AFVXB Series 60Hz

Air Cooled Screw Flooded Chillers

Cooling Capacity: 100 to 504 TR (350 to 1772 kW)

R134a

DUNHAM-BUSH

Products that perform...By people who care

INTRODUCTION

For more than 100 years, Dunham-Bush has focused on innovative product development. Today, we provide a full portfolio of HVAC/R products from Fan Coil Units to large centrifugal chillers as well as many other innovative green solutions. Our commitment to innovation, matched with an aggressive attitude toward growth, makes Dunham-Bush a leader in global markets. Our product development is tailored to meet the specific needs of customers, building-by-building, country-by-country and region-by-region. No other HVAC/R manufacturer takes this approach to meeting your performance expectations.

The Dunham-Bush name is synonymous worldwide with the Rotary Screw Compressor Chillers technology. With over 40 years of proven experience and track records in manufacturing and installation of Rotary Screw Compressors and chillers, thousands of our Chillers have clocked more than 100,000 operating hours without any compressor tear-out or overhaul! As a pioneer and industry leader in the Rotary Screw compressor technology for HVAC/R systems, Dunham-Bush now introduces the Air Cooled Rotary Screw Flooded Chillers with unsurpassed performance and reliability.

AFVXB-6SR, Air Cooled Screw Flooded Chillers, have a cooling capacity range from 100 to 504 TR [350 to 1772 kW] in 60Hz version using environmentally sound R134a refrigerant. The entire product line features high energy efficiency, installation ease, control flexibility, high reliability and advanced 2020i controller.

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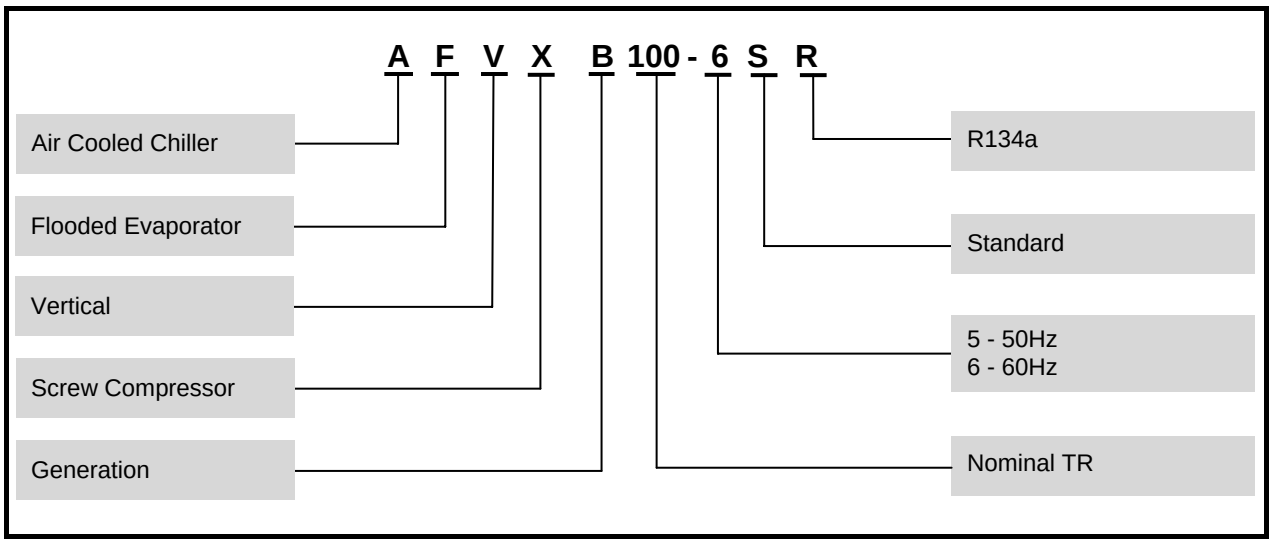
NOMENCLATURE



ADVANTAGES OF FLOODED CHILLER

In a flooded evaporator the refrigerant surrounds the tubes in the shell and the water to be cooled flows through the tubes. The level of liquid refrigerant in the shell is maintained by the combined action of an electronic level controller and electronic expansion valve which modulates the subcooled liquid refrigerant into the evaporator. Thus ensure that all the evaporator tubes are completely immersed in the liquid refrigerant for better heat transfer efficiency.

For a Direct Expansion (DX) Evaporator the refrigerant is expanded into the tubes while the chilled water is circulated through the shell. Thermostatic expansion valve is used to throttle the refrigerant in maintaining constant superheat of suction gas to the compressor.

The following are the advantages of using flooded chiller:

1. Higher Capacity and Higher EER Achievable with the Same Compressor

The flooded evaporator with all the copper tubes immersed in the “boiling” liquid refrigerant enable a small approach temperature between the “boiling” liquid refrigerant temperature in the shell and the outlet chilled water temperature in the evaporator tubes to be achieved. This approach temperature or temperature difference between the evaporating temperature of the boiling liquid refrigerant and the chilled water outlet temperature, for a flooded evaporator, is typically less than 3°F [1.7°C].

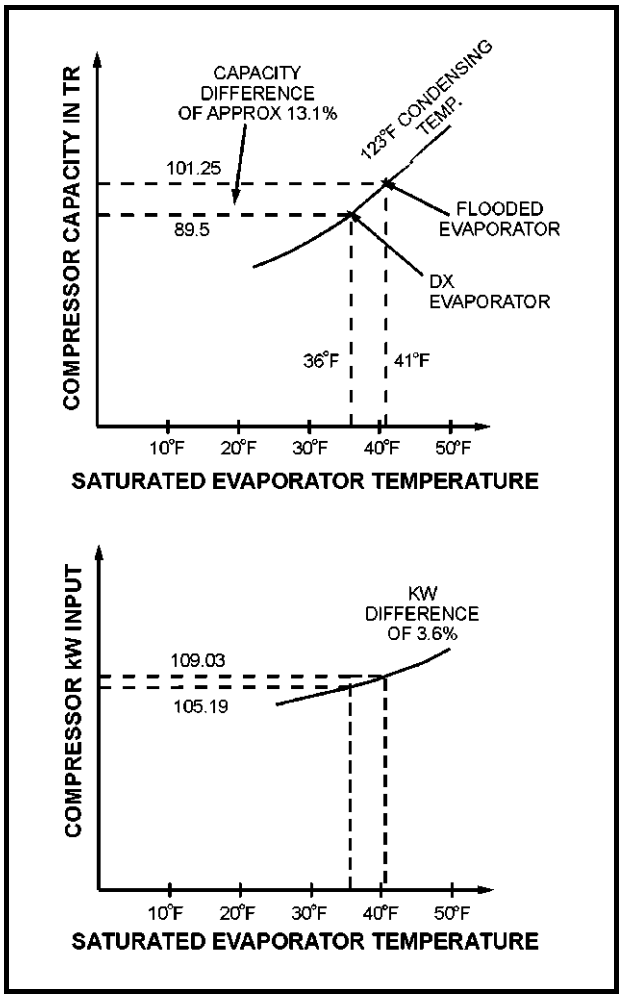
On the contrary, for a DX or Direct Expansion Evaporator, the typical approach temperature is between 8°F [4.4°C] to 10°F [5.5°C]. This simply means that for the same compressor in a flooded evaporator system will operate at a higher saturated evaporating temperature when compare to the same compressor in a DX Evaporator system, when outlet chilled water temperatures in both cases are set at the same temperature.

Figure 1 shows the typical Dunham-Bush screw compressor capacity performance curve at a particular condensing temperature over saturated evaporating temperature of between 30°F [-1.1°C] to 50°F [10°C], and the typical power input curve over the same conditions. It can be noted that the same compressor when operating with a flooded evaporator will generates approximately 13.1% more cooling capacity while kW input increases negligibly of less than 3.6%. Therefore, same compressor when coupled to a flooded evaporator will typically achieve higher cooling capacity with correspondingly higher Energy Efficiency Ratio (EER) or (BTU/Watt) or lower kW/TR.

DX Evaporator uses TXV throttling to maintain about 10°F [5.5°C] to 15°F [8.3°C] suction superheat to prevent liquid flood back to compressor. In a flooded evaporator, the refrigerant boils off in the shell and gas only can be sucked out from the top of evaporator back to compressor. The suction superheat is usually about 2°F [1.1°C] to 3°F [1.7°C]. Reduction in suction superheat will further increase the capacity performance of the compressor.

DX Evaporators are typically designed with higher tube velocities to ensure proper oil return to compressor both at full load and at reduced load. This will contribute to higher refrigerant pressure drop through the evaporator. On the contrary, there is very little shell side pressure losses for a flooded evaporator. Therefore, lower suction pressure drop in flooded design will impose less capacity penalty on the compressor and this further enable the compressor in a flooded evaporator to generate more capacity than one in a DX Evaporator.

FIGURE 1



ADVANTAGES OF FLOODED CHILLER

2. Better Part Load Performance

The Dunham-Bush Air Cooled Flooded Chiller with its sophisticated controller control and patented oil management system ensure all evaporator tubes are completely immersed in the “boiling” liquid refrigerant to achieve superior heat transfer efficiency while ensuring adequate oil return to the compressor(s). This ensures superior full-load efficiency and even better part-load efficiency as the full heat transfer surface areas of the evaporator tubes are utilized even at part-load conditions. On the contrary, in the direct expansion evaporator, because of the need to maintain adequate refrigerant gas velocities in the evaporator tubes for proper oil return, it is typical for certain bundle of evaporator tubes to be “blocked” or “baffled off” at part-load conditions. Therefore not utilizing the full-load transfer surface of the evaporator tubes means lower efficiency when compared with flooded evaporator chiller at part-load conditions.

3. Economizer/ Vapor Injection Cycle for Increase Capacity and Higher EER

The renowned Dunham-Bush vertical screw compressor allows for **economizer vapor injection cycle** to be incorporated, **increasing** capacity by as much as **25% with marginal 10% to 15% increase in kW-input.** Most of Dunham-Bush’s competitors who produce Rotary Screw Chillers do not incorporate economizer vapor injection cycle- not to mention flooded evaporator!

4. Excellent Capacity Modulation in Response to Building Loads

Dunham-Bush utilizes its state-of-the-art Vision 2020i controller in combination with the electronic level controller and electronic expansion valves to ensure instantaneous and precise feeding of liquid refrigerant to the flooded evaporator in response to changes in building loads demand; and maintains precise (±1/2°F) preset outlet chilled water temperatures even at very low load conditions; whereas most of Dunham-Bush’s competitors, in screw chillers, still utilizes the conventional “centrifugal chiller” method of using orifice plates to modulate refrigerant feed to the evaporator; and as such their machines does at function efficiently at low-load conditions and can encounter oil return problem!

5. Maximum Reliability and Redundancy

Today, the Dunham-Bush vertical screw compressors are increasingly accepted for its reliability. The 2-compressor models are designed to have 2 independent refrigerant circuits for redundancy. Individual compressor is provided with suction stop valve, discharge stop valve and other isolating valves in the oil management system to allow complete isolation of an unlikely faulty compressor without contaminating the refrigerant system.

6. Cleanable Evaporator

Evaporator water heads can be removed easily without dismantling the chilled water piping connections, for inspection and for mechanical tubes cleaning with brushes. This will enable low tube fouling factor in the evaporator to be ensured, thus maintaining system efficiency.

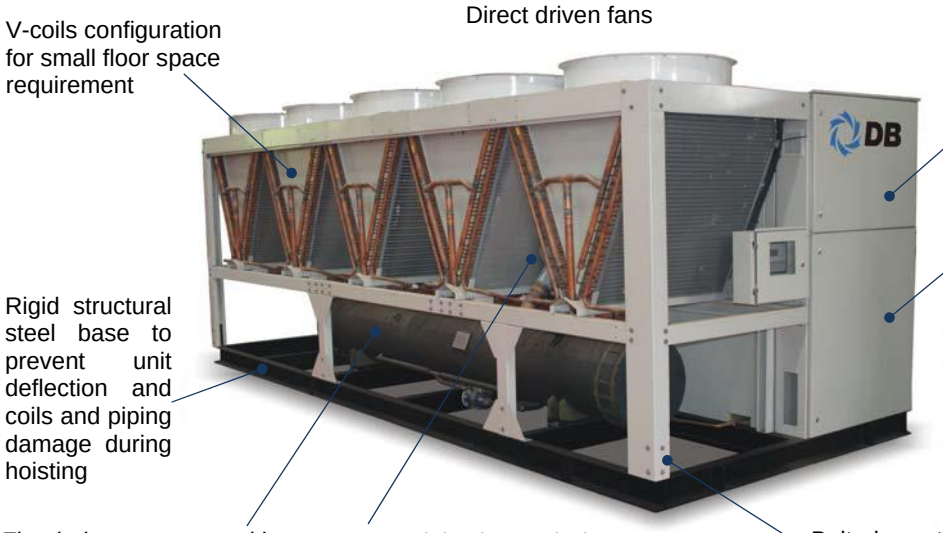
7. Lower Water Side Pressure Drop

In a DX Evaporator, the water flows transversely over the outside of the tubes. The water flow is guided with vertical baffles. This will have higher-pressure drop as compared with the water flow in the tubes of a flooded evaporator. In other words, the flooded chillers will require smaller water pumps to operate at lower power consumption.

8. Commonly Use In Large Tonnage Chillers Where Efficiency Is Critical

As a general rule, the DX Evaporator are typically used in small and medium tonnage chillers where efficiency is not important and the low initial cost is the main consideration! However, with increasing energy cost and the drive to reduce **global warming, flooded evaporator chillers will increasingly become more popular not only in the large tonnage but also in the small and medium tonnage chillers. Dunham-Bush, again, leads the industry in this respect!**

COMPONENTS



STANDARD FEATURES

Size / Range

- 13 models from 100 to 504 TR [350 to 1772 kW] at AHRI standard conditions.
- Multiple compressor models provide redundancy, and superior part load efficiency.

Compressor(s)

- Improved, quiet, reliable MSC Vertical Rotary Screw Compressors with up to 2 integral oil separators.
- Optimized for R134a and optimized volume ratio for best efficiency.
- Improved rpm and noise level.
- Optimized rotor drive.
- Improved rotor and anti-reverse rotation bearing design.
- Optimized VI port position and geometry.
- Compartmentalized to reduce noise breakout.
- Multiple rotary screw compressors design for better reliability and redundancy.
- Welded hermetic design with no requirement for internal parts service, no periodic compressor tear down and overhaul, and eliminates casing leakages.
- Consistent loading and unloading with dependable slide valve mechanism.
- No external oil pump required.
- Double-delta motor winding with 1/3 lock-rotor amps at start-up. Star-delta motor winding for MSC 226 mm series.
- Faulty or damaged compressors reworkable at minimal cost at various Dunham-Bush's authorized compressors reworked facilities. To ensure minimum downtime during rework of faulty or damaged compressor, Dunham-Bush can arrange to provide a substitute reworked compressors while the faulty compressor is being reworked or repaired.
- Vapor injection cycle to increase capacity and improve efficiency.

Evaporator

- Two pass for all models.
- Cleanable and removable integral fin copper tubes for easy serviceability.
- For a wide variety of applications.
- Removable water heads for service.
- Flange/victaulic water connections for quick installation or service (refer Dimensional Data).
- Build according to ASME code, PED whenever required.
- JKKP approval.
- Relief valves(s) standard – 3/4" [19mm] FPT.

STANDARD FEATURES

Controller/ Factory Packaged Power Panel

- Proactive advanced controller adapts to any abnormal operating conditions and for safety protections.
- Tolerant and accommodating of extreme conditions at start-up.
- Capable of controlling multiple chillers, pumps, and etc.
- Circuit breaker on each multiple compressors unit.
- Unit mounted step-start contactors and delay for reduced inrush starting current.
- Under and over voltage phase protection relay.
- Indicator lights for compressor overloads, controller alarm, control power, compressor control circuit, and etc.

Condenser Coil/ Fans

- Constructed with seamless inner-grooved copper tubes expanded into die-formed aluminum fins in staggered configuration. Leaked and pressure tested to 450psig [31bar].
- High efficiency low-noise condenser fan.
- "V" coil design to increase condensing surface area.
- "V" coil with internal baffle for fan cycling and fan staging.

UNIT FEATURES

ADVANCED CONTROLLER

Vision 2020i a flexible and advance programmable microprocessor controller designed specifically for the application and precise control of Dunham-Bush Rotary Screw compressor chillers.

The controller board is provided with a set of terminals that connect to various devices such as temperature sensors, pressure and current transducers, solenoid valves, compressors and fans contactors, control relays etc. Three sizes of controller boards are provided to handle different number of input and output requirements: DB5-S small, DB5-M medium and DB5-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 terminal with a semi-graphic display and dedicated keys that provides easy access to the unit operating conditions, control set points and alarm history.

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

The Vision 2020i controller is designed to work with a user friendly back-lit 132 by 64 pixels DBG1 Semi-Graphic Display panel connected with the controller through a telephone cable. The terminal allows carrying out of all program operations and also allows the unit working conditions, compressor run times and alarm history to be displayed. Set points and other parameters can be modified via the user terminal. The display has an automatic self-test of the controller on system start-up. Multiple messages will be displayed automatically by scrolling from each message to the next. All of these messages are spelled out in English on the display terminal.

UNIT FEATURES

There are 15 dedicated buttons to enable the user to access information, based on the security level of the password. For more detail operation of the DBG1 Display Terminal, please refer to the Unit Operation Manual.

Easily accessible measurements include:

- Leaving chilled water temperature
- Entering chilled water temperature
- Compressor discharge temperature
- Leaving chiller water temperature derivative
- Evaporator Pressure
- Condenser Pressure
- Compressor amp draw of each compressor
- Compressor elapsed run time of each compressor
- Compressor starts status
- Oil level sensor status
- Water temperature reset value
- Water flow switch status
- External start/stop command status

Optional ambient temperature is available. With this option the operator can quickly and accurately read all significant temperatures and eliminate the need for thermometers. Voltmeter is also offered as an optional feature.

Capacity Control

Leaving chilled water temperature control is accomplished by entering the water temperature setpoint and placing the controller in automatic control. The unit will monitor all control functions and move the slide valve to the required operating position. 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 direct BMS protocols connection to the controller communication ports, or from an external hardwired control signal from BMS to supply a chilled water reset 4 to 20mA analog input signal. Remote reset of compressor current limiting function may 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 ensure system reliability:

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

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

Remote Monitoring

Vision 2020i controller can be completed with an optional RS485 communications card and NETVISOR software for remote monitoring and controlled from a PC terminal and optional phone modem.

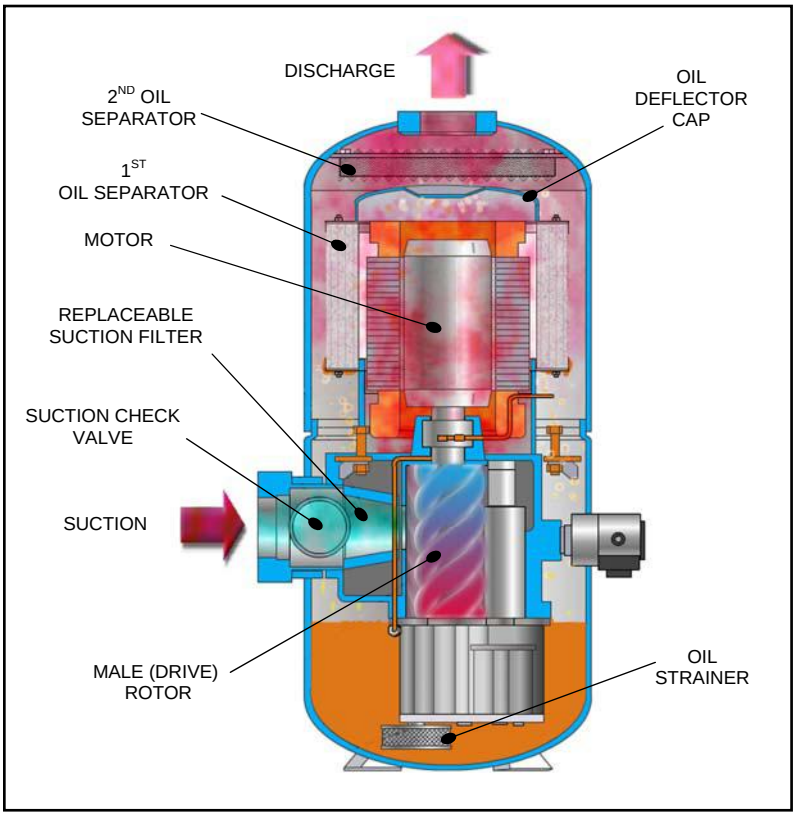
With various optional add-on cards the Vision2020i controller can also be interfaced directly to the Building Management System (BMS) with the standard communication protocols using MODBUS, LONWORKS, BACNET MSTP as well as over IP.

This sophisticated feature makes servicing easier and more convenient to the system. The controller as standard is additionally equipped with history files which can be used to take logs and which may be retrieved via the phone modem or internet connection periodically. Now owners of multiple buildings have a simple and inexpensive method of investigating potential problems quickly and in a highly cost effective manner.

UNIT FEATURES

The Revolutionary Dunham-Bush Vertical Screw Compressor

Dunham-Bush introduced the revolutionary Vertical Screw Compressors in the early 1970's. Since then, the compressor has undergone several design changes to improve efficiency, and reliability! Today, The Dunham-Bush vertical screw compressors is not only the most efficient and reliable screw compressor in its capacity range; but it is the most completely "packaged" rotary Screw Compressors for use in flooded chillers! The Dunham-Bush vertical screw compressor and motor assembly is completely housed in an integral oil separator heavy-duty steel casing -- therefore eliminating the need for an external oil separator and its associated piping connections. Now the compressor oil separator is improved to 2. The compressor does not require an external oil pump as it lubricates the bearing and rotors by use of the pressure differential between the discharge and suction cavities of the compressor. Thus, there is also no need for an external compressor oil cooler and its associated piping connections. The compressor is completely sealed to prevent leakage and there is no need to service the few internal moving parts of the compressor.



Compressor Assembly

The Dunham-Bush rotary screw compressor is a positive displacement helical-axial design optimised for use with specific refrigerants.

- The compressor consists of two intermeshing helical grooved rotors, a male drive rotor and a female driven rotor, in a stationary housing with suction and discharge gas ports.
- Uniform gas flow, even torque and positive displacement, all provided by pure rotary motion contributes to vibration-free operation over a wide range of operating conditions. Intake and discharge cycles overlap, effectively producing a smooth, continuous flow of gas.
- No oil pump is required for lubrication or sealing purposes. Oil is distributed throughout the compressor by the pressure differential between the suction and the discharge cavities.

Simplified Capacity Control

The slide valve mechanism for capacity modulation and part load operation is outstanding feature:

- The moving parts are simple, rugged and trouble-free. The slide mechanism is hydraulically actuated.
- Package capacity reduction can be down to as low as 12.5% without HGBP by stepless movement of slide valves.
- Capacity reduction is programmed by an exclusive electronically initiated, hydraulically actuated control arrangement.

Positive Displacement Direct Drive

The compressor is directly connected to the motor without any complicated gear systems to speed up the compressor and thus detract from the overall unit reliability.

Oil Separation

Each compressor is provided with up to 2 integral oil separators/impingement plate located below the discharge gas port.

- The separator is a multi-layered mesh element which effectively separates oil from the gas stream.
- The oil drains into sump and discharge gas passes around the deflection plate. An oil drain valve is located near the bottom of the oil sump.

Each rotor is fitted with a set of anti-friction tapered roller bearings. They carry both radial and thrust loads. Anti-reverse rotation bearings are used.

Rotors

The latest asymmetrical rotor profiles of patented Dunham-Bush design assure operation at highest efficiencies. Rotors are precision machined from high strength alloy steel and precision ground, in- house.

Castings

All housings are manufactured of high grade and low porosity cast iron.

UNIT FEATURES

FIG. A

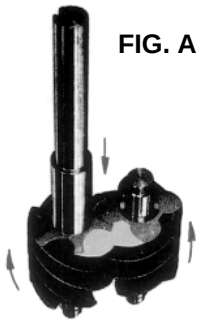


FIG. B

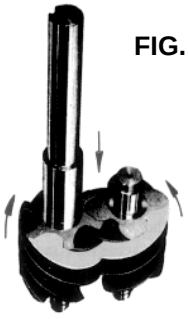


FIG. C

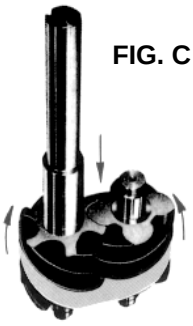


FIG. D

Solid State Motor Protection

The motor winding protection module used in conjunction with sensors embedded in the compressor motor windings is designed to prevent the motor from operating at unsafe operating temperatures. The overloads for the motor are also solid state.

Compressor Operation

Note: For clarity reasons, the following account of the compressor operation will be limited to one lobe on the male rotor and one interlobe space of the female rotor. In actual operation, as the rotors revolve, all of the male lobes and female interlobe spaces interact similarly with resulting uniform, non-pulsating gas flow.

Suction Phase

As a lobe of the male rotor begins to unmesh from an interlobe space in the female rotor, a void is created and gas is drawn in tangentially through the inlet port-- Fig. A. --as the rotors continue to turn the interlobe space increases in size-- Fig. B. --and gas flows continuously into the compressor. Just prior to the point at which the interlobe space leaves the inlet port, the entire length of the interlobe space is completely filled with drawn in gas -- Fig. C.

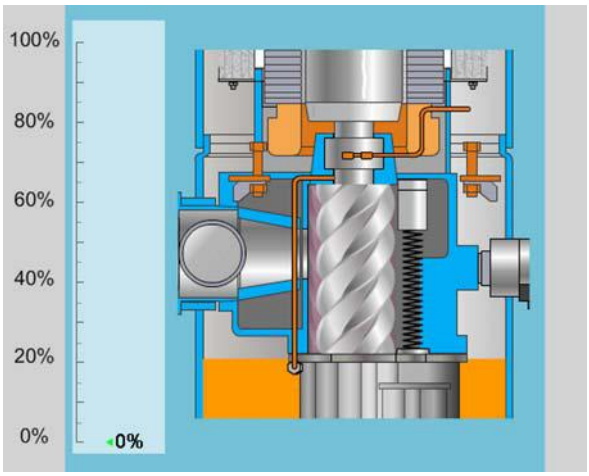
Compression Phase

As rotation continues, the gas in the interlobe space is carried circumferentially around the compressor housing. Further rotation meshes a male lobe with the interlobe space on the suction end and squeezes (compresses) the gas in the direction of the discharge port. Thus the occupied volume of the trapped gas within the interlobe space is decreased and the gas pressure consequently increased.

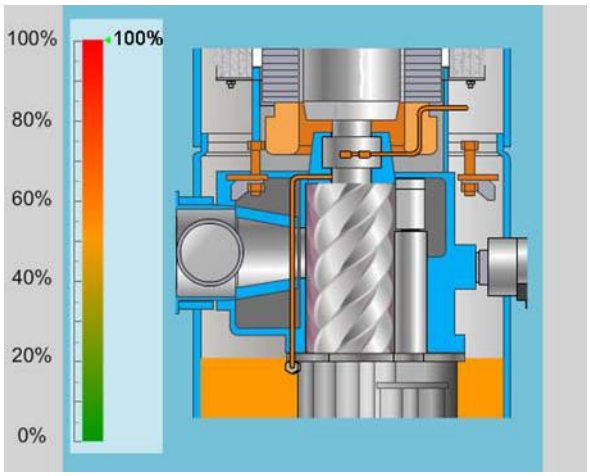
Discharge Phase

At a point determined by the designed "built-in" compression ratio, the discharge port is covered and the compressed gas is discharged by further meshing of the lobe and interlobe space--Fig D. While the meshing point of a pair of lobes is moving axially, the next charge is being drawn into the unmeshed portion and the working phases of the compressor cycle are repeated.

Compressor Fully Unloaded



Compressor Fully Loaded



Slide Valve Control

Movement of the slide valve is programmed by an exclusive Dunham-Bush electronically initiated (by variations in leaving chilled water temperature) hydraulically actuated control arrangement. When the compressor is fully loaded, the slide valve is in the closed position. Unloading starts when the slide valve is moved back away from the valve stop. Movement of the valve creates an opening in the side of the rotor housing.

Suction gas can then pass back from the rotor housing to the inlet port area before it has been compressed. Since no significant work has been done on this return gas, no appreciable power losses are incurred. Reduced compressor capacity is obtained from the gas remaining in the rotors which is compressed in the ordinary manner. Enlarging the opening in the rotor housing effectively reduces compressor displacement.

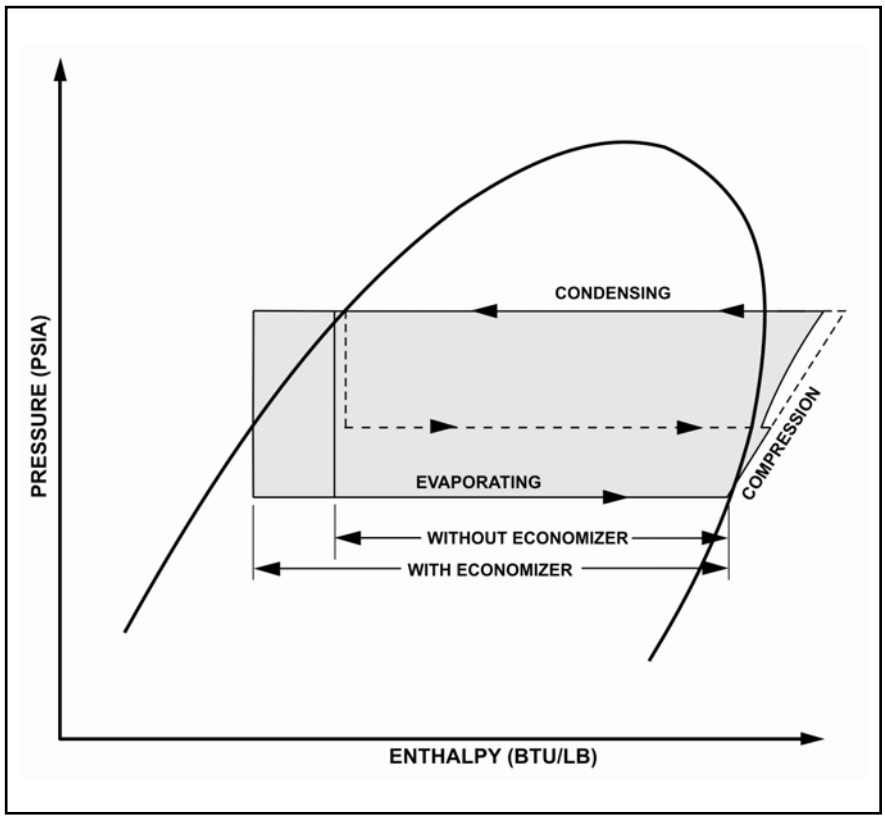
UNIT FEATURES

REFRIGERATION CYCLE

Dunham-Bush rotary screw air cooled 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 head and low capacity, a difficult condition for centrifugal compressors, the rotary screw performs in a stable manner. **It is impossible for this positive displacement compressor to surge.**

The refrigerant management system, however, is very similar to centrifugal water chillers and 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. The vaporized refrigerant is then drawn into the suction port of the compressor where the positive displacement compression begins.

This partially compressed gas is then combined with additional gas from the vapor injection port at an intermediate pressure. Compressed gaseous refrigerant is then discharged into the integral oil separator where oil, which is contained in the refrigerant vapor, is removed and returned to the oil sump.

Fully compressed and superheated refrigerant is then discharged into the condenser, where air is being drawn through the condenser tube by the propeller fan cools and condenses the refrigerant. The liquid refrigerant then passes through the economizer. A portion of liquid refrigerant is tapped passes through the first expansion device back into the economizer for further subcooling of main liquid refrigerant flow.

The gaseous refrigerant is then drawn out of the economizer and into the vapor injection port of the compressor. The remaining subcooled liquid refrigerant then passes through a second expansion device which reduces refrigerant pressure to evaporator levels where it is then distributed evenly into the evaporator.

With the additional subcooling, the enthalpy of the refrigerant flowing into the evaporator is reduced which increases the refrigeration effect and improves the efficiency of the refrigeration cycle.

PART-LOAD PERFORMANCE

Through the use of economizer and electronic expansion valve, Dunham-Bush rotary screw air cooled flooded chillers have some of best part-load performance characteristics in the industry.

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 rotary screw air cooled flooded chillers combine the efficient operation of rotary screw compressors with an economizer cycle and microprocessor control to yield the best total energy efficiency and significant operating saving under any load as the flooded evaporator fully utilize the total heat transfer area of the tubes, where DX evaporators are not able to do so.

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.

OPERATING BENEFITS

EFFICIENCY AND RELIABILITY

Compressor Experience

- 40 years of rotary screw experience and dedicated technological advancements. Compressors are CE listed.
- Simply designed for high reliability with only two rotating parts. No gears to fail.
- Ensured 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.

Energy Efficiency

- 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 economizer cycle and microprocessor controlled staging producing greater capacity with fewer compressors.
- Maximized performance through computer-matched components.
- 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.

Optional Advantages

- Dramatic payback in reduced maintenance and overhaul costs both in down time and in labor expenditures.
- Ease of troubleshooting through microprocessor retention of monitored functions.
- Factory run tested.

Safety Code

- ASME Boiler and Pressure Vessel Code, Section VIII Division 1 "Unfired Pressure Vessels".
- JKKP Code.
- ASME Standard B31.5 Refrigeration Piping.
- ASHRAE Standard 15 Safety Code for Mechanical Refrigeration.
- IEEE.
- Safety quality license for import boiler and pressure vessel, China.
- Optional PED Approval.

Refrigerant Compatibility

- Designed to operate with environmentally safe and economically smart HFC-134a with proven efficiency and reliability.
- Consult Factory for use of other HFC refrigerants.

Control Flexibility

- Controller-based with DDC (direct digital control) features precise control over every aspect of operation with built-in standard features that allow extra energy savings on start-up and throughout the life of your equipment.
- Ensured uniform compressor loading and optimal energy efficiency through microprocessor controller which utilize pressure transducers to measure evaporator and condenser pressure, and current drawn by each compressor.
- Lower energy costs resulting from automatic load monitoring and increased accuracy and efficiency in compressor staging.
- Monitor your chiller's key functions from a remote location with a simple, low costs, communication card option.
- Proactive control by controller that anticipates problems and takes corrective action before they occur. Controls will unload compressor(s) if discharge or suction pressure approach limits. This will enable unit to stay on the line while warning operator of potential problems.

UNIT OPTIONS

Options Installed At The Factory

- Heat reclaim condensers (desuperheaters) are available for special applications.
- Main Incoming Isolator – Factory installed main disconnect for entire unit.
- Copper Condenser Fins - Copper fins offer better corrosion protection for severe conditions. In more corrosive environments, hydrophilic or Adsil-coated fins would be more appropriate.
- Hot Gas Bypass - Consists of hot gas bypass regulator(s) and solenoid valve(s) for each circuit for applications with a minimum load which may dip below the unit’s minimum unloaded capacity.
- 115V Convenience Outlet - Duplex outlet located inside the control panel and protected by a 15 amp fuse.
- Low Ambient Controls (LAC option) - Kindly refer to Low Ambient Operation/ Freeze Protection.
- Compressor Start Counter - One start counter provided for each compressor, located inside the control panel.
- Compressor Elapsed Time Meter - One elapsed time meter to register run hours per compressor, located inside the control panel.
- Three Phase Ammeter - Single analog ammeter with a 3 phase selector switch for indication, located inside the control panel.
- Three Phase Voltmeter - Single analog voltmeter installed with a 3 phase selector switch for indication, located inside the control panel.

UNIT ACCESSORIES

Accessories Shipped Unmounted

- Water Flow Switch - Paddle type field adjustable flow switch available for all units, installed into the unit safety circuit so that the chiller will remain off until there is water flow. Helps to prevent evaporator from freezing. Vapor-proof enclosure, for use on water or glycol systems. The flow switch is to be shipped loose and installed at site.
- Rubber-in-shear Isolators - Designed for ease of installation, these rubber, one-piece, molded 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 applications as compared to rubber-in-shear isolators.

TYPICAL SEQUENCE OF OPERATION

The Dunham-Bush air cooled water chiller depends mainly on its on-board controller for control. Operation described is for two-compressor units and is very similar for single compressor unit.

For initial start-up, the following conditions must be met:

- Power supply to unit energized.
- Unit circuit breakers in the ‘on’ position.
- Control power switch ‘on’ for at least 15 minutes. Compressor switches ’on’.
- Reset pressed on controller keypad.
- Chilled water pump running and chilled water flow switch made.
- Leaving chilled water temperature at least 2°F [1.1°C] above setpoint.
- All safety conditions satisfied.

After all above conditions are met, the controller will call for the lead compressor to start. After a one-minute delay, the first contactor (e.g. 1M-1) is energized followed by the second contactor (e.g. 1M-2) after one-second-time delay. This provides reduced inrush stepped start. The compressor 15-minute anti-recycle timer is initiated at compressor start.

The controller monitors compressor amps, volts, leaving water temperature and suction and discharge pressures. The compressor and cooling capacity is controlled by pulsed signals to load and unload solenoid valves on the compressor. When the compressor starts, it is fully unloaded, about 25% of its full load capacity. As the computer gives it load signals, capacity gradually increases. The rate of compressor loading is governed by ramp control which is adjustable in the controller.

The controller responds to leaving chilled water temperature and its rate of change which is proportional and derivative control. If leaving chilled water temperature is within the deadband (+/-0.8°F [0.5°C] from setpoint), no load or unload commands are given. If chilled water temperature is above deadband, the controller will continue loading the compressor until a satisfactory rate of temperature decline is observed. If leaving chilled water temperature is below the deadband, the compressor is commanded to unload. Thus the compressor capacity is continuously modulated to match applied load and hold leaving chilled water temperature at setpoint.

If the applied load is greater than one compressor can handle, it will load fully and then the controller will call for a second compressor. After one minute, the second compressors will start in the same manner as the first. Then both compressors will be commanded to adjust load to approximately 50%. They are gradually loaded up together until the applied load is satisfied. In this way the two compressors share the load equally.

If the applied load decreases to the point that both compressors are running at about 40% capacity, the computer shuts down the lag compressor and loads the remaining compressor to about 90%. If applied load decreases further, the remaining compressor unloads proportionally. If applied load decreases to less than the minimum capacity of one compressor, the leaving chilled water temperature will gradually decline to 2°F [1.1°C] below setpoint, and then the lead compressor will shut down. It will restart automatically if leaving chilled water temperature rises to 2°F [1.1°C] above setpoint and both 15 minute anti-recycle and one minute start delay timers are satisfied.

During start-up operation, the controller monitors the difference between discharge and suction pressures to ensure that minimum of 30psi [2bar] differential is available for compressor lubrication. If the difference falls below a minimum of 30psi [2bar], the controller closes refrigerant flow control valves, starving the evaporator, causing evaporator pressure to drop, hence increasing differential pressure. This is especially helpful at startup, when warm chilled water and low ambient temperature would cause a low head situation. This feature is called EPCAS: Evaporator Pressure Control at Startup. It is one of several proactive control features of the controller which overcome potential problems while continuing operation.

Two additional proactive features are low suction and high discharge pressure override. If operating pressures approach trip level, compressors are unloaded as necessary to continue operation.

APPLICATION DATA

Low Ambient Operation / Freeze Protection

If unit is required to operate below 65°F [18.3°C], optional head pressure control is required. Glycol is recommended for added protection. If wind in area is over 5 mph [8 kph], a wind barrier is recommended.

Desuperheaters

A hot gas desuperheater can be factory supplied for field installation. Desupperheater reclaim the desuperheated gas energy for hot water utility. Consult factory for further details.

Water Circuit

Constant water flow required with a minimum of 3 gallons per TR [3.3 liters/kW] increasing up to 10 gallons per TR [11 liters/kW] for process, low load applications with small temperature ranges and/or vastly fluctuating load conditions.

Glycol Freeze Protection

If the chiller or fluid piping is to be exposed to temperatures below freezing, glycol protection is recommended. The re-commended protection is 10°F [5.6°C] below the minimum ambient temperature. Use only glycol solutions approved for heat exchanger duty. The use of automotive anti-freeze is not recommended because they have short-lived inhibitors and fouling of the vessels will occur. If the equipment is exposed to freezing temperature and not being used, the water in vessels and piping should be drained.

The use of glycol causes a performance derate as shown below which needs to be included in the unit selection procedure.

Ethylene Glycol

% E. G. By Weight	Freeze Point		C1 Capacity Factor	K1 kW Rate	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	0.969	0.988	1.097	1.275
40	-10.0	-23.3	0.957	0.982	1.116	1.331
45	-17.5	-27.5	0.935	0.970	1.138	1.398
50	-28.9	-33.8	0.913	0.958	1.161	1.466

Note: The Correction Factor is for LWT down to 44°F only.

Propylene Glycol

% P. G. By Weight	Freeze Point		C2 Capacity Factor	K2 kW Rate	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: The Correction Factor is for LWT down to 44°F only.

Correction Factor - Elevation

Elevation above Sea Level		Capacity Correction Factor	kW Correction Factor
Feet	Meters Factor		
0	0	1.00	1.00
2000	600	0.99	1.01
4000	1200	0.98	1.02
6000	1800	0.97	1.03

Correction Factor - FF

Fouling Factor		Capacity Correction Factor	kW Correction Factor
hr.ft².°F/BTU	m².°C/kW		
0.00010	0.018	1.000	1.000
0.00025	0.044	0.990	0.995
0.00050	0.088	0.970	0.990

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