



# POSEIDON

Variable Speed Water Cooled Screw Chillers

WCFX-V 50/60Hz

Cooling Capacity: 133 to 747 TR (467 to 2627 kW)



# DUNHAM-BUSH®

Products that perform...By people who care

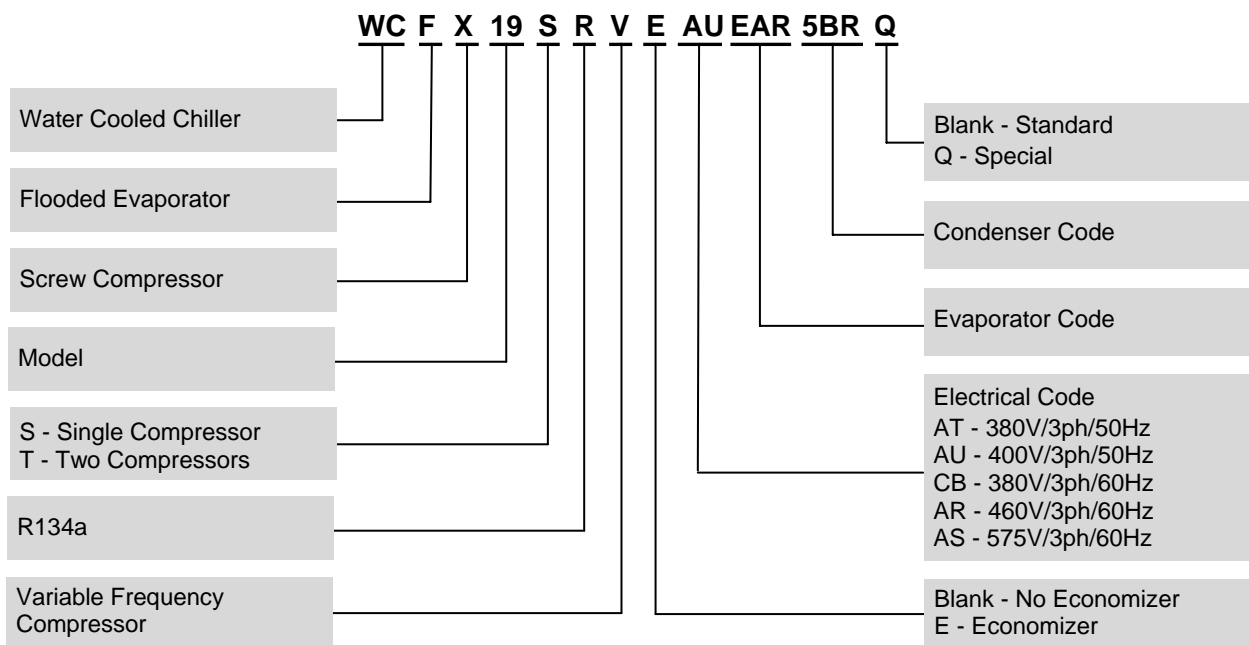
# INTRODUCTION

The Dunham-Bush POSEIDON series WCFX-V Variable Speed Water Cooled Rotary Screw Flooded Chillers are available from 133 to 747 TR [467 to 2627 kW]. These units are supplied with rotary screw compressors that are backed by more than 45 years of experience. The WCFX-V series are Dunham-Bush premium chillers for commercial and industrial applications where installers, consultants and building owners require maximum quality and optimal performances especially at part load. The WCFX-V series are AHRI certified.

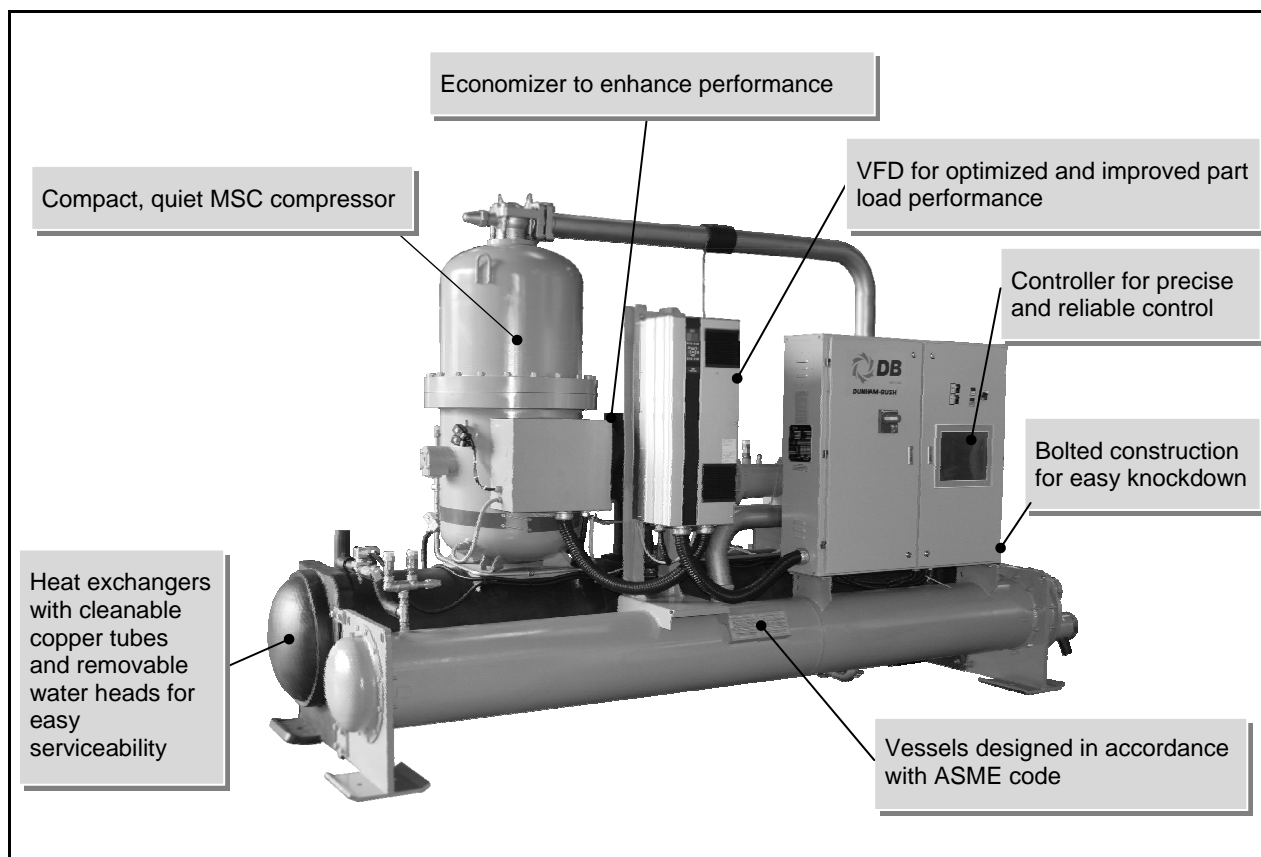
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# NOMENCLATURE



# COMPONENTS



# GENERAL CHARACTERISTICS

## GENERAL

- ✿ 20 models from 133 to 747 TR [467 to 2627 kW]
- ✿ Built-in with Variable Frequency Drive (VFD) for compressor, no starter is required
- ✿ Direct-drive, twin screws compressors driven by VFD offers superior part load energy efficiency
- ✿ Models with twin compressors provide unparallel redundancy and reliability, with enhanced superior part load energy efficiency
- ✿ Great improvement on ***Integrated Part Load Value*** (IPLV), which rated in accordance with AHRI Standards 550/590-2011
- ✿ Substantially reduced operating sound level, especially at part-load operation; sound level can be reduced up to 12 dB(A) for twin compressors models at part load operation
- ✿ Units are ETL listed for North America and Canada regions

## Computer Performance Ratings

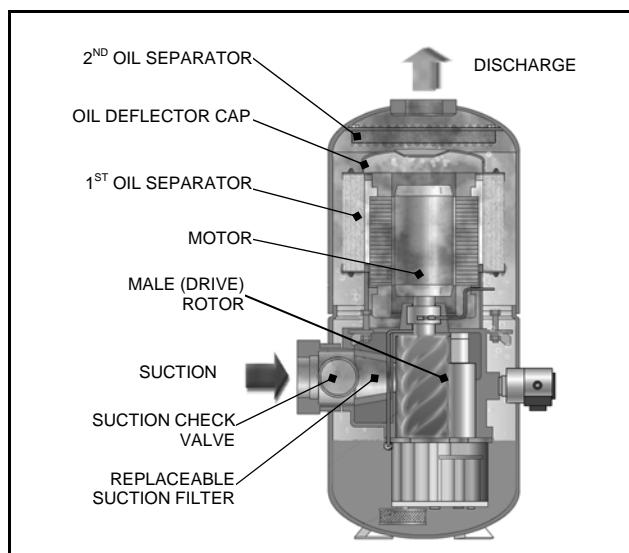
Dunham-Bush WCFX-V Chillers are available from 133 to 747 TR [467 to 2627 kW]. The vast number of combinations of heat exchangers, compressors and motors make it impractical to publish tabular ratings for each combination. A chiller may be custom matched to certain building requirements by your Dunham-Bush Sales Representatives utilizing the WCFX-V Computer Selection Program. Data which can be provided to you will include:

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

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

# GENERAL CHARACTERISTICS

## Compressors



- ✦ New generation of Dunham-Bush MSC Vertical Screw Compressors with Unique Patented Screw compressor technology, offers further improved reliability and stability, with lower sound level
- ✦ Optimized oil management with up to 2 integral oil separators. Multi-layered mesh element effectively separates oil from the gas stream
- ✦ No external oil pump required
- ✦ Vertical screw design with unparalleled reliability on compressor lubrication; rotor bearings are submerged in oil that guarantees rotor lubrication whenever the compressor is in operation
- ✦ Patented screw profile design which is specially made for R134a application, to assure operation at highest efficiencies
- ✦ Optimized volume ratio, VI port position and geometry for best efficiency
- ✦ Hermetic design eliminates casing leakage, with no requirement for internal parts service, no periodic compressor tear down and overhaul
- ✦ Suction and discharge service valves are provided for the ease of servicing

## Evaporator / Condenser

- ✦ Shell-and-tube type heat exchanger
- ✦ Flooded type evaporator
- ✦ 2-pass arrangement. 1-pass or 3-pass arrangement available as option
- ✦ Integral finned copper tubes to maximized heat transfer area
- ✦ Cleanable copper tubes for easy serviceability
- ✦ Removable water heads for service
- ✦ Victaulic Groove Water connection comply to ANSI/AWWA C-606
- ✦ Evaporator comes with 1" [25mm] thick closed cell insulation
- ✦ Standard relief valve(s) – 3/4" [19mm] FPT
- ✦ Pressure test up to 220psig for refrigerant side, and 195psig for water side

- ✦ Condenser design capable for full pump down operation

## Variable Speed Drive (VSD)

- ✦ Regulates motor speed to matched with capacity demand
- ✦ Offers faster response on load changed, and precise capacity control
- ✦ Soft start the compressor to minimized compressor inrush current to virtually, zero inrush current
- ✦ Built-in harmonic filter
- ✦ Built-in Radio Frequency Interference (RFI) filter
- ✦ Maintain displacement power factor at minimum 0.95 at all operating conditions

## Electronic Expansion Valve (EEV)

- ✦ EEV is used for precise control of liquid refrigerant flow into the evaporator
- ✦ Refrigerant liquid level in evaporator is controlled at precise level for optimum performance
- ✦ EEV with variable speed compressors offer unit operation at most outstanding part-load energy efficiency. This benefits owners by reducing the unit annual operating and lifecycle costs

## Economizer

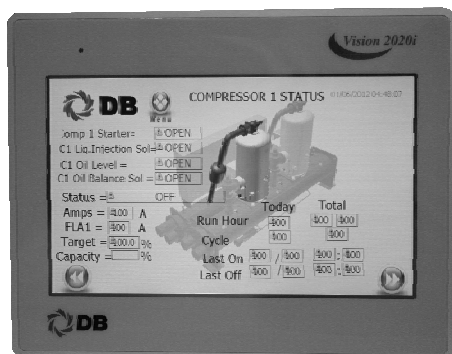
- ✦ The economizer circuit consists of plate type heat exchanger, expansion valve and solenoid valve
- ✦ Refrigerant is sub-cooled at economizer before entering the evaporator; the flash refrigerant from economizer is fed into compressor at intermediate pressure
- ✦ The economizer increased cooling capacity by means of the sub-cooling circuit
- ✦ Cooling capacity is increased significantly with marginal increases in kW-input, thus, unit EER is improved

## Control Panel

- ✦ Electrical enclosure fabricated by heavy gauge sheet steel with powder coated baked finishing
- ✦ Single point power connection for all models
- ✦ Circuit breaker for each compressor motor
- ✦ VFD for compressor motor
- ✦ Solid state motor protector module for compressors
- ✦ Step down transformer for control circuit
- ✦ Main power supply monitoring module. Protection on under or over voltage, phase reversal, phase losses and imbalance
- ✦ Unit mounted Remote/Off/Local (R/O/L) selector switch, an operation and servicing friendly feature
- ✦ Vision 2020i – the state-of-art Dunham-Bush proactive advanced controller monitors the unit operation and maintains optimal operation of the unit. Vision 2020i is an intelligent controller that able to operate the unit with optimum efficiency at off-design conditions. Vision 2020i adapts to any abnormal operating conditions and will execute preventive controls and actions for safety protections

# UNIT FEATURES

## VISION 2020i CONTROLLER



Vision 2020i, an advance programmable electronic controller designed specifically for the applications and precise control of Dunham-Bush Variable Speed Rotary Screw compressor chillers, WCFX-V.

The controller is provided with a set of terminals that connected to various devices such as temperature sensors, pressure and current transducers, solenoid valves, control relays and etc. Three sizes of controller boards are provided to handle different number of input and output requirements: DB3-S small board, DB3-M medium board and DB3-L large board.

The unit algorithm program and operating parameters are stored in FLASH-MEMORY that does not require a back-up battery. The program can be loaded through PC or programming key.

Vision 2020i controller is equipped with a user friendly DBG5 graphical touch screen color display panel. DBG5 display terminal has dedicated touch keys that provides easy access to the unit operating conditions, control set points, trend graphs and alarm histories.

Each unit's controller can be configured and connected to the local DBLAN network that allows multiple units sequencing control without additional hardware. The DBLAN is local area network made up of several chillers' controller.

### Display and User Terminal

Vision 2020i controller is designed to work with the DBG5 terminal display, a 7" TFT, 65k colors, LED backlight touch screen graphical display panel. DBG5 terminal display allows carrying out all program operations. The user terminal allows displaying the unit working conditions, compressor run times, alarm history and modifying the parameters. The display 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 display terminal.

Touch keys on DBG5 graphical display panel allow user to access information and settings, based on security level of the password. For more detail operation of the Display Terminal, please refer to the Unit Operation Manual.

Easily accessible measurements include:

- ✿ Leaving chilled water temperature
- ✿ Rate of Change for leaving chilled water temperature
- ✿ Evaporator pressure

- ✿ Condenser pressure
- ✿ Compressor discharge temperature and superheat
- ✿ Current drawn by each compressor
- ✿ Compressor operating frequency
- ✿ Compressor capacity (percentage of FLA, Full Load Amps)
- ✿ Run hours of each compressor
- ✿ Number of starts of each compressor
- ✿ Electronic Expansion Valve (EEV) Opening Percentage
- ✿ Compressors motor status
- ✿ Oil Level Status, Water Flow Switch Status, Remote Start/Stop Command Status
- ✿ Trend graph of leaving chilled water temperature

### Capacity Control

Leaving chilled water temperature control is accomplished by entering the water temperature setpoint and placing the controller in automatic control. WCFX-V chillers visualized precise capacity control thanks to the VFD controlled, direct driven compressor. Vision 2020i monitors all control functions and regulates compressor motor speed to match closely to the actual building load requirement. This will put the chiller operation at optimum efficiency at all time, and thus, maximized the energy saving of the chiller plant operation.

The compressor ramp (loading) cycle is programmable and may be set for specific building requirements. Remote adjustment of the leaving chilled water setpoint is accomplished either through High Level Interfacing (HLI) via BMS communication, or Low Level Interfacing (LLI) via an external hardwired, 4 to 20mA chilled water reset control signal. Remote reset of compressor current limiting function can be accomplished in a similar fashion

### System Control

The unit may be started or stopped manually, or through the use of an external signal from a Building Automation System. In addition, the controller may be programmed with seven-day operating cycle or other Dunham-Bush control packages may start and stop the system through inter-connecting wiring.

### System Protection

The following system protection controls will automatically act to insure system reliability:

- ✿ Low evaporator pressure
- ✿ High condenser pressure
- ✿ Freeze protection
- ✿ Low suction discharge pressure differential
- ✿ Low compressor oil level
- ✿ Compressor run error
- ✿ Power loss
- ✿ Chilled water flow loss
- ✿ Sensor error
- ✿ Compressor over current
- ✿ Compressor Anti-recycle
- ✿ VFD fault

The controller can retains up to 99 alarm histories complete with time of failure together with data stamping on critical sensor readings in an alarm condition. This tool will aid service technicians in troubleshooting tasks enabling downtime and nuisance trip-outs to be minimized.

# UNIT FEATURES

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## Remote Monitoring & Control (Option)

Dunham-Bush, the leader of HVAC solution provider understands the arising focus on chiller plant performance and optimization. Several solutions as below are offered to the building owner to achieved optimized chiller plantroom controls, operation and performance.

## DB-LAN Master Slave Sequencing Control (MSS)

In a chiller system with multiple Dunham-Bush chillers, Vision 2020i controller of each chiller can be connected to the DB-LAN network via a communication bus without additional controller, to enable Master-Slave Sequencing Control of this chiller system. **MSS** will stage in/out chiller in operation to match building required cooling capacity. Chiller Lead-lag, duty-standby and alarm changeover controls are come with **MSS**, as well as the chilled water pumps control. Each **MSS** DB-LAN network can be connected up to 8 numbers of chillers.

## Dunham-Bush Chiller Plant Manager (CPM)

DB Chiller Plant Manager (**CPM**) is a trustworthy and headache-free solution for building owners and users on chiller plant control and automation system. **CPM**'s advanced controllers monitor and control equipments in chiller plant such as chillers, primary and secondary

chilled water pumps, condenser water pumps, cooling towers, variable frequency drives (VFD), motorized valves, bypass modulating valves, and etc. Field devices such as flow meters, BTU meters, digital power meters, sensors & transducers can be interfaced with **CPM** via HLI or LLI. CPM controls chillers, pumps and cooling towers sequencing, as well as lead-lag, duty-standby and alarm changeover operations.

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

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

## Building Management System (BMS) Communication

Vision 2020i is able to communicate to BMS through the add-on communication card via various common protocols as:

- Modbus RTU RS485, ModBus TCP/IP
- BACnet over IP, MS/TP, or PTP
- LONworks FTT 10

# OPTIONS AND ACCESSORIES

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- ❁ **1-pass Evaporator and Condenser** – 1-pass evaporator or condenser is suitable for applications with low temperature different (delta T) or high fluid flow, where the evaporators or condensers are piped in series
- ❁ **3-pass Evaporator and Condenser** – 3-pass evaporator or condenser is suitable for applications with high delta T and low fluid flow
- ❁ **Evaporator and Condenser Flanged Connection** – Flanged connection is available on request
- ❁ **Marine Water Box** – Marine water box for condenser, for ease of condenser tube cleaning without interfere with field water piping
- ❁ **250 psig Evaporator and Condenser** – Evaporator and condenser vessels with 250 psig working pressure at water side is available to suite site installation
- ❁ **Double Thick Insulation** – Evaporator with double thick 2" [50mm] closed cell insulation, for extra resistance to condensation
- ❁ **Heat Recovery** – Heat recovery cycle that reclaims 'waste' heat from refrigerant system to produce hot water up to 140°F [60°C]. Two methods of heat recovery are available: shell-and-tube desuperheater or double-bundle condenser
- ❁ **Condenser Insulation** – 1" thick closed cell insulation is provided to discharge piping and double-bundle condenser of heat recovery unit.
- ❁ **Hotgas Bypass** – To maintain unit operation below minimum unloaded capacity
- ❁ **Flanged Semi-hermetic Compressor** – Semi hermetic compressor is available on request

- ❁ **Compressor Acoustic Jacket** –Compressor acoustic jacket is added to further reduce sound level
- ❁ **Dual Mode Operation** – The unit with dual mode operation can deliver chilled fluid temperature down to 18°F [-7.8°C] during ice making mode. Units with Dual Mode Operation is used for Ice Thermal Storage System
- ❁ **Low Temp. Operation** – The unit with Low Temp. Operation can deliver chilled fluid temperature down to 18 °F [-7.8 °C] for process cooling application.
- ❁ **ASME / PED / CRN / JKKP Compliance** – Evaporator, condenser and desuperheater with ASME / PED / CRN / JKKP approval is available on request
- ❁ **CE Compliance** – Unit with CE compliance is available on request

## Electrical & Controls

- ❁ **Unit Mounted Main Disconnect Switch** – Non-fused disconnect switch with external lockable handle is furnished to isolate unit main incoming power supply for servicing
- ❁ **Harmonic Filter** – Additional harmonic filter is added to meet IEEE 519 requirements, which to reduce harmonic distortion to less than 5% of total harmonic distortion (THD)
- ❁ **Ground Fault Interrupt (GFI)** – Provides equipment with ground fault protection
- ❁ **Ammeter / Voltmeter** – Analog ammeter and voltmeter with 3 phase selector switch for indication; located on the control panel

# OPTIONS AND ACCESSORIES

- ❖ **Refrigerant Leak Detector** – A refrigerant detection sensor module is connected to Vision 2020i to monitor refrigerant concentration around the unit. Alarm is triggered and unit is shut down when the refrigerant concentration has exceeded the preset safety limit
- ❖ **Chilled Water Reset / Demand Limiting** – Low level interfacing with Building Automation System (BAS). Chilled Water Reset allows controlled temperature setpoint to be reset by a 4-20mA signal from BAS; while Demand Limiting will limit the maximum current drawn by the compressors by 4-20mA signal from BAS.
- ❖ **Chilled Water Pump Control** – Primary chilled water pump is controlled by chiller's Vision 2020i controller for enhanced safety operation
- ❖ **Condenser Water Pump Control** – Condenser water pump is controlled by chiller for enhanced stable operation
- ❖ **Condenser Water Modulating Valve Control** – A 0-10Vdc control signal is output from Vision 2020i controller to regulates the condenser water modulating valve (field supplied) to bypass portion of condenser water, to allow chiller operation at lower ambient temperature
- ❖ **Cooling Tower Fan Staging Control** – Cooling tower fans staging are controlled by chiller's Vision 2020i controller based on operating condenser pressure. This provides energy saving on cooling tower operation, while maintaining chiller operation at optimum performance
- ❖ **Complete Temperature Monitoring** – Entering evaporator water temperature sensor, leaving and entering condenser water temperature sensors can be included for complete temperature monitoring of the unit
- ❖ **IP54 Control Panel** – IP54 rated control panel can be supplied for harsh working environment
- ❖ **System Voltage Readout** – Voltage of power supply is displayed and logged at Vision 2020i controller
- ❖ **GFCI Convenience Outlet (US Region Only)** – 115Vac convenience outlet with female receptacle
- ❖ **BMS Communication** – Various add-on communication cards provide BMS communication via common protocols: Modbus RTU RS485 / TCP/IP, LONworks FTT10, BACnet over IP / MSTP / PTP

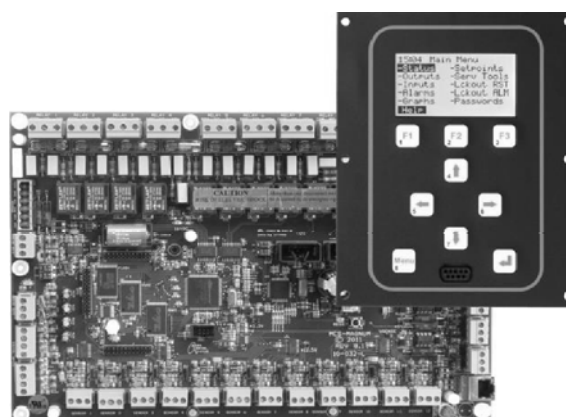
## Factory Supplied, Field Installed Accessories

- ❖ **Water Flow Switch** – Flow switch to be installed at evaporator and condenser outlet piping as safety interlock to evaporator and condenser water flow status. Three options are available: Weather tight flow switch with CE mark; NEMA 3R, and NEMA 4 rated flow switch
- ❖ **Rubber-In-Shear Isolators** – Designed for ease of installation. These one-piece molded rubber isolators are applicable for most installations.
- ❖ **Spring Isolators** – These housed spring assemblies have a neoprene friction pad at the bottom to prevent the passage of noise, and a spring locking levering bolt at the top. Neoprene inserts prevent contact between the steel upper and

lower housings. Suitable for more critical application as compared to rubber-in-shear isolator.

- ❖ **DB-LAN Master Slave Sequencing Control (MSS)** – Pre-programmed at factory; field supplied and installed inter-connection wiring between chillers to provide communication bus among chillers' controllers to enable Master-Slave Sequencing Control
- ❖ **Chiller Plant Manager (CPM)** – Factory supplied control panel; field supplied and installed interconnection wiring and field devices; for complete chiller plant room automation

## DB DIRECTOR (For US Region Only)



DB-Director control system is offered to US region as an option to Vision 2020i control system.

DB-Director is a rugged microprocessor based controller designed for the the HVAC/R applications. DB-Director provides flexibility with setpoints and control options that can be selected prior to commissioning a system or when the unit is live and functioning. Displays, alarms and other interfaces are accomplished in a clear and simple language that informs the user as to the status of the controller.

DB-Director is equipped with 128 x 64 pixels monochrome graphics LCD display with 2.8" diagonal viewing area, and 9 dedicated keys that enable user to access information, base on security level of the password. The user terminal is allows displaying and easy access to the unit working conditions, compressor run times, alarm histories and modify the parameters. 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 display terminal.

The display also has an automatically self-test of the controller on system start-up. For more detail operation of the DB-Director keypad, please refer to the Unit operation Manual.

## Remote Monitoring For DB-Director

DB-Director is equipped with RS485 and Ethernet communication ports as standard. This user friendly design allows Building Management System (BMS) to interface directly with the chiller via either of Modbus RTU, Modbus IP, or BACnet IP communication protocol.

LONworks or BACnet MSTP communication protocol can be established with installation of external adapter.

# OPERATING BENEFITS

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## EFFICIENCY & RELIABILITY

### Compressor Experience

- ✦ More than 45 years of rotary screw experience and dedicated technological advancements. Compressors are CE listed
- ✦ Designed for high reliability with only two rotating parts. No gears to fail
- ✦ Insured continuous oil flow to each compressor through integral high efficiency oil separation for each compressor
- ✦ Chillers use multiple rotary screw compressors for fail-safe reliability and redundancy

### Refrigerant Compatibility

- ✦ Designed to operate with environmentally safe and economically smart HFC-134a with proven efficiency and reliability
- ✦ Consult factory for use with new HFC refrigerants

### Energy Efficiency

- ✦ VFD driven compressor provides superior efficiency and sound level at part load
- ✦ Designed to provide the greatest amount of cooling for the least kilowatt input over the entire operating range of your building
- ✦ Delivers outstanding efficiency and total energy savings through the utilization of Variable speed compressor, economizer and controller controlled staging, producing greater capacity with fewer compressors
- ✦ Maximized performance through computer matched components and multiple compressors on a single refrigerant circuit
- ✦ High efficiency oil recovery system guarantees removal of oil carried over in the refrigerant and maintains the heat exchangers at their maximum efficiency at both full and part load operation

### Installation And Maintenance Ease

- ✦ Side-by-side evaporator/condenser plus snug arrangement of rotary screw compressors result in an extremely compact work envelope
- ✦ Units feature optional split design to allow easy fit through any standard commercial doorway

- ✦ Dramatic payback in reduced maintenance and overhaul costs both in down time and in labor expenditures
- ✦ Ease of troubleshooting through controller retention of monitored functions
- ✦ Evaporators and condensers are designed with removable water heads which can be removed easily without dismantling the chilled water piping connections, for inspection and for mechanical tubes cleaning with brushes or auto-brush. This will enable low tube fouling factor in the evaporator and condenser to be assured, thus maintaining system efficiency

### Factory Testing

- ✦ Each chiller undergoes the factory testing prior to unit shipment. This assures consistencies of workmanship at highest quality
- ✦ Thus, all units shipped are completely factory tested; charged and adjusted according to the design parameters, for ease of installation and minimal field start-up adjustments

### Control Flexibility

- ✦ Controller-based with DDC (direct digital control) features precise touch keys control over every aspect of operation with built-in control philosophy that allow extra energy savings on start-up and throughout the life of your equipment
- ✦ Insured uniform compressor loading and optimal energy efficiency through controller controls which utilize pressure transducers to measure evaporator and condenser pressure
- ✦ Lower energy costs resulting from automatic load monitoring and increased accuracy and efficiency in compressor staging
- ✦ Various communication options for remote monitoring of the unit operation
- ✦ Proactive control by controller that anticipates problems and takes corrective action before they occur. Controls will unload compressor(s) if condenser or evaporator pressure approach limits. This will enable unit to stay on the line while warning operator of potential problems
- ✦ Stable and efficient operation with precise chilled water temperature control. Chilled water temperature is controlled at  $\pm 0.8$  °F [0.5 °C] range for your comfort cooling, with best energy saving



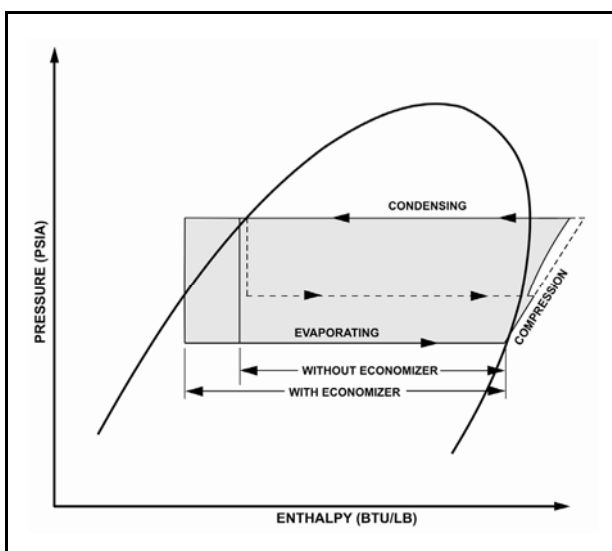
# OPERATING BENEFITS

## REFRIGERATION CYCLE

Dunham-Bush WCFX-V Chillers are designed for efficiency and reliability. The rotary screw compressor is a positive displacement, variable capacity compressor that will allow operation over a wide variety of conditions.

Even at high condenser pressure and low capacity, a difficult condition for centrifugal compressors, the rotary screw performs easily. It is impossible for this positive displacement compressor to surge.

The refrigerant management system is shown in the refrigerant cycle diagram below.



Liquid refrigerant enters the flooded evaporator uniformly where it absorbs heat from water flowing through the evaporator tubes, and vaporized. The vaporized refrigerant is drawn into the compressor suction port where the positive displacement compression begins.

This partially compressed refrigerant gaseous is then mixed with additional flash refrigerant from the economizer in the compression chamber. The compressed gaseous refrigerant is now discharged into the integral oil separator, to separate lubrication oil from the gaseous refrigerant, and recovers lubrication oil back to the oil sump.

The fully compressed and superheated refrigerant is discharged into the condenser, where water in the condenser tubes cools and condenses the refrigerant. Liquid refrigerant leaves the condenser is further sub-cooled by the economizer.

The gaseous refrigerant is drawn out from the economizer and is injected into compressor through the vapor injection port. The remaining liquid refrigerant shall pass through the Electronic Expansion Valve (EEV) which reduces refrigerant pressure to evaporator

levels where it is then distributed evenly into the evaporator.

This delivers outstanding efficiency and total energy savings through the utilization of economizer cycle. Unit EER is improved with economizer cycle.

## PART LOAD PERFORMANCE

Through the use of economizer and multiple compressors, Dunham-Bush WCFX-V Chillers, some of the best part-load performance characteristics in the industry when measured in accordance with AHRI Standard 550/590-2011.

In most cases, actual building system loads are significantly less than full load design conditions, therefore chillers operate at part load most of the time.

Dunham-Bush WCFX-V Chillers combine the efficient operation of Variable Frequency Drive (VFD), multiple rotary screw compressors with economizer and controller control to yield the best total energy efficiency and significant operating savings under any load.

When specifying air conditioning equipment, it is important to consider the system load characteristics for the building application. In a typical city, the air conditioning load will vary according to changes in the ambient temperature. Weather data compiled over many years will predict the number of hours that equipment will operate at various load percentages.

The Air Conditioning and Refrigeration Institute (AHRI) has established a system, in AHRI Standard 550/590-2011, for measuring total chiller performance over full and part-load conditions. It defines the Integrated Part-Load Value (IPLV) as an excellent method of comparing diverse types of equipment on an equal basis. The IPLV is a single number estimate of a chiller's power use weighted for the number of hours the unit might spend at each part-load point. IPLV's are based on AHRI Standard Rating Conditions.

The formula for calculating an IPLV is:

$$IPLV = \frac{1}{\frac{0.01}{A} + \frac{0.42}{B} + \frac{0.45}{C} + \frac{0.12}{D}}$$

**where: A= kW/ton at 100% load point**  
**B= kW/ton at 75% load point**  
**C= kW/ton at 50% load point**  
**D= kW/ton at 25% load point**



# PHYSICAL SPECIFICATIONS

Model WCFX-V	19S	20S	23S	24S	27S	30S	36S	38T	40T	41S
Nominal Capacity TR [kW]	132.8 [467.1]	163.9 [576.4]	186.3 [655.2]	201.7 [709.4]	220.4 [775.1]	248.5 [874.0]	292.2 [1027.7]	270.3 [950.6]	329.9 [1160.3]	332.1 [1168.0]
Nominal Power Input kW	79.6	97.1	107.9	118.9	127.5	147.4	168.0	155.7	191.5	190.2
Energy efficiency kW/TR COP	0.599	0.592	0.579	0.590	0.579	0.593	0.575	0.576	0.581	0.573
Min. % Unit Capacity	5.87	5.94	6.07	5.96	6.07	5.93	6.12	6.11	6.05	6.14
Power Supply V/PH/Hz	380-415/3/50 or 460/3/60									
<b>Compressor</b>										
Model (Qty)	1220(1)	1222(1)	1222(1)	1227(1)	1227(1)	1230(1)	2233(1)	1220(2)	1222(2)	2236 (1)
<b>Evaporator</b>										
Model	FAR	EAR	JAR	JBR	6DR	6ER	7CR	6CR	8BR	7BR
Water Connection Inch	8	6	8	8	8	8	8	8	10	10
Design Press. Water Side psig [kPa]	150[1034]									
Flowrate USgpm [m <sup>3</sup> /h]	316.9[71.9]	391.1[88.8]	444.4[100.9]	481.2[109.2]	525.8[119.4]	592.8[134.6]	697.1[158.2]	644.8[146.4]	787.1[178.7]	792.3[179.9]
Pressure Drop ft wg [kPa]	4.2[12.4]	9.2[27.6]	9.5[28.3]	9.7[29.0]	8.3[24.8]	9.5[28.3]	9.9[29.6]	10.8[32.4]	9.9[29.6]	10.1[30.3]
<b>Condenser</b>										
Model	D2R	5BR	5BR	5CR	6CR	1KR	RAR	K5R	M3R	M1R
Water Connection Inch	6	6	6	6	6	8	8	8	10	10
Design Press. Water Side psig [kPa]	150[1034]									
Flow Rate USgpm [m <sup>3</sup> /h]	373.5[84.8]	460.2[104.5]	521.4[118.4]	565.9[128.5]	616.6[140.0]	697.7[158.4]	816.9[185.4]	755.8[171.6]	923.6[209.7]	927.9[210.6]
Pressure Drop ft wg [kPa]	6.9[20.7]	9.5[28.3]	11.5[34.5]	10.1[30.3]	10.8[32.4]	10.4[31.0]	11.1[33.1]	13.4[40.0]	12.5[37.2]	10.6[31.7]
<b>General</b>										
Unit Length Inch [mm]	132 3/16 [3358]	164 3/16 [4171]	164 3/16 [4171]	164 3/16 [4171]	164 3/16 [4171]	164 3/16 [4171]	174 3/16 [4425]	196 12/16 [4997]	196 12/16 [4997]	174 3/16 [4425]
Unit Width Inch [mm]	70 [1778]	70 [1778]	70 [1778]	70 [1778]	70 [1778]	70 [1778]	70 [1778]	75 [1905]	80 [2032]	70 [1778]
Unit Height Inch [mm]	76 [1930]	76 [1930]	76 [1930]	76 [1930]	78 [1980]	80 [2031]	96 [2438]	86 [2185]	88 [2235]	97 [2464]
Unit Shipping Weight lbs [kg]	8576 [3890]	10496 [4761]	10915 [4951]	11325 [5137]	11962 [5426]	13087 [5936]	15205 [6897]	14103 [6397]	17414 [7899]	16180 [7339]
Unit Operating Weight lbs [kg]	9370 [4250]	11173 [5068]	11632 [5276]	12119 [5497]	12833 [5821]	14065 [6380]	16473 [7472]	15393 [6982]	18673 [8470]	17633 [7998]
R134a Charge (Approx)lbs [kg]	419 [190]	529 [240]	558 [253]	584 [265]	705 [320]	750 [340]	981 [445]	882 [400]	1014 [460]	1102 [500]

Model WCFX-V	46S	46T	50T	54T	57T	60T	73T	75T	81T	87T	90T
Nominal Capacity TR [kW]	375.8 [1321.7]	375.1 [1319.2]	409.4 [1439.9]	444.2 [1562.3]	474.1 [1667.4]	503.7 [1771.5]	582.1 [2047.2]	621.8 [2186.9]	665.0 [2338.8]	707.0 [2486.5]	747.0 [2627.2]
Nominal Power Input kW	212.2	213.4	232.7	252.5	270.7	288.8	337.8	359.7	381.3	399.3	430.2
Energy efficiency kW/TR COP	0.565	0.569	0.568	0.568	0.571	0.573	0.580	0.578	0.573	0.565	0.576
Min. % Unit Capacity	6.23	6.18	6.19	6.19	6.16	6.13	6.06	6.08	6.13	6.23	6.11
Power Supply V/PH/Hz	380-415/3/50 or 460/3/60										
<b>Compressor</b>											
Model (Qty)	2246 (1)	1222 (2)	1222 (1) 1227 (1)	1227 (2)	1227 (1) 1230 (1)	1230 (2)	2233 (2)	2233 (1) 2236 (1)	2236 (2)	2236(1) 2246(1)	2246 (2)
<b>Evaporator</b>											
Model	8DR	8DR	KBR	YAR	YBR	YCR	MAR	MBR	NAR	PAR	PAR
Water Connection Inch	10	10	10	10	10	10	12	12	12	12	12
Design Press. Water Side psig [kPa]	150[1034]										
Flow rate USgpm [m <sup>3</sup> /h]	896.5 [203.5]	894.8 [203.1]	976.7 [221.7]	1059.8 [242.8]	1131.1 [256.8]	1201.6 [272.8]	1388.7 [315.5]	1483.5 [336.7]	1586.6 [360.2]	1686.8 [382.9]	1782.1 [404.5]
Pressure Drop ft wg [kPa]	13.4[40.0]	11.1[33.1]	10.8[32.4]	10.8[32.4]	11.3[33.8]	11.5[34.5]	12.2[36.5]	12.5[37.2]	11.3[33.8]	13.4[40.0]	15.0[44.8]
<b>Condenser</b>											
Model	M5R	M5R	T5R	YAR	YBR	YCR	JAR	JBR	KAR	7CR	8AR
Water Connection Inch	10	10	10	10	10	10	12	12	12	12	12
Design Press. Water Side psig [kPa]	150[1034]										
Flow Rate USgpm [m <sup>3</sup> /h]	1047.9 [237.9]	1047.1 [237.7]	1142.7 [259.4]	1240.0 [281.5]	1324.2 [300.6]	1407.6 [319.5]	1629.5 [369.9]	1740.0 [395.0]	1858.6 [421.9]	1971.7 [447.6]	2088.8 [474.2]
Pressure Drop ft wg [kPa]	11.8[35.2]	10.6[31.7]	11.3[33.8]	10.8[32.4]	11.3[33.8]	11.5[34.5]	13.1[39.3]	12.0[35.9]	11.1[33.1]	13.4[40.0]	13.8[41.4]
<b>General</b>											
Unit Length Inch [mm]	174 3/16 [4425]	196 12/16 [4997]	196 12/16 [4997]	196 12/16 [4997]	196 12/16 [4997]	196 12/16 [4997]	206 12/16 [5251]	206 12/16 [5251]	206 12/16 [5251]	213 12/16 [5429]	213 12/16 [5429]
Unit Width Inch [mm]	75 [1905]	80 [2032]	80 [2032]	80 [2032]	80 [2032]	80 [2032]	88 [2235]	88 [2235]	88 [2235]	90 [2286]	90 [2286]
Unit Height Inch [mm]	100 [2540]	88 [2235]	92 [2337]	97 [2464]	97 [2464]	97 [2464]	100 [2540]	100 [2540]	100 [2540]	108 [2740]	112 [2840]
Unit Shipping Weight lbs [kg]	17505 [7940]	18210 [8260]	19928 [9039]	21645 [9818]	22476 [10195]	23091 [10474]	26819 [12165]	27597 [12518]	29952 [13586]	29729 [13485]	32915 [14930]
Unit Operating Weight lbs [kg]	19255 [8734]	19864 [9010]	21689 [9838]	23587 [10699]	24509 [11117]	25230 [11444]	29145 [13220]	30111 [13658]	32774 [14866]	33687 [15280]	36207 [16423]
R134a Charge (Approx)lbs [kg]	1113 [505]	1113 [505]	1312 [595]	1356 [615]	1422 [645]	1477 [670]	1455 [660]	1543 [700]	1808 [820]	2701 [1225]	2701 [1225]

Notes: 1. The units are rated in accordance with AHRI Standard 550/590. The above data are rated on Superior models with following conditions: Inlet/Outlet Chilled Water Temperature 54/44°F; Inlet/Outlet Cooling Water Temperature 85/95°F; evaporator fouling factor 0.0001hr.ft<sup>2</sup>.°F/Btu; condenser fouling factor 0.00025 hr.ft<sup>2</sup>.°F/Btu; 2-pass evaporator and condenser.  
 2. To consult nearest Dunham-Bush sales office for computer selections other than above operating conditions.



# SOUND PRESSURE DATA

Model WCFX-V	Octave Band (Hz)								Total dB (A)
	63	125	250	500	1000	2000	4000	8000	
19S	68	57	63	68	75	72	72	54	79
20S	68	57	63	68	75	72	72	54	79
23S	68	57	63	68	75	72	72	54	79
24S	69	59	64	68	76	73	74	56	80
27S	69	59	64	68	76	73	74	56	80
30S	70	61	65	69	78	75	74	59	81
36S	70	61	65	69	78	75	74	59	81
38T	71	60	66	71	78	75	75	57	82
40T	70	59	65	70	77	74	74	56	81
41S	70	61	65	69	78	75	74	59	81
46S	73	64	68	72	81	78	77	62	85

Model WCFX-V	Octave Band (Hz)								Total dB (A)
	63	125	250	500	1000	2000	4000	8000	
46T	70	59	65	70	77	74	74	56	81
50T	71	60	66	70	78	75	75	57	82
54T	71	61	66	70	78	75	76	58	82
57T	71	62	66	70	79	76	76	60	83
60T	72	63	67	71	80	77	76	61	83
73T	72	63	67	71	80	77	76	61	83
75T	72	63	67	71	80	77	76	61	83
81T	72	63	67	71	80	77	76	61	83
87T	74	65	69	73	82	79	78	63	86
90T	75	66	70	74	83	80	79	64	87

Note: Sound Pressure Level dB(A) @ 3.3ft [1m] (free field) ± 2dBA.

# ELECTRICAL DATA

## 50Hz

Power Supply		380Vac ± 10% -3Ph-50Hz					400Vac ± 10% -3Ph-50Hz				
Model WCFX-V	Compressor Model	Unit			Compressor		Unit			Compressor	
		RLA	MCA	MFS	RLA	LRA	RLA	MCA	MFS	RLA	LRA
19S	1220 (1)	129	161	250	129	733	122	153	250	122	696
20S	1222 (1)	157	196	350	157	929	149	186	320	149	883
23S	1222 (1)	174	218	350	174	929	166	208	350	166	883
24S	1227 (1)	192	240	400	192	1140	183	229	400	183	1083
27S	1227 (1)	206	258	450	206	1140	196	245	400	196	1083
30S	1230 (1)	238	298	500	238	1320	226	283	500	226	1254
36S	2233 (1)	272	340	600	272	1477	258	323	500	258	1403
38T	1220 (2)	252	284	400	126	733	240	270	350	120	696
40T	1222 (2)	310	349	500	155	929	294	331	450	147	883
41S	2236 (1)	307	384	630	307	1762	292	365	630	292	1674
46S	2246 (1)	343	429	700	343	2111	326	408	700	326	2005
46T	1222 (2)	344	387	500	172	929	328	369	500	164	883
50T	1222 (1) 1227 (1)	376	427	630	172 204	929 1140	357	406	500	163 194	883 1083
54T	1227(2)	408	459	630	204	1140	388	437	630	194	1083
57T	1227 (1) 1230 (1)	438	496	700	205 233	1140 1320	415	470	630	194 221	1083 1254
60T	1230 (2)	466	524	700	233	1320	444	500	700	222	1254
73T	2233 (2)	546	614	800	273	1477	518	583	800	259	1403
75T	2233 (1) 2236 (1)	581	659	800	271 310	1477 1762	552	626	800	258 294	1403 1674
81T	2236 (2)	616	693	1000	308	1762	586	659	800	293	1674
87T	2236 (1) 2246 (1)	646	732	1000	299 347	1762 2111	613	695	1000	284 329	1674 2005
90T	2246 (2)	696	783	1000	348	2111	660	743	1000	330	2005

## 60Hz

Power Supply		460Vac ± 10% -3Ph-60Hz					575Vac ± 10% -3Ph-60Hz				
Model WCFX-V	Compressor Model	Unit			Compressor		Unit			Compressor	
		RLA	MCA	MFS	RLA	LRA	RLA	MCA	MFS	RLA	LRA
19S	1220 (1)	106	133	225	106	608	85	106	175	85	484
20S	1222 (1)	130	163	250	130	771	104	130	225	104	613
23S	1222 (1)	144	180	320	144	771	115	144	250	115	613
24S	1227 (1)	159	199	350	159	946	127	159	250	127	752
27S	1227 (1)	170	213	350	170	946	136	170	300	136	752
30S	1230 (1)	197	246	400	197	1096	157	196	350	157	871
36S	2233 (1)	224	280	500	224	1226	179	224	400	179	975
38T	1220 (2)	208	234	320	104	608	166	187	250	83	484
40T	1222 (2)	256	288	400	128	771	204	230	320	102	613
41S	2236 (1)	254	318	500	254	1462	203	254	400	203	1163
46S	2246 (1)	283	354	630	283	1752	227	284	500	227	1393
46T	1222 (2)	284	320	450	142	771	228	257	350	114	613
50T	1222 (1) 1227 (1)	311	353	500	142 169	771 946	249	283	400	114 135	613 752
54T	1227(2)	338	380	500	169	946	270	304	400	135	752
57T	1227 (1) 1230 (1)	361	409	600	169 192	946 1096	289	328	450	135 154	752 871
60T	1230 (2)	386	434	600	193	1096	308	347	500	154	871
73T	2233 (2)	452	509	700	226	1226	360	405	500	180	975
75T	2233 (1) 2236 (1)	480	544	800	224 256	1226 1462	384	435	630	179 205	975 1163
81T	2236 (2)	510	574	800	255	1462	408	459	630	204	1163
87T	2236 (1) 2246 (1)	534	605	800	247 287	1462 1752	426	484	700	197 229	1163 1393
90T	2246 (2)	574	646	800	287	1752	460	518	700	230	1393

Note: RLA – Rated Load Amps

MCA – Minimum Circuit Amps

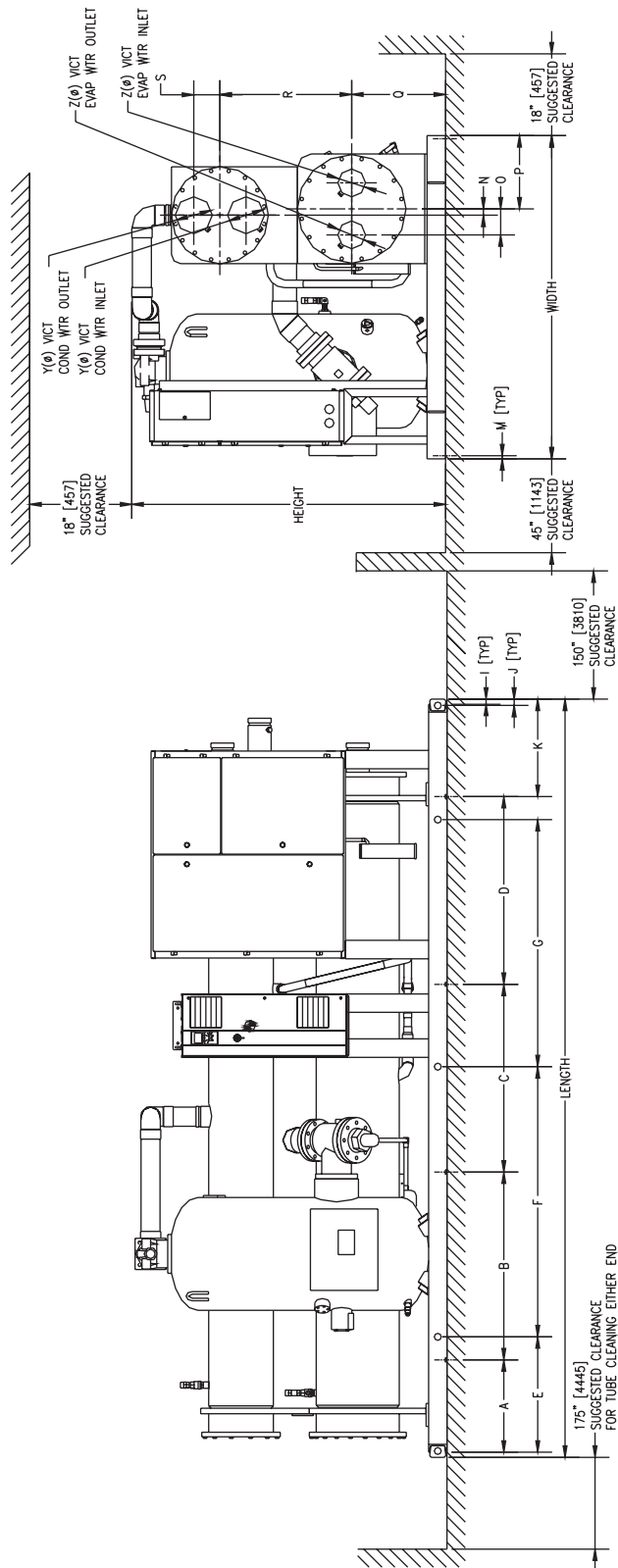
MFS – Maximum Fuse Size

LRA – Locked Rotor Amps

# DIMENSIONAL DATA

## WCFX-V 19S, 20S, 23S, 24S, 27S, 30S, 36S, 41S, 46S

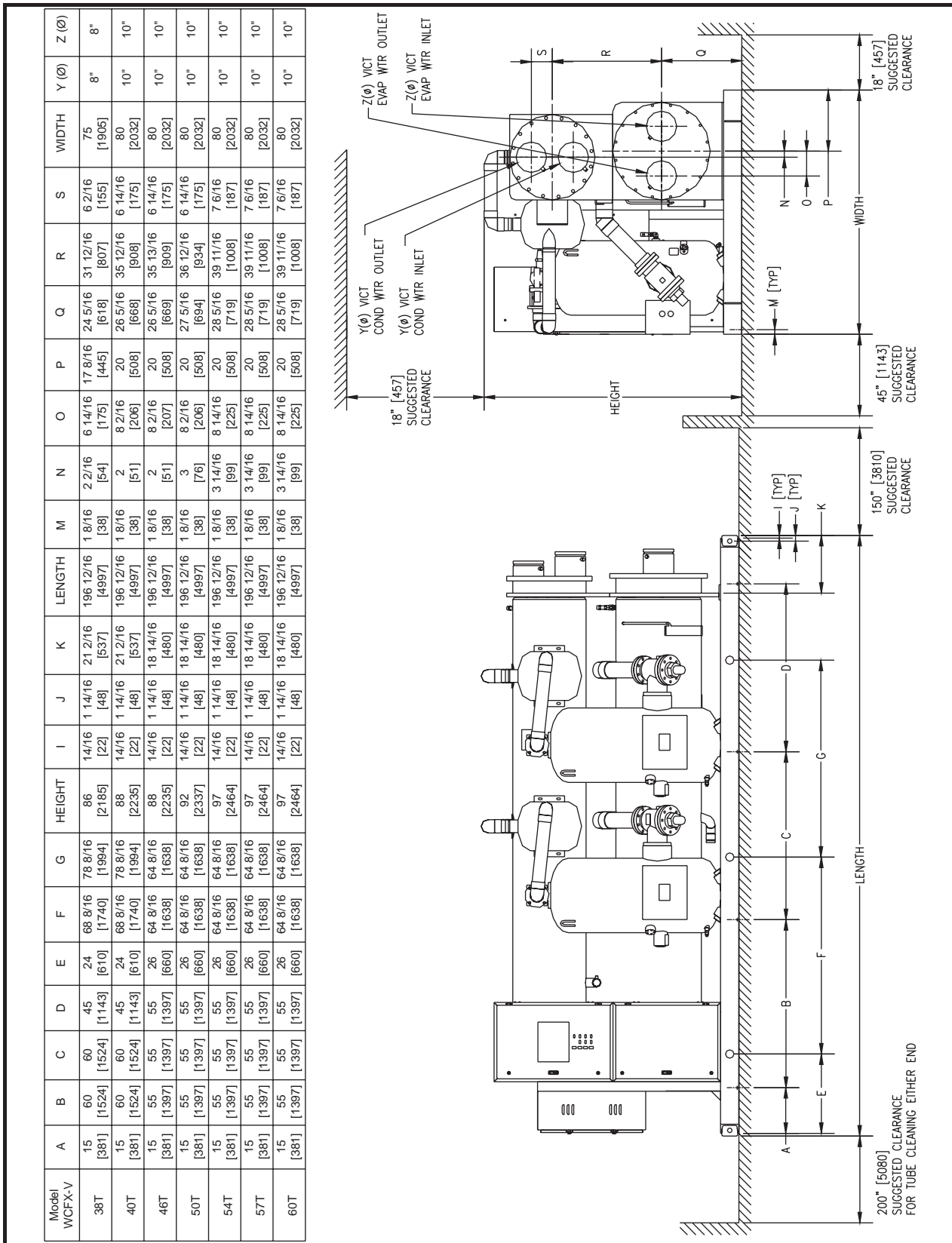
Model	A	B	C	D	E	F	G	HEIGHT	I	J	K	LENGTH	M	N	O	P	Q	R	S	WIDTH	Y (Ø)	Z (Ø)
19S	15 [351]	33 3/16 [843]	33 3/16 [843]	33 3/16 [843]	17 8/16 [445]	37 13/16 [960]	51 3/16 [1300]	76 [1930]	29 [35]	1 2/16 [29]	20 14/16 [530]	132 3/16 [3358]	11/16 [17]	28/16 [64]	6 14/16 [175]	15 14/16 [403]	21 5/16 [541]	29 12/16 [756]	5 10/16 [143]	70 [1778]	6"	8"
20S	20 [508]	40 11/16 [1033]	40 11/16 [1033]	40 11/16 [1033]	25 [635]	58 8/16 [1486]	53 8/16 [1359]	76 [1930]	28 [35]	1 2/16 [28]	20 14/16 [530]	164 3/16 [4171]	11/16 [17]	1 4/16 [32]	5 10/16 [143]	15 14/16 [403]	20 5/16 [516]	28 9/16 [725]	5 10/16 [143]	70 [1778]	6"	6"
23S	20 [508]	40 11/16 [1033]	40 11/16 [1033]	40 11/16 [1033]	25 [635]	58 8/16 [1486]	53 8/16 [1359]	76 [1930]	28 [35]	1 2/16 [28]	20 14/16 [530]	164 3/16 [4171]	11/16 [17]	2 8/16 [64]	6 14/16 [175]	15 14/16 [403]	21 5/16 [542]	29 12/16 [756]	5 10/16 [143]	70 [1778]	6"	8"
24S	20 [508]	40 11/16 [1033]	40 11/16 [1033]	40 11/16 [1033]	25 [635]	58 8/16 [1486]	53 8/16 [1359]	76 [1930]	28 [35]	1 2/16 [28]	20 14/16 [530]	164 3/16 [4171]	11/16 [17]	2 8/16 [64]	6 14/16 [175]	15 14/16 [403]	21 5/16 [542]	29 12/16 [756]	5 10/16 [143]	70 [1778]	6"	8"
27S	20 [508]	40 11/16 [1033]	40 11/16 [1033]	40 11/16 [1033]	25 [635]	58 8/16 [1486]	53 8/16 [1359]	78 [1980]	28 [35]	1 2/16 [28]	20 14/16 [530]	164 3/16 [4171]	11/16 [17]	3 8/16 [96]	6 14/16 [175]	15 14/16 [403]	22 5/16 [567]	30 13/16 [782]	5 10/16 [143]	70 [1778]	6"	8"
30S	20 [508]	40 11/16 [1033]	40 11/16 [1033]	40 11/16 [1033]	25 [635]	58 8/16 [1486]	53 8/16 [1359]	80 [2032]	28 [35]	1 2/16 [28]	21 2/16 [536]	164 3/16 [4171]	11/16 [17]	2 2/16 [54]	6 14/16 [175]	15 14/16 [403]	22 5/16 [567]	31 12/16 [807]	70 [155]	8"	8"	
36S	20 [508]	40 11/16 [1033]	40 11/16 [1033]	50 11/16 [1287]	30 11/16 [780]	60 [1524]	60 [1524]	96 [2438]	28 [35]	1 2/16 [28]	21 2/16 [536]	174 3/16 [4425]	11/16 [17]	2 [51]	8 2/16 [207]	15 14/16 [403]	24 5/16 [618]	35 4/16 [895]	70 [175]	8"	8"	
41S	20 [508]	40 11/16 [1033]	40 11/16 [1033]	50 11/16 [1287]	30 11/16 [780]	60 [1524]	60 [1524]	97 [2464]	28 [35]	1 2/16 [28]	21 2/16 [536]	174 3/16 [4425]	11/16 [17]	1 [25]	7 6/16 [187]	15 14/16 [403]	24 5/16 [618]	36 4/16 [921]	70 [175]	10"	10"	
46S	20 [508]	40 11/16 [1033]	40 11/16 [1033]	50 11/16 [1287]	30 11/16 [780]	60 [1524]	60 [1524]	100 [2540]	28 [35]	1 2/16 [28]	21 2/16 [536]	174 3/16 [4425]	11/16 [17]	2 [51]	8 2/16 [206]	15 14/16 [403]	26 5/16 [668]	37 5/16 [947]	75 [1905]	10"	10"	



Notes : 1.) All dimensions are in inches[mm].  
 2.) Above drawing is for Superior model. Consult factory for Standard and Premium model dimension.

# DIMENSIONAL DATA

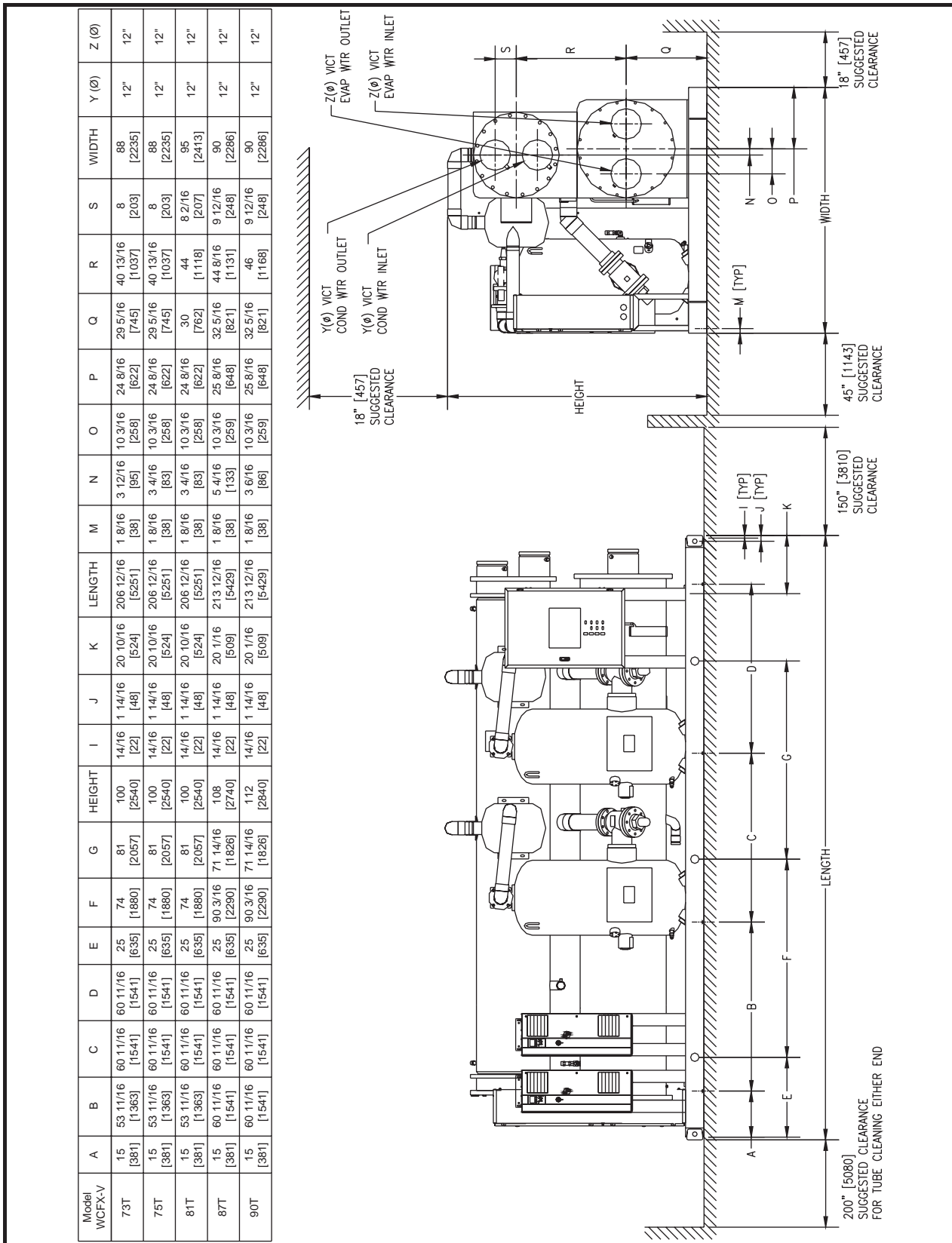
## WCFX-V 38T, 40T, 46T, 50T, 54T, 57T, 60T



Notes : 1.) All dimensions are in inches[mm].  
 2.) Above drawing is for Superior model. Consult factory for Standard and Premium model dimension.

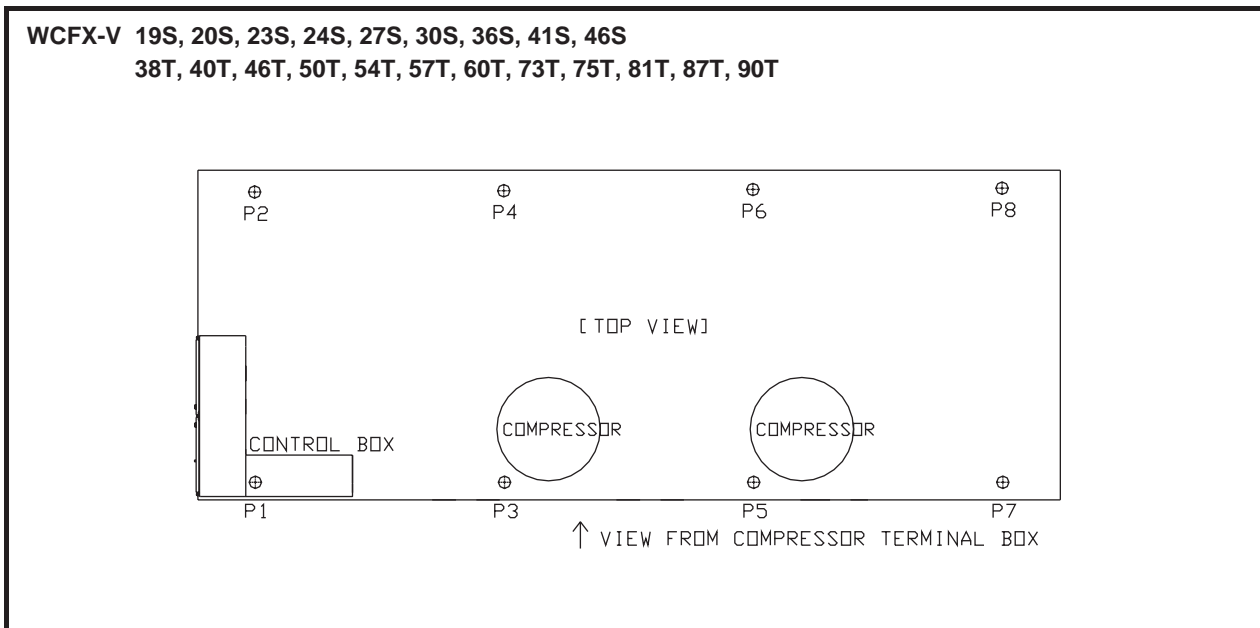
# DIMENSIONAL DATA

## WCFX-V 73T, 75T, 81T, 87T, 90T



Notes : 1.) All dimensions are in inches[mm].  
 2.) Above drawing is for Superior model. Consult factory for Standard and Premium model dimension.

# FLOOR LOADING DIAGRAM



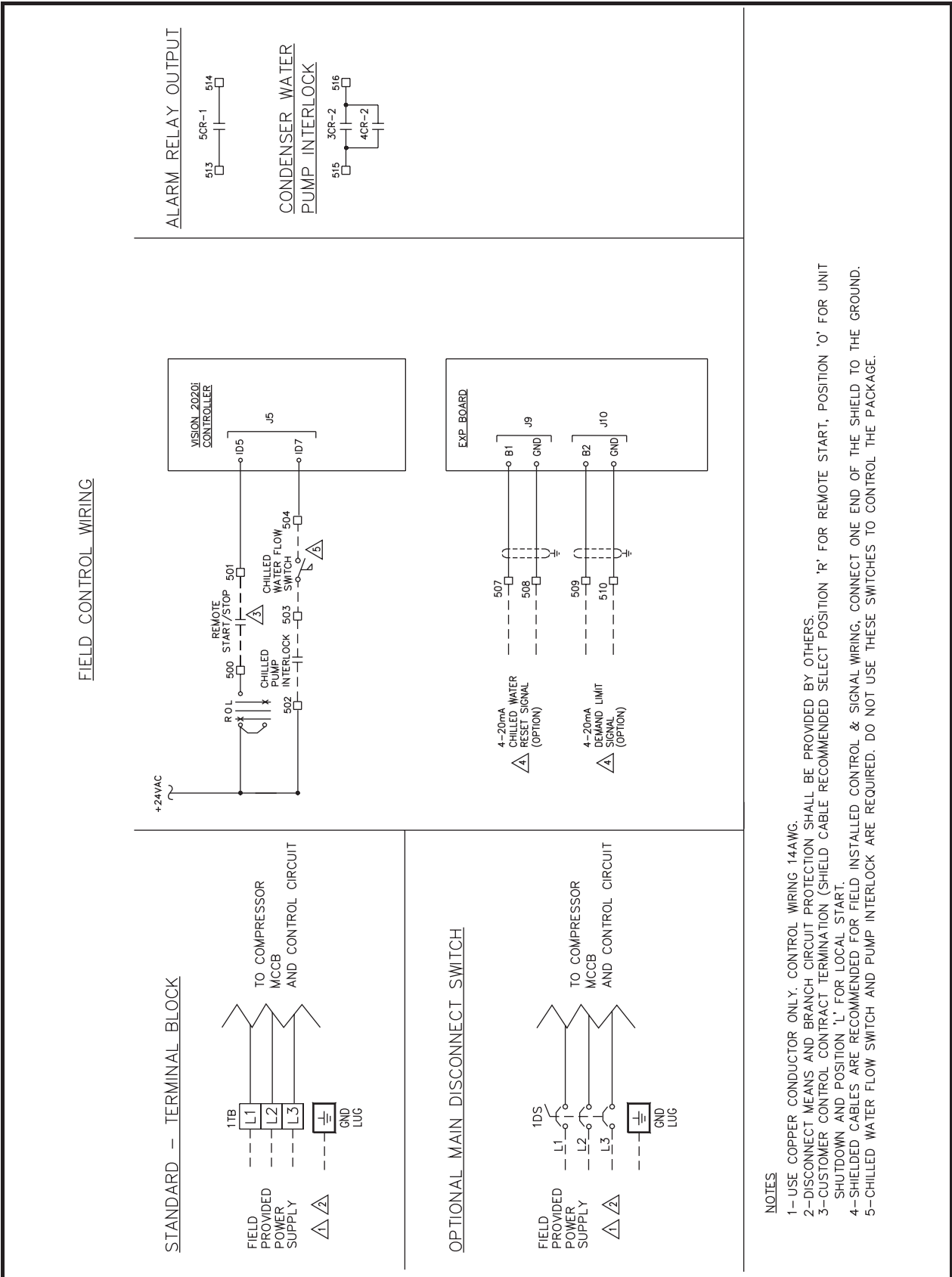
## POINT LOAD DATA

Model WCFX-V	P1	P2	P3	P4	P5	P6	P7	P8	Operating Weight
	Lbs [kg]	Lbs [kg]	Lbs [kg]	Lbs [kg]	Lbs [kg]	Lbs [kg]	Lbs [kg]	Lbs [kg]	Lbs [kg]
19S	1131 [513]	1545 [701]	1034 [469]	1420 [644]	935 [424]	1296 [588]	838 [380]	1171 [531]	9370 [4250]
20S	1292 [586]	1934 [877]	1173 [532]	1764 [800]	1054 [478]	1595 [724]	935 [424]	1426 [647]	11173 [5068]
23S	1329 [603]	2023 [918]	1210 [549]	1846 [837]	1090 [494]	1670 [757]	970 [440]	1493 [677]	11631 [5276]
24S	1411 [640]	2106 [955]	1273 [578]	1918 [870]	1136 [515]	1731 [785]	999 [453]	1544 [700]	12118 [5497]
27S	1468 [666]	2247 [1019]	1329 [603]	2049 [929]	1190 [540]	1850 [839]	1050 [476]	1651 [749]	12833 [5821]
30S	1621 [735]	2456 [1114]	1463 [664]	2238 [1015]	1305 [592]	2020 [916]	1147 [520]	1802 [817]	14052 [6374]
36S	1709 [775]	2838 [1287]	1608 [729]	2653 [1203]	1507 [684]	2468 [1120]	1406 [638]	2283 [1036]	16473 [7472]
38T	1936 [878]	2357 [1069]	1793 [813]	2202 [999]	1651 [749]	2048 [929]	1510 [685]	1896 [860]	15393 [6982]
40T	2348 [1065]	2859 [1297]	2176 [987]	2672 [1212]	2004 [909]	2485 [1127]	1832 [831]	2297 [1042]	18673 [8470]
41S	1813 [822]	3055 [1386]	1705 [773]	2856 [1296]	1597 [725]	2658 [1205]	1489 [676]	2459 [1115]	17633 [7998]
46S	2026 [919]	2980 [1352]	1954 [886]	2924 [1326]	1883 [854]	2867 [1300]	1811 [821]	2811 [1275]	19255 [8734]
46T	2337 [1060]	3057 [1387]	2233 [1013]	2875 [1304]	2129 [966]	2694 [1222]	2025 [919]	2512 [1140]	19863 [9010]
50T	2521 [1144]	3385 [1536]	2403 [1090]	3181 [1443]	2285 [1036]	2976 [1350]	2166 [983]	2771 [1257]	21688 [9838]
54T	2696 [1223]	3713 [1684]	2579 [1170]	3489 [1583]	2461 [1116]	3265 [1481]	2343 [1063]	3041 [1380]	23588 [10699]
57T	2811 [1275]	3809 [1728]	2698 [1224]	3590 [1628]	2585 [1173]	3371 [1529]	2472 [1121]	3151 [1430]	24486 [11107]
60T	2888 [1310]	3897 [1768]	2786 [1264]	3677 [1668]	2684 [1218]	3456 [1568]	2582 [1171]	3236 [1468]	25208 [11434]
73T	3733 [1694]	4850 [2200]	3255 [1476]	4464 [2025]	2777 [1259]	4077 [1849]	2298 [1042]	3690 [1674]	29144 [13220]
75T	3840 [1742]	5012 [2274]	3354 [1521]	4615 [2094]	2868 [1301]	4219 [1914]	2382 [1080]	3822 [1734]	30111 [13658]
81T	4082 [1852]	5504 [2497]	3582 [1625]	5076 [2302]	3082 [1398]	4647 [2108]	2582 [1171]	4218 [1913]	32773 [14866]
87T	2870 [1302]	2294 [1041]	3281 [1488]	4055 [1839]	3691 [1674]	5817 [2639]	4101 [1860]	7578 [3437]	33687 [15280]
90T	2620 [1188]	2100 [953]	3260 [1479]	4348 [1972]	3900 [1769]	6595 [2991]	4541 [2060]	8842 [4011]	36206 [16423]

Notes: 1.) Refer to dimensional drawings for location of mounting points.  
2.) Unit must be lowered onto mounting springs in a level fashion or spring damage may occur.  
3.) Above point load data is for Superior model. Consult factory for Standard and Premium model.

# TYPICAL WIRING SCHEMATIC

## Two Compressors Unit (Vision 2020i)



- NOTES**
- 1--USE COPPER CONDUCTOR ONLY. CONTROL WIRING 14AWG.
  - 2--DISCONNECT MEANS AND BRANCH CIRCUIT PROTECTION SHALL BE PROVIDED BY OTHERS.
  - 3--CUSTOMER CONTROL CONTRACT TERMINATION (SHIELD CABLE RECOMMENDED SELECT POSITION 'R' FOR REMOTE START, POSITION 'O' FOR UNIT SHUTDOWN AND POSITION 'L' FOR LOCAL START.
  - 4--SHIELDED CABLES ARE RECOMMENDED FOR FIELD INSTALLED CONTROL & SIGNAL WIRING; CONNECT ONE END OF THE SHIELD TO THE GROUND.
  - 5--CHILLED WATER FLOW SWITCH AND PUMP INTERLOCK ARE REQUIRED. DO NOT USE THESE SWITCHES TO CONTROL THE PACKAGE.



# APPLICATION DATA

## EVAPORATOR FLUID CIRCUIT

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

### Variable Evaporator Flow

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

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

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

### Operating Limits - Leaving Evaporator Fluid Temperature

Leaving Fluid Temperature	Minimum	Maximum
Standard	40 °F [4.5 °C]	55 °F [12.8 °C]
Dual Mode / Low Temp. Operation	18 °F [-7.8 °C]	55 °F [12.8 °C]

### Performance Correction- Evaporator Fouling Factor

Fouling Factor		Capacity Correction Factor	kW-input Correction Factor
hr.ft <sup>2</sup> .°F/BTU	m <sup>2</sup> .°C/kW		
0.00010	0.018	1.000	1.000
0.00025	0.044	0.995	0.998
0.00050	0.088	0.985	0.995
0.00075	0.132	0.975	0.991
0.00100	0.176	0.964	0.987

## CONDENSER FLUID CIRCUIT

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

The unit can be operated with condenser inlet water temperature above 55°F up to 105°F. If the unit is required to operates with condenser inlet water temperature lower than 55°F, a bypass control at condenser water loop is recommended to maintain condenser inlet water temperature is always higher than 55°F.

### Performance Correction - Condenser Fouling Factor

Fouling Factor		Capacity Correction Factor	kW-input Correction Factor
hr.ft <sup>2</sup> .°F/BTU	m <sup>2</sup> .°C/kW		
0.00025	0.044	1.000	1.000
0.00050	0.088	0.998	1.007
0.00075	0.132	0.996	1.010
0.00100	0.176	0.995	1.014

## GLYCOL FREEZE PROTECTION

If the chiller or fluid piping may be exposed to temperatures below freezing, glycol protection is recommended if the water is not drained. The recommended protection is 10°F [5.6°C] below the minimum ambient temperature in the equipment room and around piping. Use only glycol solutions approved for heat exchanger duty. DO NOT use automotive anti-freezing.

If the equipment is being used for applications below 38°F [3.3°C], glycol should be used to prevent freeze damage. The freeze protection level should be 15°F [8.3°C] lower than the leaving brine temperature.

Table 1 and 2 are to be used to calculate performance and power input with the addition of glycol.

**Table 1 : Ethylene Glycol**

% E. G. By Weight	Freeze Point		C1 Capacity Factor	K1 kW-input Factor	G1 Flow Factor	P1 P.D. Factor
	°F	°C				
10	26.2	-3.2	0.995	0.998	1.019	1.050
15	22.4	-5.3	0.991	0.997	1.030	1.083
20	17.8	-7.9	0.988	0.996	1.044	1.121
25	12.6	-10.8	0.984	0.995	1.060	1.170
30	6.7	-14.1	0.981	0.994	1.077	1.219
35	0.0	-17.8	0.977	0.992	1.097	1.275
40	-10.0	-23.3	0.973	0.991	1.116	1.331
45	-17.5	-27.5	0.968	0.990	1.138	1.398
50	-28.9	-33.8	0.964	0.989	1.161	1.466

**Table 2 : Propylene Glycol**

% P. G. By Weight	Freeze Point		C2 Capacity Factor	K2 kW-input Factor	G2 Flow Factor	P2 P.D. Factor
	°F	°C				
10	26.1	-3.3	0.988	0.994	1.005	1.019
15	22.8	-5.1	0.984	0.992	1.008	1.031
20	19.1	-7.2	0.978	0.990	1.010	1.051
25	14.5	-9.7	0.970	0.988	1.015	1.081
30	8.9	-12.8	0.962	0.986	1.021	1.120

Note: P.D. – Pressure drop vessels across

## HEAT RECOVERY

The Dunham-Bush WCFX-V Chiller can significantly reduce building operating costs when the heat recovery option is selected. Any building which requires simultaneous heating and cooling may be an excellent candidate for this system.

### Hotter Hot Water

Most centrifugal water chillers are limited in producing leaving condenser water temperatures to 105°F[40°C] or below. Dunham-Bush WCFX-V Chillers are able to provide leaving hot water temperatures up 140°F[60°C] allowing for the installation of smaller heating coils at a lower first cost than systems utilizing centrifugal water chillers. The warmer supply air temperatures available will also improve tenant comfort.

### Lower Energy Consumption

The efficient unloading characteristics of the Dunham-Bush WCFX-V Chiller compressor make it ideal for heat recovery duty. Heat recovery chillers must be selected to operate at many operating conditions, not just full load heating and full load cooling duties. Heat recovery chillers spend the majority of their time at lower loads, conditions at which centrifugal chillers must often be operating with energy inefficient hot gas bypass.

# APPLICATION DATA

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## Greater Design Flexibility

The heat recovery Dunham-Bush WCFX-V Chiller, on the other hand, utilizes Variable Frequency Driven (VFD), positive displacement compressor which will not surge. This chiller is capable of unloading its compressors to their minimum capacity at all head conditions, both cooling and heat recovery, for greater design flexibility.

In order to maximize the user's flexibility on design and operation, Dunham-Bush chillers offer two heat recovery designs.

**Desuperheater:** A shell-and-tube desuperheater is installed at chiller to reclaim "waste" heat from superheated refrigerant produced by the vapor compression cycle.

**Double-Bundle Condenser:** Double-bundle condenser with two sets of water connectors allow connections to hot water loop and cooling tower water loop simultaneously. Double-Bundle condenser is rated at 300 psig [20.7Bar] working pressure on refrigerant side, and is pressure test up to 330 psig [22.8 Bar] in the factory. This design reclaims "waste" heats generated by vapor compression cycle, and full heat reclaim can be done with this design. Condenser thermal insulation is can be included to provide heat insulation on double-bundle condenser and discharge piping. The 1" thick closed cell insulation will reduce heat losses during heat recovery operation, and prevent unpleasant human contact with hot surface.

To further improve the operational flexibility, for units with full heat recovery design, priority on controlled temperature can be selected through a digital input signal. When "Heating Mode" contact is closed, controlled temperature will switch from leaving evaporator water temperature to leaving condenser water temperature; thus, the unit is now operated as a heat pump. This control function is available when Condenser Water Pump Control & Complete Temperature Monitoring options are included together with double-bundle condenser option.

## CONDENSER PRESSURE CONTROL

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

Most chiller manufacturers recommend that condenser water be controlled so that its temperature never goes below 55°F [12.8°C] (even when the machine is off) and that its rate of change is not rapid. Rapid can be defined as not exceeding 2°F [1.1°C] per minute. This is necessary because a chiller operates in a dynamic environment and is designed to maintain a precise leaving chilled water temperature under varying entering chilled water conditions. The additional dynamic of rapidly varying condenser water temperature subjects the machine to fluctuating pressure on differentials across the evaporator and

condenser. This varies the refrigerant flow and, therefore, the capacity. If this occurs faster than the machine can accommodate it, the condenser pressure or evaporator pressure will soon exceed their safety setpoints and the machine will shut down.

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

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

Further to condenser pump control, a 0-10 Vdc analog signal can be output from the chiller's controller to bypass some of the condenser water flow to maintain chiller's condenser pressure. Cooling tower fans control is also available to achieve better system efficiency.

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

Dunham-Bush WCFX-V Chillers have as standard a control feature called EPCAS (Evaporator Pressure Control at Start) which will allow for an inverted start. This occurs when the chilled water loop in a building is at a higher temperature than the condenser/tower loop. This occurs in many buildings after a weekend shut down. The chilled water loop can be as high as 90°F and the condenser/tower loop as low as 60°F. With the EPCAS feature, the valve feeding the evaporator will be throttled to create a pressure differential to help load the compressor.

# APPLICATION DATA

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## ICE THERMAL STORAGE SYSTEM (ITES)

The globe is progressively marching towards a serious electric energy crisis. The HVAC/R industry is shifting to operate with more efficient machines, as well as alternate system designs and solutions. Dunham-Bush, as a leader of HVAC/R solutions provider, we provide packaged solution for ITES, which include, equipments selections, chillers, Ice Cels and CPM for ITES system controls.

Dunham-Bush WCFX-V Chillers, with positive displacement rotary screw compressor can easily cool low temperature glycol down to 20°F [-6.7 °C] to charge the ice storage tanks. The same chiller can also produce warmer supply fluid temperature, 40 to 45 °F [4.4 to 7.2 °C], for those building systems designed for only peak shaving.

Dunham-Bush is the only HVAC/R manufacturer who can provide complete ITES packaged solution, with own products for chillers, ice storage tanks and plant room control system, with following benefits.

**Demand Charge:** ITES allows some of the peak demand to be shifted to low-demand nighttime periods, thus reducing demand charges for the entire year.

**Energy Cost:** ITES, by operating chillers at night, will fully utilize incentive on electricity night tariff, which is much lower compare to day tariff

**Rebates:** ITES usually qualifies for rebates offered by electric utilities or governments for equipment that shift peak loads to off-peak hours

**Colder Air Temperature:** ITES can produce chilled liquid at supply temperature of 38°F [3.3°C] or even lower without scarifying system's efficiencies. This realizes energy saving on chilled water pumping system, AHUs and FCUs. Colder supply air distribution lowers room humidity, and thus, comfort cooling can be achieved with higher room temperature. This reduce air conditioning load required, and therefore, reduces the installation cost and system operating cost.

**Standby Cooling Capacity:** Energy stored in ITES can be utilized to cater peak or unexpected loads which exceeded total cooling capacity available from the installed chillers. This is savior to the regions which having difficulties on power generation plants expansion, where with ITES, will significantly reduced total demand of the buildings.

# GUIDE SPECIFICATIONS

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## SCOPE

Supply and commissioning of complete factory assembled water cooled rotary screw chiller(s). The rotary screw chiller(s) shall contain rotary screw compressor(s), evaporator, condenser, interconnecting refrigerant piping, electronic expansion valve, control panel, Variable Frequency Drive (s), chilled liquid connections, condenser water connections. The control panel shall be fully wired by the manufacturer connecting & interlocking, controller, Variable Frequency Drive, electrical protection devices with electrical power and control connections. Packaged chiller shall be factory assembled, charged with a full operating refrigerant and oil charge and tested. The refrigerant type shall be R134a, and shall not have phasing out schedule.

Capacity of each chiller shall be not less than \_\_\_\_\_ refrigerant tons (kW output) cooling at \_\_\_\_\_ USGPM (liters/min.) of water from \_\_\_\_\_ °F[°C] to \_\_\_\_\_ °F[°C]. Power input requirements for the unit(s), incorporating all appurtenances necessary for unit operation, including but not limited to the control accessories and pumps, if required, shall not exceed \_\_\_\_\_ kW input at design conditions. The unit shall be able to unload to \_\_\_\_\_% of cooling (refrigeration) capacity when operating with leaving chilled water and entering

condenser water at design temperatures. The unit shall be capable of continuous operation at this point, with stable compressor operation, without the use of hot gas bypass.

Heat transfer surfaces shall be selected to reflect the incorporation of a fouling factor of 0.00025 hr.sq.ft.°F/btu [0.000044 m<sup>2</sup>.°C/W] for the water condenser and 0.0001 hr.sq.ft.°F/Btu [0.0000176 m<sup>2</sup>.°C/W] for evaporator. Water pressure drop at design conditions shall not exceed \_\_\_\_\_ feet of water through the condenser, and \_\_\_\_\_ feet of water through the evaporator.

## QUALITY ASSURANCE

- ✿ Chiller performance shall be certified by AHRI as per AHRI 550/590 standard latest edition
- ✿ [Optional] ASHRAE Standard 15 safety code for mechanical refrigeration
- ✿ ASME standard B31.5 for Refrigerant piping
- ✿ Vessels shall be fabricated and pressure tested in compliance with ASME Boiler and Pressure vessel code, Section VIII, Division 1 "Unfired Pressure Vessels"
- ✿ [Optional] JKPP code for vessels required in Malaysia
- ✿ [Optional] PED certification required in Europe market place

# GUIDE SPECIFICATIONS

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- ✿ [Optional] CRN certification required in Canada region
- ✿ Manufacturer shall have experience of minimum 10 years in manufacturing water cooled screw chillers in their facility
- ✿ Unit shall be manufactured in ISO 9001 registered manufacturing facility
- ✿ Factory run test: Chiller shall be pressure tested, evacuated and fully charged with refrigerant and oil. The chiller shall be run tested with water flowing through the vessels
- ✿ Manufacturer shall have a service organization with trained service personal

## OPERATING REQUIREMENT

The unit shall be capable of starting up with entering fluid temperature to the cooler at 95°F.

Unit shall be able to operate with 3-phase 50Hz/60Hz with unit rated voltage +/- 10%. Control Voltage shall be 115V/1ph/50Hz or 115V/1ph/60Hz.

## COMPRESSOR AND MOTOR

The packaged chiller shall be furnished with single-stage hermetic direct connected positive displacement rotary screw compressor(s) as required, driven by a 3500 RPM-60Hz 2 poles motor. Each compressor shall include integral oil separation system, oil sump and oil filter. The oil differential pressure shall be controlled during operation to maintain proper oil lubrication throughout the lubrication system. An electric oil heater shall be supplied with each compressor to maintain oil temperature during shutdown period. The heater shall be energized when the chiller is switched off. Each compressor shall have a sight glass, suction check valve, suction filter, suction service valve, a discharge check valve (for multiple compressor chillers) and a discharge service valve (Provide isolation valves on all connections to compressor to allow condenser to be used as a pump down receiver). Compressor capacity control shall be obtained by Variable Frequency Driven motor in combination with slide valve at low load within each compressor. The bearing shall be heavy duty, anti-friction tapered roller type, anti-reverse, and shall be able to carry both radial and thrust loads.

The compressor motor shall be hermetic refrigerant gas cooled, 2 pole, squirrel cage induction type with class H insulation. Motor winding shall have thermistors embedded in the motor windings to protect motor from over heating. The thermistors shall be wired to the solid state motor protection module.

## EVAPORATOR

Evaporator vessel shall be cleanable shell and tube, flooded type. Shell shall be fabricated from rolled carbon steel sheet with fusion welded seams or carbon steel standard pipes. End plates shall be of carbon steel with precision drilling, reamed in order to accommodate tubes. Intermediate tube support shall be in place to provide required tube support between

tube sheets. Tubes shall be of copper, seamless, high efficient, internally enhanced and externally finned, mechanically expanded into fixed steel tube sheets. Tube dia shall be ¾ inch and thickness shall be 0.025 inch. The flooded evaporator shall have a built in distributor for feeding refrigerant evenly under the tube bundle to produce a uniform boiling action and baffle plates shall be provided to ensure vapor separation. Water box shall be removable for tube cleaning, shall have stub out water connections with victaulic grooves in compliance to ANSI / AWWAC-606. They are to be available in one, two or three pass design as required on the drawings. Vent and drain plugs are to be provided in water box. The shell side of the evaporator shall have pressure relief valve with provision for refrigerant venting. Evaporators refrigerant side shall be designed, constructed in accordance with the ASME Code for Unfired Pressure Vessels. Evaporator shell side shall undergo pneumatic pressure test at 220psi, shall be designed for working pressure up to 200psi. Tube side shall undergo hydrostatic pressure test at 195psi, shall be designed for 150psi working pressure.

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

All low temperature surfaces shall be factory insulated with 25mm thick Polyethylene resin having K factor of 0.26 btu-in / hr - ft<sup>2</sup> - °F.

## CONDENSER

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

# GUIDE SPECIFICATIONS

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## REFRIGERANT CIRCUIT

The refrigerant circuit shall include suction and discharge service valves (which facilitate compressor isolation), oil filter, replaceable filter drier on oil return line, sight glass on liquid line, economizer, pressure relief valves on the cooler and condenser, liquid line angle valve for refrigerant charging. The packaged chiller shall be furnished with an electronic expansion valve for precise modulation of refrigerant flow control and improve efficiency by optimizing suction and discharge superheat while protecting compressor. In addition, the refrigerant control system shall monitor the liquid refrigerant level in the flooded evaporator and restrict refrigerant flow entering the evaporator upon a rise in the refrigerant level, protecting the compressor from slugging liquid refrigerant. Fixed orifice control systems will not be acceptable. (Option Hot gas bypass shall be factory installed for operation down to approximately 10% of full load.)

## OIL MANAGEMENT

The chiller package shall ensure proper lubrication during the operation in order to have prolonged compressor life as well as maintaining system efficiency. An efficient Pressure differential lubrication system shall be provided with oil filter, oil separator, sight glass, oil sump and oil sump heater. The oil heater shall be energized during the chiller switched off to prevent oil from dilution. Oil pump is not acceptable.

## ELECTRICAL AND CONTROL PANEL

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

## ELECTRICAL POWER PANEL

The chiller manufacturer shall provide a Variable Frequency Drive (VFD) for each compressor motor which also minimize the starting current in addition to capacity modulation function. The VFD shall be factory mounted, wired to the motor and controller. The VFD shall be able to provide adequate starting torque and the required acceleration for the compressor during starting.

NEMA-1 electrical panel compartment shall include:

- ✿ Main incoming power terminal block suitable to receive single entry of three phase 3-wire power supply with specified voltage
- ✿ Circuit breakers for each compressor
- ✿ Solid state compressor motor over current protection for each phase shall be inherent feature of Variable Frequency Drive
- ✿ Solid state compressor motor overheat protection module

- ✿ Under/over voltage phase reversal and imbalance relay
- ✿ [Optional] Ground fault interrupter

The Variable Frequency Drive and circuit breakers shall be wired securely to the main incoming terminal block. Over heating protection modules, over/under voltage phase relay shall be interlocked with the compressor in order to provide adequate protection to the compressor motor.

## CONTROL PANEL

The packaged chiller shall be equipped with stand along proactive advance controller which shall be able to adapt to abnormal operation conditions. The unit algorithm program and operating parameters shall be stored in flash-memory. Battery back-up is not acceptable. 115V Power supply to the controller shall be provided by a control transformer provided with the panel. External power source to the controller is not acceptable. The controller shall be equipped with a user friendly terminal with color touch screen LED back lit graphical display and dedicated touch keys that provides easy access to the unit operating parameters, control set points and alarm history. There shall be dedicated physical buttons and touch keys enable user to access information, based on security level of password. There shall be min three level of password for operator, service personnel and for the manufacturer for critical settings in order to protect the chiller controller from unauthorized access.

The controller board shall be provided with a set of terminals that connected to various devices such as temperature sensors, pressure transducers, current transducers, solenoid valves, VFDs, electronic expansion valve controls relays. The controller should be able to configured and connected multiple unit that allow sequencing control without additional hardware. The controller shall be able to carry out all program operations, It shall be able to display unit operating parameters, compressor information, alarm history and shall able to modify the parameters.

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

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

Leaving chilled water temperature control shall be accomplished by entering the water temperature set point with accuracy to 0.8°F and placing the controller automatic control mode. The controller shall monitor all control functions and modulate the VFD (and slide valve in required) to the calibrated position. The compressor loading cycle shall be programmable and shall be adjusted to the building load requirement. The loading adjustable range shall be from 0.1% to 0.4% per increment to prevent excessive demand hike at start up.

# GUIDE SPECIFICATIONS

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The controller shall continuously monitor evaporator leaving water temperature, rate of change of chilled water leaving temperature, evaporator and condenser pressure, compressor amp draw, and discharge refrigerant temp.

The controller shall be complete with all hardware and software necessary to enable remote monitoring of all data through the addition of an optional web card if accessing the controller via web or network cards if linking chiller to the Building Management Systems. The controller shall be completed with a RS485 long distance differential communications port, the remote connection shall be established by a twisted pair of wire. The controller shall also accept a remote start and stop signal, 0 to 5VDC [Optional], chilled water temperature reset signal and 0 to 5VDC compressor current limit reset signal [Optional].

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

## MANUAL CONTROLS

- ✿ Auto/Local/Remote switch
- ✿ Control circuit stop and start switches
- ✿ Compressor enable switch
- ✿ Compressor over current
- ✿ Compressor anti-recycle
- ✿ Programmable with Seven day operation cycle
- ✿ [Optional] chilled liquid and condenser water pump on/off control
- ✿ [Optional] dual mode operation to produce Ice at 21°F-26°F for Ice thermal energy systems

## AUTOMATIC CONTROLS

- ✿ Variable Frequency Drive
- ✿ Start delay timer
- ✿ Anti-recycle timer
- ✿ Oil sump heater interlock relays

## REFRIGERANT FLOW CONTROLS

- ✿ Refrigerant flow control shall be carried out electronically by a precision electronic expansion valve
- ✿ Liquid refrigerant level sensor for evaporator
- ✿ Compressor VFDs and load and unload solenoid valves

## INDICATING LIGHTS

- ✿ Compressor Motor high temperature
- ✿ Compressor motor overload
- ✿ System common alarm

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

## SYSTEM OPERATION INFORMATION

The chiller display shall provide following operating information

- ✿ Leaving chilled water temperature
- ✿ Leaving chilled water temperature derivative
- ✿ Evaporator pressure
- ✿ Condenser pressure
- ✿ Compressor amps draw for each compressor
- ✿ Operating supply Voltage [Optional]
- ✿ Compressor elapsed run time of each compressor
- ✿ Compressor start status
- ✿ Oil level sensor status
- ✿ Water temperature re-set value
- ✿ Water flow switch status
- ✿ External start/stop command status
- ✿ Trend graph for leaving chilled water temp
- ✿ Percentage of compressor capacity
- ✿ Electronic expansion valve percentage of opening

## SAFETY PROTECTIONS

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

Controller shall be able to retain up to 99 alarm conditions complete with time of failure and all critical sensor readings. This aids service technicians in their trouble shooting task enabling downtime and nuisance trip-outs to be minimized.

## UNIT MOUNTED VARIABLE FREQUENCY DRIVE (VFD)

Each compressor shall have separate VFD for capacity modulation and shall be operating in tandem with the chiller main controller.

Drive shall meet the EMC product standard EN 61800-3.

The VFD enclosure shall be IP54/ NEMA12 suitable for indoor use. The drive shall be able to operate with maximum output at 50°C ambient temp and humidity range from 5% to 95%.

The Motor and power cables shall be mounted securely through glands in the base plate.

# GUIDE SPECIFICATIONS

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EMC filters, harmonics suppression and brake modules shall be integrated into the enclosure.

VFD shall be able to deliver 110% torque for 60 seconds during normal operation.

Supply voltage shall be 380 – 480 V with +/- 10% operating range.

Ramp time adjustable range shall be 1 – 3600 sec.

Maximum output frequency at frequency output shall be from 0 to 32 kHz.

VFD shall have numerical display which shall indicate power input, frequency, motor current and running hour.

Temperature monitoring of the heat-sink ensures that the frequency converter trips if the temperature reaches  $95^{\circ}\text{C} \pm 5^{\circ}\text{C}$ .

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

VFD shall have inbuilt Electronic thermal motor protection against overload.

The frequency converter shall be protected against short-circuits on motor terminals U, V, W.

It shall also Protection against mains phase loss.

## DELIVERY, STORAGE AND HANDLING

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

## WARRANTY

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

## EXECUTION

### INSTALLATION

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

### START-UP/COMMISSIONING

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



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