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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

Nominal Cooling Capacity TR

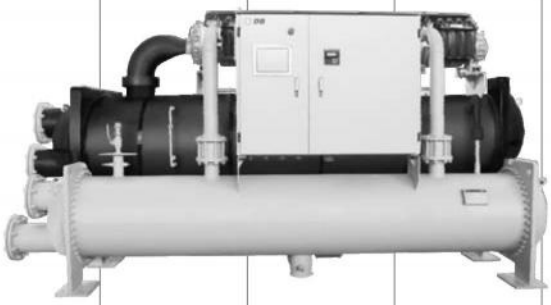
VFD Operation
Blank - Constant Speed Operation
V - Variable Speed Operation

PRODUCT LINE UP

PROmetheus
DCLC-M Series
Magnetic Bearing Oil Free Centrifugal Chillers

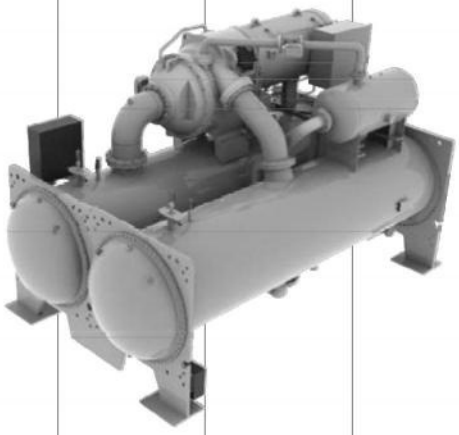
90 ~ 680TR
(315 ~ 2390kW)

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

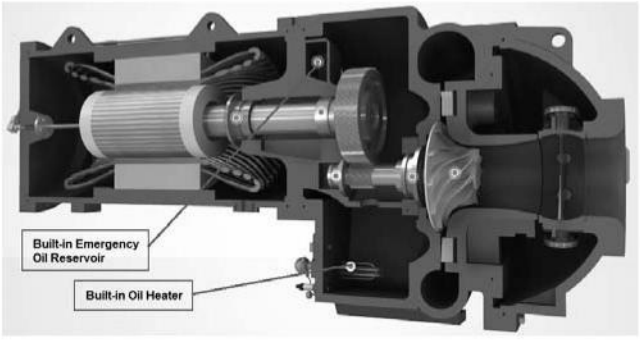
Dunham-Bush DCLC Chillers are available from 300 to 4000 TR [1055 to 14068 kW]. The vast number of combinations of heat exchangers, compressors and motors make it impractical to publish tabular ratings for each combination. A chiller may be custom matched to certain building requirements by your Dunham-Bush 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

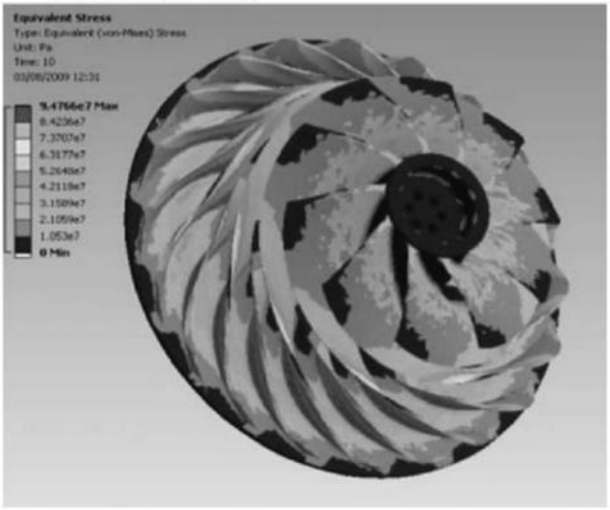
- Semi-hermetic compressor for reliable operation; compressor and motor are direct gear driven. Shaft alignment, refrigerant and oil leaking at shaft seals are not applicable with this design



- 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°C] 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

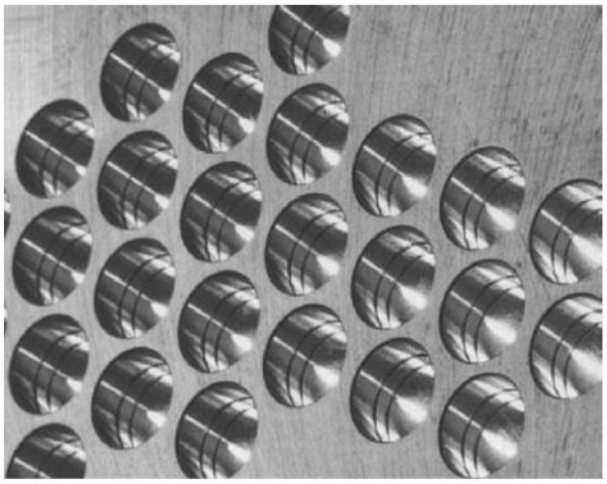


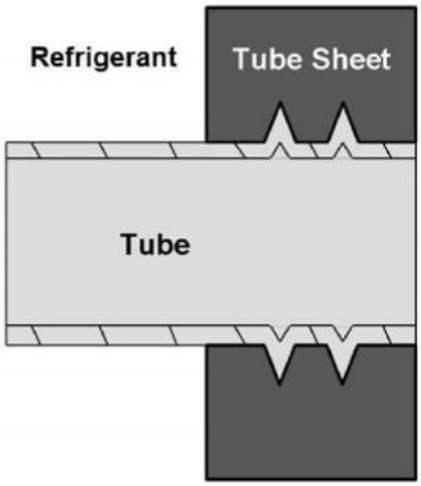
- Each impeller has succeeded in stringent balancing test and over-speed test up to 125% of rated value; to ensure stable and reliability operation
- Impellers design are aerodynamically contoured with CFD software to improve compressor full load and part load operating efficiency. Compressor efficiency 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

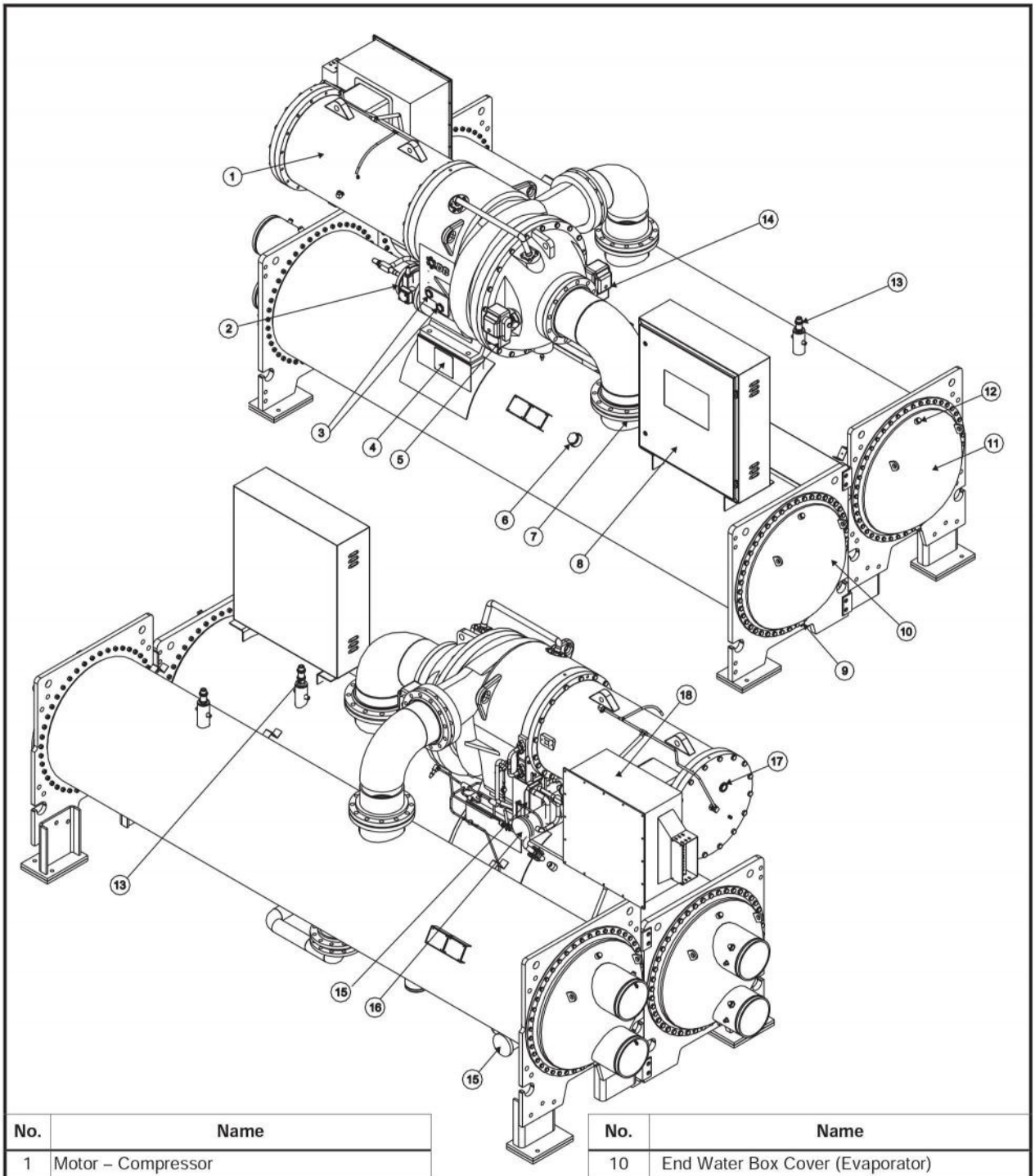
- All DB DCLC chillers are thoroughly run tested at the factory prior to shipment
- This ensured proper operation of all components in the system, including compression, power transmission, vibration & sound, oil lubrication system, and electrical & control system

INTELLIGENT 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)

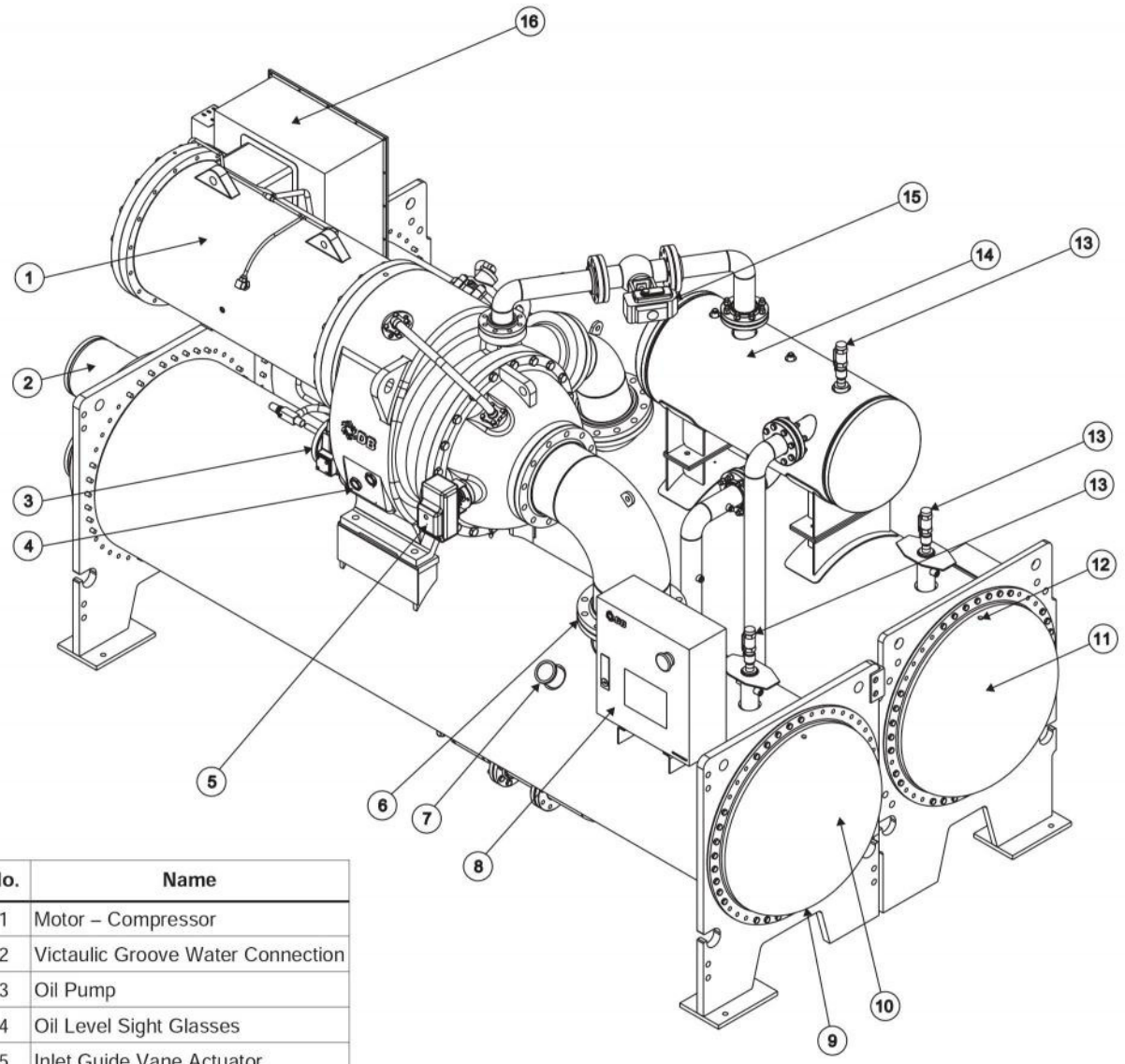


No.	Name
1	Motor – Compressor
2	Oil Pump
3	Oil Level Sight Glasses
4	Unit Name Plate
5	Inlet Guide Vane Actuator
6	Evaporator Sight Glass
7	Typical Flanged Connection
8	Control Panel
9	Typical Water Box Drain Port

No.	Name
10	End Water Box Cover (Evaporator)
11	End Water Box Cover (Condenser)
12	Typical Water Box Vent Port
13	Safety Valve (PRV)
14	Adjustable Diffuser Actuator
15	Oil Cooler
16	Replaceable Oil Filter
17	Motor Rotation Sight Glass
18	Motor Terminal Box

CHILLER COMPONENTS

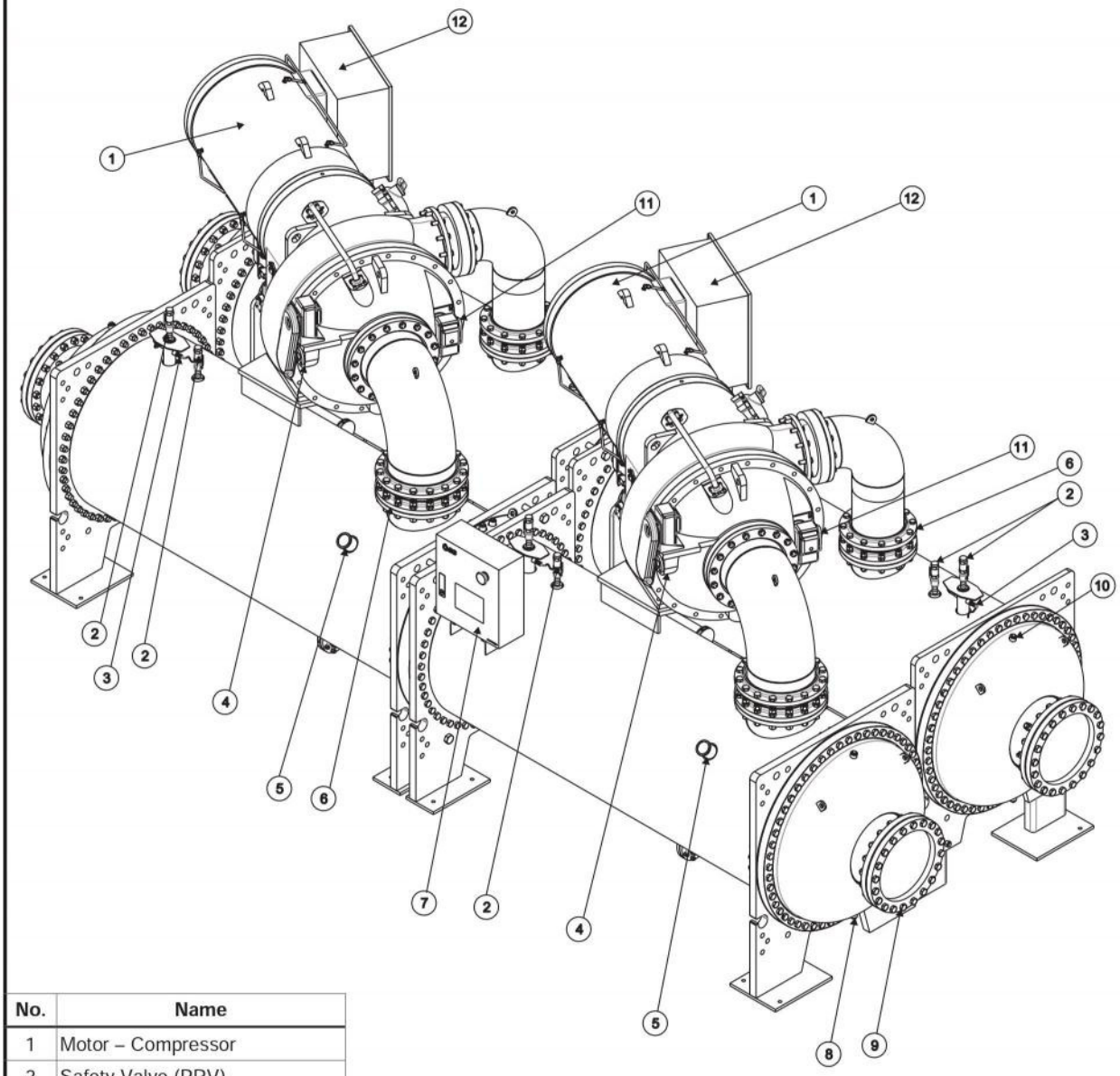
DCLCD Series (Dual Stage Centrifugal Chillers)



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.

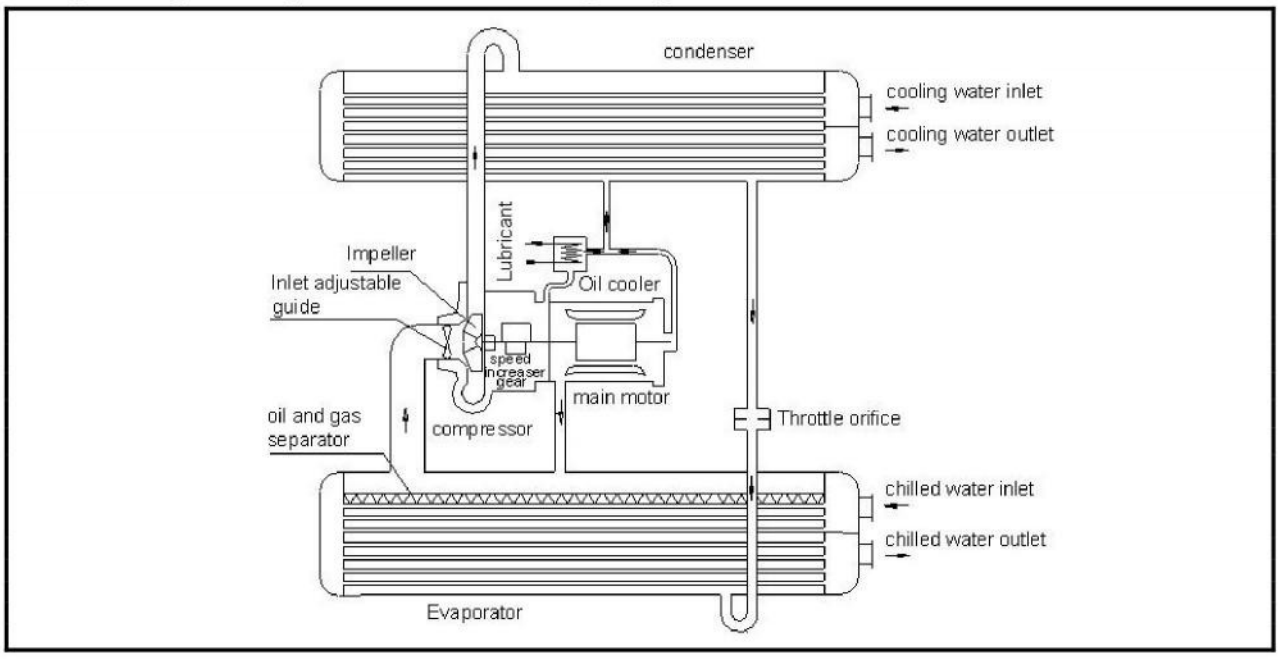
Condenser:
The high pressure hot vapour is condensed into a high pressure hot liquid, or saturated liquid at its pressure corresponds to its condensing temperature. This high pressure liquid refrigerant discharges from the bottom of the condenser and is passed through an expansion valve or some other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

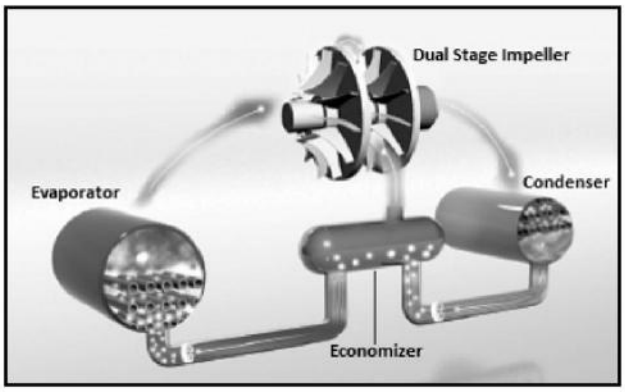
DCLCD Series (Dual Stage Centrifugal Chillers)

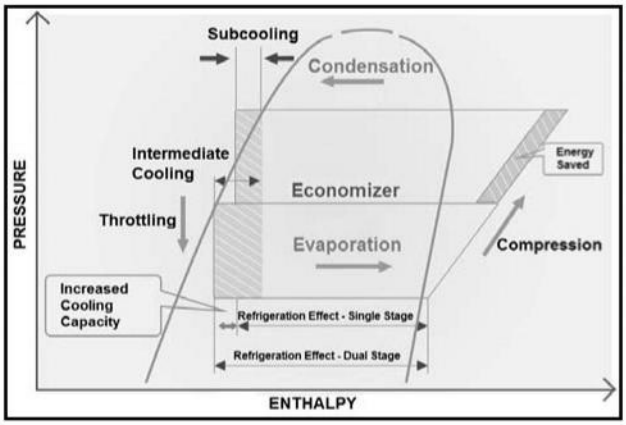
The refrigerant cycle of DCLCD chillers with dual-stage impellers are similar to the DCLC chillers with single stage impeller, except for below.

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



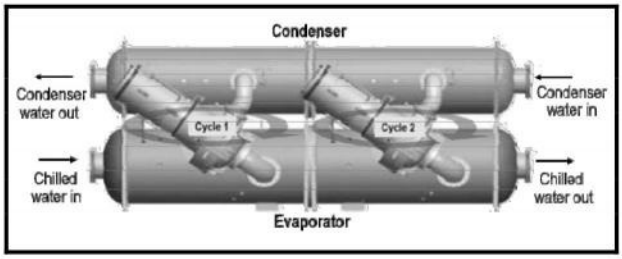


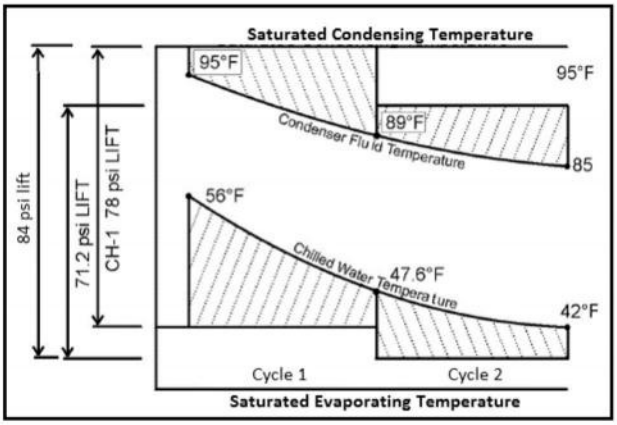
Besides energy saving operations, DCLCD also visualized stable operation in high lift conditions, as well as better resistance to surging.

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

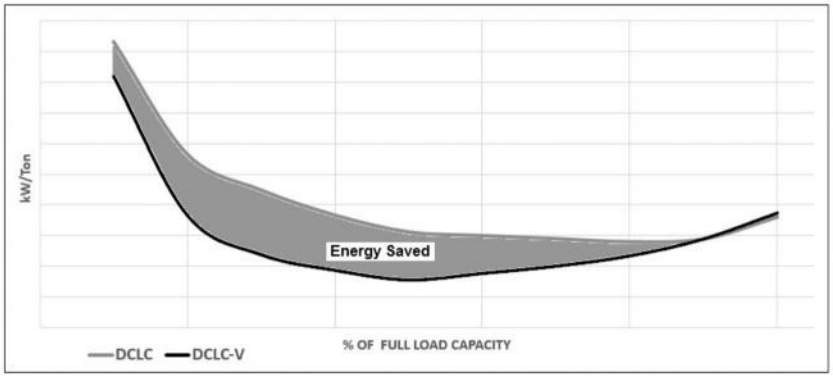
VARIABLE SPEED OPERATION
(DCLCV, DCLCDV & DCLCTV Series)

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.

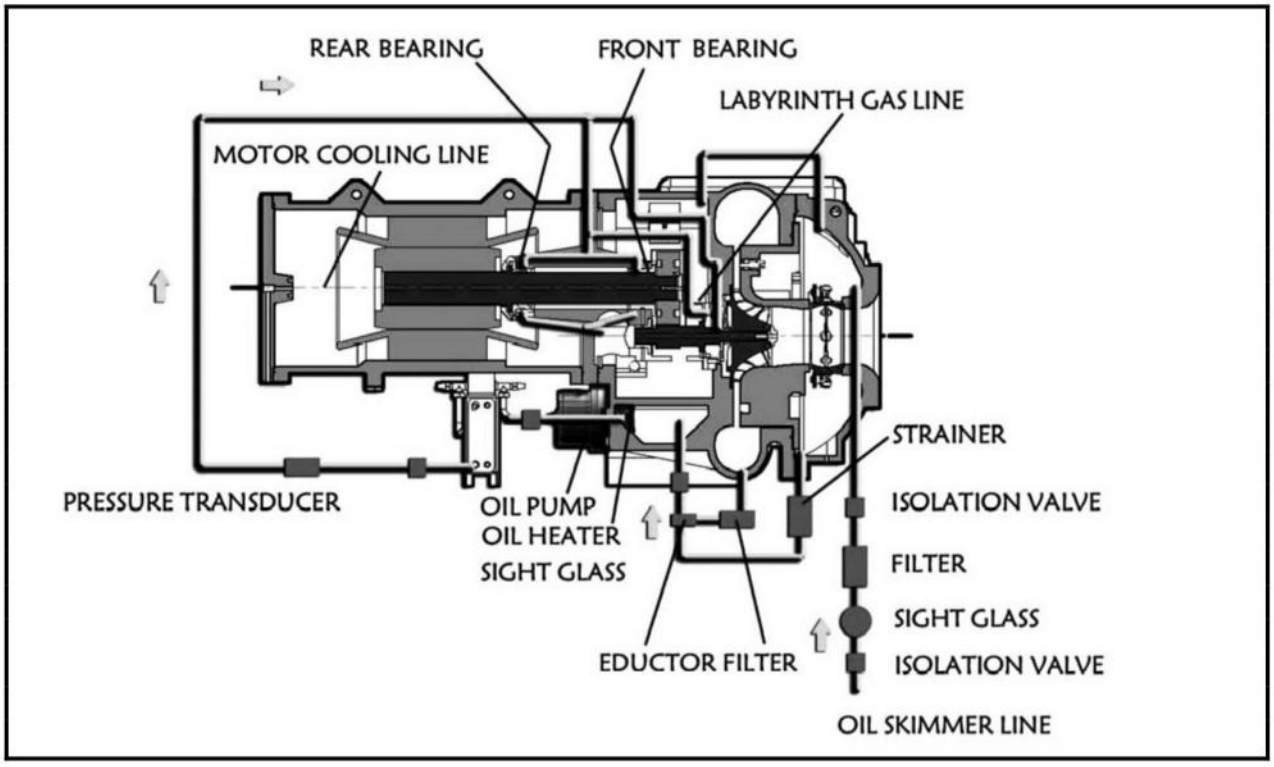
To minimize the quantity of lubricating oil entering and mixing with the refrigerant, comb (labyrinth) seals are installed at inner side of motor bearings at both ends.

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



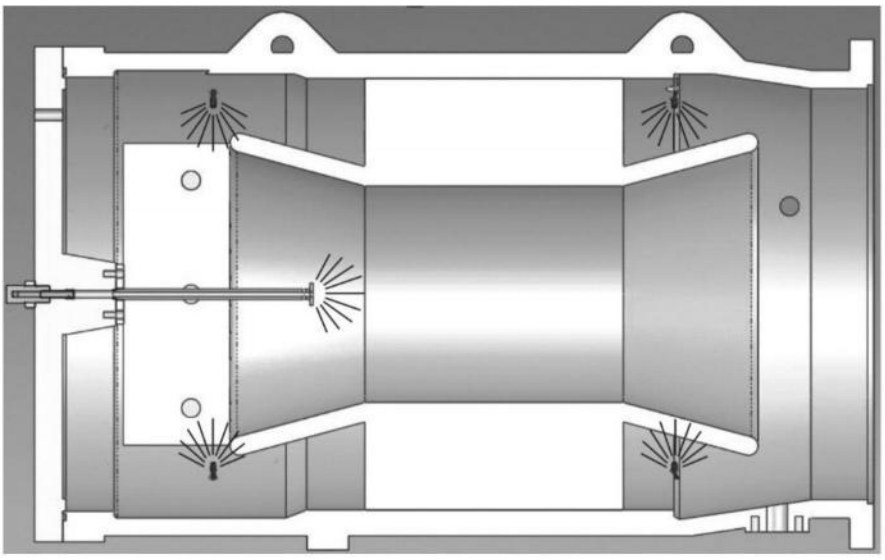
MOTOR REFRIGERANT-COOLED SYSTEM

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°C], the compressor will shut down automatically.



WORKING PRINCIPLE AND STRUCTURE

INSULATION

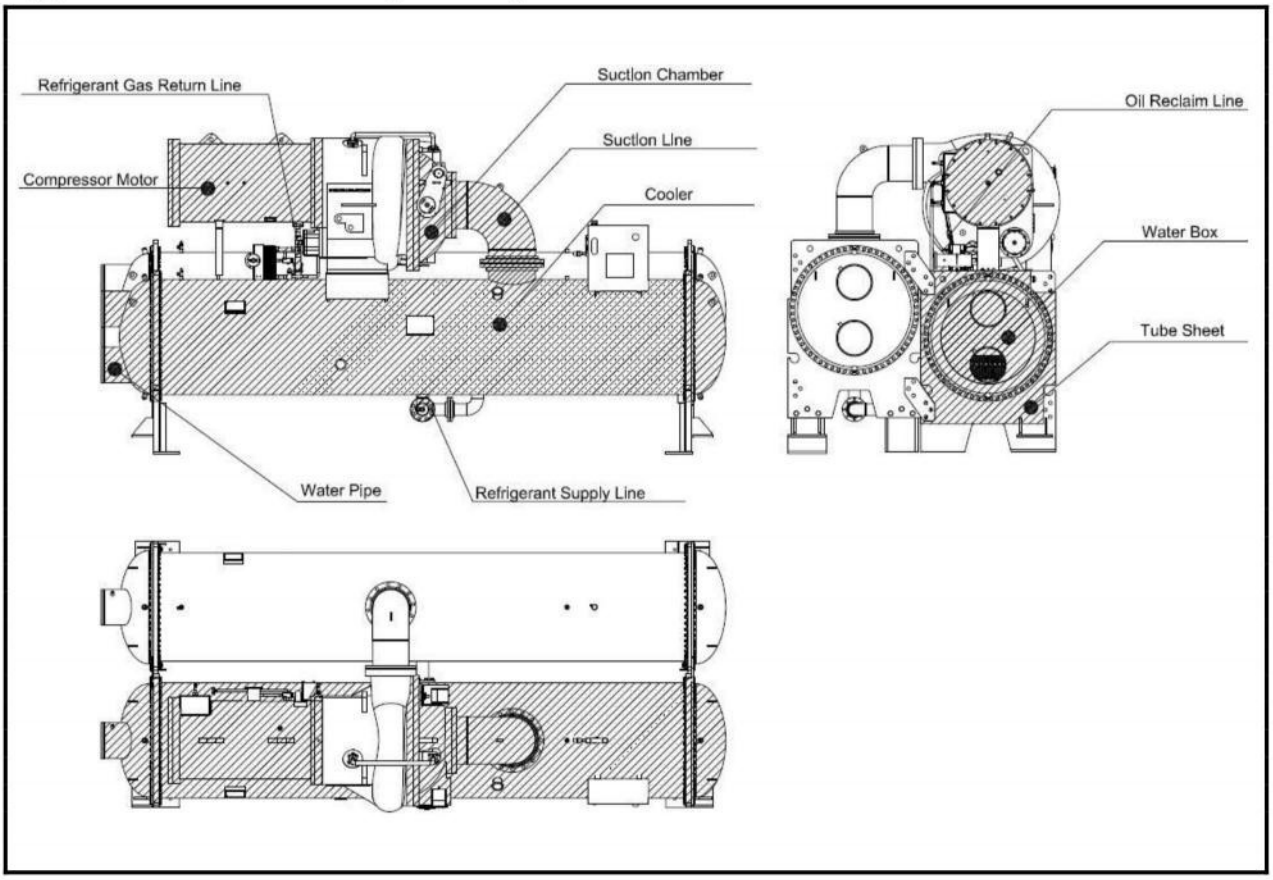
Factory insulation on DCLC chillers with 19mm closed cell insulation are standard supply. The factory insulation for the DCLCs includes the following areas:

- 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.

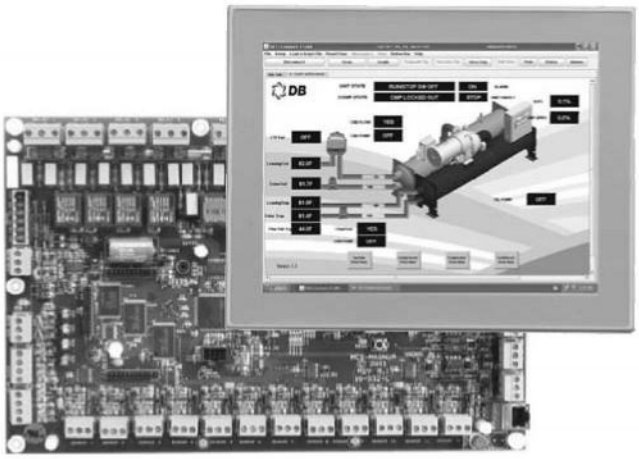
Item	Input Power kW
Oil Heater	1.0
Oil Pump	1.5

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.

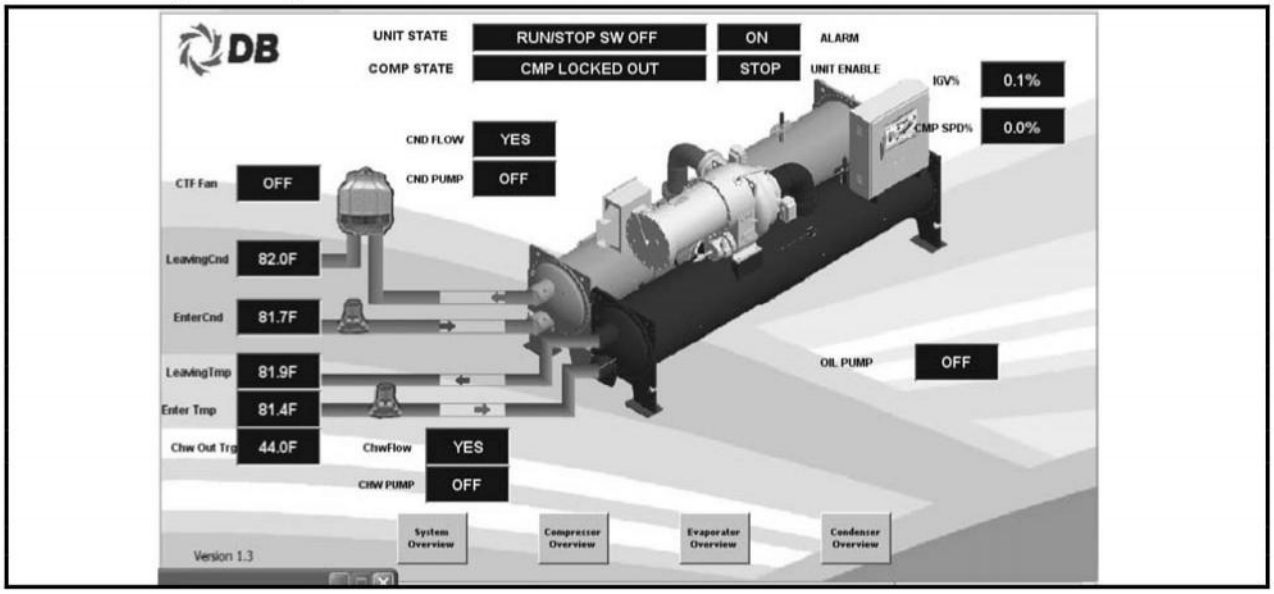
Below readouts are available on the display panel.

- 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