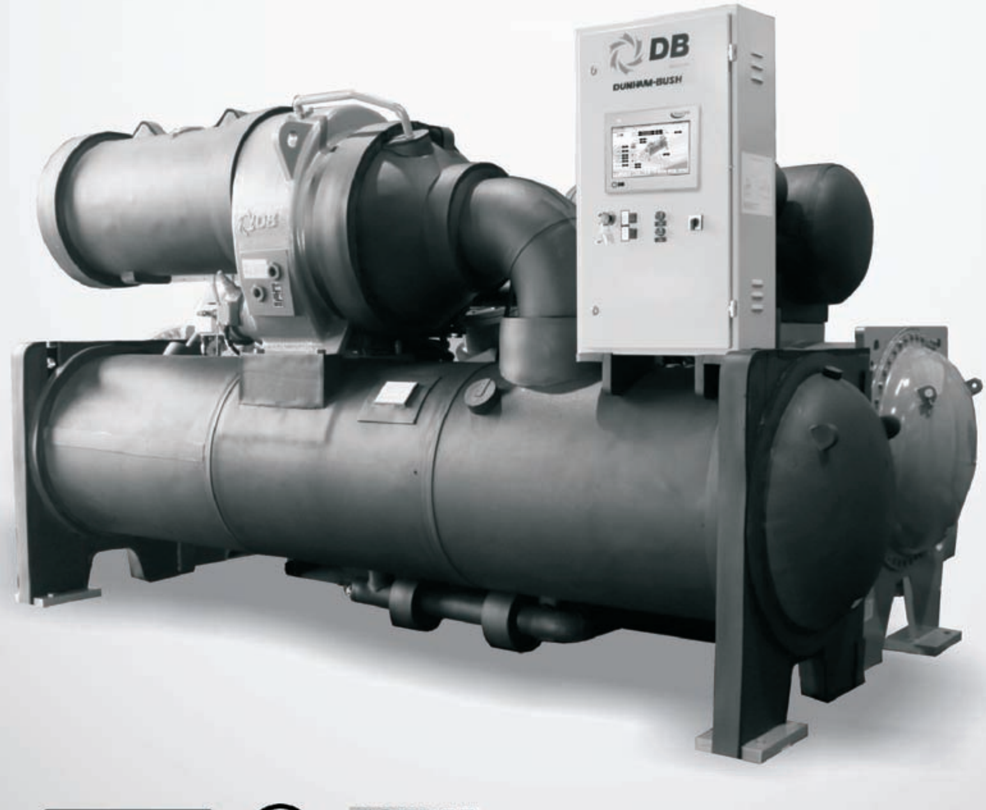
HERCULES

Water Cooled Centrifugal Chillers

DCLCD Series 50/60Hz

Cooling Capacity: 300 to 3000 TR (1055 to 10550 kW)

INSTALLATION, OPERATION & MAINTENANCE MANUAL



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ASHRAE 90.1 COMPLIANT

Intertek

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SAFETY CONSIDERATIONS

This document is a guide of after sale service when water-cooled centrifugal chillers are operated under designed condition. Installers, servicers and installing contractors must acknowledge the potential hazards that could result in equipment damage, personal injury and death.

Operator and service technician must be fully trained and officially authorized.

Before any action of installation, operation and maintenance, operators are required to understand and observe the operation guide and safety precautions in this document based on the observance of National Standard and Code.

DANGER!

- In accordance with the latest edition of ANSI/ASHRAE 15 (American National Standards Institute/American Society of Heating, Refrigeration, and Air Conditioning Engineers), DO NOT VENT safety valves within a building. Outlet from valves must be vented outdoors. PROVIDE adequate ventilation, especially for enclosed and low overhead spaces. Inhalation of high concentrations of vapor is harmful and may cause heart irregularities, unconsciousness, or death. Misuse can be fatal. Vapor is heavier than air and reduces the amount of oxygen available for breathing. Product causes eye and skin irritation. Decomposition products are hazardous.
- DO NOT USE OXYGEN to purge lines or to pressurize a chiller for any purpose.
- DO NOT USE air for leak testing. Use only refrigerant or dry nitrogen.
- NEVER EXCEED specified test pressures, verify the allowable test pressure by checking the instruction literature and the design pressures on the chiller nameplate.
- DO NOT BY PASS any safety device.
- BE SURE that all pressure safety valves are properly, installed and functioning before operating any chiller.
- PLEASE be aware of ELECTRIC SHOCK! When Wye-Delta or Solid State Starter is applied, the terminal block is always energized even when the chiller is not commissioning. Must cut off the power when wiring.
- DO NOT work on high-voltage equipment unless you are qualified.
- ONLY qualified people can work on electrical components. Do not work on control box until ALL POWER IS OFF, which can be done through the main breaker.
- DO NOT WORK ON electrical components, including control panels, switches, starter cabinet and oil heater etc., until you ensure ALL POWER IS OFF; because residual voltage can leak from capacitors or other electrical components. LOCK OPEN AND TAG electrical circuits during servicing. IF WORK IS INTERRUPTED, confirm that all circuits are de-energized before resuming work.
- During installation, commissioning, operation and maintenance, the engineers must be equipped with safety glasses, gloves, shoes and protective clothing.

SAFETY CONSIDERATIONS

WARNING!

- All installation parts must be maintained by the personnel in charge, in order to avoid material deterioration and injuries to people. Any Fault or leak must be repaired immediately by authorized technician.
- Only qualified personnel familiar with the construction can work on the refrigeration components, and all welding job must be done by qualified welder.
- The refrigerant must be discharged and leaking point must be examined and repaired once any leak occurs. The weight of refrigerant should be charged after repair, refers to the nameplate of the chiller. If stop valves are applied to the chiller, the refrigerant could be stored in the vessel rather than discharged during repair. The refrigerant is only being charged through liquid tube and at the meantime make sure there is water flow in the vessel.
- DO NOT attempt to vent Oxygen to any pipe on the chiller because Oxygen gas reacts violently with oil, grease, and other common substances.
- The chiller must work under its maximum designed pressure.
- If water system is installed and the environment temperature is under zero degree, the drain valve must be open to empty the tube water.
- Fire extinguisher must be easy to locate once a fire occurs.
- DO NOT WELD OR FLAMECUT any refrigerant line or vessel until all refrigerant (liquid and Vapor) has been removed from chiller. Traces of Vapor should be displaced with dry air nitrogen and the work area should be well ventilated. Refrigerant in contact with an open flame produces toxic gases.
- AVOID SPILLING liquid refrigerant on skin or getting it into the eyes. USE SAFETY GOGGLES AND SAFETY GLOVES. Wash any spills from the skin with soap and water. If liquid refrigerant enters the eyes, IMMEDIATELY FLUSH EYES with water and consult a physician.
- DO NOT USE eyelets to lift any part of the machine or the complete machine.
- NEVER apply an open flame or live steam to refrigerant cylinder; otherwise it may result in dangerous overpressure. If necessary, use warm water under 43.3°C.
- DO NOT REUSE disposable (non-returnable) cylinders or attempt to refill them. It is DANGEROUS AND ILLEGAL. When cylinders are emptied, evacuate remaining gas pressure, loosen the collar and unscrew and discard the valve stem. DO NOT INCINERATE.
- During refrigerant operations, CHECK THE REFRIGERANT TYPE before adding refrigerant to the machine. The introduction of the wrong refrigerant can cause damage or malfunction to this machine. When applying refrigerant from other manufacturers, the refrigerant must meet the requirements of DUNHAM-BUSH material regulations.
- Make sure the relative pressure is 0 Pa before doing any work on any connection.
- PERIODICALLY INSPECT all valves, fittings, and piping for corrosion, rust, leaks, or damage.
- DO NOT LOOSEN a packing gland nut before checking that the nut has a positive thread engagement.

CAUTION！

- DO NOT WALK ON the refrigerant pipe in order to prevent it from damage.
- DO NOT climb over a chiller. Use platform, catwalk or staging and observe the safety operation rules.
- USE MECHANICAL EQUIPMENT (crane, hoist, etc.) to lift or move heavy components. Even if components are light, use mechanical equipment when there is a risk of slipping or losing your balance.
- BE AWARE that automatic restart schedule CAN ENGAGE TOWER FAN, OR PUMPS. Disconnect the power of the tower fans and pumps.
- USE only repair or replacement parts that meet the code requirements of the original equipment.
- DO NOT VENT OR DRAIN water boxes containing industrial brines, liquid, gases, or semisolids without the permission of your process control group.
- DO NOT LOOSEN water box cover bolts until the water box has been completely drained.
- DOUBLE-CHECK that coupling nut wrenches, dial indicators, or other items have been removed before rotating any shafts.
- PROVIDE A DRAIN connection in the vent line near each pressure relief device to prevent a build-up of condensate or rain water
- Do not short or jumper between terminations on circuit boards or modules, which may result in control or board failure.
- Please contact DUNHAM-BUSH in case customer needs to know the vessel tube diameter for the purposes of installation of automatic tube cleaning devices.

1.0 INTRODUCTION

The DCLCD chiller performance is rated in accordance to AHRI 550/590 standard latest edition.

Vessels are fabricated and pressure tested in accordance to ASME Boiler and Pressure vessel code, Section VIII, Division 1 “Unfired Pressure Vessels”.

The primary technical parameters can be found on the nameplate of the chiller.

The usage of the unit should comply with relative pressure vessel standard.

2.0 INSTALLATION GUIDE

2.1 BRIEF INTRODUCTION

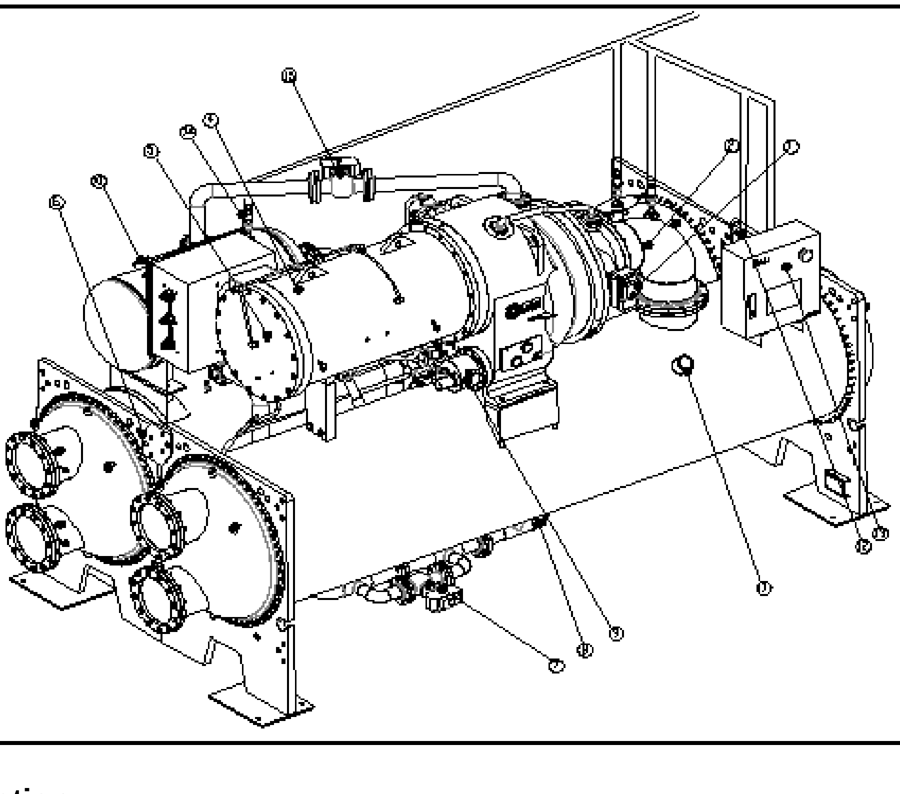
2.1.1 General

The DCLCD chiller is factory fabricated, wired, leak tested, insulated and delivered to specified site. Onsite machine uploading, rigging, foundation, wiring, piping, and insulation of water box covers are to be completed by the contractor and/or customer.

Dunham-Bush also can ship the chiller parts separately if there is rigging limitation. The onsite installation must be supervised by representative of Dunham-Bush and comply with this manual.

Figure 2.1 Typical DCLCD Unit Components

1-IGV Actuator
2-Suction Piping
3-Condenser PRV
4-Compressor Motor
5-Motor Sight Glass
6-Vessel Joint Plate
7-Liquid Level ball valve
8-Charging Valve
9-Oil Pump
10-Economizer Sight Glass
11-Evaporator Sight Glass
12-Evaporator PRV
13-Controller
14-Economizer PRV
15-Vapor Injection ball valve



2.1.2 Technical Information

Be familiar with the following information before installation:

- Contract and Technical Agreement
- Unit Location Drawing
- Rigging Requirements
- Pipe Connection Drawing and Details
- Electrical drawing
- Installation information of starters
- Official drawings provided by DUNHAM-BUSH

2.0 INSTALLATION GUIDE

2.2 INSTALLATION

2.2.1 Check and accept the chiller

! CAUTION: Do not open any valves or loosen any connection. The standard DCLCD chiller is shipped with quantitative refrigerant gas

2.2.1.1 Inspect Transportation Quality

- Check if there is any damage occurred during delivery before unloading. If damaged or moved, have it examined, confirmed and taken photos by transportation inspectors before unloading, and then analyze the reasons and determine the responsible party.
- Check if the chiller and accessories are intact according to the package list. If there is anything missing, please notify your local DB representative immediately.
- Leave all parts in original packages until installation.

2.2.1.2 Confirm the chiller and accessories

Check and confirm the chiller and accessories according to the contract, technical agreement and package list, if there is anything missing, please immediately notify DUNHAM-BUSH. The models of the chiller and heat exchangers are noted in the nameplate.

2.2.1.3 Storage

Protect the chiller and starter from humidity during storage. Do not remove the cover plates before installation. Prevent dust and impurities from entering the system while installing.
The chiller should be prevented from freezing after water circuits installed. For standard chiller， when the environment temperature is under 0℃， open water drains in the water box and remove all water from cooler and condenser. And leave drains open during installation.

2.2.2 Rigging

The chiller can be lifted integrally as well as separately

2.2.2.1 Lift the chiller

The chiller is shipped with the base; do not remove the base until the chiller reaches the jobsite. The weight of the base follows Table 2-4. When lifting the entire chiller, see rigging instruction on the label attached to chiller， and refer to the Machine Rigging Guide (Figure 2.2.2). Lift chiller only from the points indicated in the chiller rigging drawings， do not lift from the screw eye. Each lifting cable or chain must be capable of supporting the entire weight of the chiller. Chiller weight follows Table 2-1.

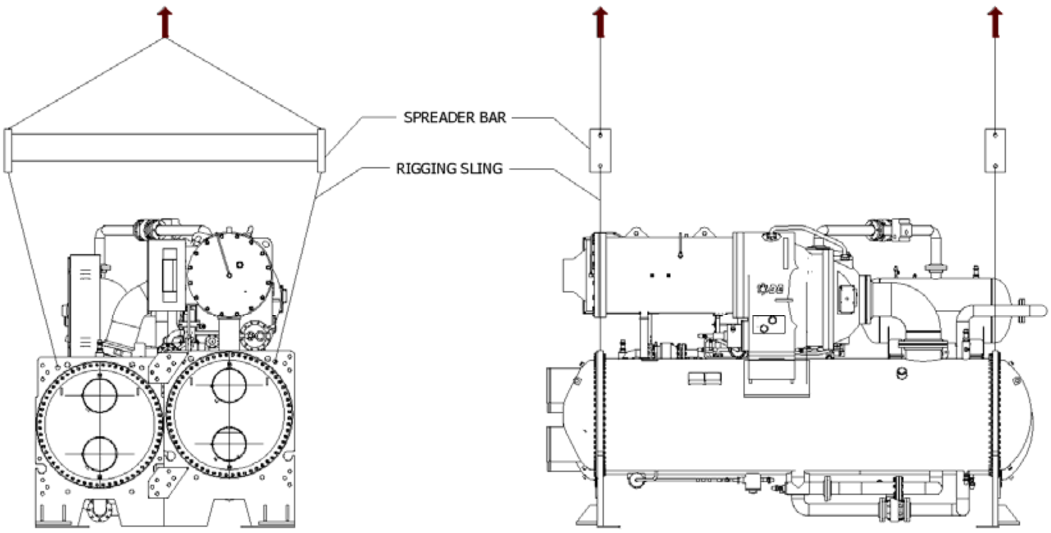
! Warning: Lifting the chiller from points other than those specified in the drawing may result in serious damage to the unit and personal injury. Rigging equipment and procedures must be adequate for the chiller weight.

! Note: Protect the unit before rigging to prevent the body and weak parts from scraped and damaged by cable.

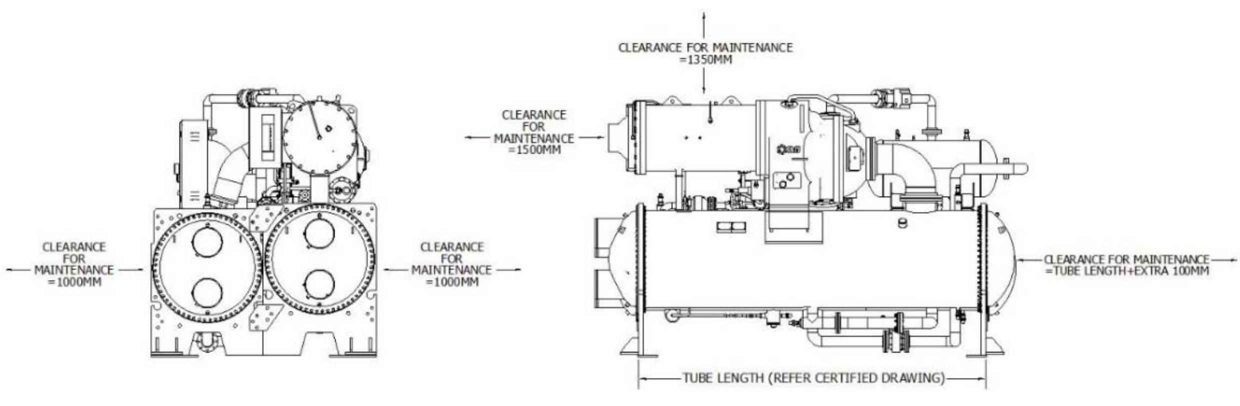
2.0 INSTALLATION GUIDE

Figure 2.2.2 DCLCD Unit Rigging Guide

CHILLER RIGGING INSTRUCTIONS



NOTE:
1. MUST USE SPREADER BAR TO AVOID SLING IN CONTACT/DAMAGE THE UNIT COMPONENT
2. THE UNIT SHOWN IS FOR ILLUSTRATION ONLY AND MAY DIFFER FROM ACTUAL
3. EACH SLING CAN STAND THE WHOLE CHILLER WEIGHT
4. EACH SLING CAN BE ADJUSTED ACCORDING TO THE PRACTICAL SITUATION
5. DO NOT MOVE OR LIFT THE CHILLER USING FORKLIFT



2.0 INSTALLATION GUIDE

2.2.2.2 Lift chiller components

Disassemble and rig units according to chiller disassemble drawings provided by DUNHAM-BUSH. The machine must be operated by qualified service technician, who is supervised and guided by the representative of DUNHAM-BUSH.

! Warning: Do not attempt to loosen any bolts when the chiller is under pressure, or may result in personal injury and equipment damage.

Disassemble the compressor according to the following steps:

1) Loosen compressor suction elbow bolts on the cooler flange (Figure 2.2.2.2A piece 1);
2) Loosen bolts of motor cooling piping and motor end (Figure 2.2.2.2A piece 6);
3) Loosen refrigerant reclaim piping from motor to cooler (Figure 2.2.2.2A piece);
4) Disconnect and mark every electrical wire: oil sump temperature sensor cable (Figure 2.2.2.2C piece 4), bearing temperature sensor cable (Figure 2.2.2.2B piece 3), motor overheat protector (Figure 2.2.2.2C piece 1), guide vane actuator cable (Figure 2.2.2.2C piece 6), compressor oil sump pressure sensor cable (Figure 2.2.2.2C piece 2), compressor oil supply pressure sensor cable (Figure 2.2.2.2C piece 5);
5) Loosen oil reclaim piping bell-mouthed nuts (Figure 2.2.2.2A piece 2);
6) Loosen compressor discharge elbow bolts (Figure 2.2.2.2B piece 5);
7) Seal all of openings;
8) Disconnect motor power wire in starter cabinet (Figure 2.2.2.2A piece 3);
9) Loosen the fixed bolts connected the compressor and cooler (Figure 2.2.2.2A piece 8);

   Rig the compressor after disassemble it. It may slope backwards when stored, because the end of the motor is heavier. Block up the end of the motor to ensure it is horizontal while stored.

   Disconnect the condenser and the cooler according to the following steps (if the installation condition is allowed, it would be better to skip this step):

   1) Install support sheet under each tube sheet to ensure the heat exchangers are horizontal (Figure 2.2.2.2A piece 5);
   2) Loosen the bolts of liquid line to the cooler (Figure 2.2.2.2A piece 9);
   3) Seal all of openings;
   4) Disconnect and mark every electrical wire: water box temperature sensor cable (Figure 2.2.2.2D piece 3,4,6,7), cooler pressure sensor cable (Figure 2.2.2.2B piece 1), condenser pressure sensor cable (Figure 2.2.2.2B piece 6), motor power cable in the starter cabinet, wires from control box to starter cabinet and cable from control box to oil pump control panel.

      Rig the cooler and condenser separately after disjunction. The four rig points must be fastened before lift. Note that the cooler and condenser have two welded unit bases, and it needs to block up the end with no welded base while stored separately to ensure cooler and condenser are horizontal.

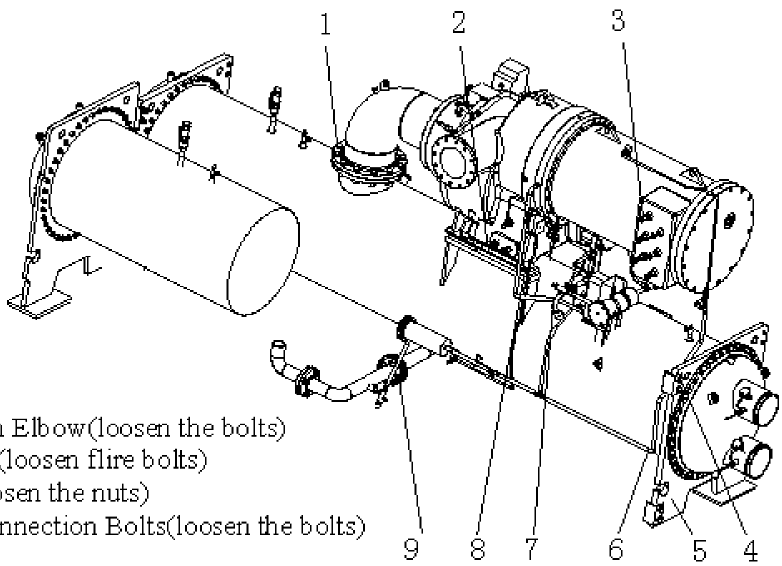
Note: Coat the new O rings with silicon grease while reassembled, and coat the new gasket with seal glue.

2.2.3 The condition of the installation field

1) The chiller room cannot be close to fire source and tinder;
2) The chiller room with indoor temperature should be below 43.3℃, ventilated, with no corrosive surroundings;
3) The foundation is solid enough to support the running weight;
4) There is drain around the unit and the chiller room;
5) The chiller room should have enough space for operation and maintenance (refer to Figure 2.2.3).

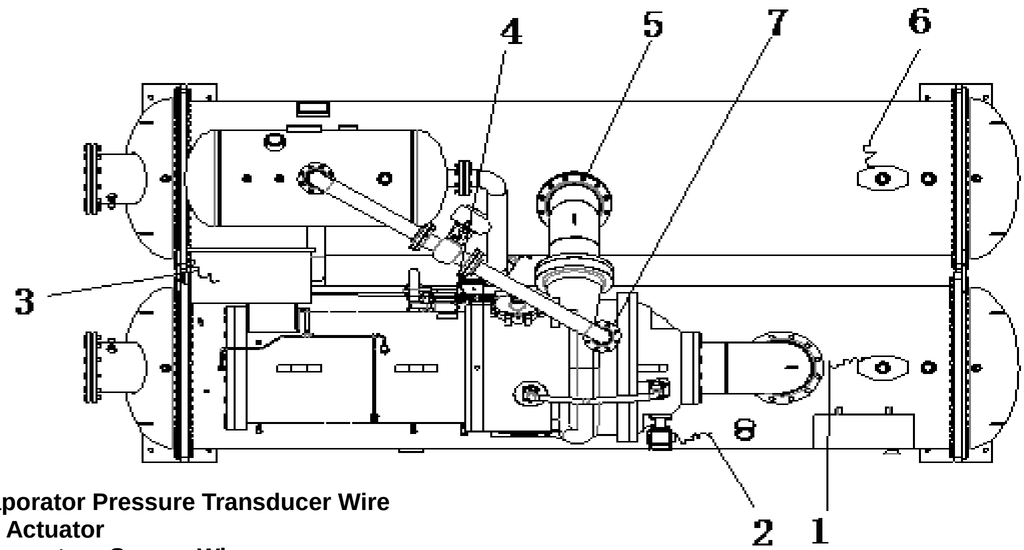
2.0 INSTALLATION GUIDE

Figure 2.2.2.2A Isometric of Cooler



1-Compressor Suction Elbow(loosen the bolts)
2-Oil Reclaim Piping(loosen flire bolts)
3-Motor Terminal(loosen the nuts)
4-Heat Exchanger Connection Bolts(loosen the bolts)
5-Tube Sheet
6-Motor Cooling Piping(loosen the nuts)
7-Connection Piping Between Motor and Cooler(loosen the nuts)
8-Compressor Fixed Bolts(lossen the bolts)
9-Liquid Line to Cooler(loosen the bolts)

Figure 2.2.2.2B Top View



1-Evaporator Pressure Transducer Wire
2-IGV Actuator
3-Temperature Sensor Wire
4-Motor Winding Overheat Protector Wire
5-Compressor Discharge Port
6-Condenser Pressure Transducer Wire
7-VI Port

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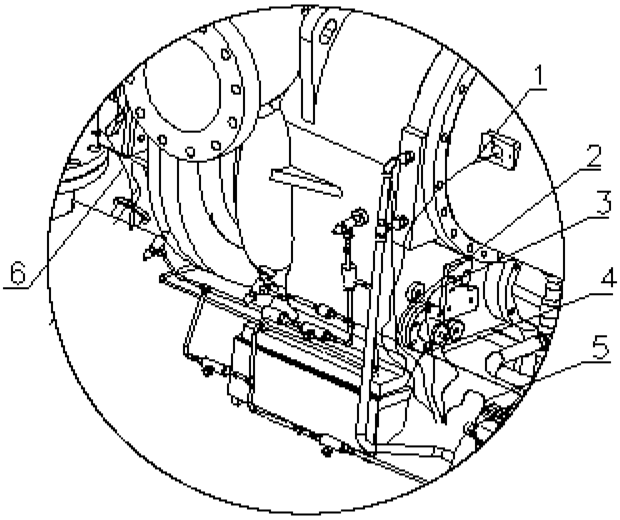
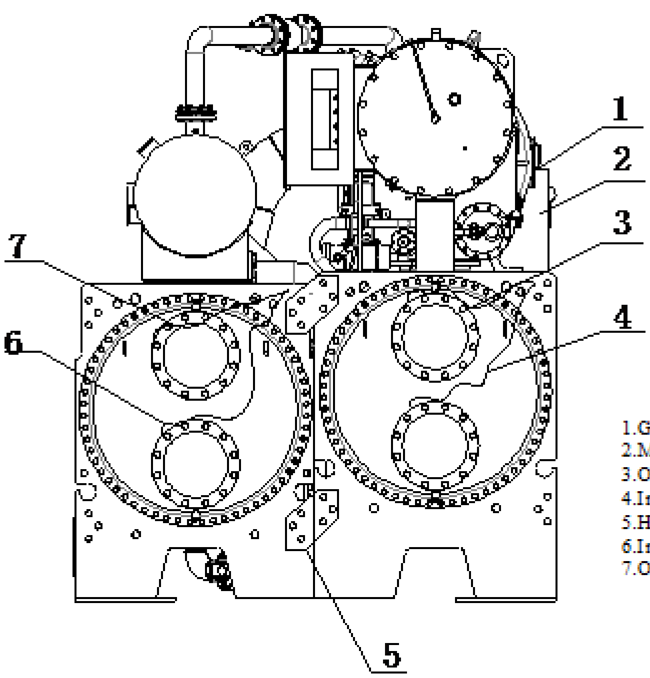
Figure 2.2.2.2C Compressor Detailed Drawing



1.Motor Overheat Protector Cable
2.Compressor Oil Sump Pressure Sensor Cable
3.Bearing Temperature Sensor Cable
4.Compressor Oil Sump Temperature Sensor Cable
5.Compressor Oil Discharge Pressure Sensor Cable
6.Guide Vane Actuator Cable

Figure 2.2.2.2D Left View



1.Guide Vane Actuator
2.Micro-computer Based Control Panel
3.Outlet Chilled Water Temperature Sensor Cable
4.Inlet Chilled Water Temperature Sensor Cable
5.Heat Exchangers Connection Plate
6.Inlet Cooling Water Temperature Sensor Cable
7.Outlet Cooling Water Temperature Sensor Cable

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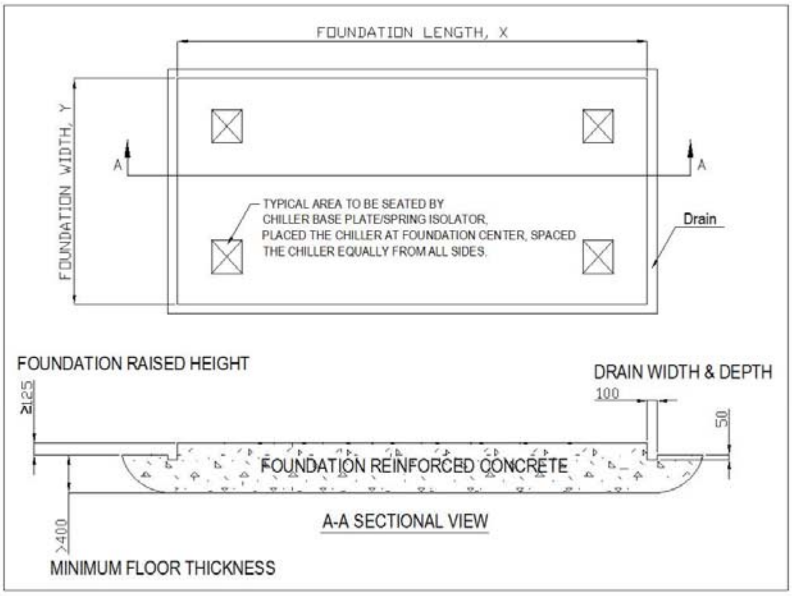
2.2.4 Foundation

2.2.4.1 Chiller foundation materials and the scope of works are by customer.

Figure 2.2.4.1 Chiller Foundation (for reference only)

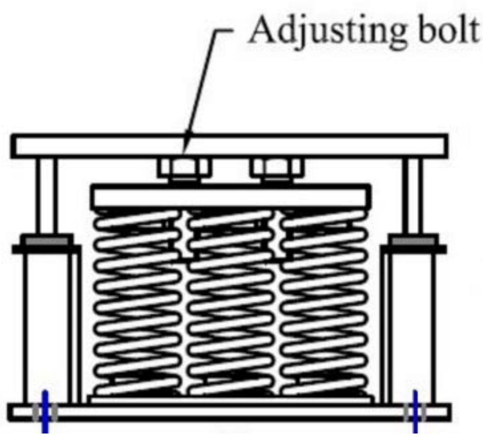


VESSEL	FOUNDATION LENGTH, X	FOUNDATION WIDTH, Y
D20, D21, D22 DX20, DX21, DX22, DX23	4572	2184
D25, D26, D27 DX25, DX26, DX27, DX28	5156	2184
DC25, DC26, DC27	4318	2184
D30, D31, D32, D3U, D3V, D3W DX30, DX31, DX32, DX33	4648	2413
D35, D36, D37, D3X, D3Y, D3Z DX35, DX36, DX37, DX38	5182	2413
DC35, DC36, DC37	4318	2413
D40, D41, D42, D4U, D4V, D4W DX40, DX41, DX42, DX43	4674	2515
D45, D46, D47, D4X, D4Y, D4Z DX45, DX46, DX47, DX48	5207	2515
DC45, DC46, DC47, DC4X, DC4Y, DC4Z	4343	2515
D50, D51, D52, D5U, D5V, D5W DX50, DX51, DX52, DX53	4699	2515
D55, D56, D57, D5X, D5Y, D5Z DX55, DX56, DX57, DX58	5232	2515
DC55, DC56, DC57, DC5X, DC5Y, DC5Z	4369	2515
D60, D61, D62, D6U, D6V, D6W DX60, DX61, DX62, DX63	5334	3048
D65, D66, D67, D6X, D6Y, D6Z DX65, DX66, DX67, DX68	5944	3048
DC65, DC66, DC67, DC6X, DC6Y, DC6Z	4775	3048

Notes:
1. This foundation drawing is for reference only, all dimension in mm.
2. When building the concrete foundation, a drain should be established around the foundation.
3. The surface flatness of the foundation must within ±3mm/m.
4. The chiller base plate/spring isolator, are advised to be secured in concrete using foundation bolt.
5. Construction, foundation reinforced concrete and foundation bolts are by customer.

2.2.4.2 Spring Isolator

Spring Isolator are optional items, if required, can purchase from DUNHAM-BUSH.



***Example photo & picture – for reference only, may differ from actual.**

<u>Spring Isolator Installation:</u>

1.Secure the spring with a bolt as per the photo, only one bolt is required.
2.Adjust the adjusting bolt to level the chiller if required.

2.0 INSTALLATION GUIDE

2.2.5 Pipe Connection

2.2.5.1 Water System Pipe connection

Typical water system arrangement and installation refer to Figure 2.2.5A, Figure 2.2.5B.

1) Offset the pipe flanges for maintenance and pipe cleaning;
2) Provide openings on pipes for pressure gages and thermometers;
3) Install flow meter at both inlet and outlet of chilled water;
4) Install air vents at high points of the pipes;
5) Install perpetual filter at the water inlet;
6) Install brackets under pipes where needed;
7) The water should enter to the lower pipe and leave from the upper one;
8) To prevent insulation from being damaged by welding sparks, please cover a wet canvas while welding;
9) Remove all sensors before installation, and then assemble them back after installation.

Figure 2.2.5ATypical Piping Connection (the inlet and outlet may not on the same side for some chillers)

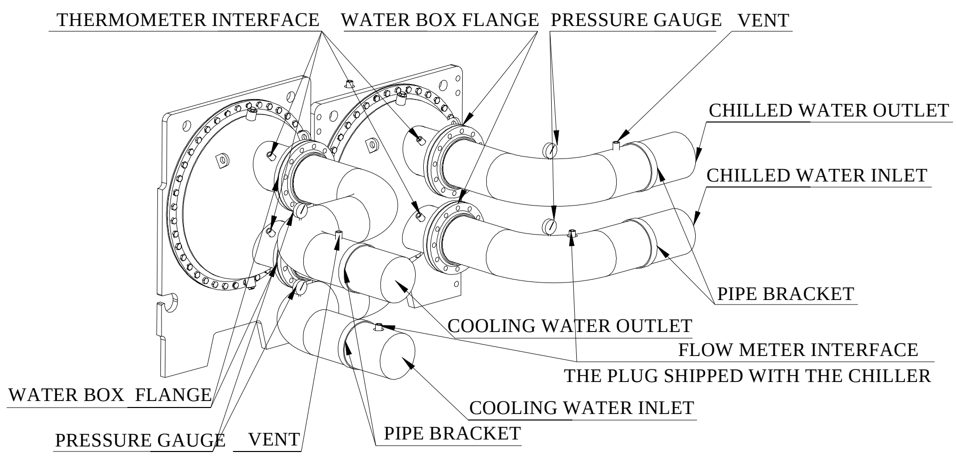
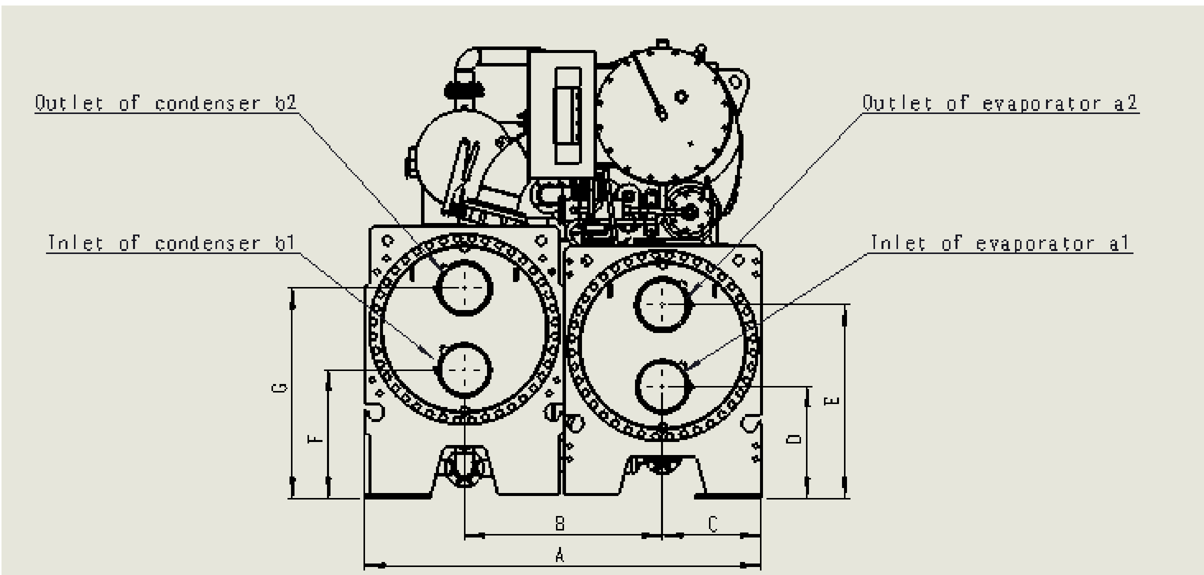


Figure 2.2.5B Water Pipe Connection Arrangement



Please refer certified drawing for dimensional detail.

2.2.5.2 Install Vent Piping to Safety Valves

Refrigerant discharged into confined spaces can displace oxygen and cause asphyxiation. It is advised that the safety valve should discharge outdoors according to ANSI/ASHRAE 15 and location safety laws and regulations. Please install the pipe referring to Figure 2.1.

1) The cross-sectional area of the relief pipe must be no less than the sum of the areas required for the individual relief pipes. (standard single valve flow area is 254mm^2)
2) Install pipe bracket where needed, ensure no load on the safety valve discharge pipe line. A length of the flexible tubing or piping near the device is essential on spring-isolated chillers.
3) Cover the outdoor vent with a rain cap and place a filter at the bottom of the pipe.
4) The discharge pressure of the safety valve is 1.28MPa/1.9MPa.

2.2.6 Electrical Connection

Wire connection must be accordance with the wiring diagram and all electrical codes. The drawing is for your reference only, and actual installation refers to onsite installation drawing.

! WARNING

Do not start the compressor or oil pump when the unit is vacuum (even though just to check the rotation). Do not connect any detection voltage either, or the motor insulation may be seriously damaged.

2.2.6.1 Connect Input Points

Reserved interlock stop, remote stop, remote start and chilled water interruption are to be connected on site by client. Connect to micro-computer control panel with main motor ready, run and current points from starter cabinet.

2.2.6.2 Connect Output Points

Connect output devices, such as chilled pump, cooling pump, cooling tower and others required.

2.2.6.3 Connect Starter Cabinet

Install the DCLC starter on site, as shown in Figure 2.2.6.3.
Before connecting wires, please ensure that it meets the following requirements.

1) Ambient temperature range: -5～+45°C。
2) Relative humidity: <90％, without condensation。
3) The height above sea level where the unit is installed is not exceed 2000m
4) Pollution grade 3: Conductive contamination or dry nonconductive contamination become conductive due to condensation
5) There is no serious quake on the site, the incline angle with vertical does not exceed 5°.
6) Power supply range: compared to rated voltage, the error band is ±10％.
7) The low-voltage starter power supply is 3-phase 5-wire, while the medium/high-voltage is 3-phase 4-wire.
8) Current unbalance between phases must ≤ 5%
9) Voltage unbalance between phases must ≤ 2%

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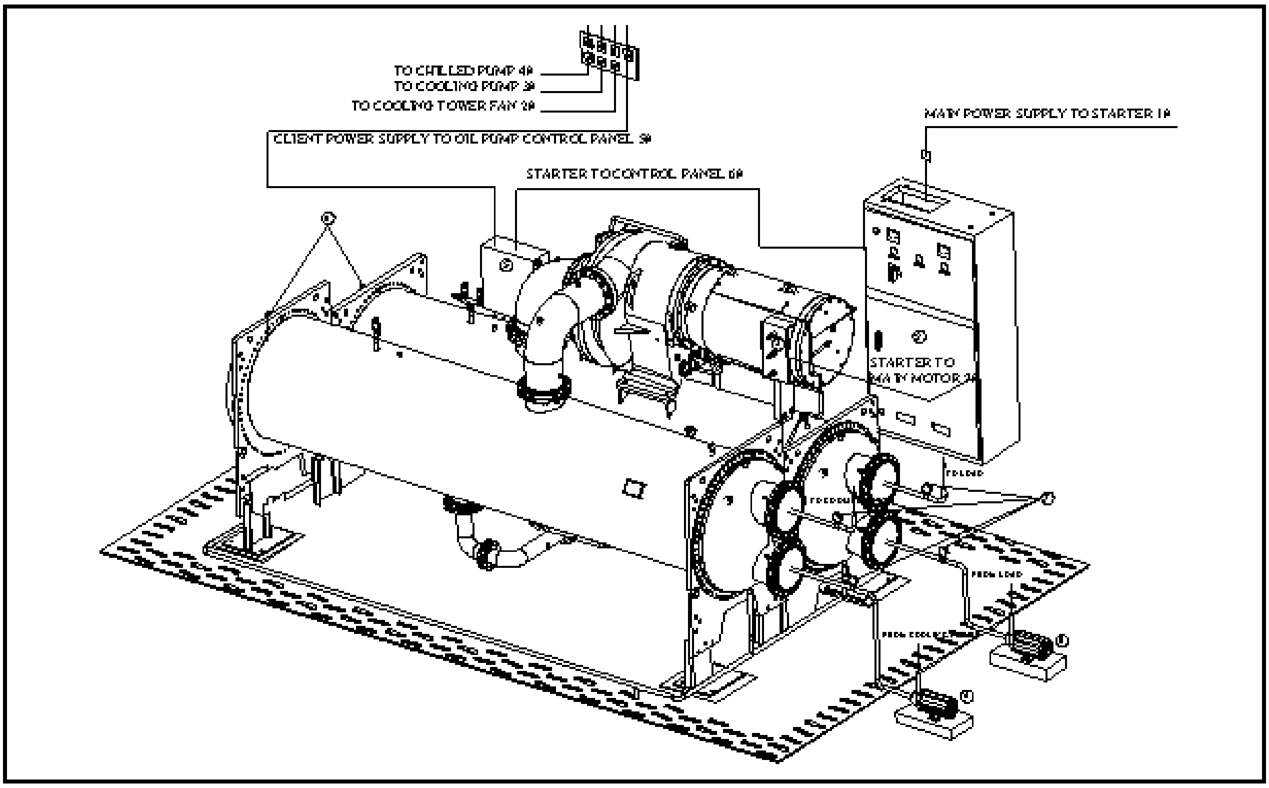
Figure 2.2.6.3 DCLCD Unit External Wiring Drawing



1. Circuit Breaker
2. Free Standing Starter
3. Motor Terminal Block
5. Control Panel
6. Vent Valve
7. Pressure Gauge
8. Chilled Water Pump
9. Cooling Water Pump
10. Chilled Pump Starter
11. Cooling Pump Starter
12. Cooling Tower Starter
13. Air Switches
14. Oil Pump Air Switch

Cable NO.	Application	Specification
1#	Main power to starter cabinet	415V AC: 3P, 1 neutral line, 1 earth line; 6KV, 10KV AC: 3P, 1 earth line
2#	Control panel to cooling tower starter	2 control lines (optional)
3#	Control panel to cooling pump starter	2 control lines (optional)
4#	Control panel to chilled pump starter	2 control lines (optional)
5#	Starter cabinet to control panel	415V AC: 3P, 1 earth line, 600V, 80℃，grounding in the starter cabinet.
6#	Starter cabinet to main motor	415V AC: 6 motor lead lines (the minimum carrying current is 0.721 times of the rated current), 2 earth lines; 6KV/10KV AC: 3 motor lead lines, 1 earth line (2 sets).

Power up the compressor according to the wiring diagram, only copper wire can be used. The motor should be grounded at the same time. Check the motor rotation. The installer should be responsible for the damages caused by wrong wiring.

For low-voltage unit, the compressor motor terminals, wire terminals and wire should be insulated to prevent them from water condensation and electric arc. For high-voltage unit, specific terminal treatment is compulsory in accordance with the local electrical standards.

Connect the starter and micro-computer control panel with control wires, including the main motor start, trip, and run; motor ready and current. All control wires must be shielded.

2.2.6 Install Insulation on Site

Install insulation on site after unit installation.

1) The form of insulation is in accordance with the project regulation, or the minimum thickness of material could prevent the vessel from condensation under environment temperature of -1°C.
2) If no special requirements, the unit has already insulated in factory, and only the insulation of chilled water pipe is installed on jobsite.
3) As required in the contract should insulate the following parts: compressor motor, compressor suction line, shell and tube sheet of cooler, liquid line from cooler to orifice, water box and connection pipe of cooler etc.

2.0 INSTALLATION GUIDE

2.2.7 Others

1) Any loss caused by water quality is undertaken by the client. The water quality should be inspected before installation and during operation. Once the water quality is worse than required for long time, the high-efficiency tube may corrode and go dirty, and it may cause leakage of tubes or reduce the efficiency of heat exchange so that it will influence the normal operation of the unit.
2) The unit is normally shipped with R134a refrigerant gas holding charge. If there is no leak, refrigerant can be charged without vacuum inspection. If the unit is shipped without oil and refrigerant, leak and vacuum test should be qualified before being charged oil and refrigerant.

2.3 INSTALLATION INSPECTION BEFORE STARTUP

DUNHAM-BUSH will supply service of installation check, initial startup and operation. After the chiller is installed, piped and wired according to this manual, inform DUNHAM-BUSH local office to arrange initial startup service by contract. Three copies of “Installation Checklist” are required for this service.

INSTALLATION CHECKLIST

Model NO.: ________________ **Series NO.:** ________________
Project name: ________________ **Contract NO.:** ________________
Telephone: ________________ **FAX:** ________________
Project address: ________________________________
Agency name: ________________________________
Installation company name: ________________________________

	Yes	No	Accomplished Time / Date
1) Unit is horizontal			
2) Install and connect every component according to installation manual			
3) Install every component of foundation			
4) Install vent piping to safety valve			
5) Install water system and identify the pipeline and flow direction			
a) Chilled water pipe			
b) Cooling water pipe			
c) Water box drain			
d) Others			
6) Install all kinds of measure meters needed by water system			
a) Pressure gage for inlet and outlet			
b) Temperature gage for inlet and outlet			
7) Connect main power wire			
a) Main power wire for compressor motor			
b) Control line for starter cabinet			
c) Power line for oil pump control panel			
d) Power line for control panel			
e) Others			
8) Open oil sump angle valves and oil return angle valves.			

Your suggestions:

____
____
____

2.0 INSTALLATION GUIDE

STARTUP CHECKLIST

Item	Yes	No	Accomplished Time / Date
1) Check the blade space and operation condition of the cooling tower fan			
2) Check the pipe of the water system			
a) Make sure the pipes are filled completely			
b) Pressure detection			
c) Over fall			
d) Venting			
e) Installation, cleaning, inspection of filter			
3) Check the chilled water pump and cooling water pump if operate and has flow normally			
4) The loading needed			
a) 25%			
b) 50%			
c) 75%			
d) 100%			
5) The refrigerant is charged			
6) The power has prepared before starting up			
7) Debug on site by after sales of DUNHAM-BUSH			
8) The operator of the user should be trained onsite after starting up			

Requirements to the device installation and other assistants:

____

____

____

____

Representative Of User Signature:

____

DATE： ______________________________

Field Management Signature:

____

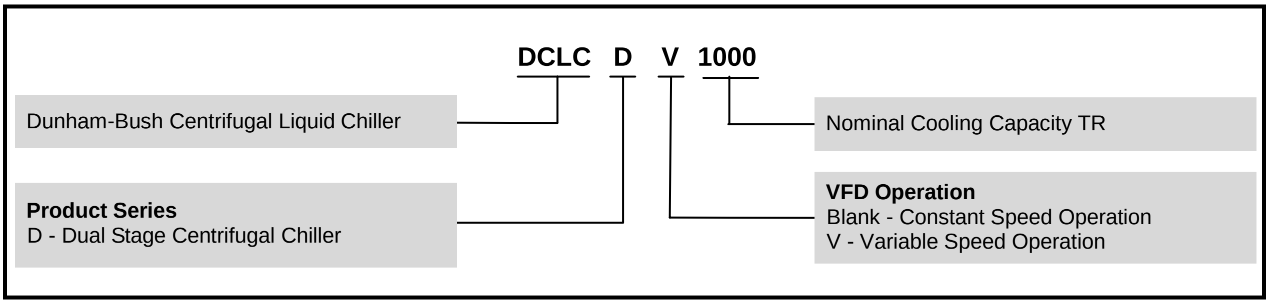
DATE： ______________________________

3.0 SYSTEM ARCHITECTURE

3.1 CHILLER NAMEPLATE

The model code of DCLCD products contains unit type, nominal cooling capacity and etc (Figure 3.1). Nameplate is located under the discharge line on the condenser as shown in Figure 2.1.

Figure 3.1 Nomenclature



3.2 SYSTEM COMPONENTS

The system components contain compressor, motor, guide vane actuator, evaporator, condenser, control box, oil pump control box, regulating ball valve (3nos), starter (optional) and Economizer. (Refer to Figure 2.1)

3.2.1 Compressor

The dual stage centrifugal compressor adopts the sealed dual-stage structure. The impeller and guide vane are assembled in the inlet housing, while the transmission gear is assembled in the transmission housing. The impeller is made of special aluminum alloy, good corrosion resistance and has enough strength to ensure high speed rotation. For the design and aerodynamic performance calculation of the compressor impeller, the most advanced technologies in the world were deployed, to ensure excellent hydrodynamic performance. Especially, Ternary Toroidal Technology is used for the impeller, so that the impeller can run with a high efficiency within a wide flow range. The gear parameters are optimized designed, specially modified for good performance, low noise. The big gear is directly mounted on the motor shaft; the impeller and the small gear shaft are connected with a key connection. The whole compressor structure is advanced, compact and reliable.

3.2.2 Motor

The main motor is hermetic induction type and cooled by liquid R134a from the condenser. The refrigerant is vaporized to gas, cools the rotor and stator and returns to cooler. The mass of the refrigerant needed for cooling cycle is fixed in factory. Do not modulate while operating, because if too much, it will increase power consumption; if too little, it may cause motor overheat. Strictly prohibit modulating the mass of refrigerant supplied for cooling motor without authorization of Dunham-Bush. The insulation of high reliable winding can resist corrosion of refrigerant and oil.

3.2.3 Guide Vane Actuator

Cooling capacity control of the chiller is achieved by adjusting the degree of opening of the inlet guide vane to adjusting the volume flow rate.

The modulation of the guide vane is given by micro-computer control system based on chilled water outlet temperature change. The actuator drives the guide vane through connecting rod and gear to open and close. Guide vane manual operation also can achieve modulation of cooling capacity.

The Chiller also employs vapor injection modulation valve.

3.2.4 Evaporator

The cooler is horizontal shell-tube type with inside high-efficiency tube. There are intermediate support sheets along the tube. Installed an eliminator on the top of the cooler to prevent liquid refrigerant from entering the compressor.

Vessels are fabricated and pressure tested in accordance to ASME Boiler and Pressure vessel code, Section VIII, Division 1 “Unfired Pressure Vessels”.

3.0 SYSTEM ARCHITECTURE

3.2.5 Condenser

The condenser is also horizontal shell-tube type with inside high-efficiency tube. Its main construction is the same with the cooler. Installed a buffer along the axial direction to prevent the high speed superheat vapor from the compressor impinge on the condenser tube directly. In the refrigerant piping that connected the condenser and cooler there installs an orifice, which throttles the high pressure and temperature liquid in the bottom of condenser to low pressure and temperature liquid entering to the cooler.

Vessels are fabricated and pressure tested in accordance to ASME Boiler and Pressure vessel code, Section VIII, Division 1 “Unfired Pressure Vessels”.

3.2.6 Micro-computer Control Panel

DCLCD deploys micro-computer control system (Figure 3.2.6) to ensure the chiller operate safely and reliably.

Figure 3.2.6 Micro-computer Control Panel

- User friendly touchable LCD display screen
- Direct parameters settings and control of the chiller operation on the screen
- The screen displays parameters of the chiller operation and real time monitoring
- Safe and reliable start/stop and automatic control procedures can be carried out by the user simply through a button.
- Easily Swap automatic and manual control mode.
- Protective alarm can make the chiller run safely. The last 99 fault alarms can be recorded.
- The control system can carry out initial self-diagnosis and indicate the possible causes of malfunction.
- RS 485 interface for Standard Modbus protocol available and Bacnet protocol (optional)

3.2.7 Oil Pump control part

DCLCD series Chillers oil pump is located inside the control panel, it controls oil pump and oil heater. It supplies the signal of oil pump run and malfunction status, however, it is controlled by the control centre in aspects of oil pump run/stop and oil heater run/stop.

3.2.8 VFD Motor Starter (optional)

VFD motor starter for DCLCD (refer to Figure 3.2.8) is mainly used to control the main motor. It supplies main current feedback, main motor operation status and ready signal to control center, while it also gets the signals of run and stop from the control center.

Figure 3.2.8 VFD Motor Starter

4.0 REFRIGERANT

DCLCD series use R134a as refrigerant which is internationally recognized as no harm to ozone layer (ODP = 0); its molecule formula is $C_2H_2F_4$. Following is the main properties of R134a:

- Low boiling point: gaseous under normal pressure (under normal conditions, the boiling point is – 26.2 ℃).
- Colorless, smell-less, non-flammable, can't explode whichever proportion mixed with air, basically non-toxic. But when contact with open fire or high temperature produced by electro heater, R134a will decompose toxic and pungent compound (such as hydrogen fluoride). So open fire (electric welding, gas welding etc.) is forbidden on the site.
- Liquid R134a is colorless, transparent, can't mix with water, heavier than water, water is on the surface of liquid R134a.
- R134a is generally non-corrosion to metal copper, iron, aluminum, lead and so on.
- R134a almost do not dissolve with common mineral oil, but can dissolve with ester oil, so use R134a as refrigerant, should use ester oil, in order to avoid mineral oil degenerate and product oil mud that can jam the small hole of the tube and pollute insulation material of the motor, thereby influence the unit performance and regular operation.
- Though R134a gas is basically non-toxic and generally harmless to people and animal, but because of R134a gas is 4.3 times heavier than air, it discharged from the unit while disassembled will accumulate at or below ground level, when the density is very dense, it can cause anesthesia, spoor because of anoxic, even worse out of the count. So empty the R134a from the chiller while disassemble the unit, and note that ventilation is well on operate site.
- Quality requirements of the R134a:

  Appearance: colorless, transparent, limpid

  Purity (mass fractions):≥99.9 %

  residual after evaporating (mass fractions): ≤0.01%

  Odor: ethereal no condensable gas (volume fractions): ≤1.5 %

  Moisture: (mass fractions): ≤0.001%

  Acidity: (HCl): ≤0.0001%
- The pressure –temperature relation of R134a under saturated condition refer to Table 4.0

Table 4.0 Pressure-temperature Relation of R134a Under Saturated Condition

Temp °C	Absolutely pressure (kPa·A)	Temp °C	Absolutely pressure (kPa·A)	Temp °C	Absolutely pressure (kPa·A)	Temp °C	Absolutely pressure (kPa·A)
0	292.32	16	504.16	32	815.28	48	1252.6
1	303.57	17	520.42	33	838.63	49	1284.8
2	314.62	18	537.08	34	862.47	50	1317.6
3	325.98	19	554.14	35	886.82	51	1351.0
4	337.65	20	571.60	36	911.68	52	1385.1
5	349.63	21	589.46	37	937.07	53	1419.8
6	361.95	22	607.76	38	962.98	54	1455.2
7	374.59	23	626.50	39	989.42	55	1491.2
8	387.56	24	645.66	40	1016.4	56	1527.8
9	400.88	25	665.26	41	1043.9	57	1565.2
10	414.55	26	685.30	42	1072.0	58	1603.2
11	428.57	27	705.80	43	1100.7	59	1641.9
12	442.94	28	726.75	44	1129.9	60	1681.3
13	457.68	29	748.17	45	1159.7	61	1722.5
14	472.80	30	770.06	46	1190.1	62	1763.1
15	488.29	31	792.43	47	1221.1	63	1804.3

5.0 REFRIGERATING CYCLE

Centrifugal chiller is a way of vapor-compress refrigerating, whose refrigerating principle is to increase the pressure and temperature of refrigerant vapor through imposing energy to it by the compressor, then process it with condensing, throttling procedures to turn it into refrigerant liquid of low pressure and temperature; during its evaporation into vapor in the cooler, it absorbs heat from the surrounding environment (refrigerant medium, such as chilled water) to bring down the temperature of refrigerant medium, thus achieving the goal of artificial refrigeration. It follows that the cycle of vapor-compress refrigeration includes 4 indispensable processes: compressing, condensing, throttling and evaporating. The following is the principle in details:

5.1 COMPRESSING

After the refrigerant vapor in the cooler has been absorbed into the centrifugal compressor, the motor imparts energy to the vapor through compressor impeller, increasing its pressure and forcing it into the condenser; meanwhile, the temperature of refrigerant vapor is increased at the end of compression process.

5.2 CONDENSING

The refrigerant vapor of high pressure and temperature from the compressor will exchange heat with cooling water in the tubes, at the saturation pressure (the corresponding condensing pressure to the condensing temperature) it condenser to liquid. The temperature of the cooling water will increase as it absorbs heat from the refrigerant vapor. The cooling water temperature is directly relating to the condensing temperature.

5.3 SUB-COOLING

The refrigerant vapor condensed into liquid in the condenser further exchange heat with cooling water through the sub-cooler, cooling capacity is increased with sub-cooling.

5.4 THROTTLING

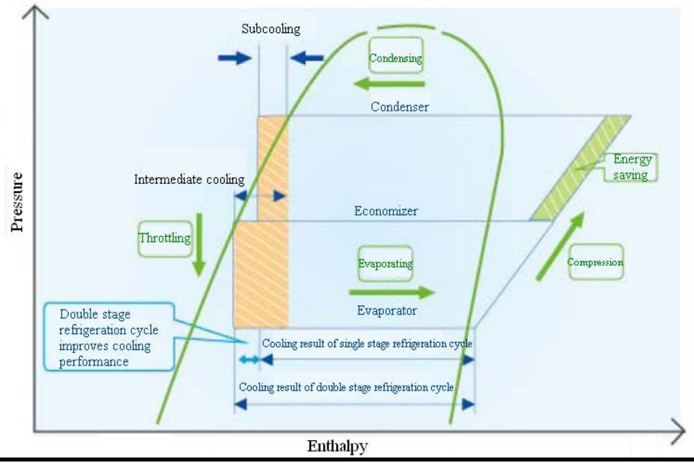
The high temperature and high pressure liquid refrigerant leaving bottom of the condenser undergo pressure reduction and expansion when the liquid passing the throttle orifice. As the pressure and temperature both decrease, it will enter the cooler as liquid of low pressure and temperature.

5.5 EVAPORATING

The low pressure and low temperature liquid refrigerant absorb heat from cooling medium (such as chilled water) in the cooler and evaporate and become vapor. This process brings down the temperature of the cooling medium (water) to realize the goal of artificial refrigeration. The refrigerant vapor in the cooler will be absorbed and compressed by the compressor once again, repeating the 4 processes mentioned above. Continuous refrigerating is then realized in such a circulating process.

The cooling capacity is directly proportional to refrigerant gas flow through the compressor. An adjustable guide vane is installed at the inlet of centrifugal compressor to control the suction flow of the compressor and the evaporating capacity, then the cooling capacity can be steplessly regulated in certain range.

Figure 5.5 Vapor-Compress Refrigerating Cycle



6.0 LUBRICATION CYCLE

6.1 LUBRICATION SYSTEM

The oil pump, oil filter, and oil cooler make up a lubrication system, which lubricates motor, compressor bearings and gears (refer to Figure 6.1). The oil is pumped into a filter assembly to remove foreign particles and then forced into oil cooler where the oil is cooled to proper operational temperatures. After the oil cooler, part of the flow is directed to the gears and the high speed shaft bearings; the other part is directed to the motor shaft bearings. At last, oil drains into the oil sump to complete the cycle.

In order to prevent oil migration, it is required that the oil heater to be turned on(energized) if the chiller in storage more than 3 months. Referring to the wiring diagram for the chiller, please ensure that the oil heater is energised by supplying a power to the chiller. The power supply for the oil heater will required separate power source or fed before the main incoming isolator in the starter panel.

- Typically for unit mounted softstarter, user are required to connect and turn on the power supply before the incoming MCCB (labelled as 1MCCB) in the starter panel. The power to the oil heater will be fed by factory pre-wired circuit to the control panel. In such, even the incoming MCCB is not switched on, there will be power fed to energised the oil heater

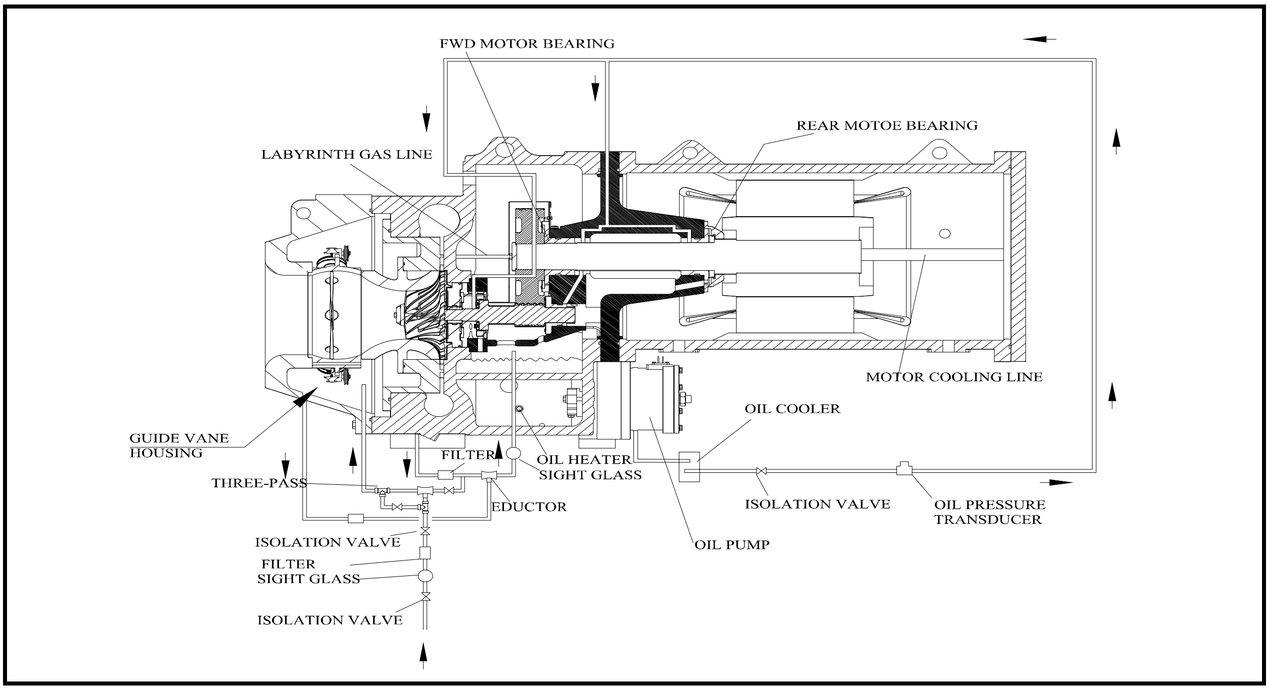
- For unit mounted VFD starter, user are required to connect and turn on the power supply before the incoming MCCB (labelled as QF0) in the starter panel. Then, please make sure the MCCB (labelled as QF01) feeding the power to the control panel are turned on. The power to the oil heater will be fed by factory pre-wired circuit to the control panel. In such, even the incoming MCCB is not switched on, there will be power fed to energised the oil heater

- For free standing VFD starter, users are required to provide separate power supply to the control panel. The 3-phase power supply to be connected to the L1/L2/L3 terminal at the 1TB terminal strip located inside the control panel.

Please ensure that 2MCB (for oil heater) and 3MCB (for control circuit) are turn on.

Do contact DUNHAM-BUSH service team in case customer need to know how to connect the power supply to the oil heater

Figure 6.1 Lubrication Cycle



6.0 LUBRICATION CYCLE

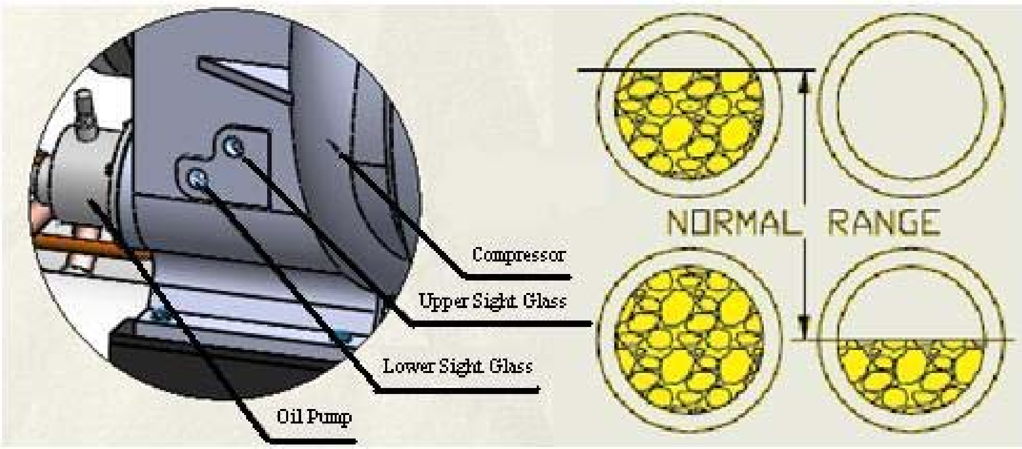
6.2 OIL

The unit uses the oil that can dissolve R134a; it is advanced purpose-made ester oil and is complex with POE oil base. The oil has strong water absorbent, must seal the oil while delivering, storing, and using to prevent from the moisture in the air entering into the oil and making it degenerated. The oil used for the unit must comply with standards of DUNHAM-BUSH.

6.3 LUBRICATION SYSTEM CONTROL PARAMETERS

- Oil level: Two sight glasses in the oil reservoir permit oil level observation. Normal oil level is between the middle of the upper sight glass and the top of the lower sight glass when the compressor is shut down. The oil level should be visible in at least 1/2 of the lower sight glasses during operation (refer to Figure 6.3).
- Oil temperature：Oil sump temperature is displayed on the micro-computer control panel, the chiller controls the oil temperature, and maintains a certain temperature (45～50℃) when shutdown. Oil sump temperature ranges during compressor operation between 52～66°C, and the oil temperature will fall to 45～60°C after the oil cooler; During shutdown, it is recommended that keep the oil heater in use, in order to automatically maintain the oil sump temperature in the range of 45～50°C; If the chiller shutdown for long time, once need to restart the chiller, the oil heater must start in advance to ensure the oil temperature higher than 45°C.
- Oil Differential Pressure：This differential pressure can be read directly from the micro-computer control panel. The oil is pumped out and passed the oil cooler, an oil pressure relief valve maintains 140～220KPa differential pressure. If the lubrication is poor, the oil differential pressure falls below 80kPa, and then the compressor will shut down. During the chiller start-up, the control center will energize the oil pump and provide 45 seconds of pre-lubrication to the bearings after pressure is verified before starting the compressor. During shutdown, the oil pump will run for 60 seconds to post-lubricate after the compressor shuts down.

Figure 6.3 Location of Sight Glasses and Normal Oil Level Drawing



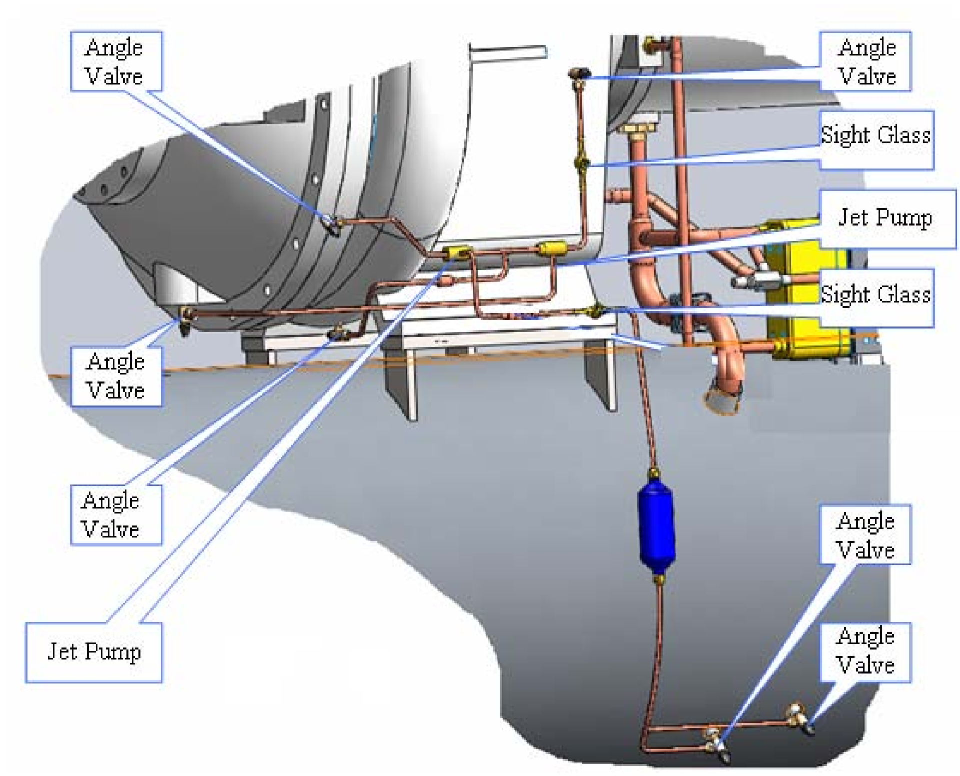
6.0 LUBRICATION CYCLE

6.4 OIL RECLAIM SYSTEM

Oil is normally entrained with the refrigerant in the chiller. As the compressor pulls the refrigerant up from the cooler into the guide vane housing, the oil normally drops out at this point and falls to the bottom of the guide vane housing where it accumulates; Besides, when the chiller is at low load, the oil will gather on the surface of the refrigerant in the cooler, after flashing in the cooler, the oil & refrigerant mixture will be pressured into the guide vane housing. Due to the low pressure in the housing, the refrigerant vaporizes, and the oil is left in the bottom of the housing.

The oil reclaim system returns oil lost from the compressor housing and the cooler vessel back to the oil reservoir by using a jet pump (refer to Figure 6.4).

Figure 6.4 Oil Reclaim System Drawing



7.0 MOTOR & OIL REFRIGERATION COOLING CYCLE

The motor and the lubricating oil are cooled by liquid refrigerant taken from the bottom of the condenser vessel. It contains two cycles, motor refrigerant cooling cycle and oil refrigerant cooling cycle.

With continuous research and product innovation, DUNHAM-BUSH Company has the right to update the unit equipment without informing customers.

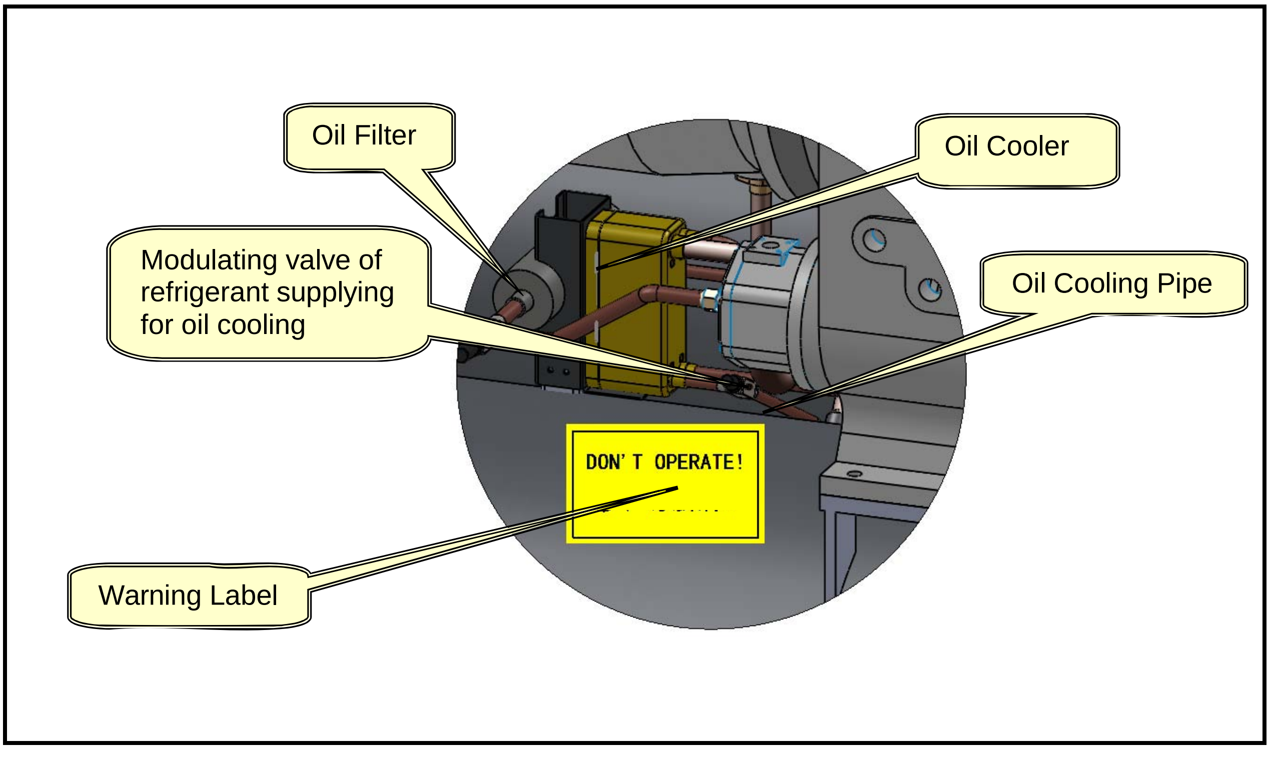
7.1 MOTOR REFRIGERATION COOLING CYCLE

The sub-cooled refrigerant liquid flow along the refrigerant-supply pipe to compressor motor, the refrigerant is directed over the motor by a spray nozzle, and then the refrigerant collects in the bottom of the motor casing and then is drained back into the cooler through the motor refrigerant drain line. The motor is protected by a temperature sensor imbedded in the stator windings. If the temperature rises above the safety limit (105°C), the compressor will shut down.

7.2 OIL REFRIGERATION COOLING CYCLE

Welded joints right angle valve is installed on the oil cooling piping, to keep the refrigerant optimum in the oil cooling piping by modulating the opening of the welded joints right angle valve to modulating the refrigerant flow. The refrigerant gas gets back to cooler. The mass flow of refrigerant needed for oil cooling cycle has been set before delivery, and strictly prohibit modulating while operating. “DON’T OPERATE!” is stuck on the welded joints right angle valve, the location of the label refers to Figure 7.2.

Figure 7.2 Oil Refrigeration Cooling Cycle



8.0 STARTUP EQUIPMENT

DCLCD Series Centrifugal Chiller requires a starter cabinet to start and stop the main motor and provide power to oil pump box and control box.

All starters must meet Dunham-Bush Starter specifications in order to properly start and satisfy mechanical safety requirements.

In wye-delta starter cabinets, there are two separate circuit breakers (as shown in Figure 8.0A), of which QF1 is for compressor motor and QF2 is for the control circuit. QF1 and QF2 are of parallel connection, in case of QF1 open, the chiller still can be logically simulated.

Figure 8.0A Starter Cabinet

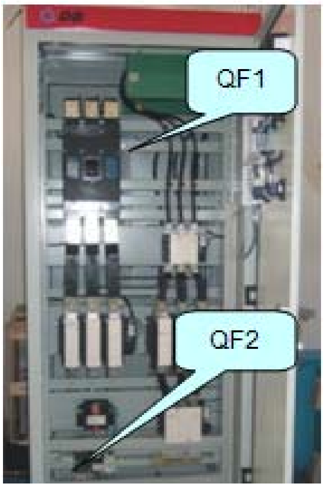


Figure 8.0B VFD Starter Cabinet (Optional)

Figure 8.0C VFD Starter Cabinet (Optional)

In VFD starter cabinets (optional), there is one main circuit breaker for the compressor motor. The DC reactor is located inside the VFD starter cabinet. The ventilation fans are installed to prevent the VFD from over-heating. There is one current transformer installed to read the current and feedback to the controller.

CAUTION!
The main circuit breaker (QF1) on the front of the starter disconnects the main motor current only. Power is still energized for the other circuits. The upper breaker must be cut off during service.

9.0 CONTROL SYSTEM (DB DIRECTOR)

DB DIRECTOR

9.1 DEFINITIONS

ANALOG SIGNAL — An analog signal varies in proportion to the monitored source. It quantifies values between operating limits. (Example: A temperature sensor is an analog device because its resistance changes in proportion to the temperature, generating many values.)

DIGITAL SIGNAL — A digital (discrete) signal is a 2-position representation of the value of a monitored source. (Example: A switch is a digital device because it only indicates whether a value is above or below a set point or boundary by generating an on/off, high/low, or open/closed signal.)

Figure 9.1A DCLCD Startup Sequential chart

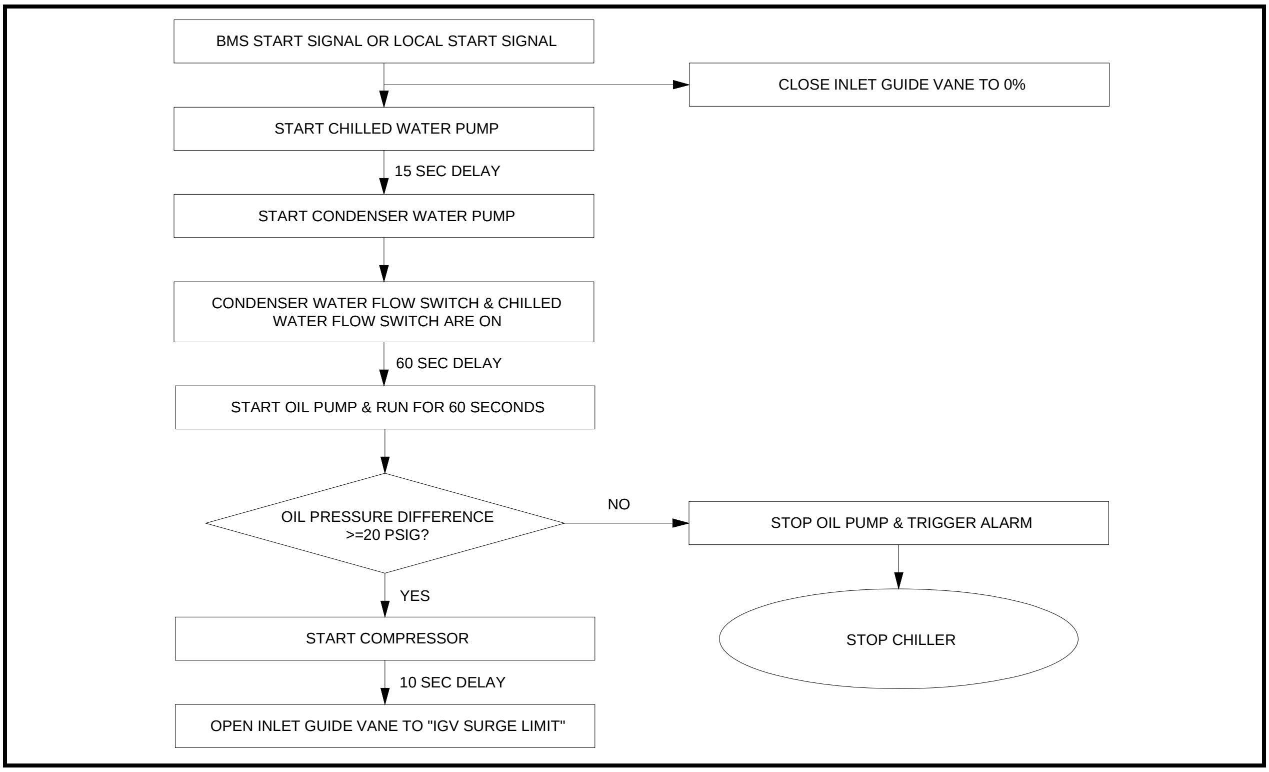
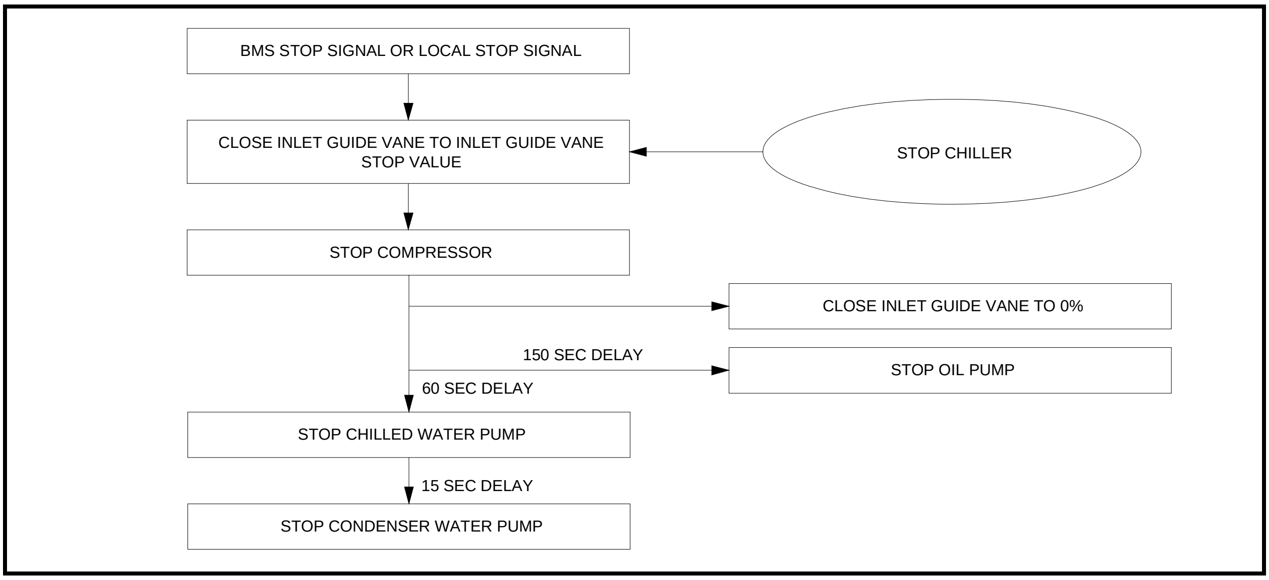


Figure 9.1B DCLCD Shut Down Sequential chart



9.0 CONTROL SYSTEM (DB DIRECTOR)

9.2 GENERAL

DCLCD Series Water cooled Centrifugal contains a micro processor based control and a user friendly Human Machine Interface (HMI) display. International brand components and function modules deployed are reliable and convenient for maintenance. Optimum process control program for chiller operation is embedded into micro processor based control box, in order to make the chiller run ideally and safely.

9.3 CONTROL SYSTEM FUNCTIONS

9.3.1 Compressor Start/Stop Control

Compressor Start/Stop is control by local or remote button. When the control center initiates the compressor start command, oil pump motor is automatically started and run for 60 seconds proceeding to main motor operation, where differential oil pressure must be greater than minimum value required. After main motor operation for 10 seconds, inlet guide vane (IGV) opens to “IGV surge limit” position, while before main motor stop, IGV closes to “IGV surge limit” position. Oil pump motor will stop at 150 second after the main motor stop.

9.3.2 Starter Management

DCLCD centrifugal chiller follows a certain sequence of start/stop (Figure 9.1A, 9.1B)

1) Startup procedure:

   Close IGV to 0 → Start oil pump → 60 seconds delay → Start main motor → 10 seconds delay → Open IGV to “surge limit”.

2) Shut down procedure:

   Close IGV to “surge limit” → Stop main motor → Close IGV to 0 → 2.5 minute delay → Stop Oil pump.

CAUTION!
In the occasion of very low cooling load, when the chilled water outlet temperature is lower than the “system pause temperature” (normally is 5°C), the chiller will automatically shut down, but the motor will still be in operation status. Once the chilled water temperature rises to the “system restart temperature” (normally is 15°C), the chiller will automatically start again. This process is called “Pause”, and the chiller can be manually restarted under this circumstance.

9.3.3 Inlet Guide Vane (IGV) Control

1) IGV Minimum Opening Control

To prevent chiller surging due to IGV opening too small. After unit startup, a certain time delay until the unit running stable, IGV operate according "guide vane opening surge limit", no matter what mode of operation, IGV is prohibited to open below the "guide vane opening surge limit".

2) Load Priority Control

To prevent the unit overloaded, the control system uses the load (compressor current) priority control. During IGV opening, if the compressor current reach the current limit setpoint, IGV will hold, If the compressor current still increasing until reach unload amp setpoint, then the IGV is closing.

3) IGV Automatic Control

After unit startup, if leaving water temperature above setpoint, the IGV is opening; if leaving water temperature reach setpoint, the IGV will hold it position; if leaving water temperature below setpoint, the IGV is closing.

9.3.4 Vapor Injection Modulating Ball Valve and Liquid Level Modulating Ball Valve

After unit startup, Vapor Injection Modulating Ball Valve and Liquid Level Modulating Ball Valve will follow lookup table to auto operate, do not manually operate it.

9.3.5 Oil Sump Temperature Control

When the chiller is not in operation, the oil heater would be automatically controlled by the control center to make sure the oil sump temperature is between 45 and 50 degree.

9.3.6 VFD Starter Operation (Optional)

All other free standing VFDs are controlled by the micro-computer control system. A VFD reduces the starting current inrush by controlling the voltage and frequency to the compressor motor. Once the motor has accelerated to start-up speed the micro-controller modulates the compressor speed and guide vane position to control chilled water temperature. The control logic automatically adjusts motor speed and compressor pre-rotation vane position for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.

All the required parameter for VFD application have been preset by the factory. A list of parameter can be provided to user upon request except those proprietary setting. The user can refer to the VFD manual supplied with the VFD starter cabinet for further information and instruction on the technical info about the VFD and the steps to access the VFD display.

Frequency Auto Control:
When Automatic is chosen as control mode, the control centre will regulate the cooling capacity by controlling the frequency and guide vane according to the set parameters.

Frequency Manual Control:
When Manual is chosen as control mode, it will prompt a small numeric keyboard so that any fixed frequency within range can be input. Press anywhere rather than the numbers in the keyboard to close the dialog.

9.3.7 Protective Alarm

The control system has many kinds of fault alarm functions. See details in Table 9.3.7:

Table 9.3.7 Protective Alarm

Fault	Condition judgment	System Response	Causes
Low oil pressure drop	The oil pressure drop is lower than initialization after the oil pump running for 15s, or the oil pressure drop is lower than initialization after the motor starts.	Keep running.	1. Oil filter blocked; 2. The oil pressure regulating valve turned too much; 3. Oil level too low; 4. Bearing worn off; 5. Oil pipe leakage.
Low oil sump temperature	The oil sump temperature is lower than required to start the main motor.	The operator cannot start the chiller.	1. The oil heater malfunction; 2. The oil heater did not work long enough.
High bearing temperature	The bearing temperature is higher than initialization after the main motor operating.	Keep running.	1. The oil cooler effect de-rated; 2. The refrigerant filter blocked; 3. The bearings worn off.
Unduly high bearing temperature	The Bearing Temperature is much higher than initialization after the main motor starts	Stop the chiller.	1. The oil cooler effect de-rated; 2. The filter of refrigerant blocked; 3. The bearings worn off.
Oil pump overload	Thermal relay of the oil pump is triggered.	Stop the chiller. Stop the oil pump when the motor stands by or 120s after the main motor stopped	1. Oil pump motor disorder; 2. The oil pump power supply lack of one phase; 3. Failure of the oil pump contactor; 4. Failure of the oil pump thermal relay.
Chilled water supply cut off	The water flow switch is off at evaporator side.	Stop the chiller.	1. Failure of the chilled water pump; 2. Block of the chilled water loop; 3. Failure of the water flow switch.
Unduly low chilled water temperature	The LCWT is lower than initialization.	Stop the chiller.	1. Failure of the sensor; 2. Insufficient chilled water flow. 3. Inadequate work load;
Unduly low main unit current	Main unit current is less than 20% of the rated current.	Keep running; Cancel the automatic function of the guide vane.	1. Failure of the current switch of the main unit startup cabinet; 2. Failure of the transducer of the main unit current; 3. Failure of the current transmitter.
High main unit current	Main unit current is higher than 110% of the rated current	Keep running	1. Chiller overload; 2. Failure of the guide vane electric actuator; 3. Unduly high leaving chilled water temperature; 4. liquid flood back into compressor; 5. Three phase power voltage unbalanced.
Unduly high main unit current	Main unit current is more than 115% of the rated current.	Stop the chiller.	1. Chiller overload; 2. Failure of the guide vane electric actuator; 3. Unduly high leaving chilled water temperature; 4. liquid flood back into compressor; 5. Three phase power voltage unbalanced.
Unduly long Startup time	Main unit startup is not completed within 30 seconds.	Stop the chiller.	The time relay disorder.

9.0 CONTROL SYSTEM (DB DIRECTOR)

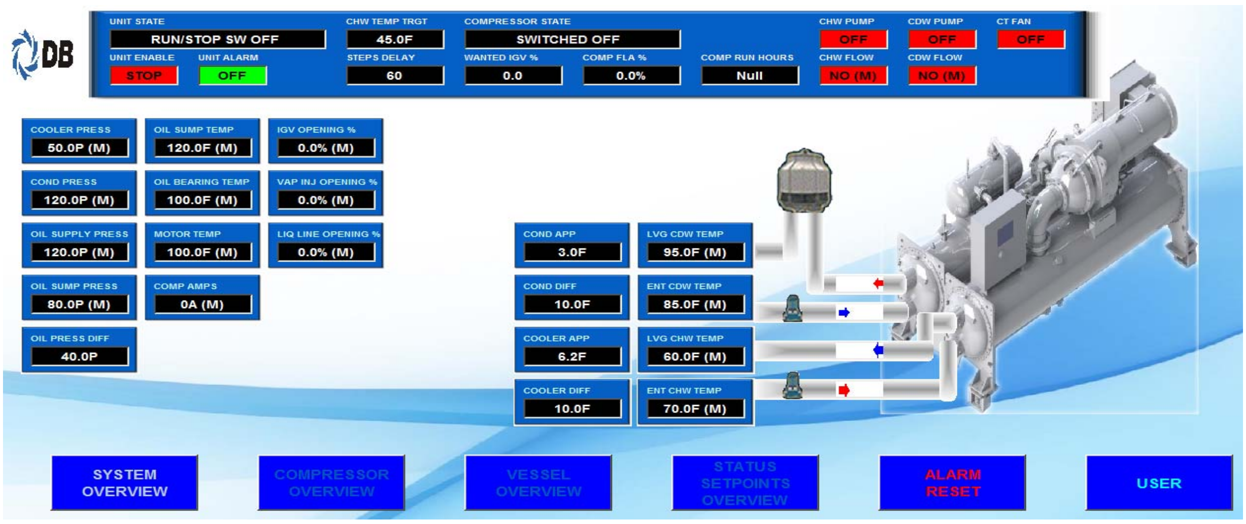
Fault	Condition judgment	System Response	Causes
Main motor coil overheat	The thermal resistor value increases.	Stop the chiller.	1. The main motor short circuit; 2. liquid flood back into compressor; 3. Three phase power voltage unbalance. 4. Small temperature difference between the chilled water and the cooling water; 5. Cooling fluid filter for the main motor blocked.
Startup cabinet failure	The failure indicator lightened. The main contactor breaks during the operation.	Stop the chiller.	1. Failure of the main unit startup cabinet;
Low evaporation pressure	Evaporation pressure is below the set value	Keep running. Close the guide vane slowly	1. Electric Throttle disorder; 2. High fouling factor in the heat exchanger of the evaporator; 3. Insufficient refrigerant; 4. Insufficient chilled water flow.
Unduly low evaporation pressure	Evaporation pressure is much lower than initialization.	Stop the chiller.	1. Electric Throttle disorder; 2. High fouling factor in the heat exchanger of the evaporator; 3. Insufficient refrigerant; 4. Insufficient chilled water flow.
High condensation pressure	Condensation pressure is above initialization.	Keep running. Close the guide vane slowly.	1. Insufficient cooling water flow; 2. Unduly high temperature of condenser entering water; 3. High fouling factor in the heat exchanger of the condenser; 4. Condenser overload.
Unduly high condensation pressure	Condensation pressure is much higher than initialization.	Stop the chiller.	1. Insufficient cooling water flow; 2. Unduly high temperature of condenser entering water; 3. High fouling factor in the heat exchanger of the condenser; 4. Condenser overload.
Guide vane failure	The guide vane varies less than 2% after taking action for 20 seconds.	Keep running and turn to manual operation.	Failure of the guide vane electric actuator
Guide vane signal breaks	Transmitter current is less than 3.8 mA .	Cancel the guide vane automatic control.	Guide vane connecting wire loosen or fallen off.
Main motor current signal breaks	Transmitter voltage is less than 0.06VDC.	Cancel the guide vane automatic control.	Main motor current signal wire loosen or fallen off.
ECWT sensor breaks	Transmitter voltage is less than 0.121VDC	Keep running. Do the examination and repairing.	ECWT sensor signal wire loosen or fallen off.
LCWT sensor breaks	Transmitter voltage is less than 0.121VDC	Stop the chiller.	LCWT sensor signal wire loosen or fallen off.
ECDWT sensor breaks	Transmitter voltage is less than 0.121VDC	Keep running. Do the examination and repairing.	ECDWT sensor signal wire loosen or fallen off.
LCDWT sensor breaks	Transmitter voltage is less than 0.121VDC	Keep running. Do the examination and repairing.	LCDWT sensor signal wire loosen or fallen off.
Oil Sump Temperature signal breaks	Transmitter current is less than 3.8 mA.	Keep running. Stop the oil heater, and the system cannot be restarted immediately.	Oil Sump Temperature signal wire loosen or fallen off.
Bearing Temperature signal breaks	Transmitter current is less than 3.8 mA.	Stop the chiller.	Bearing Temperature signal wire loosen or fallen off.
CRP. signal breaks	Transmitter current is less than 3.8 mA.	Stop the chiller.	Condenser pressure signal wire loosen or fallen off.
ERP. signal breaks	Transmitter current is less than 3.8 mA.	Stop the chiller.	Evaporator pressure signal wire loosen or fallen off.
Oil Supply Pressure signal breaks	Transmitter voltage is less than 0.5VDC	Stop the chiller.	Oil supply pressure signal wire loosen or fallen off.
Bearing Temperature signal breaks	Transmitter current is less than 3.8 mA.	Stop the chiller.	Bearing Temperature sensor disconnected.
Oil Sump Pressure signal breaks.	Transmitter voltage is less than 0.5VDC	Stop the chiller.	Oil sump pressure signal wire loosen or fallen off.

9.0 CONTROL SYSTEM (DB DIRECTOR)

9.4 CONTROL SYSTEM HMI OPERATION GUIDE

9.4.1 System Page

Figure 9.4.1 System Page



As shown in Figure 9.4.1 the “SYSTEM OVERVIEW” button is lid to indicate the system status.

There are 4 buttons at the bottom of the page. “System Overview” page can be shown like the Figure 9.4.1. Go back to the system page by pressing the “System Overview” button.

9.4.2 Oil Pump Operation

In the “Compressor Overview” (Figure 9.4.2), when chiller is in standby mode, Operation on the oil pump can only be done in this mode.

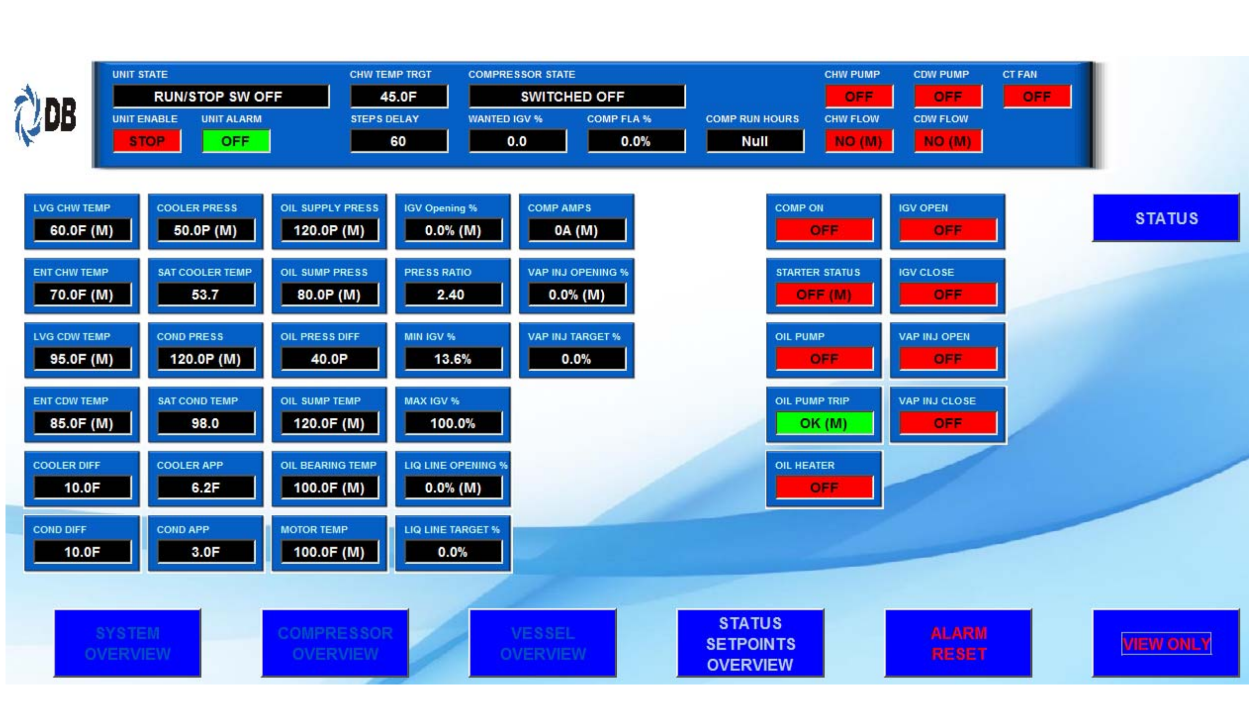
Figure 9.4.2 Compressor Page

9.0 CONTROL SYSTEM (DB DIRECTOR)

9.4.3 Status & User Settings

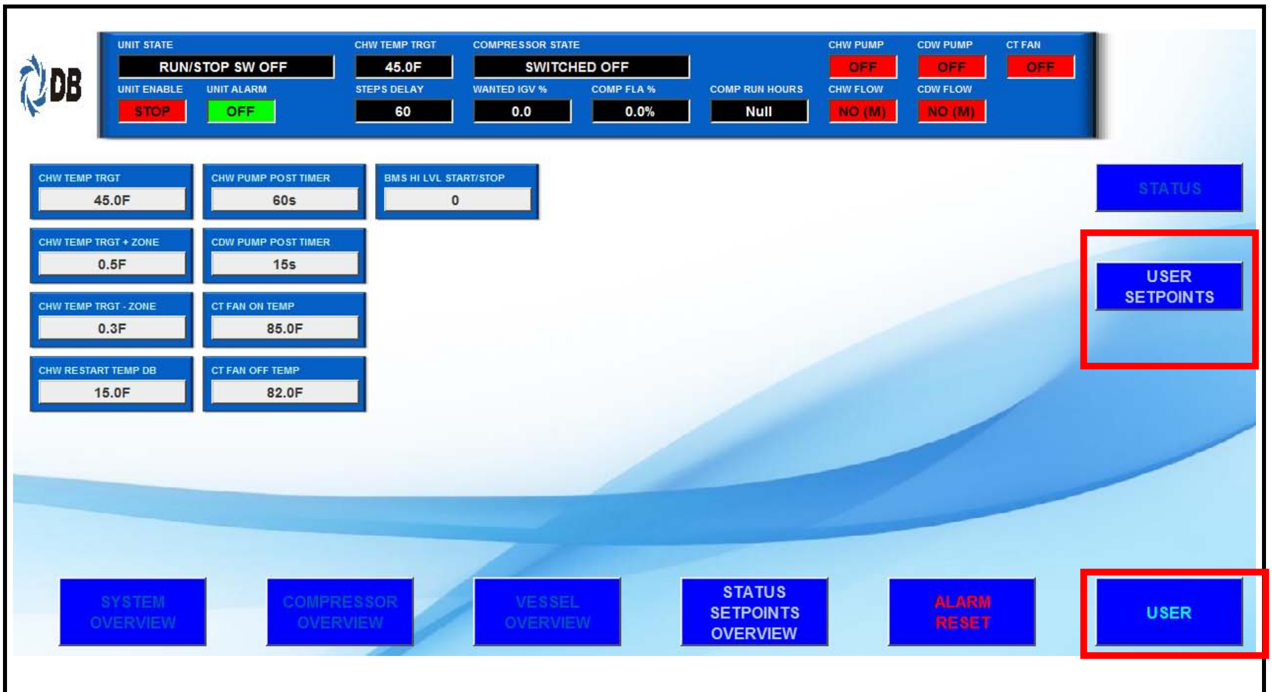
Press “Status Setpoint Overview” button and Status page (Figure 9.4.3a) will appear.

Figure 9.4.3a Status Page



Key in the user’s password by pressing the “View Only” button, if the password is corrected, the authorization button will change to “User Only” and “User Setpoints” is appeared and allowed the user to access to modify settings as Figure 9.4.3b below

Figure 9.4.3b User Setpoints Page



9.4.4 Evaporator Parameters

Press “Evaporator Overview” button and Evaporator page (Figure 9.4.4) will appear.

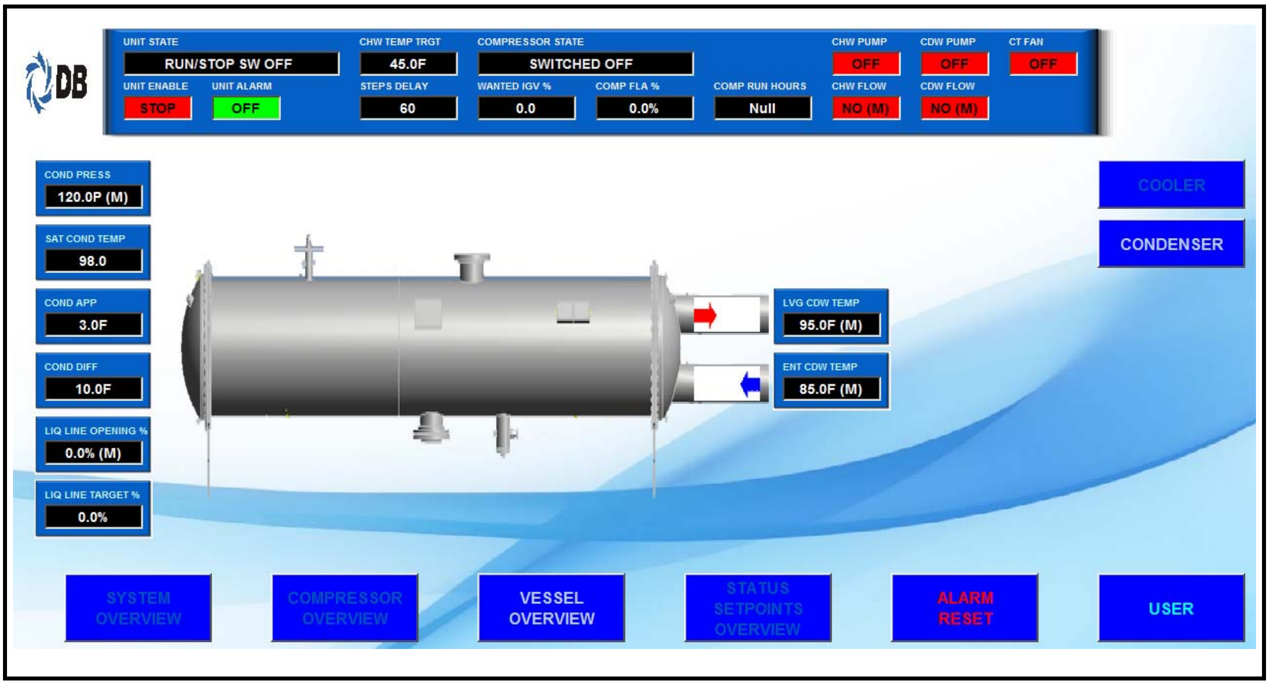
Figure 9.4.4 Evaporator Page

In this screen, user can check the evaporator parameters; press “System Overview” to go back to main screen.

9.4.5 Condenser Parameters

Press “Vessel Overview” button followed by “Condenser” button, condenser page (Figure 9.4.5) will appear.

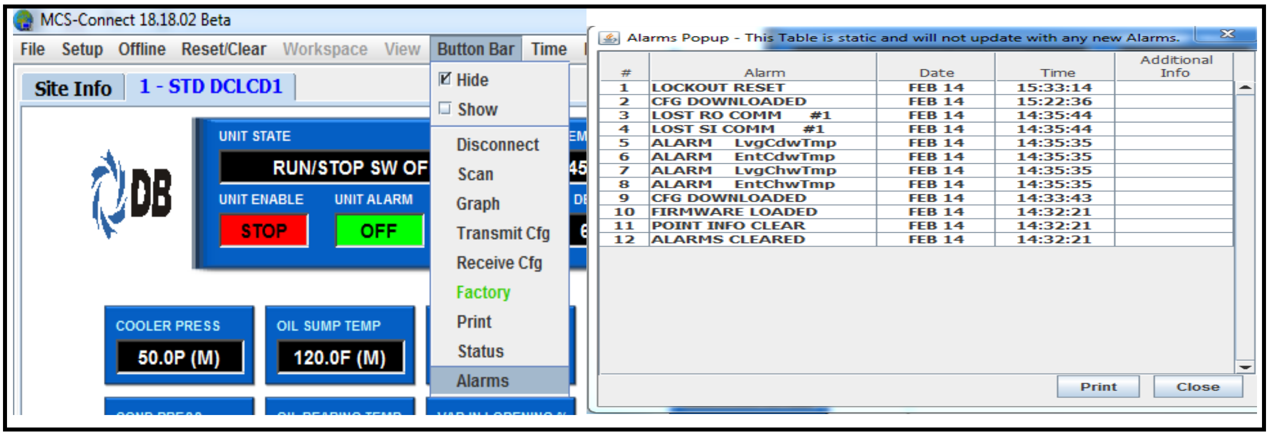
Figure 9.4.5 Condenser Page



In this screen, user can check the condenser parameters; press “System Overview” to go back to main screen.

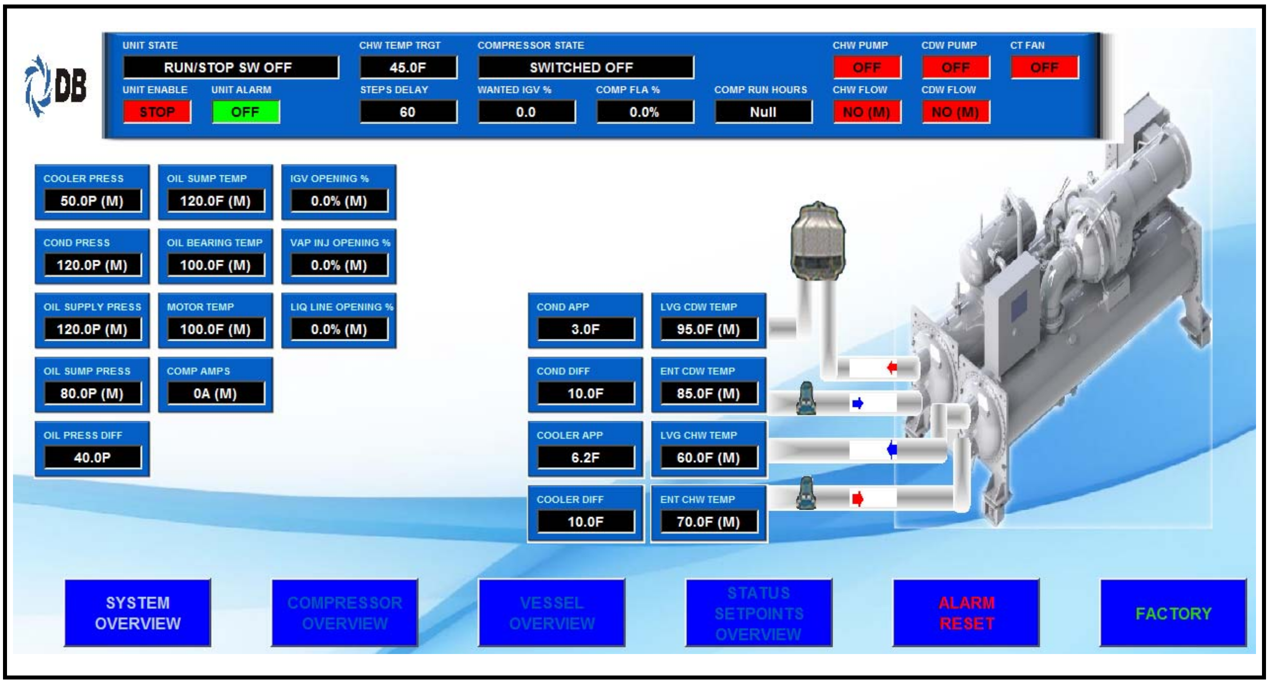
9.4.6 Fault Alarm Page

Press the “Button Bar” followed by “Alarms” button on top of the screen, the latest 99 alarm will appear with corresponding information.



To reset active alarm after the problem has been rectify, user can press the “Alarm Reset” button as figure 9.4.6 below

Figure 9.4.6 Alarm Reset



9.0 CONTROL SYSTEM (VISION 2020i)

VISION 2020i

9.5 TYPICAL OPERATION

In order to start the compressor, the following conditions must be met:

- IGV% must be below 2%
- Oil pressure difference between Oil Sump and Oil Supply more than 20 PSI (1.4 bar)
- Oil Pump has run for more than 1 minute
- Oil Heater temperature more than 100°F (38°C)
- Chilled water flow switch turned on
- Condensed water flow switch turned on
- Unit enable switched on
- Leaving chilled water temperature is 15°F (8.3°C) or more above setpoint (adjustable)
- Start delay timer has elapsed (default = 1 minute)

First compressor is started after all the above are fulfilled. Anti-recycle timer of 15 minutes is initiated when the compressor is started.

Power supply to the unit is always monitored by the PCR. The controller monitors compressor current drawn by means of:

CT

- Current transformer
- Transducer

TS (Temperature Sensors)

- Leaving chilled water temperature
- Entering chilled water temperature
- Leaving chilled water temperature
- Entering condenser water temperature
- Oil sump temperature
- Bearing temp
- Motor temp

PT (Pressure Transducer)

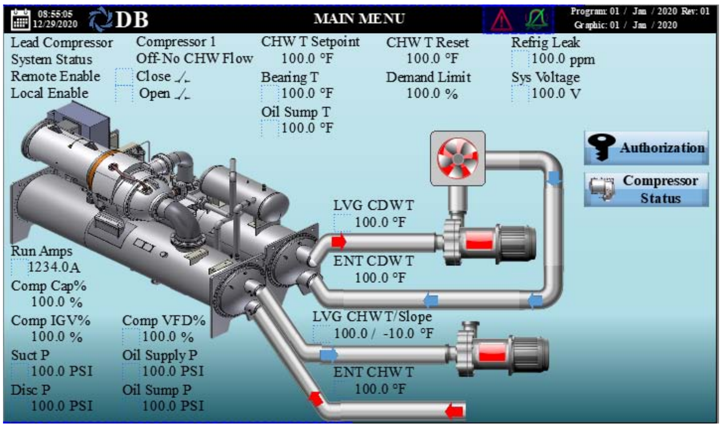
- Evaporator pressure
- Condensing pressure
- Oil sump pressure
- Oil supply pressure

These inputs are used to control the loading and staging of the compressor.

To shut down the unit automatically, the customer control contacts “remote start” signal must be opened. To shut down the unit manually, simply turn the ROL selector switch to position “O”.

9.6 VISION 2020i CONTROLLER AND DBGX10 INTERFACE

Vision 2020i controller is equipped with a user friendly DBGX display panel, with 10.1” TFT, 64k colors, 1024X600, LED backlight touch screen graphical display. DBGX terminal allows carrying out all program operations. The user terminal allows displaying the unit working conditions, compressor run times, alarm history at any time and modifying the parameters. The terminal also has an automatically self-test of the controller on system start-up. Multiple messages will be displayed by automatically scrolling from each message to the next. All of these messages are spelled out in English language on the LED screen.



9.6.1 DBGX10 Graphical User Interface

The DBGX10 display panel is a full touch screen color display panel with various touch keys to perform the command.

There is 1 basic touch key for unrestricted access, while another touch key that allows the user to unlock other buttons with the correct authorization.

9.0 CONTROL SYSTEM (VISION 2020i)

To access setting menu, Authorization key need to gain granted by login correct password.

Other buttons which are not shown are to access different level of setting changes. These are ‘Clock & Schedule’, ‘User Settings’, ‘DBLan Status’, ‘Technician Settings’ and ‘Factory Settings’ levels.

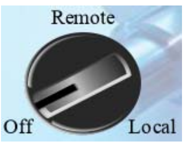
It can only be access depend on the password level. The higher password can access the lower password level's setting but not vice versa.

9.6.1.1 The Touch Keys

Key		Description
	COMPRESSOR STATUS	To view parameters status
	REM/OFF/ LOC STATUS	To enable unit ON/OFF (Applicable if no hardware switch)
	CLOCK / SCHEDULE	Displays the date, time and day.
	USER SETTINGS	To view/modify leaving water setpoint (required password)
	DBLAN STATUS	To view/modify BMS settings (required password)

9.6.2 Unit Enable

To enable unit ON/OFF, rotate selector switch either remote or local. Note: Applicable if no hardware switch.



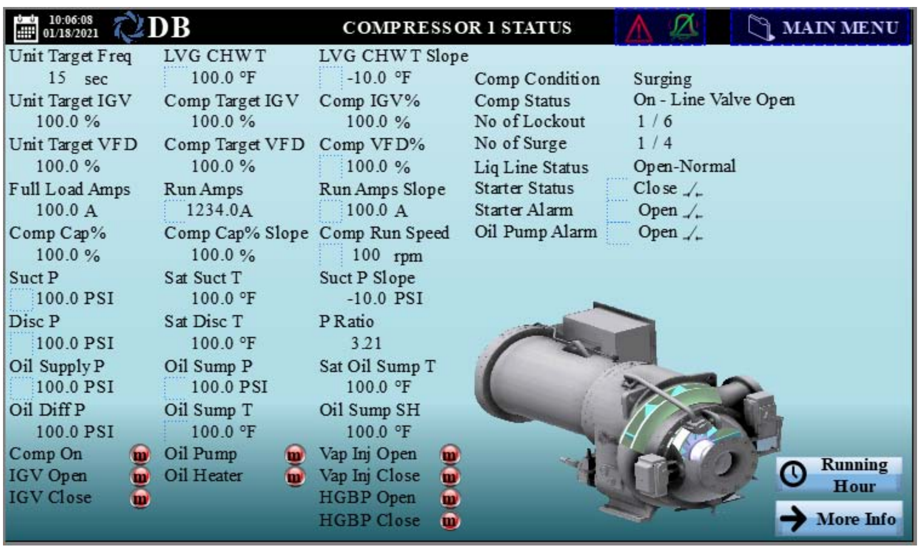
9.6.3 STATUS READING

9.6.3.1 Compressor Status

The main page shows the necessary information on the unit. However, if the user requires more information, they can choose to enter the “Compressor Status”.

To read status parameters, touch the status key:

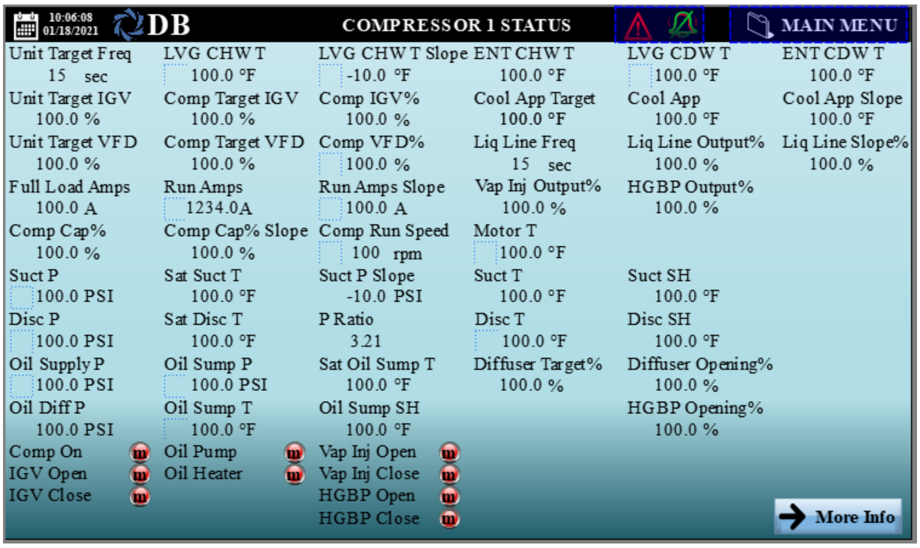
The display is showing the data as follows:



9.0 CONTROL SYSTEM (VISION 2020i)

The display has a mix of analog inputs on the top row and digital outputs on the bottom row.
On the right-hand side of the first page is where the digital inputs and compressor status are located.

To see more info on the compressor, the “More Info”
Button shows the rest of the analog input readings.



Below summary readings and status are available in the ***Main Page*** and ***Compressor Status*** screens.

MAIN MENU		
Reading	**Description**	**Status/Unit**
Lead Compressor	Compressor lead number	Compressor 1; Compressor 2;
System Status	System ON/OFF status	Off By Config; On; Off-R/O/L Input; Off-No CHW Flow; Off-No Stop; Off-On/Off Sch; Off-BMS; Off-Mode Sch Powerup Delay; Off-DBLan; Off-Freeze Done; Off-No CDW Flow;
CHW T Setpoint	Chilled Water Leaving Temperature Setpoint	°F / °C
LVG CHW T	Chilled water leaving temperature	°F / °C
LVG CHW T Slope	Rate of change of chilled water leaving temperature	°F / °C
ENT CHW T	Entering chilled water temperature (optional)	°F / °C
LVG CDW T	Condensing water leaving temperature (optional)	°F / °C
ENT CDW T	Condensing water entering temperature (optional)	°F / °C
CHW T Reset	Chilled water temperature reset	°F / °C
Demand Limit	Demand limit	%
Sys Voltage	System voltage	V
Refrig Leak	Refrigerant leakage	ppm (parts per million)
Remote Enable	Remote Enable	Open / Close
Local Enable	Local Enable	Open / Close
COMPRESSOR 1/2 STATUS		
Comp Condition	Compressor condition	Ok; Hold - Pressure; Unload - Pressure; Hold - Amps; Unload - Amps; Low Amps; Ramp; Surging

9.0 CONTROL SYSTEM (VISION 2020i)

MAIN MENU		
Reading	**Description**	**Status/Unit**
COMPRESSOR 1/2 STATUS		
Comp Status	Compressor status	Off; On-Hold; Alarm-Low Oil Level; Alarm-Comp Starter Off-Anti-recycle Timer; On-Normal Unload; On-Normal Load; On-Manual Hold; On-Manual Load; On-Manual Unload; Off-Alarm; On-Fast Unload; On-Load Too Fast; On-Line Valve Open; Off-Switched Off; Off-LVG CHW T Off-Oil Pump Prelube Off-Oil Pump Postlube On-IGV in Minimum
Liq Line Status	Liquid Line Status	Off Hold-Normal Open-Normal Close-Normal Valve Slope Over Open-High App Close-Low App Clow-Low Diff P Open-Hold Low P Close-Unld Cap% Open-Load Cap% Open-Unld Low P Close-Low DSH
Run Amps	Compressor running amperes	Ampere
Run Amps Slope	Compressor running amperes slope	Ampere
Full Load Amps	Compressor rated load amperage	Ampere
Unit Target Freq	Target response	Seconds
Unit Target VFD	Unit target VFD percentage	%
Comp Target VFD	Individual compressor VFD target	%
Comp VFD	Current compressor VFD percentage	%
Unit Target IGV	Unit target IGV percentage	%
Comp Target IGV	Individual compressor IGV target	%
Comp IGV%	Current compressor IGV%	%
Comp Cap % Slope	Individual compressor capacity slope	%
Liq Line Opening%	Liquid Line opening percentage	%
Liq Line Output%	Liquid Line Valve Percentage	%
Liq Line Slope%	Liquid line slope percentage	%
Vap Inj Opening%	Compressor 1/2 vapor injection opening percentage	%
Vapor Inj Output%	Vapor Injection Valve Percentage	%
HGBP Opening%	Compressor 1/2 hot gas bypass opening percentage	%
HGBP Output%	Hotgas Bypass Valve Percentage	%
Diffuser Target%	Compressor 1/2 diffuser target percentage	%
Diffuser Opening%	Compressor 1/2 diffuser opening percentage	%
No of Lockout	Number of compressor lockout per day over limit lockout per day	Numbers of lockout
No of Surge	Number of cumulative compressor surges	Numbers of surges
Comp Run Speed	Compressor rotational speed	Rpm (revolutions per minute)
P Ratio	Compressor 1/2 pressure ratio between suction pressure and discharge pressure	-
Liq Line Freq	Liquid line opening frequency	seconds
Suct P	Suction pressure	PSI / Bar
Suct P Slope	Suction pressure slope	PSI / Bar
Disc P	Discharge pressure	PSI / Bar
Oil Supply P	Compressor 1/2 oil supply pressure	PSI / Bar
Oil Sump P	Compressor 1/2 oil sump pressure	PSI / Bar
Oil Diff P	Compressor 1/2 pressure difference between oil sump and oil supply	PSI / Bar
Suct T	Compressor 1/2 suction temperature	°F / °C
Sat Suct T	Saturated suction temperature	°F / °C
Suct SH	Compressor 1/2 suction superheat	°F / °C
Disc T	Compressor 1/2 discharge temperature	°F / °C
Sat Disc T	Saturated discharge temperature	°F / °C
Disc SH	Discharge superheat	°F / °C
DSH Target	Discharge superheat target	°F / °C
Disc SH Slope	Discharge superheat slope	°F / °C
Cool App Target	Cooler approach setpoint	°F / °C
Cool App Offset	Cooler approach offset	°F / °C
Cool App	Cooler approach	°F / °C
Cool App Slope	Cooler approach slop	°F / °C
Motor T	Compressor 1/2 motor temperature	°F / °C
Oil Sump T	Compressor 1/2 oil sump temperature	°F / °C
Oil Sump SH	Compressor 1/2 oil sump superheat	°F / °C

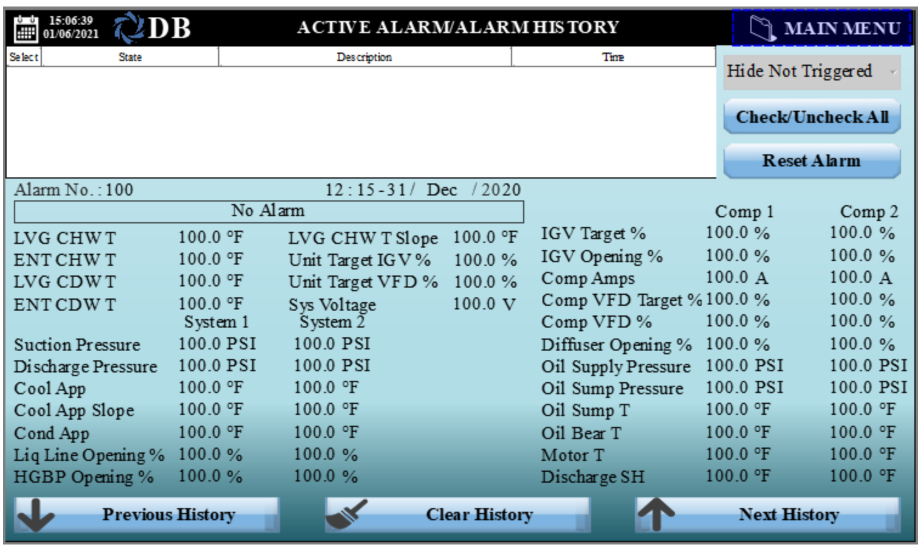
9.0 CONTROL SYSTEM (VISION 2020i)

MAIN MENU		
Reading	**Description**	**Status/Unit**
COMPRESSOR 1/2 STATUS		
Sat Oil Sump T	Compressor ½ saturated oil sump temperature	°F / °C
Bearing T	Compressor 1/2 bearing temperature	°F / °C
Starter Status	Compressor starter status	Open / Close
Oil Pump Alarm	Compressor oil pump starter alarm	Open / Close
Starter Alarm	Compressor starter alarm	Open / Close
CHW Pump	Chilled water pump control	Animation Flowing/Static
CDW Pump	Condenser water pump control (optional)	Animation Flowing/Static
Comp On	Compressor starter on	De-energize / Energize
HGBP Open	Open system 1/2 hotgas bypass valve	De-energize / Energize
HGBP Closed	Close system 1/2 hotgas bypass valve	De-energize / Energize
IGV Open	Open compressor 1/2 Inlet Guide Vane valve open	De-energize / Energize
IGV Close	Close compressor 1/2 Inlet Guide Vane valve	De-energize / Energize
Vap Inj Open	Open compressor 1/2 economizer valve (optional)	De-energize / Energize
Vap Inj Closed	Close compressor 1/2 economizer valve (optional)	De-energize / Energize
Oil Pump	Oil Pump starter status	De-energize / Energize
Oil Heater	Oil Heater starter status	De-energize / Energize
Diffuser Open	Open diffuser valve	De-energize / Energize
Diffuser Close	Close diffuser Valve	De-energize / Energize

9.6.4 ACTIVE ALARM

To check active alarm, touch on Active Alarm key on the top status bar.

The display is showing the data as follows:

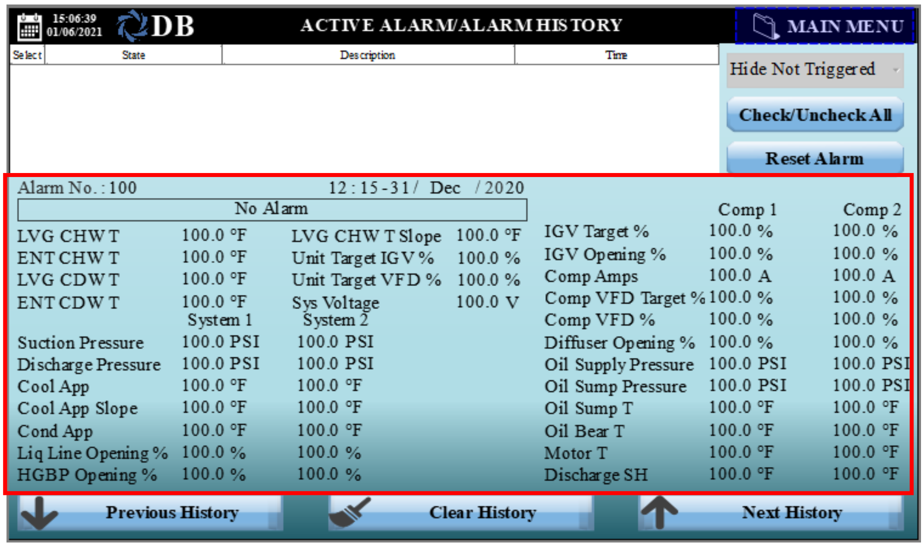


To clear/reset active alarm, select active alarm button followed by button “Reset Alarm”.

9.6.5 ALARM HISTORY

The alarm history is located within the same page as the alarm page.

The display is showing the alarm history as follows:



Touch the previous history or next history key to check the alarm history.

Key		Description
Previous History	Previous History Page	Enters previous history page
Next History	Next History Page	Enters following history page
Clear History	Clear History	Removes all alarm history

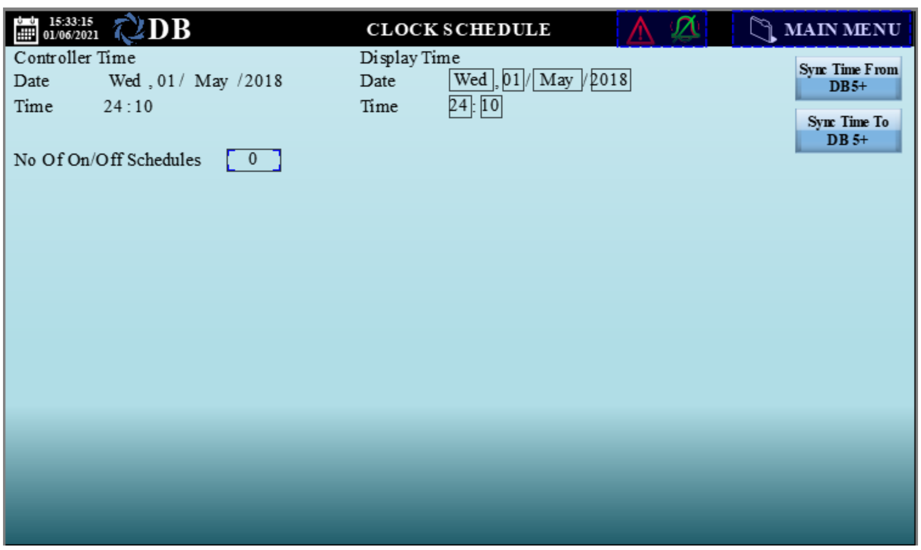
9.6.6 CLOCK & SCHEDULE

9.6.6.1 Clock Key

To alter the clock settings like time and date, unit scheduling and ice-cell mode scheduling (optional), you must be authorized. See the authorization procedure and must be authorized at least as user level. Touch the clock schedule key

Clock Schedule

The display is showing the data as follows:



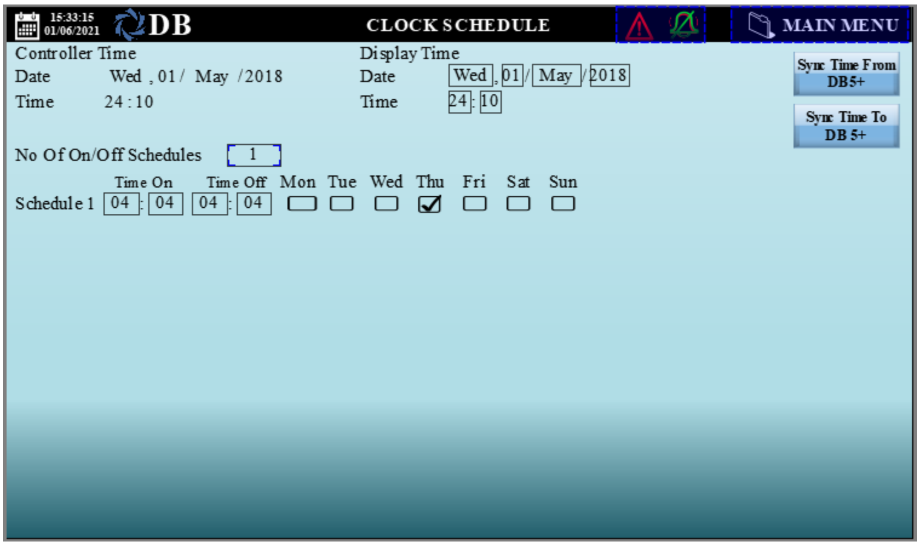
Touch on selected set point which contained in rectangle box to change the date and time. Use the popped up keypad to key in the desired setpoint value and touch "Enter" key to confirm the change.

9.0 CONTROL SYSTEM (VISION 2020i)

9.6.6.2 Schedule

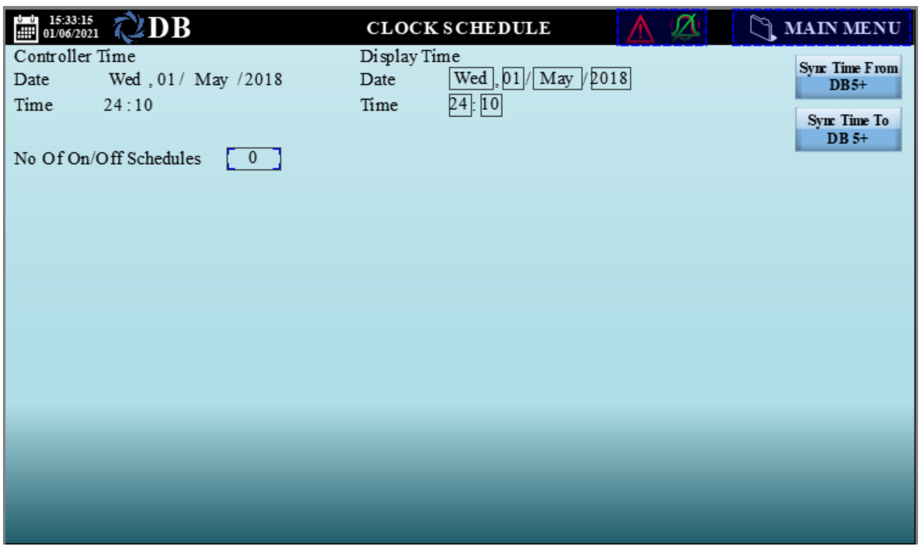
For schedule setup, set the no. of on/off schedules to 1 or more.

The display is showing the data as follows:



Setup time on, off and tick day to active the unit schedule.

The display is showing the data as follows:



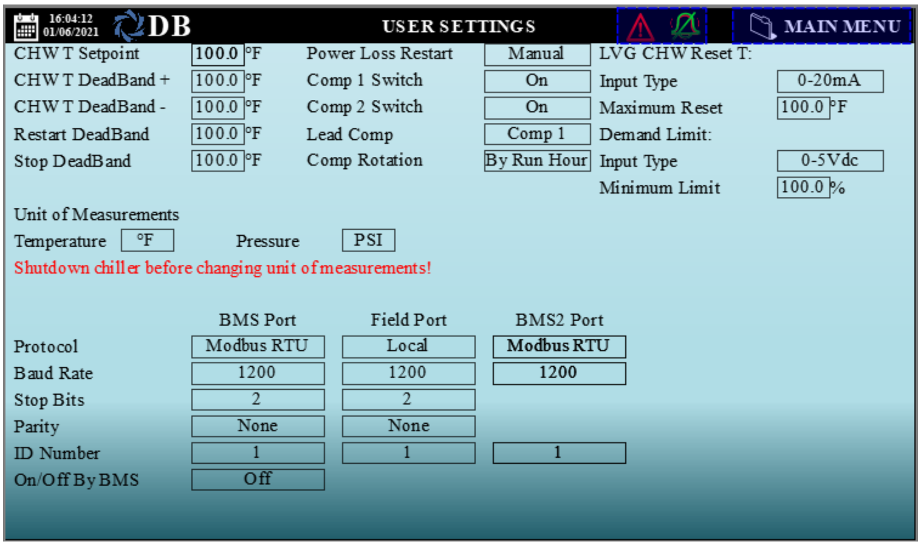
Touch on selected set point which contained in rectangle box to change the date and time. Use the popped up keypad to key in the desired setpoint value and touch “Enter” key to confirm the change.

9.6.7 USER SETTINGS

To read setpoints value, you must be authorized. See the authorization procedure and must be authorized at least as user level. Touch the setpoint key:

9.0 CONTROL SYSTEM (VISION 2020i)

The display is showing the data as follows:



Below summary readings and status are available in ***User Settings*** screens.

Reading	Description	UOM	Default Value	Range Value
LVG CHW Temperature				
CHW T Setpoint	Leaving Chilled Water Temperature Setpoint	°F / °C	44°F / 6.7°C	40~50°F / 4.4~10°C
CHW T Dead Band +	Temperature positive control band	°F / °C	0.5°F / 0.3°C	0.1~5.0°F / 0.1~2.8°C
CHW T Dead Band -	Temperature negative control band	°F / °C	0.5°F / 0.3°C	0.1~5.0°F / 0.1~2.8°C
Restart Dead Band	Temperature restart compressor control band	°F / °C	12.0°F / 6.5°C	0.0~18.0°F / 0.0~10.0°C
Stop Dead Band	Temperature stop all compressor control band	°F / °C	2.0°F / 1.1°C	0.5~3.0°F / 0.3~1.5°C

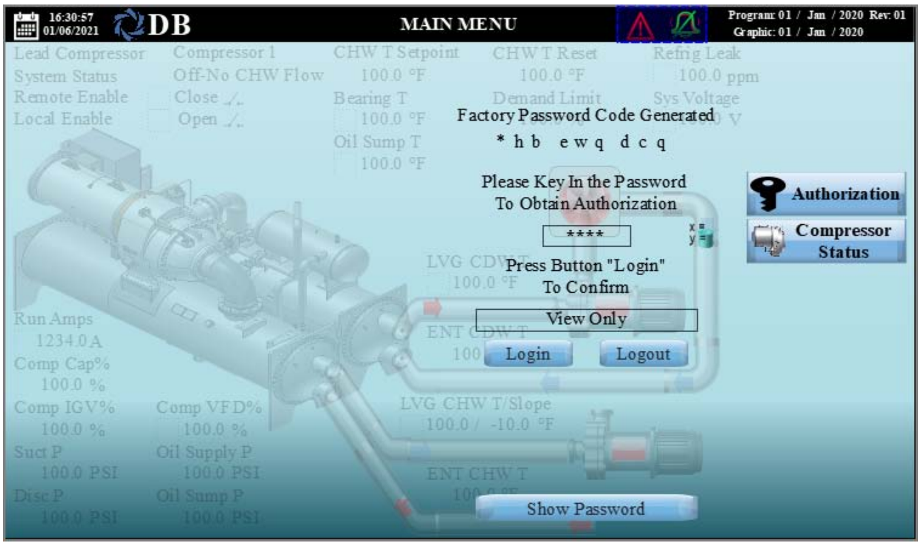
Reading	Description	UOM	Default Value
Unit of Measurement			
Temperature	Unit measurement of temperature	°F / °C	°F
Pressure	Unit measurement of pressure	PSI / BAR	PSI
Power Loss Alarm			
Power Loss Restart	Restart of unit and compressor after recover from power failure	Manual Reset; Auto Reset	Auto
Compressor Switch & Rotation			
Comp 1/2 Switch	Manual on/off compressor 1 & 2	On; Off	On
Lead Comp	Preset lead compressor	1 or 2	1
Comp Rotation	Compressor rotation	None; By Running Hours; By Day; By Staging	None

Note: Unit measurement setting is allowed to be changed during unit stop operation (standby mode) only

Touch on the selected set point which contained in rectangle box. A keypad will pop up on the screen. Use this keypad to key in the desired setpoint value and touch "**Enter"** key to confirm the change. If the value entered is out of acceptable range, the setpoint will not change and the keypad will remain to receive another value.

9.6.8 Authorization

To get authorization level, insert password in main display page. Touch on the rectangle box with "****". A keypad will pop up. Key in the authorization code and touch on "Login" key to gain the authorization access. To get out from authorization level, touch on "Logout" key



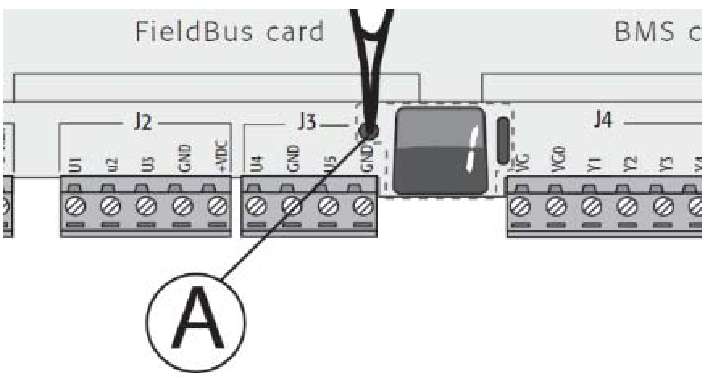
There are 3 levels of authorization; User; Technician, and Factory Level. The password for User and Technician Levels remain the same throughout the life cycle of the compressor. However, Factory level requires the password generator that can be obtained from Dunham-Bush.

9.7 ADDRESSING THE VISION 2020i CONTROLLER AND DBGX TERMINAL

9.7.1 Vision 2020i Controller (DB5+) Addressing

One major different of DB5+ controller with previous version of Vision controller is that the controller address of DB5 controllers can be set by using the button and 7-segment display on the controller.

Refer to below screen, locate button "A" (as shown below) at bottom middle of controller. Access the button using a pin or screw driver (diameter <3mm)



Press and hold button "A" for 3 seconds, the 7-segment display starts flashing and shows the stored address (factory default address setting at "1").

Press the button repeatedly to increment the address value until desired value.

Wait 10 seconds to save the new address, where the display shall flash quickly. Switch off the controller and restart again to activate the new address.

If the controller is switched off within 7 seconds after the new address is set, the new address will not be activated.

9.7.2 DBGX Touch Screen Display Panel Setup

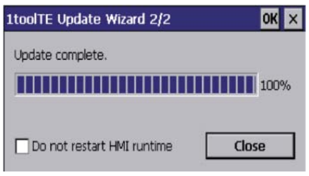
The DBGX 10.1" touch screen display panel is designed to be user friendly, with graphical layout and quick access to operating parameters.

9.7.2.1 Application Update

The menus can be accessed by pressing any point on the touch screen for few seconds until the menu is display:

Choose "Update…" from the menu pop out and next screen with title "Update wizard ½" will appeared
Choose "Auto select best match" and then select "Next"

This will start update the DBGX application software. Once done, below screen will pop out.

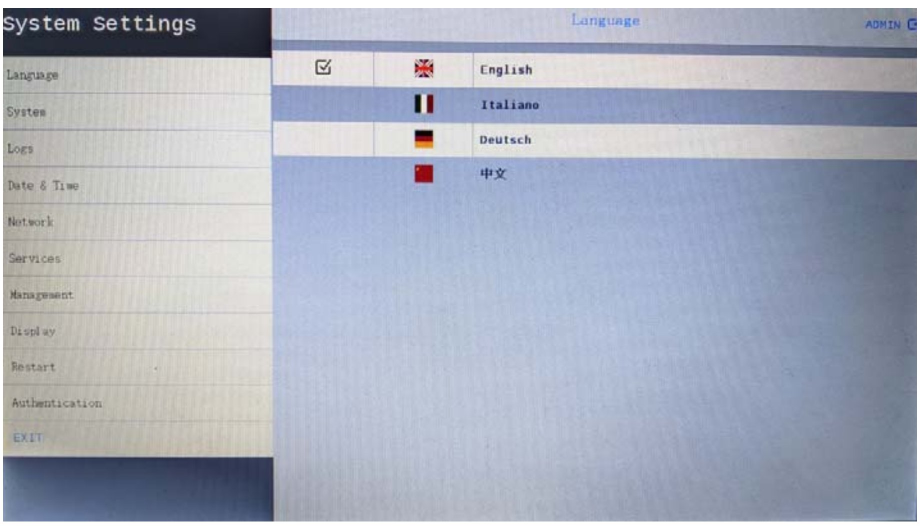


9.7.2.2 System Settings

The menus can be accessed by pressing any point on the touch screen for few seconds until the menu is display:

Choose Show system settings

Screen with title "System settings" will appeared as below:



Calibrate Touch:
Settings relating to calibrate screen

Display Settings:
Settings relating to backlight auto shut off time & brightness of screen

BSP Settings:
Version to show operating software version; Timers to show hours of operation;
Buzzer to allow buzzer sound playing when touch the screen

Network:
Settings relating to IP & Ethernet configuration

Set Device Address:
Settings for Modbus RTU Server or BACnet

9.8 CONTROL FUNCTIONS

The Vision 2020i controller performs the following functions on DCLC chillers.

9.8.1 Chilled Water Pump Control

Chilled water pump of the unit can be controlled by control output point (volt-free contact) available in the unit control panel. The chiller will start chilled water pump upon receiving start command and remain on during the entire operational period. Chilled water pump will remain running for 3 minutes after the chiller has received a stop command and all compressors are stopped.

9.8.2 Condenser Water Pump Control

Condenser water pump of the unit can be controlled by control output point (volt-free contact) available in the unit control panel. The chiller will start condenser water pump upon receiving start command and remains on during the entire operation period. Condenser water pump will remain running for 3 minutes and stop after the chiller has received stop command and all compressors are stopped.

9.8.3 Common Alarm

Volt-free contact available in unit control panel to provide indication of unit control alarm status. This contact will be closed when any of the control alarm is triggered. Control alarms are those alarms that trip off compressor or unit.

9.8.4 Chilled Water Pump Interlock and Flow Switch

These are field installed switches; both of them are used to ensure chilled water flow before the unit is allowed to start. Failure of either one during operation will cause the compressor to shut down. Chilled water flow shall remain in circulation for at least 3 minutes after the compressors are stopped. This will help to vaporize remaining cool liquid refrigerant in the evaporator to prevent potential of evaporator freeze up.

9.8.5 Condenser Water Pump Interlock and Flow Switch

These are field installed switches; both of them are used to ensure condenser water flow before the unit is allowed to start. Failure of either one during operation will cause the compressor to shut down.

9.8.6 Customer Control Interlock / Unit Enable (Remote)

Control contacts from an external source can be used to enable or disable operation of the unit. The wiring diagram specifies the terminals to which this contact must be wired. The R/O/L selector switch needs to be positioned at “R” to enable this control. To start the unit, the control contacts must be closed. To stop the unit, the control contacts must be opened.

9.8.7 Compressor Oil Sump Temperature Control

The oil heater would be controlled by the chiller control panel to make sure the oil sump temperature is constantly in between 113 ~ 122°F (45 ~ 50°C).

9.8.8 Compressor Start Delay Timer

A compressor start delay of one minute is incorporated into controller before the first compressor is started to ensure the system load requires the compressor. A start delay countdown timer is shown at compressor status screen during this timing.

9.8.9 Compressor Stage Delay Timer

A compressor stage delay of one minute is incorporated into the controller to ensure that the system load requires another compressor. A stage delay countdown timer is shown at compressor status screen during stage delay.

9.8.10 Compressor Anti-Recycle Timer & Off-cycle Timer

The anti-recycle time delay will prevent any compressor restart for 15 minutes after a start. The controller will not restart the compressor motor until the anti-recycle timer have elapsed. An "**Anti-recycle Timer**" is displayed at the compressor condition during anti-cycle timing.

The off-cycle timer is a delay preventing compressor startup after turning off for a short amount of time. This delay prevents the compressor from turning back on after turning off for 10 minutes. An "**Off-cycle Timer**" is displayed at the compressor condition during off-cycle timing.

The purpose of this feature is to avoid frequent starts which tend to elevate the motor winding temperature and impose undue wear on contactors.

CAUTION: This timer is bypassed by manual control of compressors. DO NOT manually start a compressor more than once every 15 minutes.

9.8.11 Load Control

Leaving chilled water temperature control is accomplished by entering the water temperature set point and placing the controller in automatic control. The unit will monitor all control function and move the Inlet guide vane (IGV) or the compressor variable frequency drive (optional) to the required operating position to match closely to the actual building load requirement. This will put the chiller operation at optimum efficiency, and thus, maximized the energy saving of the chiller plant operation.

The loading cycle is programmable and may be set for specific building requirements. Remote adjustment of the leaving chilled water set point is accomplished either through High Level Interfacing (HLI) via BMS communication, or Low-Level Interfacing (LLI) via an external hardwired, 0 to 20mA & 0 to 5Vdc chilled water reset control signal. Remote reset of compressor current limiting function can be accomplished in a similar fashion.

9.8.12 Ramp Control

Another feature of the controller is ramp control. In order for a centrifugal chiller to increase its cooling capacity, the degree of opening of the inlet guide vane (IGV) and the speed of compressor frequency drive (VFD) are adjusted to control the volume flow rate.

The value of the IGV% and VFD% are given by two variables; the ramping rate, and the initial ramp setpoint. The ramping rate is defined by the amount that is added to the degree of opening every second. The initial ramp setpoint determines the starting % of the IGV at which the ramp begins on the first compressor. The ramping rate varies according to the difference between the current leaving chilled water temperature and its setpoint target. The bigger the difference, the higher the ramping rate. The initial ramp setpoint for the VFD and IGV can be set anywhere between 70 ~ 100% and 15 ~ 100% respectively in the technician settings. On a compressor startup, the IGV will open to the percentage of this degree.

9.8.13 Variable Frequency Drive (VFD) Compressor (optional)

A VFD reduces the starting current inrush by controlling the voltage and frequency to the compressor motor. Once the motor has accelerated to start-up speed, the controller modulates that compressor speed and guide vane position to control chilled water temperature. The control logic automatically adjusts motor speed and compressor pre-rotation vane position for maximum part load efficiency by analyzing information fed to it by sensors located throughout the chiller.

All the required parameters for VFD application have been preset by DB. A list of parameters can be provided to the user upon request with the exception of proprietary settings. The use can refer to the VFD manual that is supplied with the VFD starter cabinet for further information and instruction on the technical info about the VFD and the steps to access the VFD display.

9.8.14 Staging Control

On multiple-compressor machines, when the controller determines that a compressor is fully loaded and temperature is not being maintained, another compressor is added. When unloading, a compressor is taken off line when the controller determines that the remaining compressor can manage the load.

9.8.15 Compressor Rotation

For multiple compressors models, besides unit operation with manually preset lead compressor, the controller is able to automatically rotate the lead compressor to balance up total running of all the compressors. Three types of automatic compressor lead/lag rotation are available, which are "*By Running Hours*", "*By Day*" or "*By Stage*".

"*By Running Hours*" – Compressor with least running hours will starts first

"*By Day*" – Lead compressor is rotated everyday
"*By Stage*" – Lead compressor is rotated at each compressor restart cycle

9.8.16 Compressor Unloaded Stop

This control feature permits compressor unloading before each stop (normal and healthy stop, except stop by alarm). Compressor(s) will close the IGV & ramp down the compressor VFD speed to a minimum before stopping, or stops after the preset unloaded stop timer is elapsed.

9.8.17 Hot Gas Bypass Control

When ***Hot Gas Bypass*** (HGBP) has been supplied with the unit, an output from the controller controls the modulating valve. The degree of opening of the modulating valve depends on multiple factors:

a. Target IGV% falls below the minimum required IGV%
b. Surge during unit normal operation
c. Low leaving chilled water temp

The DB Intelligent PID logic is able to detect which factor is affecting the unit, and controls the unit to regulate the status of the unit back to normal operation. The HGBP functions by diverting hot, high pressure vapor from the discharge line to a lower pressure side of the system. This way, the refrigerant pressure is constantly regulated to prevent overcooling.

9.8.18 Chilled Water Reset

When ***Chilled Water Reset*** option is furnished, the desired chilled water temperature can be raised automatically by an external signal provided by an external controller, or BAS (Building Automation System). The external signal can be 0–5Vdc, or 4–20mA.

9.8.19 Demand Limit

When ***Demand Limit*** option is furnished, the desired max running amp limit can be altered automatically by an external signal provided by an external source, or BAS. The external signal can be 0-5Vdc, or 4-20mA.

9.8.20 Liquid Line Modulating Valve Control

Each unit has a modulating liquid line valve to control the volume of refrigerant flow into the evaporator. The valve control is based on the cooler approach value (difference between leaving chilled water temperature and saturated evaporator temperature) and how different is the said value from the calculated approach target. The calculated approach target is derived via the difference between the leaving chilled water temperature and its setpoint. The higher the difference, the wider the opening and higher the rate of opening of the valve.

As the cooler approach is calculated, the product sends out a 0-10Vdc control signal to the valve which controls the flow of refrigerant in the liquid line. Based on the calculation of the approach target, the controller decides the rate which the valve opens.

Besides refrigerant flow control during a normal operation, the valves can also function as a preventive feature to recover the unit in operation, and to prevent the unit from causing an alarm trip.

The c controller will override the valve control logic and force the valve to open/close, to recover from abnormal situations such as:

a. Low suction pressure
b. Low discharge superheat
c. Compressor in fast loading/unloading capacity%

DB control chiller panel has an intelligent adaptive approach target which will vary based on the discharge superheat. It will be able to provide stability to the chiller system and maximum cooler efficiency at different running conditions.

9.0 CONTROL SYSTEM (VISION 2020i)

9.9 SAFETIES AND ALARMS

The Vision 2020i controller performs the following safety limiting and protection on DCLC compressor chillers

9.9.1 Low Pressure Safety

This function protects the unit from operating at abnormally low evaporator pressure. When the evaporator pressure of a refrigeration circuit drops below the Low-Pressure Cut-off safety setpoint, the controller will shut down all compressors in that refrigerant circuit and turn on the alarm light. Alarm message ***"System Low Evaporator Pressure – System Off"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.2 High Pressure Safety

This function protects the unit from operating at abnormally high condensing pressure. When the condensing pressure of a refrigeration circuit exceeded the High-Pressure Cut-off safety setpoint, the controller will shut down all compressors in that refrigerant circuit and turn on the alarm light. Alarm message ***"System High Condenser Pressure- System Off"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.3 Oil Supply-Oil Sump Low Differential Pressure Alarm

If the difference between the Oil Supply Pressure and the Oil Sump Pressure is less than 20 Psi (1.4 bar), an alarm will pop out to prevent the compressor from running. Alarm message ***"System Low Oil Supply-Sump Pressure Differential – System Off"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.4 High Discharge Temperature Alarm

If the discharge temperature sensor measures a value higher than 160°F or 70°C (setpoint changeable under Safety Cutout Setup in Factory Settings), the controller will shut down the unit and turn on the alarm light. Alarm message ***"Compressor High Discharge Temperature Alarm – Compressor Off"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.5 High Oil Sump Temperature Alarm

If the Oil Sump Temperature measures a value above 160°F or 70°C, the controller will shutdown the unit and turn on the alarm light. Alarm message ***"Compressor High Oil Sump Temperature Alarm – Compressor Off"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.6 High Bearing Temperature Alarm

If the Motor Bearing Temp sensor measures a value more than 167°F or 75°C, the controller will shutdown the unit and turn on the alarm light. Alarm message ***"Compressor High Bearing Temperature Alarm – Compressor Off"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.7 Evaporator Freeze Safety

If the leaving chilled water temperature drops below the freeze setpoint, the controller will shut down the unit and turn on the alarm light. Alarm message ***"Temperature Freeze Alarm"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.12 Unit Voltage Alarm (optional)

If the voltage transducer sensor measures a value that falls above an upper limit value or falls below a lower limit value, the controller will shut down the unit and trip the alarm light. Alarm message ***"High Voltage Alarm"*** or ***"Low Voltage Alarm"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.9 Sensor Failure Alarm

If the controller measures an analogue sensor (temperature, pressure, or Amp sensor.) with the reading is beyond its measuring range, the associated compressors or system are shutdown. Alarm light is turned on and alarm message "***Sensor Failure***" will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.10 Compressor No-Stop Alarm

If the controller turns off a compressor, but the compressor's starter status does not turn off or detects running amps, all compressors will be turned off and alarm light is turned on. Alarm message "***Compressor No Stop Alarm***" will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm. This alarm indicates a wiring or hardware error.

In the case the system detects running amps being used to power the compressor, the controller will enter a forced run mode where the following units will run:

a. Compressor
b. Chilled Water Pump
c. Condensed Water Pump
d. IGV (open at minimum)
e. Liquid Line Valve (normal operation)
f. HGBP (normal operation)

The purpose of this feature is to prevent the compressor from burning by allowing the entire system to run along with the compressor until the "***Compressor No Stop Alarm***" shows up on the DBGX display panel.

9.9.11 Compressor No-Run Alarm

When the controller has started a compressor but did not received feedback on compressor operating current, alarm will be triggered and alarm light will turn on. Alarm message ***"Compressor No Run Alarm"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.12 Compressor Starter Alarm

When the controller starts a compressor but did not received feedback on compressor's starter status, alarm will be triggered and alarm light will turn on. Alarm message ***"Compressor No Starter Feedback"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.13 Compressor Oil Pump Alarm

When the controller receives a feedback of oil pump overload status, alarm will be triggered and alarm light will turn on. Alarm message ***"Compressor Oil Pump Alarm"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.14 No Chilled Water Flow Alarm

This alarm is activated when chilled water flow switch status is opened when compressor is running. The unit will be stopped and alarm light is turn on. Alarm message ***"No Chilled Water Flow Alarm"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.14 No Condensed Water Flow Alarm

This alarm is activated when chilled water flow switch status is opened when compressor is running. The unit will be stopped and alarm light is turn on. Alarm message ***"No Condenser Water Flow Alarm"*** will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.15 Power Loss Reset

Power Loss Restart Setting is available in ***Setpoint*** menu to determine unit restart characteristic after recover from a power failure.

If ***Power Loss Restart*** Setting is set to "Auto", the unit will restart automatically after power is resumed, with alarm history recorded. No active alarm message is shown.

If ***Power Loss Restart*** Setting is set to "Manual", alarm message "***Power Loss***" with power loss and resumed time are be displayed at ***DBGX*** display panel when power supply to the unit is resumed. Manual reset at display panel is required to clear this alarm and put the unit back into operation.

9.9.16 High Compressor Motor Temperature Protection

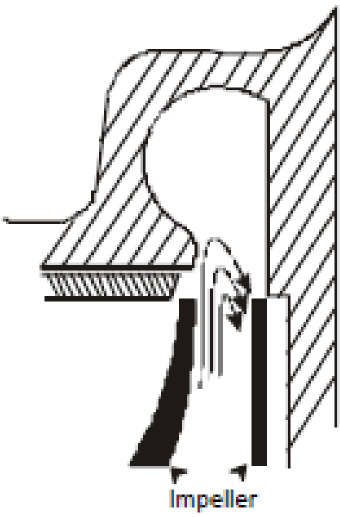
Motor winding temperature sensors are furnished at each compressor which will trips the compressor the sensor detects the motor temperature exceed 180°F (82°C). Alarm message "***Compressor High Motor Temperature Alarm***" will be displayed at ***DBGX*** display panel. Manual reset at display panel is required to clear this alarm.

9.9.17 Volt-Phase Control Relay (PCR)

The PCR protects the unit from the following electric supply malfunctions: under or over-voltage, phase reversal, phase imbalance and phase loss. If the PCR trips, control circuit will be de-energized and the unit will be shut down. PCR is auto-reset when power supply has back to pre-set range. Control circuit is re-energized again after PCR is reset. Controller treats this protection as *"**Power Loss**"*. Refer to section 9.9.15 Power Loss Reset for the unit restart characteristics.

9.9.18 Surge Trip Protection

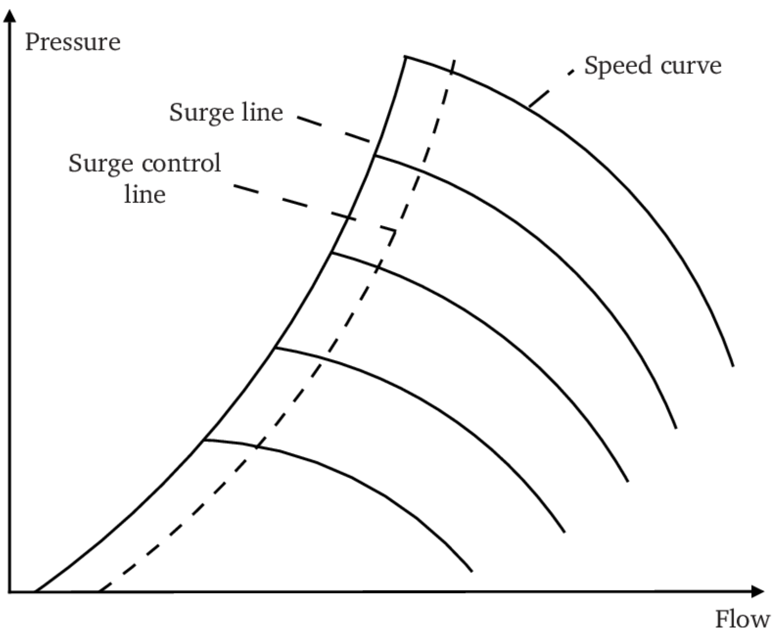
Surges are an unstable condition that occurs at low mass flows. It frequently occurs at areas of the chiller where the pressure varies differently. For instance, the gas flow into the discharge line is pushed by the rotational energy from the impeller. During part load operation, the pressure in the discharge line is much higher than the pressure of the gas in the impeller chamber. This causes a backflow of vapor back into the compressor, reducing the pressure in the discharge line and hence, causes spikes in terms of power consumption as the motor tries to work against the vapor backflow. It decreases compressor performance and efficiency that can eventually lead to permanent equipment damage. As the pressure in the discharge line is now reduced, the impeller will operate in normal conditions to push the vapor into the discharge line where a surge will eventually happen again.



To combat this issue, the controller takes action by reversing the movement of the operating point to the surge line. This action helps decrease the pressure of the surge point and increases flow through the compressor. This can be achieved by opening a hot gas bypass valve to return discharge vapor into the compressor inlet.

From the graph, we see the relation between head pressure and flow of a compressor, it surging point, and its corresponding surge controls acted out by the DB adaptive PID logic which will redraw the IGV and VFD surge control line when detected there is a surge, to prevent the compressor from re-entering the surge zone and causes the damage to the compressor again. The speed curve represents the different operating speeds of the compressor. The surge control line is placed to the right of the surge line which provides a safety margin for the PID logic.

The surge protection logic will trigger as soon as it detects a fluctuation in current difference around ±8% of the Full Load Amp (FLA) or ±7 PSI (±0.48 bar) in the last 5 seconds. When the current reading fluctuates above and below 8% or vice versa, a counter will record the trips. As soon as 4 trips are recorded, alarm message "***Compressor Surge***" will be displayed at the DBGX alarm panel. Manual reset at display panel is required to clear this alarm.



9.9.19 List of Alarms in DBGX Display

Below is the list of alarms that will display in the DBGX during unit trips.

***** = setpoint changeable in Factory Level

ALARM		
SYSTEM OFF		
Reading	**Description**	**Condition**
Sys 1/2 Off – High Disc P	System 1/2 high discharge pressure alarm	Discharge pressure more than 135 PSI (9.3 Bar) for R134a. *
Sys 1/2 Off – Low Disc P	System 1/.2 low discharge pressure alarm	Suction pressure lesser than 23 PSI (1.6 Bar) for R134a. *
Sys 1/2 Off – Disc P Failure	System 1/2 discharge pressure sensor failure alarm	Discharge pressure sensor detected discharge pressure > 500 PSI (34 Bar) or < 0 PSI (0 Bar)
Sys 1/2 Off – Suct P Failure	System 1/2 suction pressure sensor failure alarm	Suction pressure sensor detected suction pressure > 200 PSI (14 Bar) or < 0 PSI (0 Bar)
Sys 1/2 Off – Refrig Level Failure	System 1/2 refrigerant level sensor failure	Refrigerant level sensor enabled but no reading detected
UNIT OFF		
Unit Off – Comp 1/2 No Stop	Compressor 1/2 no stop alarm	Unit turned off but running amps detected in compressor
Unit Off – No CHW Flow	No chilled water flow alarm	Unit running but no chilled water flow detected
Unit Off – LVG CHW T Freeze	Leaving chilled water temperature freeze alarm	Leaving chilled water temperature less than 38°F (3.3°C) *
Unit Off – LVG CHW T Failure	Leaving chilled water temperature sensor failure	Leaving chilled water temperature sensor detected temperature < -58°F (-50°C) or > 212°F (100°C)
Unit Off – System Voltage Failure	System voltage sensor failure	System voltage enabled but no reading detected
Unit Off – High System Voltage	High system voltage alarm	System voltage detected to be 10% more than allocated voltage. *
Unit Off – Low System Voltage	Low system voltage alarm	System voltage detected to be 10% less than allocated voltage. *
Unit Off – Power Loss	Power loss alarm	Power loss when manual restart
Unit Off – No CHWP Starter Feedback	No chilled water pump starter feedback	When chilled water pump is on but digital input for Chilled Water Pump is turned off
Unit Off – Unauthorized Exp Board 1/2	Unauthorized expansion board 1/2 alarm	Unauthorized expansion board detected in system. Refer to DBI
Unit Off – No CDWP Starter Feedback	No condensed water pump starter feedback alarm	When condensed water pump is on but digital input for Condensed Water Pump is turned off
Unit Off – No CDW Flow	No condensed water flow alarm	Unit started but condensed water pump digital input is turned off
Unit Off – High Refrig Leak	High refrigerant leak alarm	When refrigerant leak sensor detects leakage more than 800 ppm.
Unit Off – Unauthorized Main Board	Unauthorized main board alarm	Unauthorised software used on controller. Refer to DBI
Exp Board 1/2/3/4/5 Offline	Expansion board 1/2/3/4/5 offline	Expansion board enabled in system but hardware not detected
COMPRESSOR OFF		
Comp 1/2 Off – Low Oil P Diff	Compressor 1/2 low oil differential pressure alarm	When the pressure difference between oil supply and oil sump is less than 20 PSI (1.4 Bar). *
Comp 1/2 Off – High Disc T	Compressor 1/2 high discharge temperature alarm	When discharge temperature is detected to be higher than 160°F (70°C). *
Comp 1/2 Disc T Failure	Compressor 1/2 discharge temperature failure	Discharge temperature sensor detected discharge temp > 212°F (100°C) or < -450°F
Comp 1/2 Off – Amps Failure	Compressor 1/2 amp sensor failure alarm	Amp sensor detects amp increase more than 10% of CT turn ratio or less than 1%
Comp 1/2 Off – No Run	Compressor 1/2 no run alarm	When compressor turns on but CT does not detect any running amps.
Comp 1/2 Off – Oil Pump Alarm	Compressor 1/2 oil pump alarm	When oil pump digital input remains off after starter delay has started.
Comp 1/2 Off – No Starter Feedback	Compressor 1/2 no starter feedback alarm	When compressor digital input remains off after compressor is supposed to run.
Comp 1/2 Off – Motor T Failure	Compressor 1/2 motor temperature sensor failure	When motor temp sensor detects reading > 212°F or < -45°F
Comp 1/2 Off – Oil Sup P Failure	Compressor 1/2 oil supply pressure sensor failure	When oil supply pressure detected pressure > 220 PSI (15.1 Bar) or < -20 PSI (-1.4 Bar)
Comp 1/2 Off – Oil Sump P Failure	Compressor 1/2 oil sump pressure sensor failure	When oil sump pressure detected pressure > 220 PSI (15.1 Bar) or < -20 PSI (-1.4 Bar)

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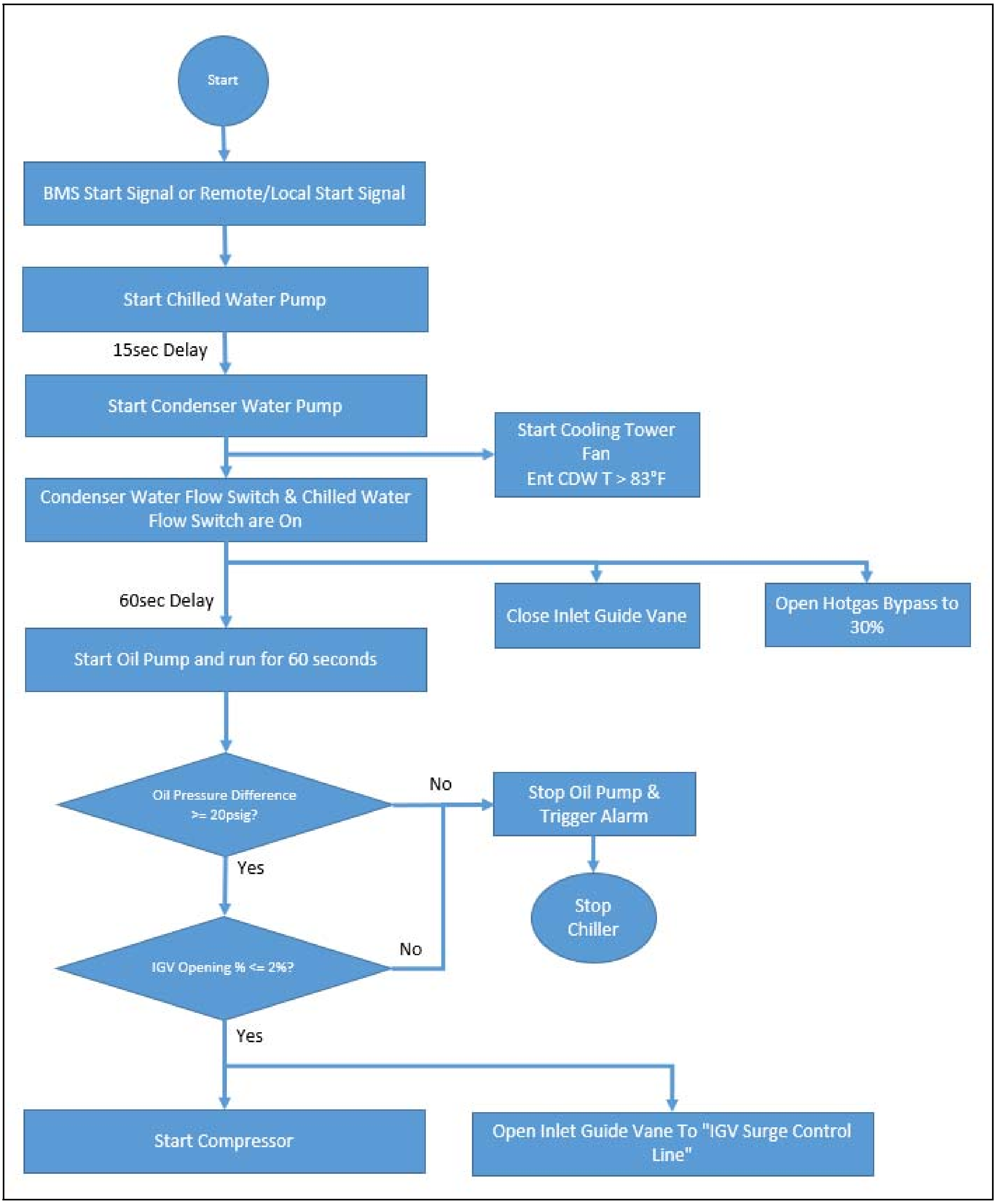
ALARM		
SYSTEM OFF		
Reading	**Description**	**Condition**
COMPRESSOR OFF		
Comp 1/2 Off – High Motor T	Compressor 1/2 high motor temperature alarm	When motor temperature > 180°F (80°C). *
Comp 1/2 Off – Starter Alarm	Compressor 1/2 starter alarm	When compressor is turned off but digital input detects compressor is switched on
Comp 1/2 Off – Oil Sump T Failure	Compressor 1/2 Oil sump temperature sensor failure	When oil sump temp sensor detects reading > 212°F or < -45°F
Comp 1/2 Off – High Oil Sump T	Compressor 1/2 high oil sump temperature alarm	When oil sump temp detects reading > 160°F (70°C). *
Comp 1/2 Off – Bearing T Failure	Compressor 1/2 bearing temperature sensor failure	When bearing temp sensor detects reading > 212°F or < -45°F
Comp 1/2 Off – IGV Module Failure	Compressor 1/2 inlet guide vane module failure	When IGV module detects opening > 110% or < -10%
Comp 1/2 Off – Diffuser Module Failure	Compressor 1/2 diffuser module failure	When diffuser module detects opening > 110% or < -10%
Comp 1/2 Off - Surge	Compressor 1/2 surge	When surge trip has occurred more than 4 times. *Refer to 9.9.18*
Comp 1/2 Off – Over Num Lockout Please Contact DBI	Compressor 1/2 over number lockout please contact DBI	When alarm off trip has occurred more than 6 times. Please contact DBI to remove
Comp 1/2 Off – IGV Open	Compressor 1/2 inlet guide vane open	During oil prelube delay IGV is open.
WARNING		
Warning – Sys 1/2 Vap Inj Module Failure	System 1/2 vapor injection module failure	When vapor Injection module detects opening > 110% or < -10%
Warning – Sys 1/2 HGBP Module Failure	System 1/2 hot gap bypass module failure	When hot gas bypass module detects opening > 110% or < -10%
Warning – Comp 1/2 Over Service	Compressor 1/2 over service	When unit is due service
Warning – Comp 1/2 Suct T Failure	Compressor 1/2 suction temperature sensor failure	When suction temp sensor detects reading > 212°F or < -45°F
Warning – LVG CDW T Failure	Leaving condensed water temperature sensor failure	When leaving condenser temp sensor detects reading > 212°F or < -45°F
Warning – ENT CDW T Failure	Entering condensed water temperature sensor failure	When entering condenser temp sensor detects reading > 212°F or < -45°F
Warning – Refrig Leak Failure	Refrigerant leak sensor failure	When refrigerant leak sensor detects reading > 2200ppm or < -200 ppm
Warning – ENT CHW T Failure	Entering chilled water temperature sensor failure	When entering chilled water temp sensor detects reading > 212°F or < -45°F
Warning – Unit Offline in DBLan	Unit offline in DBLan	Number of units online and number of actual units don't tally
Warning – Serial Port Alarm	Serial port alarm	Unit using unauthorized software

9.0 CONTROL SYSTEM (VISION 2020i)

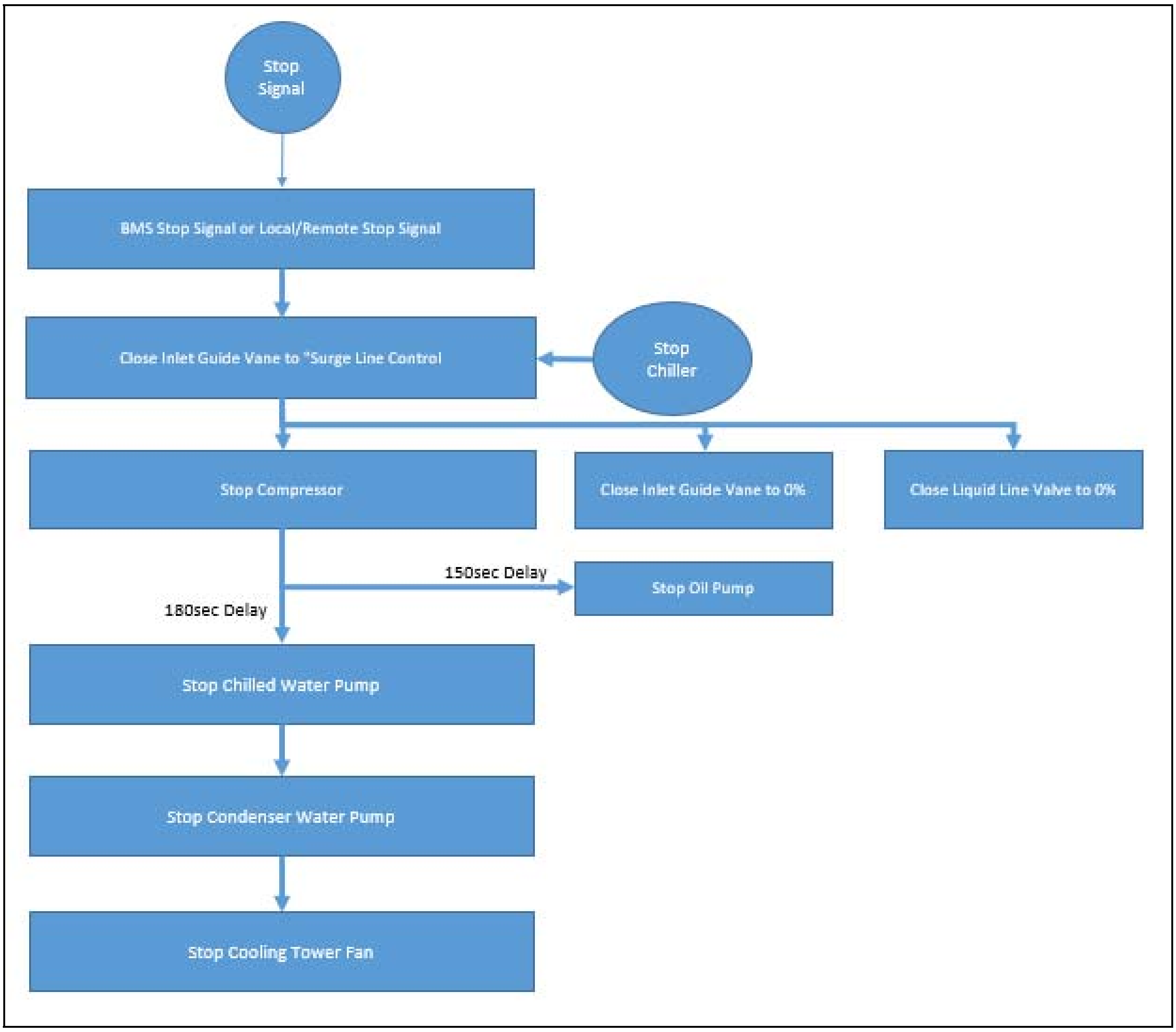
9.10 CONTROL FLOWCHART

9.10.1 DCLC Start-up Flow Chart Sequence



9.0 CONTROL SYSTEM (VISION 2020i)

9.10.2 DCLC Stop Flow Chart Sequence



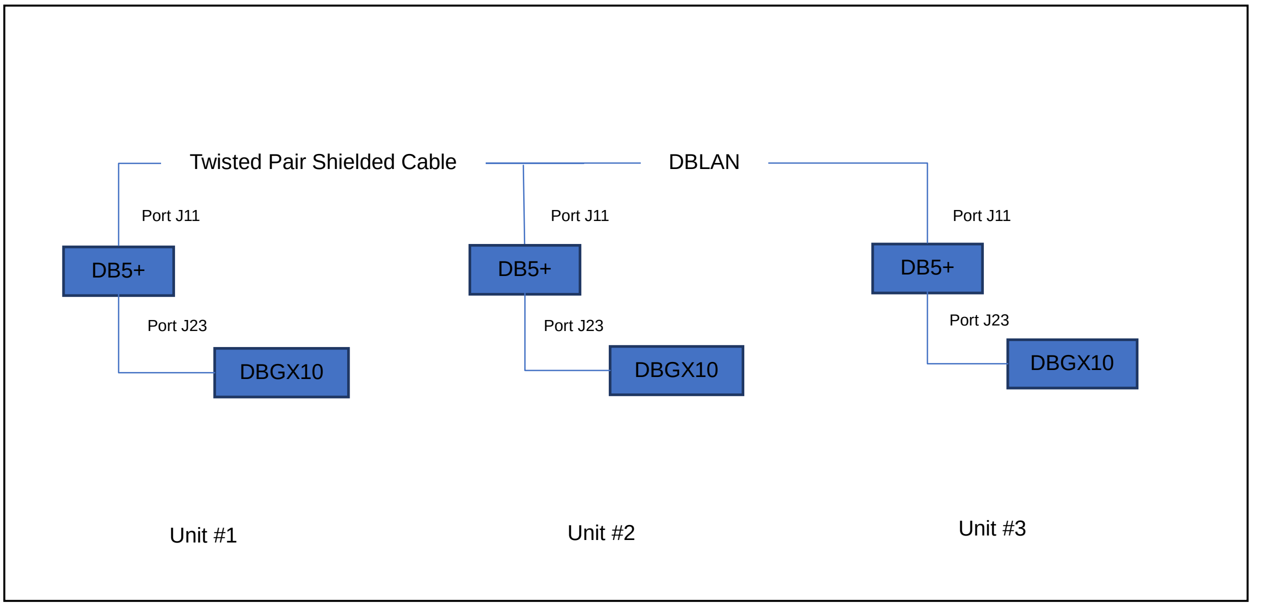
9.0 CONTROL SYSTEM (VISION 2020i)

9.11 MASTER-SLAVE SEQUENCING CONTROL (MSS)

The optional Master-Slave Sequencing Control is used to sequence multiple chillers in one installation according to the building load demand. It also controls the dedicated chilled water pump or motorized valve.

Vision2020i Controller offers this feature with minimized field wiring cost compare to conventional method that involves lots of hardware cost. It is carried out this control function via the advanced DBLAN communication bus to implement the network management for multiple chillers lead/lag communication, sequencing and monitoring.

Figure 9.11A Typical DBLAN network (3 chillers)



Notes

- Each chiller has a stand-alone ***Vision 2020i*** controller and dedicated display (DBGX10) via port J23
- Each chiller's ***Vision 2020i*** will be connected to DBLAN network through port J11 using twisted pair shielded cable
- The ***MSS*** chiller lead/lag selection can be determined by
  - Manual lead/lag setpoint
  - Schedule and holiday setup
  - Alarm conditions
- The lead/lag selection determine the chiller operation sequence as follows. The following is an example of three chillers network with two units on-duty and one unit on standby.

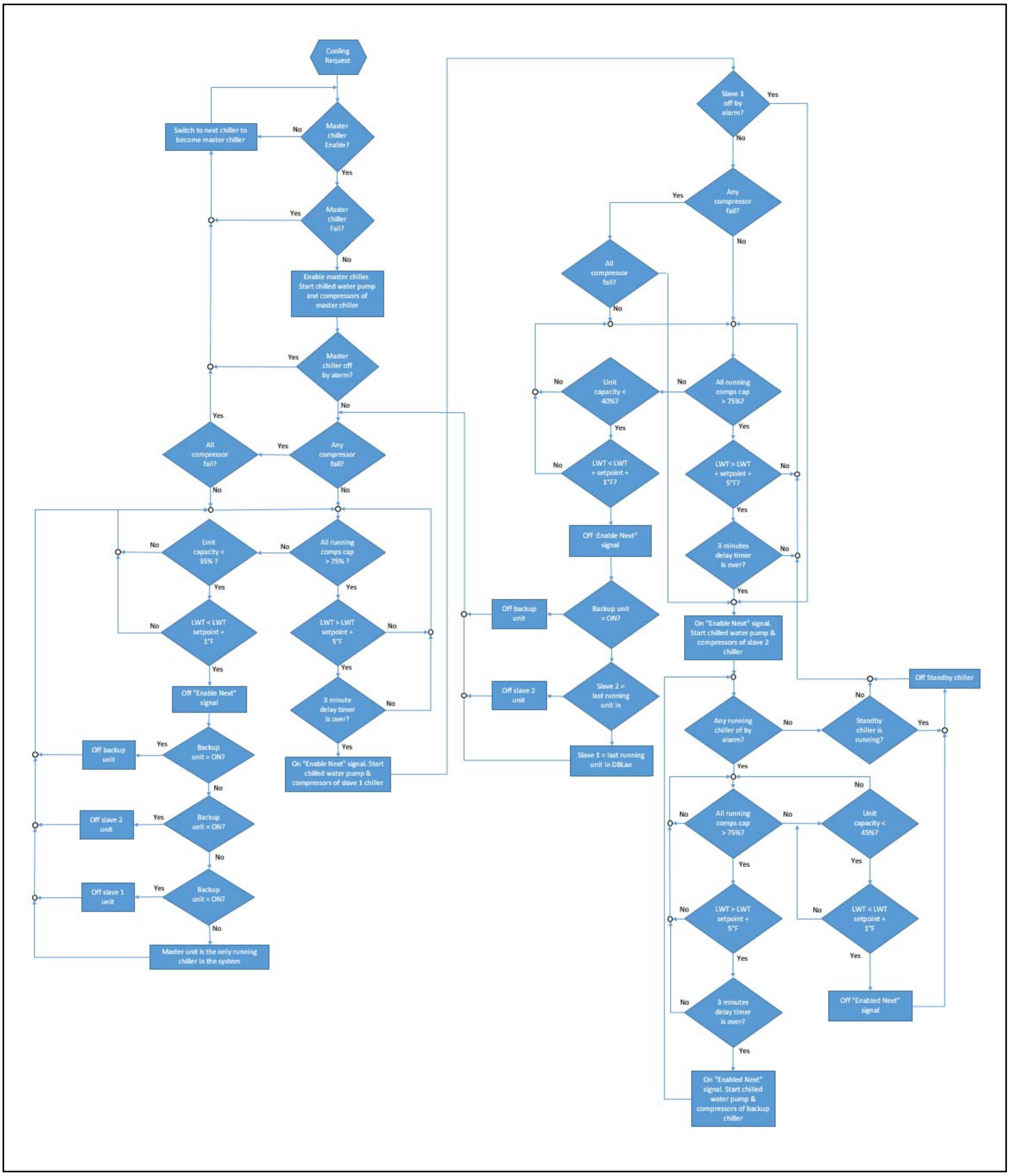
Lead chiller selection	Chiller operation sequence
1	1 & 2 on duty 3 standby
2	2 & 3 1 standby
3	1 & 3 on duty 2 standby

- If the lead/lag selection is changed over to a different chiller, the sequence of operation will be rotated
- Each chiller will use a network address setpoint to determine individual chiller network address
- Master-slave control can be extended up to maximum eight (8) chillers in the DBLAN network.

A typical sequence of operation of MSS is shown Figure 9.11A Flow Chart – Master Slave Control Sequence

9.0 CONTROL SYSTEM (VISION 2020i)

Figure 9.11B Flow Chart – Master-Slave Control Sequence



10.0 PREPARATION BEFORE STARTUP

10.1 JOB DATA REQUIRED

- This Manual
- Starting equipment details and wiring diagrams
- Diagram and instructions for special control or options

10.2 TOOLS REQUIRED

- Mechanic's tools (Refrigeration)
- Multi-meter
- Clamp on ammeter (For 415V Motor)
- 500V insulation tester (megohmmeter) for 415V motors; 2500V insulation tester for 6kV & 10kV motors.
- Electronic leak detector.

10.3 CHECK CHILLER TIGHTNESS AND LEAKING TEST PROCEDURE

Leaking test was completed before leaving factory. The vessels will have a 0.05～0.08MPa (at 20°C) refrigerant charge. Leaking test is not required if there is no leaking found.

- If pressure of chiller is less than 0.05MPa within a month after leaving factory, then it is leaking;
- Add refrigerant and test it with electronic leak detector.

If a leak is found, Dunham-Bush recommends the following leak test procedures (Figure 10.3).

- Turn off inlet valve. Check for all leaks by connecting a nitrogen bottle and raising the pressure to 0.5~0.6MPa.
- Prepare nitrogen, aerated tube and pressure reducing valve, charge the nitrogen into the unit, when the pressure is 0.5～0.6MPa, close the aerated valve and check if there is leakage with leak detection soap, then mark the leakage, find out the reason and repair it after release the pressure to 0. Rise the pressure and check again after accomplishing reparation. **DO NOT repair when there is a pressure.**
- Raise the pressure to 1.15 MPa which is the chiller designed pressure; check and repair all leaks.
- Release the pressure after making sure there is no leak in the system.

10.4 MACHINE VACUUM TEST

Chiller needs vacuum test after it passed leak test. The following is the procedure of vacuum test.

- Attach an absolute pressure manometer or wet bulb indicator to the chiller.
- Evacuate the vessel by using vacuum pump.
- Turn on all valves inside the chiller.
- Reduce the absolute pressure to below 200Pa and hold it for 0.5 hour. Record the manometer or indicator reading. If the pressure raise is to less than 50Pa, then the chiller is sufficiently tight. If the pressure raise is to greater than 50Pa, then re-pressurize the vessel and test for leaks according to 10.3.
- If any questions, please contact Dunham-Bush personnel to get professional advice.

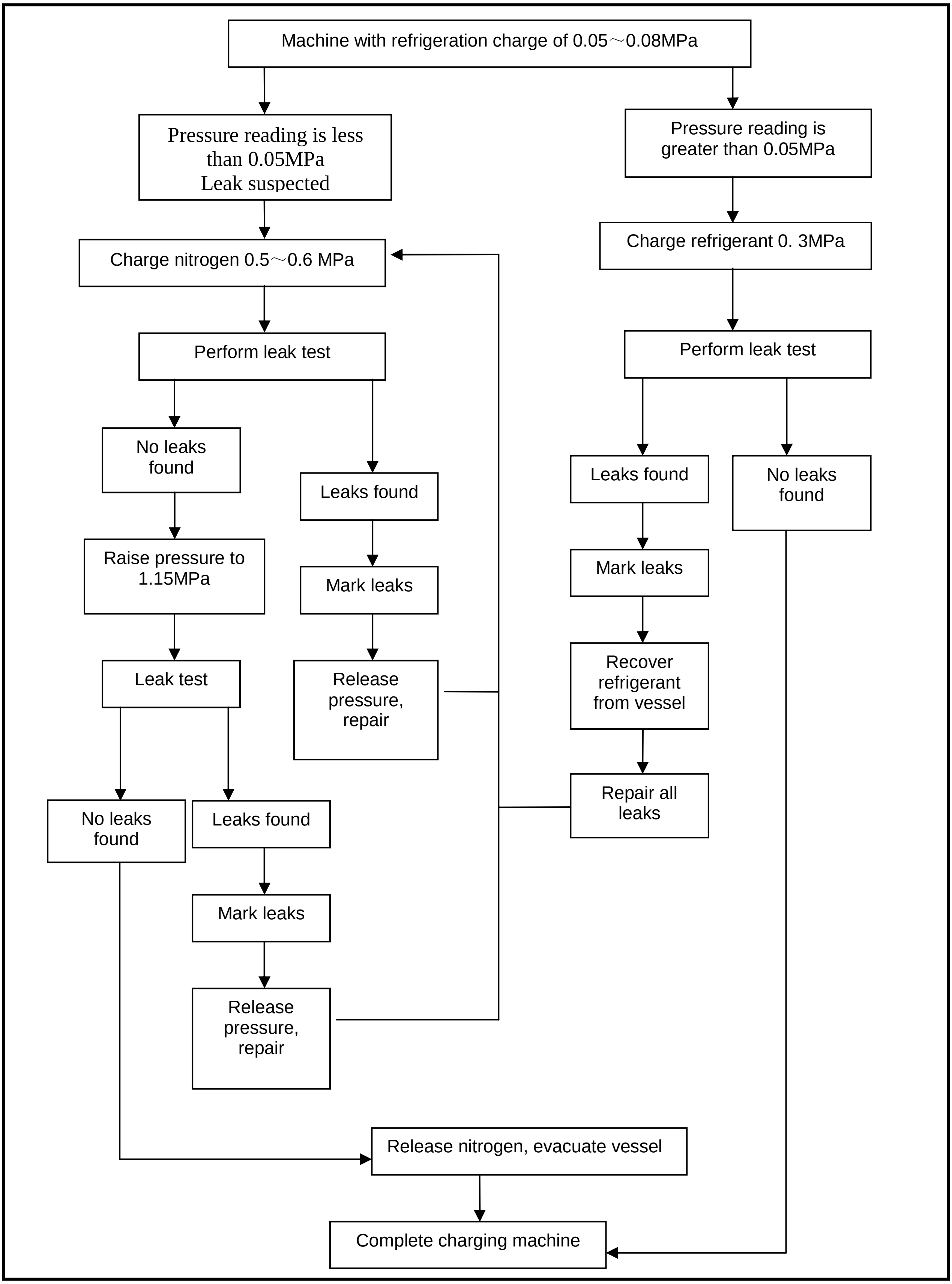
10.5 INSPECT WATER PIPING

Refer to piping diagrams provided in the certified drawings, and the piping instructions in the DCLC Installation Instructions manual.

- Inspect the piping to the evaporator and condenser. Be sure that flow directions are correct and that all piping specifications have been met.
- Make sure all valves are open in the water system.
- Inspect the cooling tower. Be sure it works properly.
- Water must be within design limits, clean, and treated to ensure proper chiller performance.

10.0 PREPARATION BEFORE STARTUP

Figure 10.3 Leaking Test Procedure

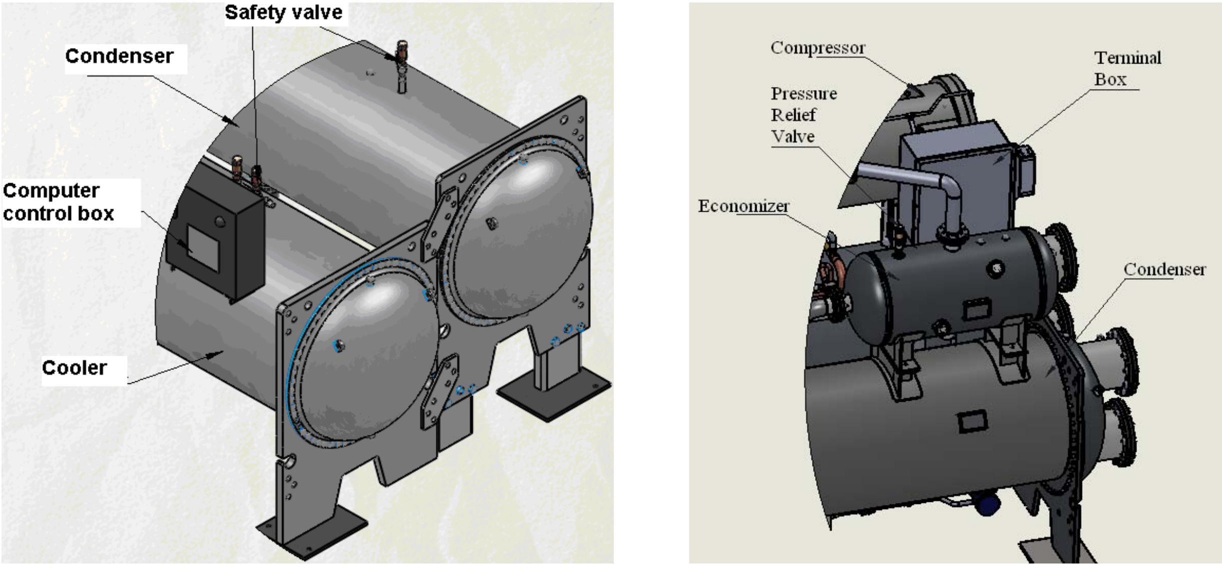


10.0 PREPARATION BEFORE STARTUP

10.6 CHECK SAFETY VALVES

Inspect safety valves according to 2.2.5.2. Safety valves locates as shown in Figure 10.6A on the machine.

Figure 10.6A Safety Valves Location



Safety valves are designed to protect the system from danger caused by over pressure. Safety valves must be in good condition in order to make sure that there is no hazard that would result in equipment damage and personal injury. Please use the safety valves properly according to the "Warning Sign" as shown in Figure 10.6B.

Figure 10.6B Safety Valve Sign

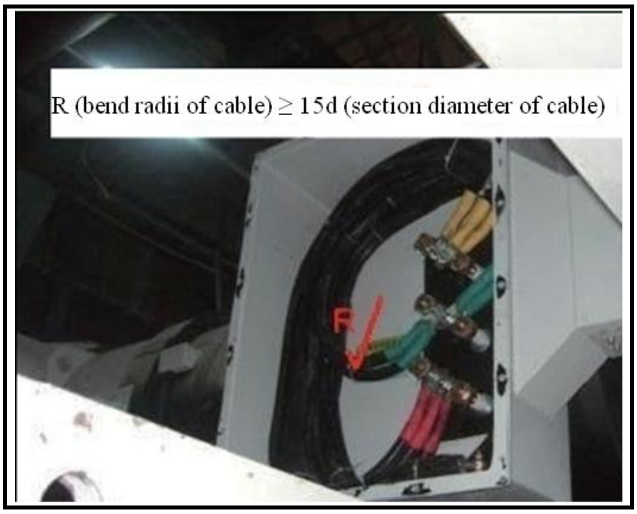
10.7 INSPECT WIRING

- User must not check the power supply until no danger is declared by qualified electrical engineer. Otherwise it will cause serious injury.
- Do not apply any kind of test voltage, even for a rotation check, if the chiller is under a dehydration vacuum. Insulation breakdown and serious damage may result.
- Examine wiring for conformance to job wiring diagrams and to all applicable electrical codes.
- On low-voltage compressors (600V or less) connect voltmeter across the power wires to the compressor starter and measure the voltage. Compare this reading with the voltage rating on the compressor and starter nameplates.
- Compare the ampere rating on the starter nameplate with the compressor nameplate. The overload trip amps must be 108% to 120% of the rated load amps.
- The starter for a centrifugal compressor motor must contain the components and terminals required for control center.
- Check the voltage to the oil pump box and compressor starter, and compare them to the nameplate values.
- Check that all electrical equipment and controls are properly grounded in accordance with job drawings, certified drawings, and all applicable electrical codes.
- Make sure that the customer's contractor has verified proper operation of the pumps, cooling tower fans, and associated auxiliary equipment. This includes ensuring that motors are properly lubricated and have proper electrical supply and proper rotation.

10.0 PREPARATION BEFORE STARTUP

- For field-installed starters only: test the chiller compressor motor and its power lead insulation resistance with insulation tester such as a megohmmeter; for 415V motor, it should be no less than 5MΩ for 415V motors and 300MΩ for 6kV and 10kV motors.
- Check the installed cable fixer in motor junction box for 6KV and 10KV motors only. If users rejected to install cable fixer that causes damage to the motor and refrigerant leaking, DUNHAM-BUSH is not responsible for the risk.
- Motor wiring pole should not be pressed when connected. Cables coming to motor box must have support to avoid damage to the wiring pole. The bending radius of cable must be no less than 15 times of cable diameter (Figure 10.7).

Figure 10.7 Motor Wiring Pole



10.8 CHECK START (FOR WYE-DELTA STARTER CABINET)

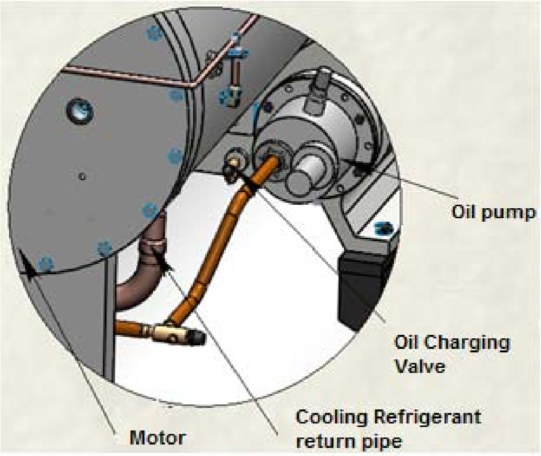
- The main disconnect on the starter front panel may not de-energize all internal circuits. Open all internal and remote including oil pump disconnects before servicing the starter.
- Check all field wiring connections for tightness, clearance from moving parts, and correct connection according to the wiring diagram.
- Inspect the contactors to make sure they move freely. Check the mechanical interlock between contactors to ensure that contactors cannot be closed at the same time.
- Re-apply starter control power (not main compressor power) to check electrical functions according to the Starter operation manual.

10.9 OIL CHARGE

The amount of oil charging varies according to DCLCD compressor model. (Compressor CDT:33L, CDF:45L, CDK:60L, CDN:80L)

The chiller will be shipped with oil charged in the compressor. Refer to section 6.3 for oil sump level. If oil is added, it must comply with Dunham-Bush's specifications for centrifugal compressor usage. Charge the oil through the oil charging valve, located near the bottom of the transmission housing (Figure 10.9). The oil must be pumped from the oil container through the charging valve due to higher refrigerant pressure. Oil should only be charged or removed when the chiller is shut down.

Figure 10.9 Oil Enter Valve Location



10.0 PREPARATION BEFORE STARTUP

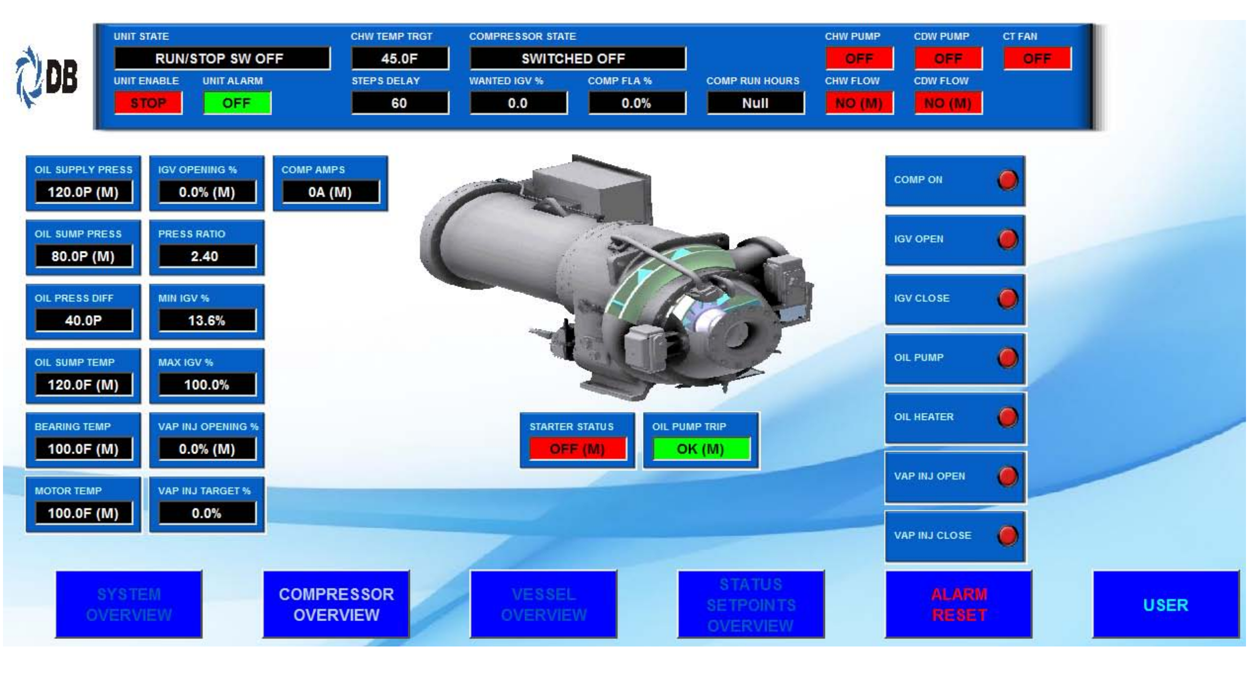
10.10 POWER UP THE CONTROL SYSTEM AND CHECK THE OIL HEATER

The oil heater should be energized 24 hours before startup to make sure the oil sump temperature is between 45 and 50 C degree.

Ensure that an oil level is visible in the compressor before energizing controls. Circuit breakers energize the oil heater and pump separately.

Control box have separate power supply from the main motor, so that oil heater control can still be working when the main breaker is off due to service. The working status of the oil heater is indicated on the panel as shown in Figure 10.10, and oil sump temperature is displayed on screen of control box (Figure 10.10).

Figure 10.10 Control Box Display



10.11 REFRIGERANT CHARGE

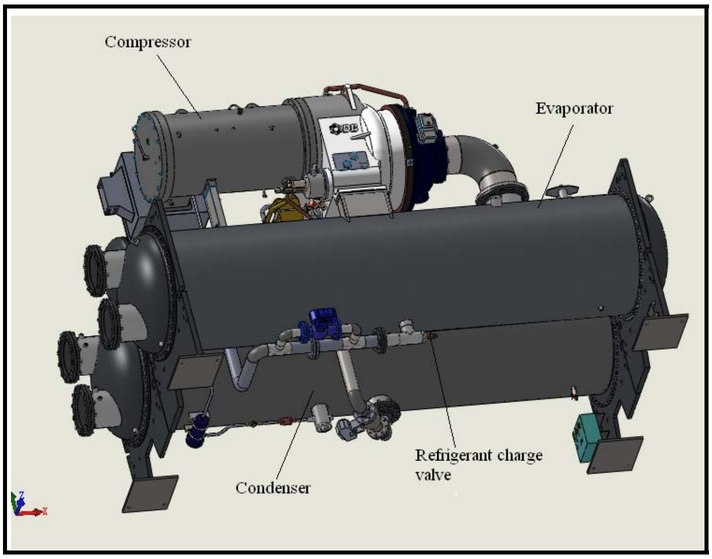
Charge refrigerant through charging valves (as shown in Figure 10.11) after it passed vacuum test.

Turn on chilled water pump, and cooling water pump. Pump out the air in the pipe which connects refrigerant container with the chiller.

Connect refrigerant container with the unit charging valve, opens refrigerant container valve and unit charging valve, charges refrigerant amount according to the nameplate, charges half amount through the charging valve 1, and remaining half amount through the charging valve 2.

Note: The charging valve 2 is a small opening valve, can only be used for charging, cannot be used to drain refrigerant.

Figure 10.11 Refrigerant Charge Valve Location



11.0 INITIAL STARTUP

11.1 PREPARATION BEFORE STARTUP

- Power is on to the main starter, and the control box.
- Cooling tower water is at proper level and at or below design entering temperature.
- Chiller is charged with refrigerant and all refrigerant and oil valves are in their proper operating position.
- Oil is at the proper level in the reservoir sight glasses.
- Oil heater control is on and oil reservoir temperature is above 45 °C.
- Valves in the evaporator, condenser and cooling tower water circuits are open.

11.2 CHECK OIL PRESSURE DIFFERENCE

- When the unit is full load. Record the oil pressure difference reading, which is should be between 0.13~0.25MPa.
- Check if there is any abnormal noise during unload.

12.0 OPERATION GUIDE

12.1 OPERATOR DUTIES

Operators must be properly trained and get authorization from DUNHAM-BUSH to work on the chillers, and become familiar with refrigeration chiller and related equipment before operating the chiller.

- Prepare the system for start-up, start and stop the chiller.
- Maintain a log of operating conditions and document any abnormal readings.
- Inspect and maintain the equipment, and make routine check points. Protect the system from any damage during shutdown periods.
- Do not change the set points, time schedules, and control logic functions.

12.2 CHILLER START, RUN, STOP

12.2.1 Start the water pumps.

12.2.2 Start the chiller.

12.2.3 After the compressor starts at least 30 minutes, the operator should monitor the control panel display and observe the parameters for normal operating conditions:

- Bearing temperature should be between 45～65°C, if it is higher than 80°C, stop the chiller and determine the cause of fault. Do not restart the chill until corrected.
- The oil level should be visible anywhere in one of the two sight glasses.
- The oil pressure should be between 0.13～0.25 MPa differential. Foaming oil is acceptable as long as the oil pressure and temperature are within limits.
- The condenser and evaporator pressures are within normal range according to their corresponding temperatures.
- The modulating ball valve indicator should show opening degree according to the given signal.
- Flash tank liquid level cannot flow over sight glass.

12.2.4 Stop the Chiller for Extended Shutdown

- Be sure that the existing operation time is greater than 30 minutes. Frequent starts should avoid.
- The compressor will shut down when turning the unit control to off button for 1 second.
- Stop the cooling tower fans.
- Unload to stop the unit during normal operation, unit will target unload to below 20% then start unloading, when fully unloaded, compressor will stop running. After the compressor stopped, shall maintain condenser water pump and chilled water pump continue operating. After the unit stopped for 10~30 minutes, stop the chilled water pump. Make sure chilled water temperature greater than 0°C, after 5~10 minutes, stop the cooling water pump, to avoid refrigerant migration and vessel tube crack.
- During extended shutdown, the refrigerant should be pumped out into a storage tank. Maintain chiller with a positive pressure by holding charge of 0.2～0.5 MPa of refrigerant.
- If freezing temperatures are likely to occur, drain/pump out the chilled water and condenser water to avoid freeze-up. Keep the water box drains open.
- Leave the oil charge in the chiller with the oil heater and controls energized in order to maintain the minimum oil reservoir temperature.
- Check the electric actuator of guide vane to make sure it is closed.
- Check the leakage of chiller during extended shutdown.
- It may be advisable to flush the water circuits to remove any soft rust which may have formed.

12.2.5 Chiller abnormal stop

- During unit operation, if happen major leakage, should immediately stop the compressor, but pump should maintain operating because if the water not flowing, the leakage can cause system refrigerant pressure drop to freeze and crack vessel tubes.
- If chilled water pump stop running due to malfunction, should immediately stop the unit, and condenser water pump should continue operating 5~10 minutes after chilled water temperature greater than 0°C, to avoid freezing crack the vessel tube; If condenser water pump stop running due to malfunction, should immediately stop the unit, and if the water temperature not greater than 0°C, must drain out condenser water to avoid refrigerant migration freezing crack the vessel tube.

Warnings:

For low temp chiller that chilled water temperature lower than 0°C, water pump power and unit power should be separated, not recommend to control the pump through the unit, to avoid unit stop due to power failure also cause the pump stop operating. When chilled water temperature below 0°C, please make sure pump still can operate even in power failure to avoid refrigerant migration/freezing crack vessel tubes.

13.0 WEEKLY MAINTENANCE TASK

13.1 CHECK THE LUBRICATION SYSTEM

- Mark the oil level on the reservoir sight glass, and observe the level each week while the chiller is shut down.
- If the level goes below the lower sight glass, check the oil reclaim system for proper operation. If additional oil is required, add it through the oil drain charging valve. A pump is required for adding oil against refrigerant pressure. Any additional oil that is added should be logged by noting the amount and date.
- The oil must be removed when the level is high.
- Oil heater control must be always on to maintain the minimum reservoir temperature. If the oil heater is energized but the sump is not heating up, check the oil level, the oil heater contactor voltage, and oil heater resistance.
- Due to the chiller protection settings, if the oil temperature is below 40°C it will cause the low oil temperature alarm, and the control centre will not permit compressor to start up

13.2 SCHEDULED MAINTENANCE

Establish a regular maintenance schedule based on the actual chiller requirements such as chiller load, run hours, and water quality. The time intervals listed (Table 13.2) in this section are offered as guides to service only.

Table 13.2 Maintenance Schedule

Section	Item	Monthly	Annually
Compressor	Replace the liquid filter, compressor oil filter and oil reclaim filter		Y
	Perform oil analysis		Y
Motor	Measure the isolation resistance		Y
Cooler and Condenser	Confirm the mass of water	Y	
	Water analysis		Y
	Clean the tubes		Y
Electrical device	Check operation of motor starter	Y	
	Check pressure transducers	Y	
	Check electrical actuator	Y	
	Isolation inspection of oil pump		Y
	Check the oil heater		Y
Others	Leakage Inspection	Y	
	Check the control box lights and fuse disconnection	Y	
	Check and tighten all electrical connections		Y
	Refrigerant filter replacement		Y
	Perform refrigerant analysis		Y

Notes: 1) Change oil after first year or 3000 hours of operation (whichever comes first). Subsequent oil change should be done as per oil analysis result.
2) More frequent service may be required depending on local operating conditions.

13.3 INSPECT THE CONTROL BOX

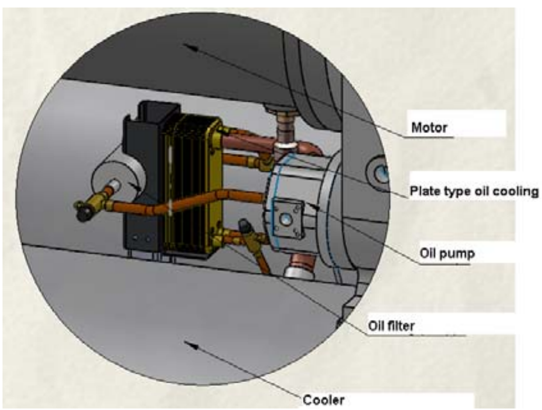
Maintenance is limited to general cleaning and tightening of connections. Vacuum or soft brush should be used to clean the cabinet.

13.4 CHANGE COMP OIL FILTER

Change Compressor oil filter on a yearly basis or when the chiller is opened for repairs. When the filter is changed with the refrigerant remaining in the chiller, use the following procedure:

- Make sure that the compressor is off and the main breaker for the compressor is open.
- Disconnect the power to the oil pump.
- Close the isolation valves before and after oil filter.
- Drain the oil from the filter and pipe. Keep the chiller clean.
- Replace the old filter with a new one.

Figure 13.4 Compressor Oil Filter Location



13.0 WEEKLY MAINTENANCE TASK

13.5 OIL CHANGE PROCEDURE

It is required to change oil after first year or 3000 hours of operation (whichever comes first). Oil analysis shall be done for the subsequent years to ensure the oil is within its characteristic.

- Transfer the refrigerant into the chiller condenser (for isolatable vessels) or a pump out storage tank.
- Mark the existing oil level.
- Open the control and oil heater circuit breaker.
- When the chiller pressure is 0.03MPa or less, drain the oil reservoir by slowly opening the oil charging valve.
- Change the oil filter at this time.
- Charge the chiller with oil until the oil level is equal to the oil level marked in Step 2. Turn on the power to the oil heater and let it warmed up to at least 45°C. Operate the oil pump manually through the Control box for 2 minutes, inspect the oil level. Check it again for shutdown conditions.

13.6 INSPECT SAFETY VALVES AND PIPING

The safety Valves on this chiller protect the system against the potentially dangerous effects of overpressure. To prevent against damage to the equipment and possible injury to personnel, these devices must be kept in peak operating condition.

The following maintenance is required but not limited to:

- At least once a year, disconnect the vent piping at the valve outlet and carefully inspect the valve body and mechanism. If the chiller is installed in a corrosive atmosphere or the safety Valves are vented into a corrosive atmosphere, make the inspections more frequent.
- If corrosion or foreign material is found, replace the valve. Do not attempt to repair the valve.
- Do not install the valves reversely or in series.

13.7 COMPRESSOR BEARING AND GEAR MAINTENANCE

The key to good bearing and gear maintenance is proper lubrication. Use the proper grade of oil, maintain it at recommended level, temperature, and pressure. Inspect the lubrication system regularly and thoroughly.

If a complete compressor teardown is required in order to inspect the bearings, operation should only be done by DUNHAM-BUSH trained and authorized service technicians.

13.8 INSPECT THE HEAT EXCHANGER TUBES

- Inspect the heat exchanger every year. Upon inspection, the tube condition will determine the scheduled frequency for cleaning.
- Because these tubes have internal ridges, a rotary-type tube cleaning system is required to thoroughly clean the tubes. Do not use wire brushes in order not to scrap and scratch the tube wall.
- Inspect the entering and leaving water temperature sensors for signs of corrosion or scale. Replace the sensor if corroded or remove any scale if found.

13.9 INSPECT THE STARTING EQUIPMENT

- Before working on any starter, shut off the chiller and open all disconnects supplying power to the starter.
- The inspector must be qualified electrician.
- Inspect starter contact surfaces for wear or pitting on mechanical-type starters. Do not sandpaper or file silver plated contacts.
- Power connections on newly installed starters may relax and loosen after a month of operation. Turn power off and retighten.
- Recheck the tightness annually thereafter, and clean the dust periodically.

13.10 INSPECT PRESSURE TRANSDUCERS

Once a year, the pressure transducers should be checked against a pressure gage reading. Check all four transducers: the 2 oil pressure transducers, the condenser pressure transducer, and the cooler pressure transducer.

14.0 TROUBLESHOOTING GUIDE

If anything is abnormal during the operation, referring to table below (Table 14.0), determine the causes and solve the problem in order to bring the machine back to normal condition.

If anything abnormal is found in or out of the list below, determine the causes and solve them as soon as possible. If any queries, please contact Dunham-Bush local office for assistance.

Table 14.0 Chiller Troubleshooting

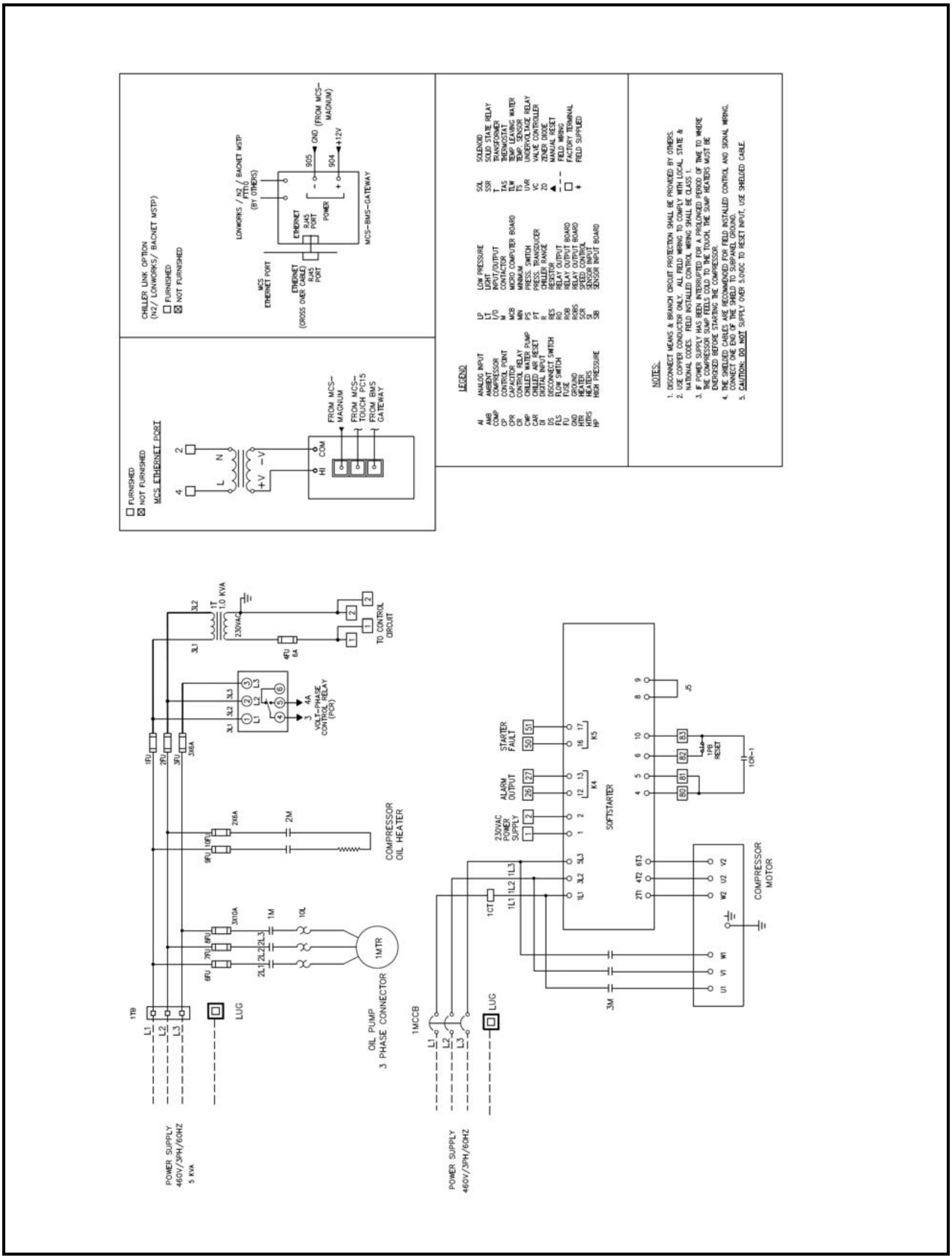
Malfunction	Cause	Solution
Compressor cannot run	1. Power off (Interrupt) 2. Overload 3. Main Breaker failure 4. vessels low (high) pressure switch	1. Power on after check 2. Determine the cause of overload. 3. Check and replace. 4. Check and adjust the pressure settings.
Unduly Low evaporating pressure	1. Insufficient chilled water flow 2. Under load 3. Orifice clogged 4. The heat exchange efficiency of tube become worse because of pollution such as scale. 5. Insufficient refrigerant	1. Check the chilled water circuit and make the water flow reach its rated value. 2. Check the auto restart/stop temperatures 3. Clean the tube. 4. Charge the refrigerant to required volume
Unduly High condensing pressure	1. Insufficient cooling water flow 2. The cooling capacity of cooling tower decreases. 3. High condenser load because of the high cooling water temperature 4. Air trapped in system 5. The heat exchange efficiency of tube become worse because of pollution such as scale.	1. Check the cooling water circuit and make the water flow reach its rated value. 2. Inspect the cooling tower 3. Clean the tube
Low differential oil pressure	1. Oil filter blocked 2. The degree of oil pressure regulating valve (oil release valve) is opened more than required. 3. The pump out oil volume decreases. 4. Bearings worn out 5. Oil pressure sensor failure 6. Lubrication oil mixed with excessive refrigerant. (the oil pressure decreases due to foaming when startup)	1. Replace the oil filter 2. Turn down the oil pressure valve to bring up the oil pressure to rated pressure. 3. Inspect the pump 4. Change the bearings. 5. Check with oil pressure gauge and readjust the pressure sensor, replace it if necessary. 6. Launch oil heater after shutdown to maintain oil temperature. (Make sure the oil heater is well connected and the set value is correct)
High oil temperature	1. The cooling capacity of oil cooler decreased. 2. Insufficient refrigerant supplied to oil cooler because the refrigerant filter blocked. 3. Bearings worn out	1. Regulate the oil temperature adjusting valve 2. Clean the refrigerant filter or replace it 3. Repair or replace the bearings.
Chilled water cut off	1. Insufficient chilled water flow	1. Check the chilled water pump and chilled water circuit, bring up the water flow to rated value.
Main motor overload	1. Phase voltage unbalanced 2. Power supply voltage drop too much 3. Insufficient cooling refrigerant supplied to main motor	1. Balance the power supply phase voltage 2. Reduce the power supply voltage drop 3. Check and clean the refrigerant filter, turn up refrigerant regulating valve
High evaporating pressure	The temperature of chilled water increases due to unexpected load	Normal
low condensing pressure	1. Low inlet cooling water temperature 2. Big cooling water volume 3. Insufficient cooling capacity due to lack of the refrigerant in the cooler	1. No failure. But pay attention to the temperature difference between entering chilled and cooling water. 2. Check the pressure difference of cooling water inlet and outlet $\Delta h'$, and adjust it to rated value. 3. Recharge more refrigerant to the set volume

14.0 TROUBLESHOOTING GUIDE

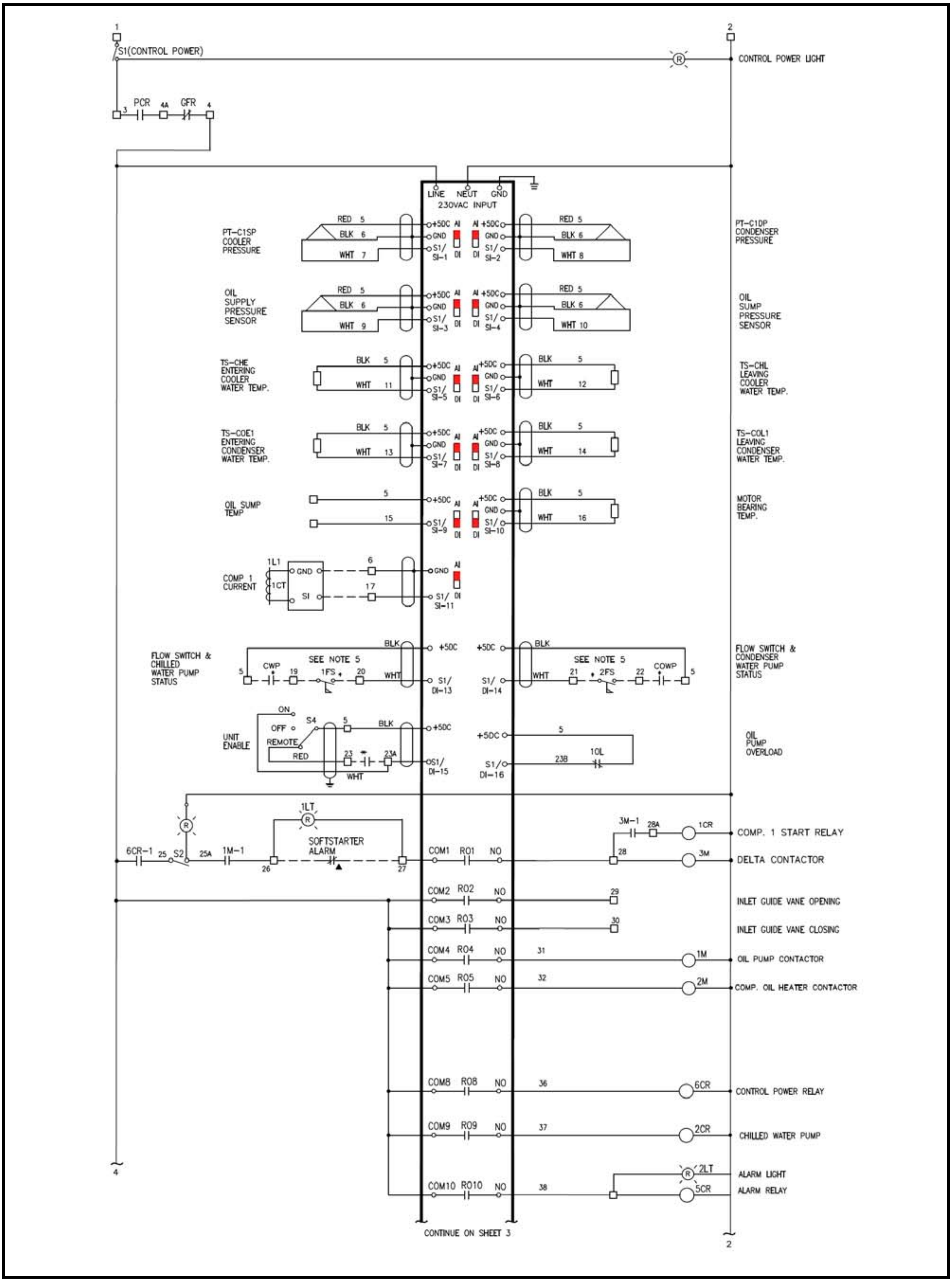
Malfunction	Cause	Solution
Pressure inside the chiller decrease (increase) when stop	The refrigerant temperature is affected by room temperature	Normal
Oil level drops during operation	1. Since the oil is mixed with refrigerant, which evaporates and brings oil together to the compressor during startup. 2. Oil is charged too much and absorbed by the compressor though balance pipe on top of gear box. 3. Nozzle, one-way valve is blocked, the oil separated from the refrigerant cannot return to the sump.	1. Launch the oil heater during the chiller shut down to maintain the oil temperature. 2. Make sure the oil level is in the normal range, or drain out excessive oil. 3. Disassemble and clean the educator and one-way valve
Oil level rises during operation	Low oil temperature, the refrigerant is mixed into the oil.	Check the oil temperature during operation and adjust it to the set value through oil temperature regulating valve.
Oil level rises during shutdown	Low oil temperature and the refrigerant is mixed into the oil.	Make sure the oil heater work.
Oil pressure fluctuates	1. Compressor surge 2. Oil temperature regulating valve unstable.	1. Refer to "Compressor surge" item 2. Adjust the oil pressure regulating valve
Low oil supply pressure during startup and operation	1. Not enough open degree of oil pressure regulating valve 2. High viscosity of lubricant oil 3. Low oil temperature	1. Turn up the oil pressure regulating valve 2. Use specific oil brand from Dunham-Bush 3. Adjust the oil temperature regulating valve.
Compressor noise	1. The rotary parts touch the fixed parts 2. Bearings worn-out or burnout.	1. Disassemble and check 2. Disassemble and replace
Vibration increases.	1. The vibration-absorbing rubber aging 2. The rotator unbalanced 3. Bearings worn-out 4. The base is broken. 5. Main motor abnormal	1. Replace the vibration-absorbing rubber. 2. Check the rotator and do dynamic balance again. 3. Replace the bearings. 4. Repair the base. 5. Check the main motor, disassemble it if necessary.
Compressor surge	1. High condensing pressure 2. Low condensing pressure	1. Refer to high condensing pressure item 2. Refer to Low condensing pressure item
Unit surge when manual operation of guide vane	Guide vane is operated out of range under its specific condition	Adjust the guide vane open degree

15.0 TYPICAL WIRING DIAGRAM

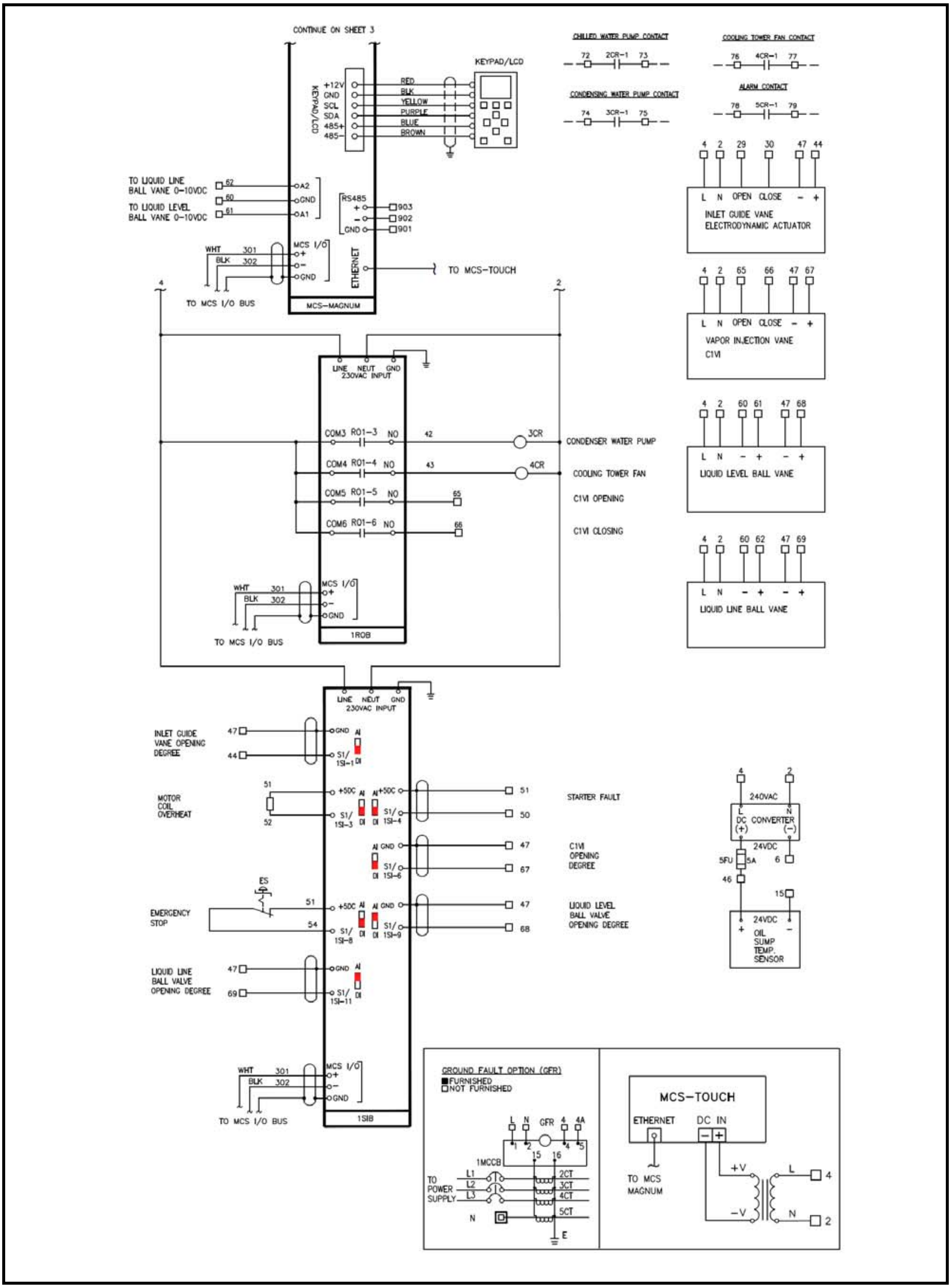
15.1 SOFT STARTER



15.0 TYPICAL WIRING DIAGRAM



15.0 TYPICAL WIRING DIAGRAM



16.0 APPENDIX

16.1 WATER QUALITY REQUIREMENT

Water quality should be maintained within the limits indicated in table below:

Water Characteristic	Limits
pH	7 - 8.5
NH_3	<1 ppm
NH^{4+}	<1 ppm
Cl_2	<1 ppm
Cl^-	<200 ppm
H_2S	<0.05 ppm
SO_4^{2-}	<70 ppm
Fe^{2+}	<0.2 ppm
Fe^{3+}	<0.2 ppm
O_2	<5 ppm
NO_3	<100 ppm
Si	<0.1 ppm
Al	<0.2 ppm
Mn	<0.1 ppm
$CaCO_3$	<150 ppm

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