be taken to provide necessary service clearance as required in the manufacturer's drawing. Install the strainers at the inlet to the evaporator to prevent debris or other particles entering to the evaporator during piping work and initial flushing the system. Required coordination to be done with the electrical contractor and the control contractors to ensure electrical supply and required communications links are established.

START-UP/ COMMISSIONING
Chiller shall be commissioned by a service representative from manufacturer or by their local representative. The service personnel shall be trained and authorized by the manufacturer for start up of the supplied units. The start-up shall include briefing operators on chiller operations and maintenance as well.

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