IPCX

# Industrial Refrigeration Rotary Screw Process Chillers

## Installation, Operation & Maintenance Instructions

DUNHAM-BUSH USA

Form No. 6139D

# TABLE OF CONTENTS



## Service Procedures





## References*

| TITLE | FORM NO. |
|---|---|
| IPCX Open Type Packaged Chillers 120 Thru 750 Tons | 6061-1A |
| LSC Compressor Parts Manual | 6136D |
| LSC Compressor Installation, Operation & Maintenance Manual | 6137 |
| HVAC System Fluid Analysis Program (Oil Kare™) | NAS3006B |
| Receiving Inspection Report | 9214 |
| Request for Authorized Start-Up Representative | 9180 |
| Daily Operating Log | 9198 |
| Monthly Operating Log | 9198-1 |

***THESE FORMS ARE AVAILABLE AT THE LOCAL DUNHAM-BUSH SALES REPRESENTATIVE'S OFFICE.**

# 1.0 General Information

## 1.1 Introduction

Each unit was designed to meet specific criteria and must be operated within conditions specified when ordered.

Fluorocarbon refrigerant must be handled with caution and release to the atmosphere should be minimized. Instructions for charging and retrieving refrigerant from these units can be found in the maintenance section of this manual.

These instructions and the drawings supplied with the IPCX Unit must be followed carefully to insure proper installation, operation, and maintenance.

This manual is written and illustrated for a single IPCX Unit installation. For instructions concerning a multiple unit installation, consult Dunham-Bush, Inc.

**WARNING**

Valves or connections which can cause loss of the factory installed refrigerant charge and lubricating oil charges shall not be opened under any conditions. The system shall not be dismantled or opened during installation except under the supervision of a Dunham-Bush, Inc., Authorized Service Representative.

The IPCX unit shall NOT be started following installation except under the direct supervision of a Dunham-Bush, Inc. Authorized Service Representative.

Warning tags attached to the unit should not be removed either prior to or after installation.

Compliance with the above is mandatory in order that the warranty shall not be jeopardized. All contacts with Dunham-Bush, Inc., regarding requests for information, service, or parts should be made to the nearest sales office.

## 1.2 Shipping

The unit is shipped with skids and lifting arms attached for ease in rigging. Refrigerant and oil systems are fully charged. Chiller and condenser water connections have covers to prevent contamination of the vessels. Check the unit nameplate to be sure the power supply meets the unit requirements. The wiring diagram number and type of refrigerant can also be found on the unit nameplate.

## 1.3 Receiving/Inspection

The unit should be inspected immediately, in the presence of the carrier's representative, for any evidence of damage during shipping. Any damage should be noted on the carrier's delivery receipt before it is signed. A damage claim should then be filed by the purchaser against the delivering carrier as all shipments are made at the purchaser's risk. The receiving inspection report (Form 9214), sent with the installation instructions, should also be filled out at this time and forwarded to the Dunham-Bush, Inc., 101 Burgess Road, Harrisonburg, VA 22801.

## 1.4 Rigging and Moving

The Riggers and installers must use every precaution to prevent damage while moving the unit from the point of shipment to its permanent location. Pushing, pulling or climbing on any of the unit components or piping can easily create damage that will result in costly repairs of leaks and malfunctioning components. The only places it is safe to apply hoisting, jacking, pushing, or pulling forces are to shipping skids and lifting arms. Cables are to be attached only to the lifting arms, spreaders must be used with the lifting cables to prevent damage to the unit.

Skidding may be done directly on the shipping skids or on properly spaced rollers under the skids. Pushing and pulling should only be directed against the skids and lifting arms.

**DUNHAM-BUSH RESERVES THE RIGHT TO MAKE CHANGES IN SPECIFICATIONS AND DESIGN WITHOUT NOTICE.**

# 2.0 Installation

## 2.1 Location

The location of the unit may be any foundation or deck that is generally level within 1/8 of an inch and structurally capable of supporting the weight of the unit. A cleared area should be left around the unit to aid in operation maintenance and removal of components. See references (packaged chiller templates) to obtain minimum clearance requirements.

## 2.2 Mounting

Resilient pads are provided for installation under the mounting legs. For critical installations, Dunham-Bush, Inc., can provide whatever type of vibration isolator the customer specifies. They must be installed and adjusted in accordance with the isolator manufacturer's instructions. The unit may be cemented or lagged to the foundation if desired.

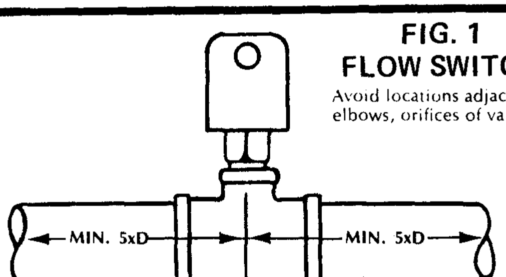
## 2.3 Leveling

When the unit is at its final location, it should be jacked or hoisted, by the lifting arms, the shipping skids removed and the unit let down on the isolator equipment supplied (felt pads or vibration isolators). It should then be checked for level longitudinally at the top center of the condenser shell and laterally across the compressor motor feet. Steel shims should be installed under the isolator pads, if necessary to level the unit.

## 2.4 Unmounted Accessories

A chiller flow switch, which is shipped in a separate container accompanying the unit, must be installed in the external chilled water outlet piping. It must be located in a horizontal section on the pipe where there is at least five (5) pipe diameters on both sides of the flow switch before any other connections, as indicated in Fig. 1. The flow switch paddle must be adjusted to the size of pipe in which the paddle is installed, and the switch set to trip at approximately 50% of the design flow. Consult the wiring diagram accompanying the unit for the electrical connections to interlock the flow switch with the control panel.

**FIG. 1**
**FLOW SWITCH**
Avoid locations adjacent to elbows, orifices of valves.




## 2.5 External Connections

### 2.5.1 Water Connection

After the unit has been leveled, the external water piping to the chiller and condenser may be made up. Air vent valves should be installed at all high points to bleed the system of entrapped air. Drain valves or plugs should be installed at low points to gravity drain the system. The unit drain plugs for the chiller, condenser and oil cooler (if equipped) must be installed prior to filling the system. Insulation should be installed on all external piping to prevent sweating and if the chiller (vessel) and associated piping was not equipped with the optional factory insulation, it too must be insulated.

All external plumbing should have manual shut-off valves installed near the unit for ease in servicing and maintenance. Strainers should also be mounted in the piping before the unit to prevent dirt and other contaminants from entering and damaging the unit and its satellite equipment.

The external plumbing must be carefully located and adequately supported by pipe hangers to prevent twisting or bending stresses on the unit when the flanges or grooved pipe connections are bolted. It is recommended that flanged elbows be used at the connection to the condenser so that the external piping will not interfere with servicing of the condenser tubes. Flexible connections on water lines throughout the machinery room are recommended for chiller and condenser piping, where sound or vibration transmission may be a problem.

Following make up of the external plumbing, a check should be made for piping stresses at the IPCX unit, as follows: Remove condenser and chiller connecting bolts. If any bolts are misaligned, adjust external piping or hangers to properly align the connections, If it is necessary to reshape and anneal the external piping, the inside of the piping must be cleaned of the resulting scale before reassembly. The piping should then be thoroughly flushed to remove all foreign material, connected to the unit, filled, vented and tested for leaks.

IPCX units are designed for a fixed evaporator water flow, and means should be employed to assure a relatively constant flow at all loads.

### 2.5.2 Water Treatment

Most industrial water supplies contain dissolved or suspended materials which cause scale formation, corrosion, and propagate slime, algae, etc. It is strongly recommended that a water treatment specialist be consulted for additive systems to counteract or prevent the damages caused by these impurities.

Cooling towers and evaporative water coolers experience a constant loss of water due to evaporation. Since evaporation is a distillation process, an increasing concentration of suspended and dissolved impurities occurs. This increase of impurities can be greatly reduced by a bleed-off system which will constantly bleed off the contaminated water and replace it with fresh water through the sump float valve.

Various water treatments, in addition to the bleed-off system, will probably be necessary. The correct rate of water bleed-off and the proper water treatment should be determined by a specialist familiar with the local water characteristics. A daily check and periodic inspections should be made to be sure the correct bleed-off rate and water treatment is maintained. Do not underestimate the importance of daily logged readings of condensing pressure, water temperatures, oil cooler water (when supplied) and oil temperatures in determining the condition of the heat transfer surfaces, and the effectiveness of the water treatment.

**NOTE:** Consult manufacturer for information concerning design, installation and operation of the cooling tower or evaporative water cooler.

**WARNING:** Dunham-Bush, Inc., will not be liable for any damage or failure resulting from the physical or chemical properties of the condenser water used in this equipment.

NOTE: Local codes may require the relief valve piping piped away from the unit.

### 2.5.3 Electrical Connections

The unit is completely wired at the factory prior to delivery. The connections which must be made by the installer are listed below. Each circuit must have adequate control and protection devices incorporated in it in accordance with the National Electric Code and/or other applicable codes in the area in which the unit is installed. The voltage, frequency and phase must be in accordance with that shown on the unit nameplate, and within 1% voltage imbalance. Flexible conduit should be used where vibration may be a problem. All wiring must be in accordance with the wiring diagram furnished with the unit, the National Electrical Code and any local codes that may apply. Any deviations from the above requirements must have the prior approval of Dunham-Bush, Inc. Customer supplied starters for the compressor motor must be individually approved in writing by Dunham-Bush, Inc. A starter interconnection wiring diagram can be found in the Operation Section of this manual.

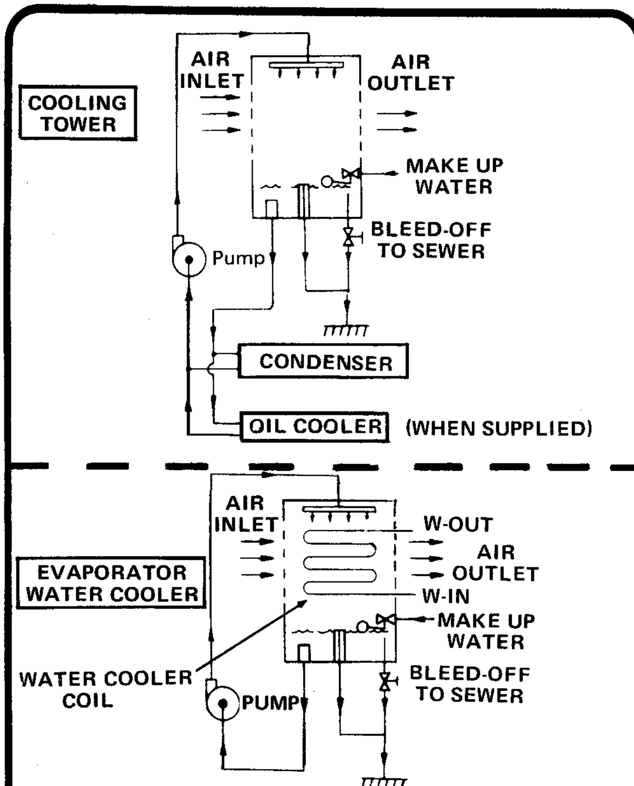



**FIG. 2 TYPICAL BLEED-OFF SYSTEMS**

The following external wiring is to be provided by the installer:

a. Power supply to compressor motor starter with circuit protection, and from starter to compressor motor.

b. Power supply to oil pump motor contactor or starter with circuit protection.

c. Chilled water pump auxiliary contacts to control panel.

d. Condenser water pump starter control circuit to control panel.

e. Compressor motor starter control circuit to control panel.

f. Compressor motor overload circuit to control panel.

g. Load limiter wiring from starter to control panel.

h. A properly sized control transformer or 120V/60 HZ/1 PH power supply to control panel, with circuit protection.

i. Flow Switch to control panel.

### 2.5.4 Mounting and Leveling

- Erected on foundation in accordance with construction and electrical drawings supplied to the customer and requirements of this manual.
- Spring isolators or pads, installed, and the unit leveled in accordance with isolator manufacturer's instructions and the requirements of this manual.

### 2. 5.5 Water Piping

- Condenser cooling water piping installed between condenser, pumps and cooling tower or well as specified in this manual.
- Chilled water piping installed between chiller, pumps, and terminal equipment as specified in this manual.
- Make-up and fill lines installed to cooling tower and chilled water system and water treatment and bleed-off systems as needed.
- Thermometers, air vents, drain plugs and pressure gauges installed in chilled and condenser water inlet and outlet lines.
- Flow switch installed in outlet chilled water line and adjusted to a minimum of 50% flow.
- All water piping checked for strain as specified in this manual.
- Water piping leak tested, flushed and vented, water strainers checked after flushing to be certain they are not clogged.
- Chiller and condenser water flow available from supply in sufficient quantity to meet unit design requirements and with adequate water treatment.

### 2.5.6 Electrical Wiring

- Power supply available with circuit protection and in accordance with the requirements on the unit nameplate and this manual.
- Wiring completed from power supply through circuit protection in accordance with the drawing supplied and the requirements of this manual.
- Wiring completed from power supply to circuit protection for oil pump motor in accordance with the wiring diagram and the requirements of this manual.
- Wiring completed from power supply through circuit protection to 115V control circuit in unit control panel (or through 115V transformer to control circuit) in accordance with the drawing supplied and requirements of this manual.
- Wiring from power supply through circuit protection to satellite equipment and interlocks wired to control panel in accordance with drawing supplied and requirements of this manual.
- Phasing correct for direction of rotation of all motors except compressor and oil pump motors phasing of compressor and oil pump motor will be checked by Dunham-Bush, Inc. startup representative.

### 2.5.7 Conditions Required for Start-Up

- Load must be available for operation and testing a refrigeration load adequate to cause normal operation of the unit MUST BE AVAILABLE.
- Competent representatives of the Allied Trades (electrical contractor, steam fitters, controls contractor, etc.) involved in the installation of this chiller must be at job site to correlate their portion of the work in starting, testing, and balancing this chiller.

## 2.6. Request for Start-Up Representative

After the installation has been completed and checked, Form 9180 must be filled out and sent to the North American Service Department of Dunham-Bush, Inc. This form is a request for the services of a Dunham-Bush, Inc. authorized start-up representative to perform the initial start-up of the Dunham-Bush chiller. The purchaser will have competent service, and operating personnel in attendance to assist in the work involved, and also to be trained in the service and maintenance of this chiller. (During the warranty period the manufacturer is responsible for parts only upon proof of defective workmanship or manufacture).

Following receipt of this signed form, a representative will be sent to the customer. He will inspect the installation to determine whether it meets Dunham-Bush, Inc. requirements, perform the initial start-up of the installation to determine whether it is in satisfactory operating condition, and instruct the specified customer personnel in its operation and maintenance for the length of time specified in the purchase contract.

**NOTE:**

Sump oil heaters should be energized a minimum of 24 hours prior to arrival of start-up representative. This will insure that the oil is warm enough to vaporize any refrigerant in the oil and is in the normal operating temperature range.

# 3.0 Operation

## 3.1 General

**WARNING:** The compressor and oil pump are NOT to be started initially except under the direct supervision of an Authorized Dunham-Bush, Inc. Start-Up Representative. Be sure that oil sump heaters are turned on for a minimum of twenty-four hours prior to initial start-up. Couplings and motors have been aligned with the compressor at the factory. During shipment they may become misaligned. Alignment and motor pinning at initial start-up must be done by a Dunham-Bush, Inc. Start-Up Representative.

While this unit is greatly simplified and incorporates features to protect it against damage, it does represent a considerable investment and deserves the attention and care normally given to any fine piece of equipment. Reliable and economical operation will be achieved if the instructions in this manual are followed.

**CAUTION:** Operate this equipment in accordance with the instructions of this manual. DO NOT alter control settings to other than those specified on the wiring diagram accompanying the unit.

This equipment has been tested prior to shipment and found satisfactory for the conditions under which it was sold. Operation in excess of these conditions will subject this equipment to stresses for which it was not designed. Failure to heed this warning may result in injury to operating personnel and may jeopardize the warranty under which the equipment was sold.

## 3.2 Systems

### 3.2.1 Refrigerant System

The IPCX packaged chiller may have either a direct expansion or flooded chiller depending on the capacity of the unit. A simple flow diagram as depicted in Fig. 3 and 4 indicates the principle parts of a basic refrigeration cycle. The compressor takes the refrigerant gas at low density and compresses it to a higher density. The temperature of the refrigerant gas is also increased. The dense refrigerant gas flows to the condenser where heat is removed, causing a change in the state of the refrigerant from a gas to a liquid. The refrigerant in a liquid state then flows through the filter/drier, through an expansion valve which meters the refrigerant into the evaporator chiller. There it changes its state back to a gas as it absorbs heat and evaporates. It is during this change of state that the refrigerant will extract heat from the medium being cooled. This low density cool gas then flows to the compressor where the cycle is repeated.

Operation of specific components within the refrigerant system may be found under System Components Section.

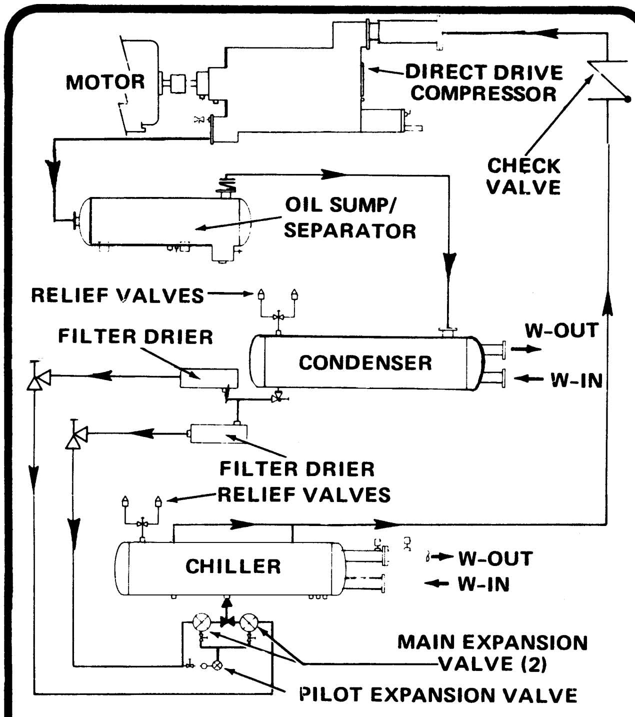



FIG. 3 TYPICAL FLOODED IPCX

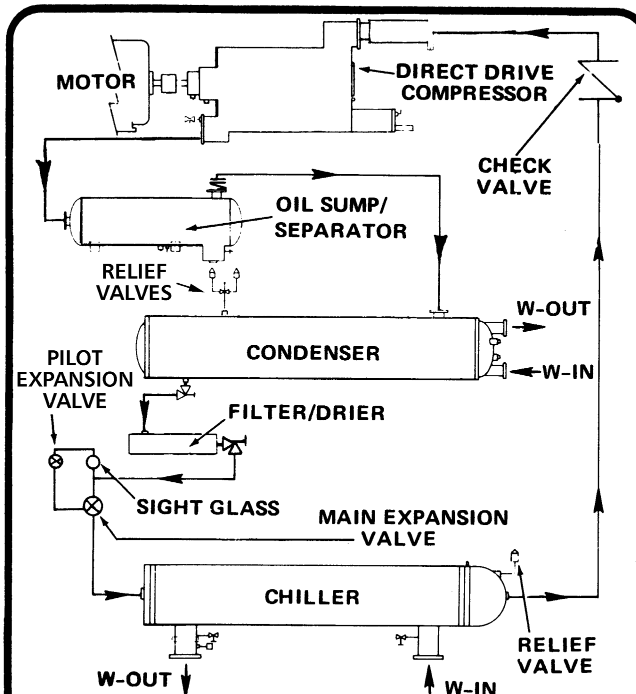



FIG. 4 TYPICAL DIRECT EXPANSION IPCX

### 3.2.2 Water Systems

The condenser water system on an IPCX unit is an open end system and the water in the system is used to condense hot refrigerant gas into a liquid. Water is pumped through the tubes of the condenser where it picks up heat condensing the refrigerant. It then flows to a water tower, evaporative water cooler, or other cooling service, where the heat is dissipated to the atmosphere. Cooled water is picked up here and is pumped to the condenser to absorb more heat from the refrigerant.

Some units have water cooled oil coolers. The water used to cool the oil is either diverted from the input of the condenser to the oil cooler or is supplied from an exterior source. A thermally actuated valve monitors the leaving oil temperature and modulates the water flow through the cooler.

The condenser for heat recovery units is constructed with two entirely separate water circuits. Hot gas from the compressor is discharged to the condenser where the heat is absorbed by either one of the water circuits or both simultaneously, depending on the building requirements. The heat reclaim condenser features the split system to prevent contamination of the heating circuit, associated piping, and heating coils from the cooling tower water which may absorb dirt, chemicals or corrosives.

The chilled water system is a closed system and the flow pattern varies for a flooded system versus a direct expansion system. Both systems use shell and tube heat exchangers, but in a flooded system the water is pumped through the tubes while in a direct expansion system, water is pumped through the shell. As the chilled water leaves from either of these systems, it is monitored by electronic arrangement which controls the operation of the unit. The chilled water then flows to the cooling coils where it picks up heat from the space or item being cooled. The water is then circulated back to the pump and chiller.

Operation of specific components within the refrigerant system may be found under the Component Operation Section.

### 3.2.3 Lubricating System

The oil in an IPCX system is used to lubricate the compressor and is additionally used to dissipate heat generated within the compressor, provide a seal between the male and female rotors during compression of the refrigerant, as a hydraulic medium for capacity control, and to provide quiet operation.

There are a number of variations of lubricating systems. The choice of each system is dependent upon the type of unit and its purpose. Operation of these systems can be found in the Component Operation Section.

## 3.3 Component Operation

### 3.3.1. Compressor/Motor Assembly

The IPCX compressor motor is air cooled and is connected to the compressor by a flexible coupling.

The compressor used on the Dunham-Bush, Inc., packaged chiller is a positive displacement, helical-axial flow compressor designed for use with high pressure refrigerants. Unlike centrifugal compressors, no purge system is needed.

For clarity reasons, the following account of the IPCX 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.

### 3.3.2 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 through the inlet port - Fig. 5 as the rotors continue to turn the interlobe space increases in size - Fig. 6 - 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. 7.

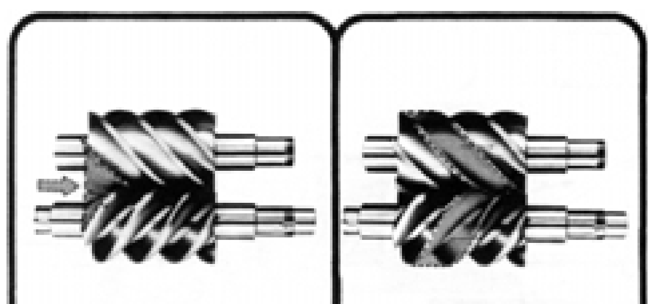


FIG. 5 FIG. 6

### 3.3.3 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.

### 3.3.4 Discharge Phase

At a point determined by the designed "built-in" compressor ratio, the discharge port is uncovered and the compressed gas is discharged by further meshing of the lobe and interlobe space - Fig. 8. While the

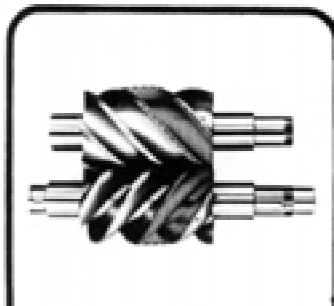


FIG. 7

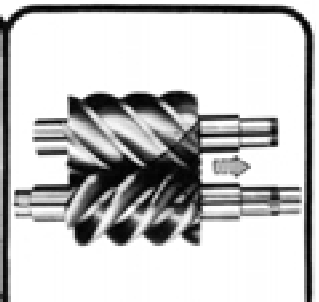


FIG. 8

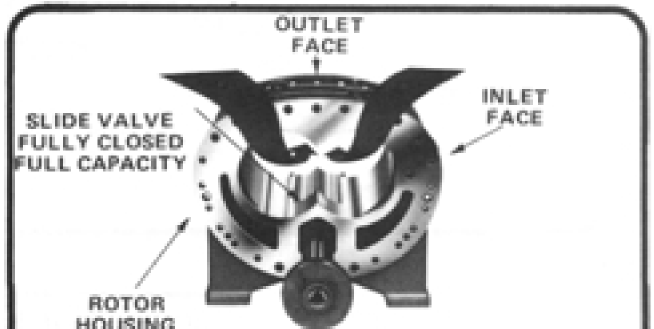



FIG. 9

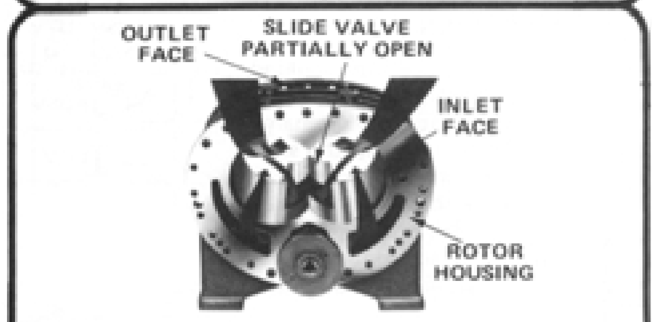



FIG. 10

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.

### 3.3.5 Capacity Control

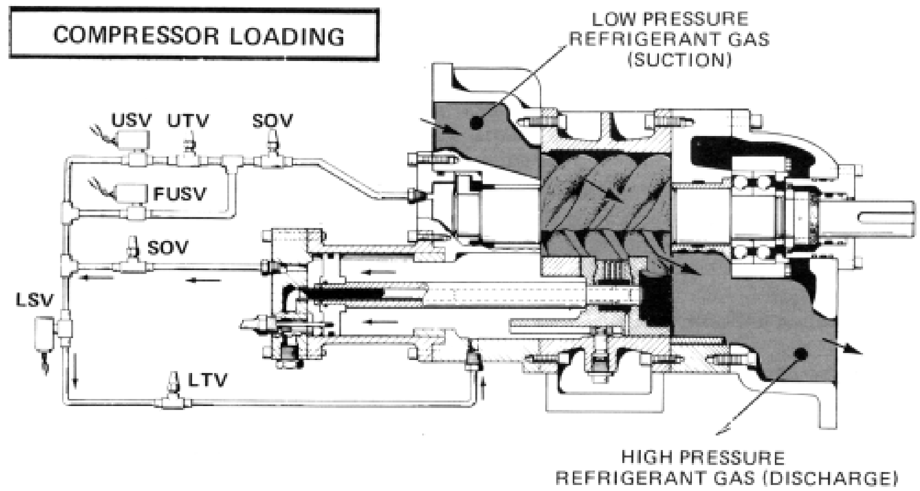
Compressor vapor displacement is controlled to balance the flow rate of liquid refrigerant entering the evaporator with the changing cooling demand.

The capacity control valve is located in the rotor housing as shown in Fig. 9 and 10. The movement of this valve along the axes of the rotors is programmed by a solid state, temperature initiated, hydraulically actuated control arrangement. When the compressor is fully loaded the slide valve is in the closed position against the valve stop as shown in Fig. 9, and all gas flows through the rotor housing as described previously. When the compressor starts to unload, as shown in Fig. 10, the compressor slide valve will move away from the valve stop. The movement of the slide valve creates an opening in the bottom of the rotor housing through which suction gas can pass back to the inlet port. As no significant amount of work has been done on the returned suction gas, no appreciable losses have been incurred. Reduced capacity is obtained from the gas remaining in the interlobe, which is compressed in the ordinary manner. In principle, as the opening in the rotor housing is enlarged, the compressor displacement is reduced. Optional capacity control system information can be found under Optional Sub-System Operation.

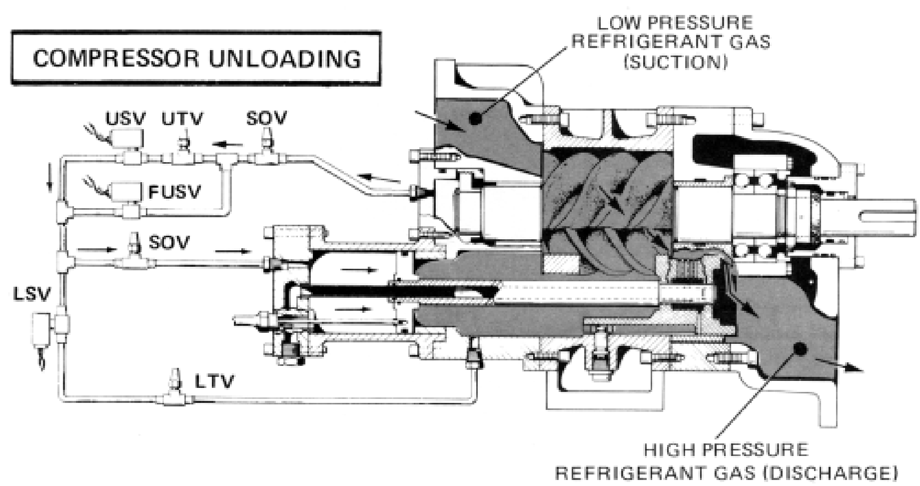
3.3.6 The temperature load controller (TLC) supplies power to the load solenoid valve (LSV) and unload solenoid valve (USV) to control the position of the compressor slide valve piston. Control is achieved electronically by a monitoring leaving chilled water temperature. The TLC will always act to meet a specific load demand and stabilize unit operation.

| | | | |
|---|---|---|---|
| LEGEND: | LTV - Load Throttling Valve | UTV - Unload Throttling Valve | SOV - Shut Off Valve |
| | FUSV - Fast Unload Solenoid Valve | USV - Unload Solenoid Valve | LSV - Load Solenoid Valve |
| | ☐ Refrigerant Gas | ☐ Refrigerant Oil | |

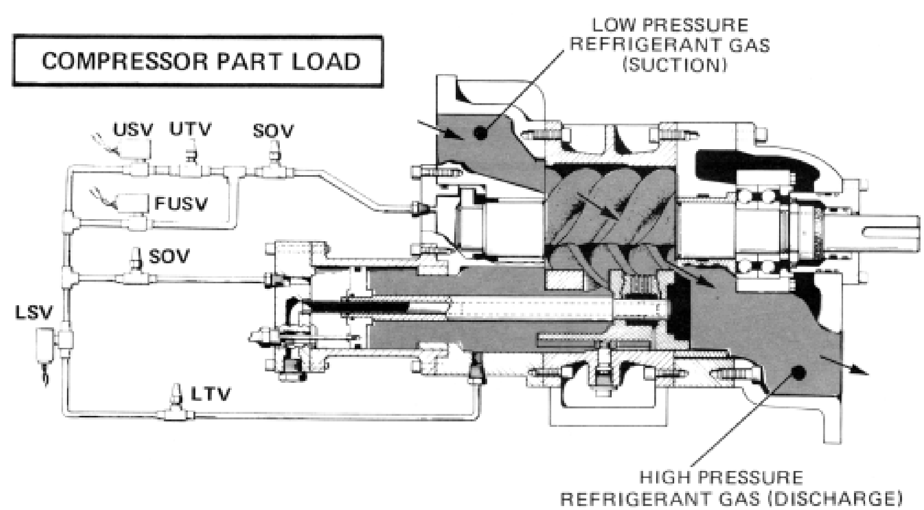
- **LOADING**
  When energized, the load solenoid valve (LSV) opens and discharge pressure pushes the slide valve towards load, forcing oil out of the cylinder into the suction housing. Piston speed is controlled by an adjustable restrictor valve located in the oil line.




- **UNLOADING**
  When energized, the unload solenoid valve (USV) opens. The combination of discharge plus oil pressure on the slide valve piston will move the slide valve toward the unload position. Piston speed is controlled by an adjustable restrictor valve located in the oil line.




- **PART LOAD**
  The unit will remain in the part load position as long as the leaving chilled water temperature remains at the desired temperature. Both load and unload solenoid valves will be closed and the piston will be stationary at the part load position.



## 3.4 Lubrication System Operation

### 3.4.1 Oil Separation and Collection

Prior to entering the condenser, the discharge refrigerant vapor and the oil are mechanically separated. The oil/vapor mixture is discharged from the compressor to a separator, or combination sump/ separator (depending upon the unit model). A liquid injection arrangement controlling discharge temperature at the compressor insures the proper conditions necessary for efficient oil separation.

- **Open Drive Units** - Units featuring a direct drive compressor incorporate a combination oil/sump separator in a single vessel. The upper portion of the shell contains mesh beds which serve to remove the oil from the discharge vapor. The bottom portion of the shell acts as a sump for the collected oil. The discharge refrigerant vapor is piped from the upper portion of the sump/separator to the condenser.
- **Oil Sump Heaters** - Electric resistance heaters are located in the lower portion of the sump vessel and serve to vaporize excess refrigerant that may have diluted the oil during shutdown, and heat the oil to a suitable temperature for start-up. Normally the heaters must be energized a minimum of 24 hours and the oil sump temperature must be at a minimum of 100°F (38°C) prior to start-up of the unit.
- **Oil Sump Sight Glasses** - Sight glasses are provided in the sump vessel to monitor the oil level. When the unit is shut-down and the oil is at design discharge temperature, the normal oil level is 1/2 to 1/3 visible in the (top) sight glass.

### 3.4.2 Oil Pumps

A gear type oil pump is used to provide oil at sufficient pressure to lubricate the compressor and actuate the capacity control slide valve. The pump is open drive and located exterior of the oil sump. The open pump is coupled to a motor. To avoid circulation of solid contaminants, a 100 mesh strainer is located at the pump suction. Service valves and a check valve are provided for ease of maintenance.

### 3.4.3 Oil Systems

There are two basic types of oil system piping arrangements used on packaged chillers that serve the compressor's lubrication and hydraulic purposes; a partially pumped system and a fully pumped system. Typical lubrication systems are shown in Fig. 11 and 12.

NOTE: Net oil pressure is the oil pressure supplied to the bearings minus the discharge pressure at the compressor.

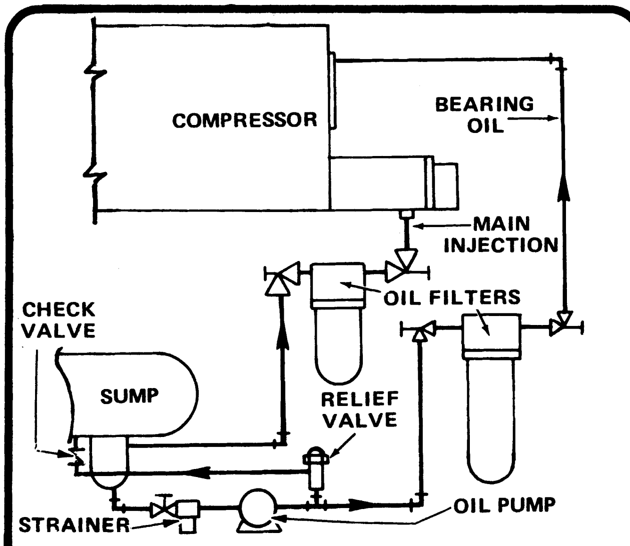



FIG. 11 - PARTIALLY PUMPED OIL SYSTEM WITH OPEN OIL PUMP

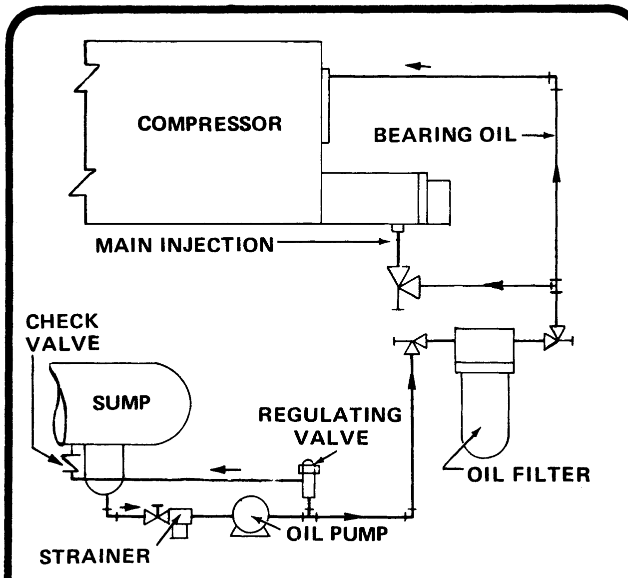



FIG. 12 - FULLY PUMPED OIL SYSTEM

- Partially Pumped Oil System - In a partially pumped lubrication system, strained oil is pumped through an oil filter.
- **Fully Pumped Oil System** - Both injection and bearing oil are pumped in the fully pumped oil system. Net oil pressure is maintained by a regulating valve mounted at the oil pump discharge. The regulating valve may be adjusted to obtain the required net oil pressure.

### 3.4.4 Oil Filters

The filters used in the oil system consist of a shell with replaceable 10 micron pleated paper element(s). The normal operating pressure drop across the filter is 1 thru 2 PSID (62 thru 131 kPa) with a new element. The maximum allowable pressure drop across the filter is 6 PSID (41.4 kPa). Service valves are provided for easy maintenance.

### 3.4.5 Evaporator Oil Return System (Flooded Chiller, Low Temperature Direct Expansion Chiller)

Powered by discharge gas, a jet pump eductor is used to remove residual oil that accumulates in the chiller. This device is used on all flooded chillers, and direct expansion chillers with low suction temperature applications.

- **Flooded Chiller** - The flooded chiller has 4 to 5 valve taps in the chiller shell which are connected to the suction of the jet pump. The bottom tap should be opened partially for pulldown and overload conditions, when the liquid level is depressed. For high chiller liquid levels, when the load is low, the top tap, generally, should be closed unless field conditions require otherwise. The remaining valve taps permit oil pick-up as the level varies. These taps should be open somewhat, and the one that is closest to the normal liquid level, when operating at the design condenser leaving water temperature, should be wide open.

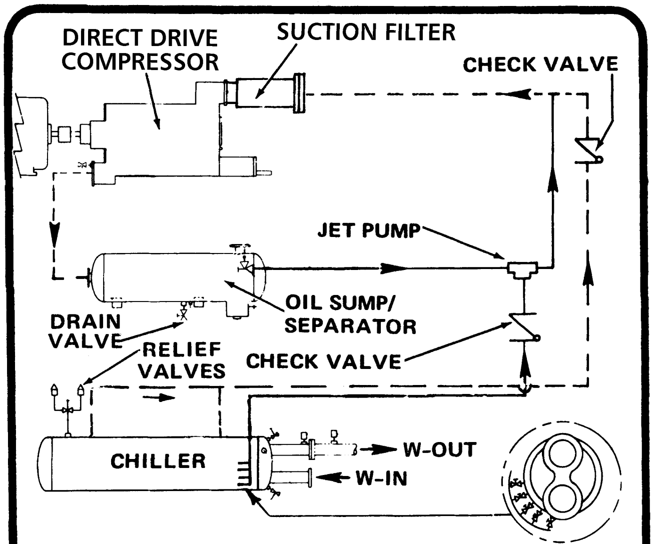



FIG. 13 JET PUMP (FLOODED CHILLER)

NOTE: Avoid having valves wide open that draw only gas from the chiller.

- **Direct Expansion Chiller** - The direct expansion chiller has one valve tap in the chiller suction head which is connected to the suction of the jet pump.

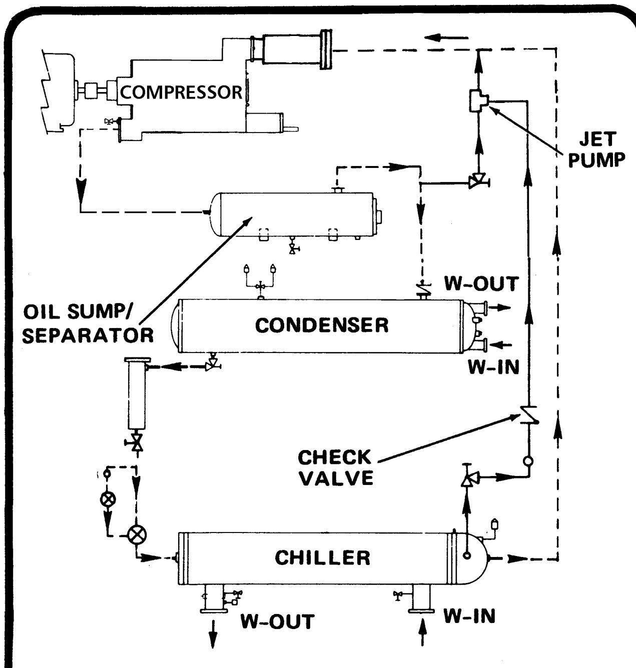



FIG. 14 JET PUMP DIRECT EXPANSION

Both the valve at the chiller head and the valve at the jet pump remain fully open.

## 3.5 Oil Cooling System Operation

Liquid injection or a water cooled oil cooler is supplied for oil cooling.

### 3.5.1 Liquid Injection

Liquid injection is used to cool the oil and refrigerant vapor, and is controlled within the compressor during compression to insure efficient oil separation, minimize refrigerant solubility in the oil, and maximize lubrication properties. By controlling oil temperature on hermetic units, the liquid injection system, additionally, facilitates the dissipation of heat from the motor windings.

- **Normal Operation** - This system is designed to hold the oil temperature above 135°F (57.2°C) to minimize excessive oil dilution. This is accomplished by a thermostat sensing discharge temperature. The liquid injection solenoid will de-energize when the discharge temperature reaches the design cut-out setting for the thermostat, as noted on the unit wiring diagram accompanying the unit. The solenoid will cycle to maintain 140°F ± 5°F (60°C) oil temperature, minimizing dissolved refrigerant in the oil.

  To insure proper oil separation by maintaining discharge superheat under all load conditions, the thermoexpansion valve is factory pre-set to maintain a minimum 40° thru 50°F (22.2 thru

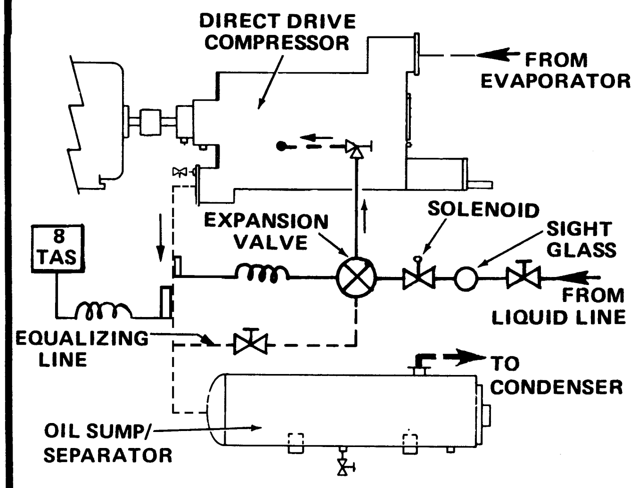



FIG. 15 LIQUID INJECTION

27.8°C) discharge superheat at 100% load. On any given unit, the controls should be set to maintain a minimum of 35°F (19.4°C) superheat at any load.

- **Heat Reclaim** - The liquid injection assembly for heat reclaim units operate in the same manner except that the liquid injection throttling device is a temperature operated valve that will react to discharge temperature only rather than discharge superheat.

### 3.5.2 Seal Oil Cooling (Open Drive Units)

Seal oil cooling is provided to control the viscosity and temperature of the oil supplied to the shaft seal cavity under all operating conditions. The temperature of the oil entering the seal cavity is maintained at 115°F ± 5°F (46°C ± 2.8°C). The major components of the seal oil cooling system consist of a liquid line solenoid, a temperature operated expansion valve, a direct expansion heat exchanger and a safety thermostat. A check valve is provided upstream of the seal cavity to maintain a full oil level in the cavity, preventing refrigerant leakage through the seal during shutdown.

- **Normal Operation** - The seal oil cooler liquid line solenoid energizes on start-up allowing liquid refrigerant to enter the heat exchanger. The safety thermostat is electrically bypassed during start-up by a timer until conditions stabilize for normal operation. The expansion valve modulates refrigerant flow entering the heat exchanger by responding quickly to temperature changes in the oil entering the seal cavity.

### 3.5.3 Water Cooled Oil Coolers (Low Temperature or Special Applications)

Constructed with an externally finned tube bundle mounted in a steel shell, the heat exchanger provides the required oil cooling capacity under all operating conditions. A thermostatically actuated two way valve regulates the water flow through the tubes, as the sensing element monitors the leaving oil temperature. The baffle arrangement in the shell side channels the oil flow for a more effective heat transfer.

## 3.6 High/Low Side Component Operation

### 3.6.1 Discharge Check Valve

To prevent migration of refrigerant from the condenser into the compressor during shutdown, a discharge check valve may be used. Located between the compressor and condenser, the check valve also prevents excessive spin-down of the compressor, and allows the unit to be pumped down for servicing.

### 3.6.2 Condenser

The condenser is a 'shell and tube' heat exchanger which serves to condense the discharge refrigerant vapor by removing heat. Water is circulated through the tubes absorbing heat from the discharge vapor condensing in the shell side of the externally finned copper tube bundle. The water flow rate or temperature will have a significant effect on refrigerant condensing pressures under all operating conditions. Dual refrigerant relief valves are mounted on the condenser vessel serving as a protection device.

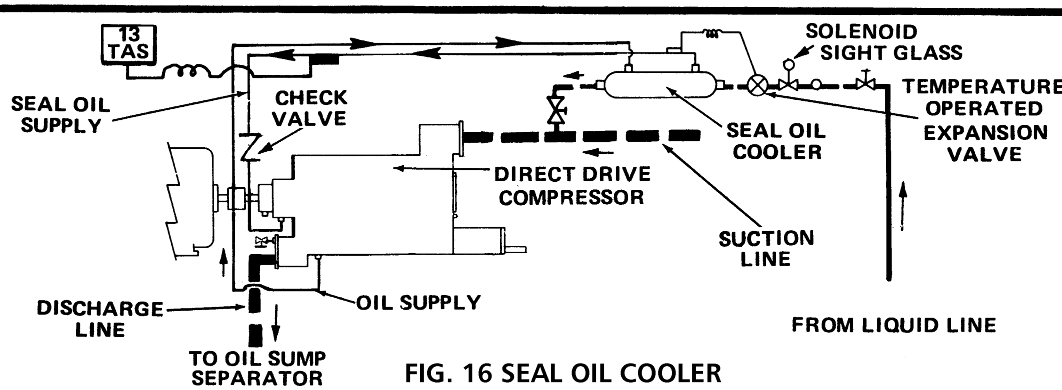



FIG. 16 SEAL OIL COOLER

- **Heat Reclaim Condenser** - As heat reclaim applications are specialized, the most economical operation must be evaluated for each job. Generally, when the heat reclaim water circuit is operating, the condensing pressure elevates became of a high entering water temperature, resulting in a higher kilowatt draw. When or if the tower water should operate during the heat reclaim cycle depends upon the heating and cooling load characteristics, and the percentage of heat rejected for heat reclaim.

### 3.6.3 Filter Drier

The filter/drier is composed of a strainer and replaceable desiccant cartridges which remove contaminants, acid, and moisture from the refrigerant. A shut-off valve is at the outlet end of the filter/drier.

### 3.6.4 Throttling

Throttling liquid refrigerant serves to regulate the refrigerant flow into the chiller while maintaining the required evaporating temperature. Throttling is accomplished by a multiple valve arrangement. The pilot thermo valve is mounted in a branch liquid line and is used in conjunction with the pilot operated solenoid (P.O.S.) thermal expansion valve which is located in the main liquid line.

- **Pilot Thermo Valve** - The pilot thermo valve meters a branch refrigerant liquid line while sensing either leaving water temperature or suction temperature, and serves to supply a pilot signal to the P.O.S. valve.
- **Pilot Operated Solenoid Valve** - The P.O.S. valve positions according to the signal pilot supplied from the pilot thermo valve. During shutdown the solenoid valve closes the pilot line allowing the valve to close. A manual opening stem is provided for service purposes and must be fully counterclockwise for normal operation.

### 3.6.5 Chillers

Designed for a fixed flow rate, the "shell and tube" heat exchanger transfers heat from the medium being cooled to the refrigerant, causing the refrigerant to vaporize. The two types of chillers are flooded and direct expansion. Both types have pressure taps at the water inlet and outlet connections, a bulbwell for the water freeze-up thermostat, and a temperature load control sensor.

- **Flooded** - Flooded chillers have liquid refrigerant flooding the lower portion of the shell with the medium being cooled flowing through the tubes. The tubes are externally finned so that the refrigerant will have a large surface area to extract heat from be medium being cooled. Also supplied on the flooded chiller is a dual relief valve to serve as a protection device.
- **Direct Expansion** - The refrigerant enters the chiller through a distributor where it is directed into the tubes (the evaporating refrigerant is at a rate depending upon the cooling load). The tubes are of the patented Inner-Fin® extended surface design which improves heat transfer while minimizing refrigerant pressure drop, permitting a compact and efficient chiller design. The refrigerant vapor passes through an effective filter built into the suction head of the chiller (for additional system protection). The chiller is provided with a single relief valve to protect it from refrigerant over pressure.

### 3.6.6 Suction Check Valve

Located in the piping between the compressor and the chiller, they are used to prevent excessive "spin-down", equalization of pressure between the compressor and chiller, and to prevent migration of oil into the chiller.

### 3.6.7 Suction Filter

- **Flooded Units** - Units with a flooded chiller may have a 10 micron suction filter mounted on the compressor at the compressor inlet.
- **Direct Expansion Units** - Units with a direct expansion chiller have a dacron felt filter located in the suction head of the chiller.

## 3.7 Optional Sub-System Operation

### 3.7.1 Vapor Injection System

The vapor injection system is used to provide additional subcooling to the liquid refrigerant supplied to the evaporator for increased refrigeration effect and system capacity. Its main components are a subcooler, subcooler thermo-expansion valve, evaporator pressure regulator, check valve, solenoid valve, vapor injection filter, oil feed valve, dual feed lines to the pilot valve of the main thermo-expansion valve and a minimum load limit switch.

### 3.7.2 Hot Gas Bypass - Unloaded Start

Hot gas bypass unloaded start is accomplished by diverting gas from the compressor discharge port through a solenoid valve to the compressor suction port. The bypass line is open at start-up and the solenoid valve is used to close it. The purpose for unloading is that the compressor is designed to start under a low load (torque) condition, such as when the low side and high side pressures are equal (balance). The equal pressures allow the compressor and motor to reach operating RPM before the solenoid closes and compression starts. The motor therefore draws fewer inrush amps. In the case of open compressor units, unloaded start may allow use of a smaller horsepower motor.

### 3.7.3 Hot Gas Bypass Capacity Control

Hot gas bypass capacity control is used to feed hot gas directly into the chiller when the compressors load falls to 10% or less. When this occurs, a solenoid valve in the capacity control line is energized. The introduction of hot gas provides a stable refrigerant flow and keeps the machine from short cycling under low load conditions.

### 3.7.4 Micro Switch

The micro switching assembly controls various system components at different percent slide valve positions. Adjustments may be required upon installation to balance the unit performance with load characteristics.

- **High/Low Limit Switches -** These serve to limit slide valve positioning from extending beyond the range of application The low limit switch is adjusted correctly when the differential temperature across the chiller is 1°F to 2°F (.56°C to 1.12°C). The high limit switch is factory set and should be adjusted only by an Authorized Dunham-Bush serviceman.
- **Hot Gas Capacity Control Limit Switch** - (If applicable) is used in conjunction with the low limit switch.
- **Large TX Valve Limit Switch** - (If applicable) Refer to the specific unit wiring diagram for correct positioning.

For any additional information, refer to the specific unit wiring diagram or to Dunham-Bush Service Bulletin No. SR109A.

## 3.8 Typical Piping Schematic

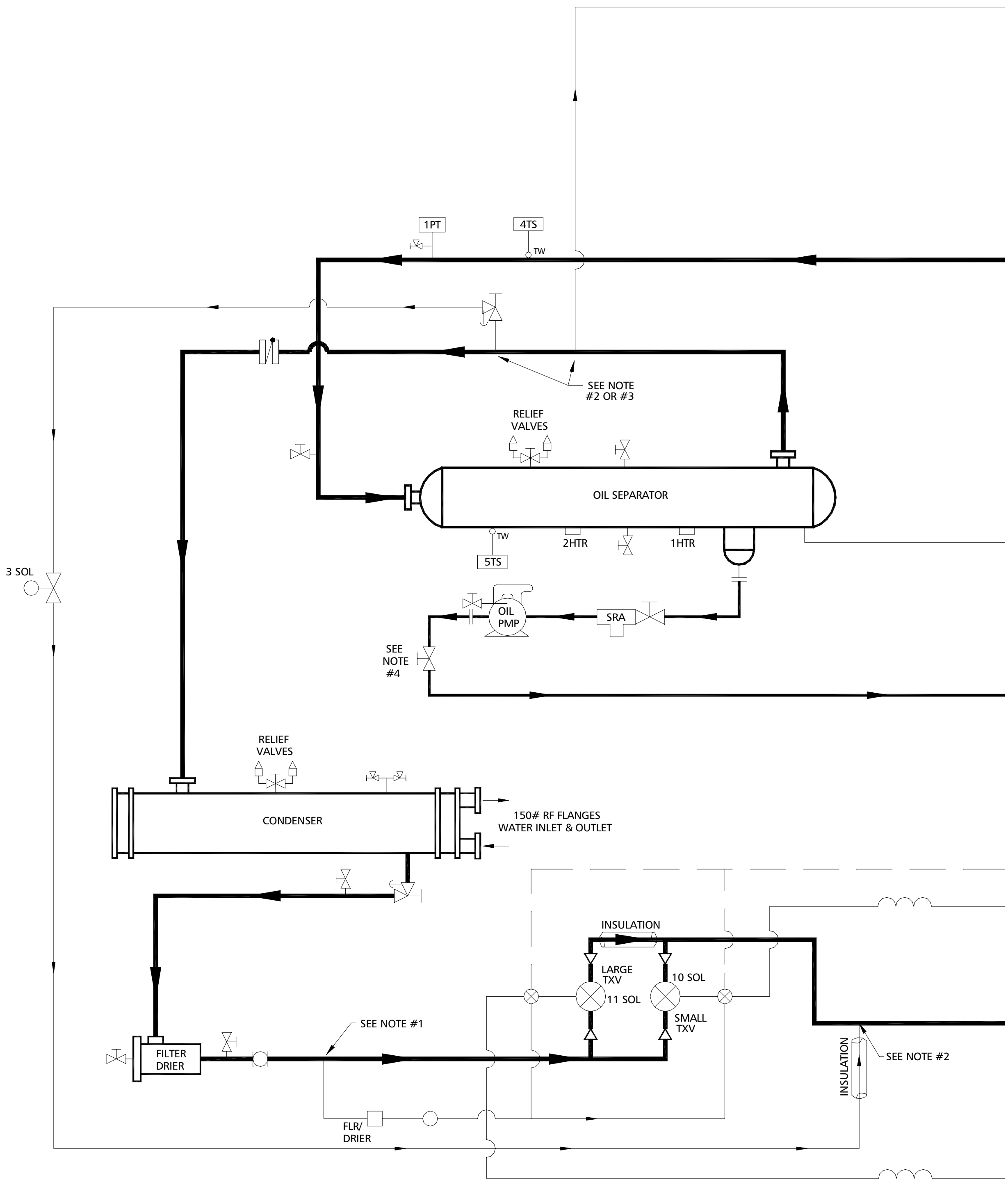
The piping schematics which appear on the next two pages are typical only. These schematics depict control systems and refrigerant and oil flow through the unit to furnish you with an understanding of the screw compressor packaged chiller.

Shown below are the symbols, codes and items with their descriptions which appear on the piping schematic.

PIPING SYMBOLS

| SYMBOL | DESCRIPTION | SYMBOL | DESCRIPTION |
|---|---|---|---|
| | Refrigerant | | Hand Valve |
| | Refrigerant & Oil | | Hand Angle Valve |
| | Oil | | Solenoid Valve |
| | Control | | Check Valve |
| | Remote Bulb Capiliary Tubing | | Sight Glass |
| | Unloaded Start | | Expansion Valve |
| | Hot Gas Bypass | | Pilot Expansion Valve |
| | Relief Valve | | |

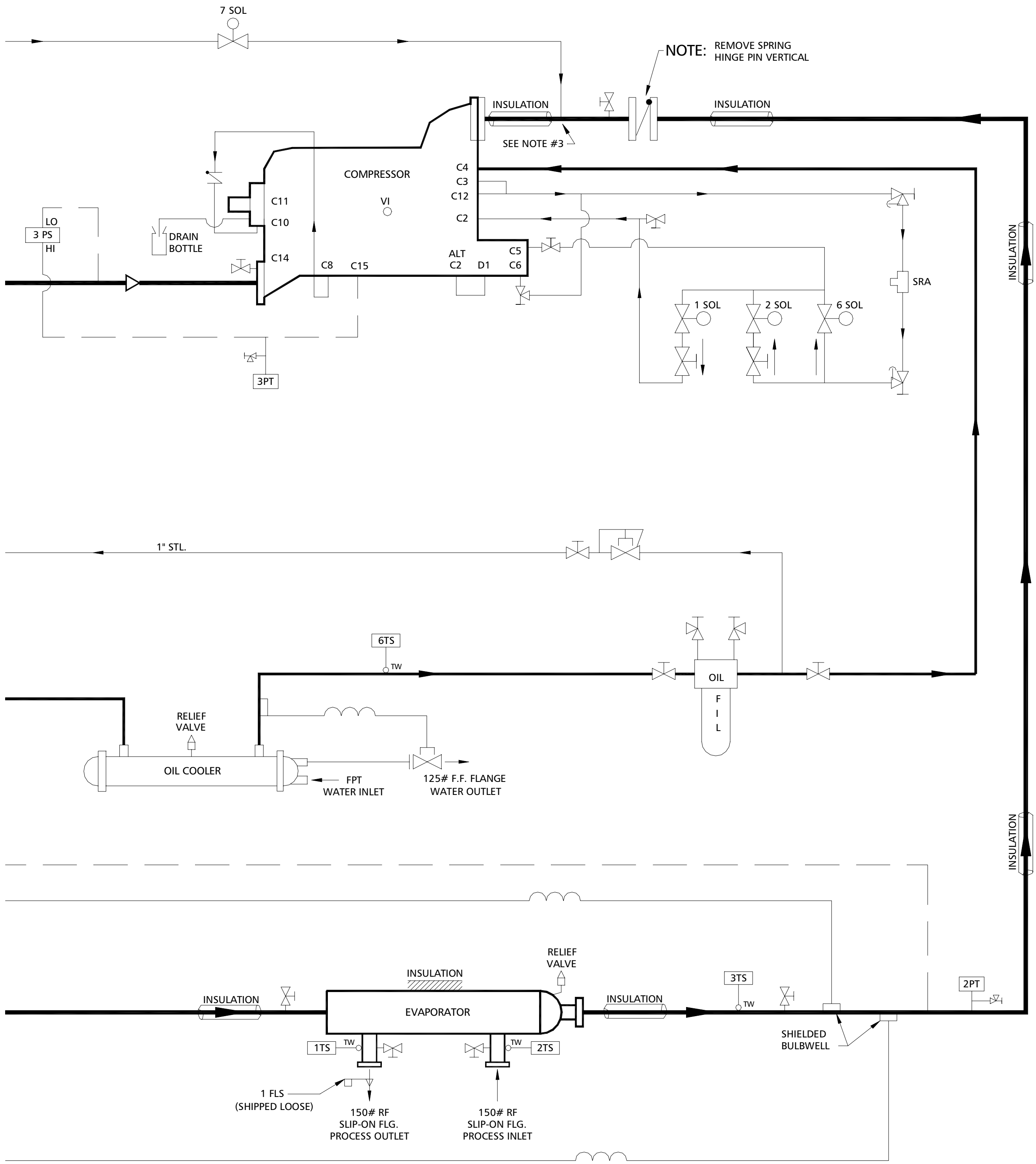
## 3.8 Typical Piping Schematic (Cont.)




| | NUM. | DESCRIPTION |
|---|---|---|
| | 1TS | LEAVING COOLER BRINE TEMP. RTD |
| | 2TS | ENTERING COOLER BRINE TEMP. RTD |
| | 3TS | SUCTION TEMP. RTD |
| | 4TS | DISCHARGE TEMP. RTD |
| | 5TS | OIL SUMP TEMP. RTD |
| | 6TS | OIL INJECTION TEMP. RTD |
| | | |
| * | 1PT | DISCHARGE PRESSURE TMR |
| * | 2PT | SUCTION PRESSURE TMR |
| * | 3PT | OIL LINE PRESSURE TMR |

* - LOCATE PRESSURE TRANSDUCERS IN A VERTICAL UPRIGHT POSITION.

## 3.8 Typical Piping Schematic (Cont.)




NOTES:

1) TAKE OFF BOTTOM OF LINE.
2) TAKE OFF TOP OF LINE.
3) TAKE OFF SIDE OF LINE.
4) LOCATE VALVE AS CLOSE TO OIL PUMP AS POSSIBLE.
5) VALVES WITH THE SYMBOLS ( OR ) TO BE MOUNTED WITH PRESS. TAP ON VALVE AS SHOWN IN ORDER TO BE ABLE TO EVACUATE TRAPPED GAS.

| CODE | DESCRIPTION |
|---|---|
| 3 PS | OIL FAILURE SWITCH |
| | |
| 1 FLS | FLOW SWITCH (EVAPORATOR) |

| CONN. | DESCRIPTION |
|---|---|
| C2 | BLEED OFF - SUCTION |
| C3 | FEMALE INLET BEARING |
| C4 | MAIN OIL |
| C5 | UNLOADER OIL |
| C6 | MAIN OIL INJECTION |
| C8 | SEAL OIL SUPPLY |
| C10 | SHAFT SEAL |
| C11 | SEAL LEAKAGE DRAIN |
| C12 | UNLOADER OIL SUPPLY |
| C13 | LIQUID INJECTION |
| C14 | DISCHARGE PRESSURE VAL. |
| C15 | OIL FAILURE |

### 3.9 Functions of Electrical Controls

The IPCX depends on its on-board microcomputer for control. For initial start-up, the following conditions must be met:

- Chilled fluid pump running
- Chilled fluid flow switch made
- Customer control contact closed
- Control and compressor switches on
- Main system voltage turned on
- All safety conditions satisfied
- Reset pressed on microcomputer keypad
- Compressor has not started within the last 20 minutes
- Leaving chilled fluid temperature 2°F(1°C) or more above set point
- Oil sump temperature is greater than 70°F(21°C)

The microcomputer starts the oil pump by energizing 4CP (control point). If capacity indicator is below 8% and a minimum of 27 psid (186 kPa) oil pressure is established, seconds later the microcomputer signals 2CR (control ready) which starts the compressor motor.

When the compressor starts, the microcomputer monitors leaving water temperature, ramp schedule, and load limiting to control load and unload solenoids. The refrigerant level sensor and discharge temperature are used to control the refrigerant modulating motor. When minimum compressor capacity exceeds system load and water temperature falls below set point, the compressor and oil pump are shut down.

The control system is composed of several microcomputer boards, a display board and analog and digital sensors. The display board has a 20-key keypad and a 2 x 40 LCD display. The keypad and display can be used to determine the status of the compressor, oil pump, and refrigeration system. Various set points can also be displayed and altered.

The status of the machine can also be monitored by a computer terminal either locally or remotely by a modem. The terminal must be able to handle RS232 communications.

The microcomputer controls the leaving water temperature within a narrow dead band by pulsing load and/or unload solenoids on the compressor. The load and unload solenoids position the compressor's slide valve to control the capacity. The microcomputer determines a desired level of loading and varies pulse duration depending on the difference between load target and actual load. The load target is varied based on rate of approach to desired temperature (derivative control) preventing significant temperature oscillations. The current limit functions override the temperature control.

When a maximum desired current is specified by amp limit, the compressor will not load above that point. If the amps rise above the limit set point, the computer will send an unload signal to the compressor until the current drops below the set point.

Another feature of the microcomputer is ramp control, which is the ability to vary load time of the package from start. The user can program the computer so that it loads at a pre-determined rate. Two variables are used to define the ramp profile: Ramp Rate and Start Point. Ramp rate defines the length of time the unit takes to load from start point to full load. Start point is the point of full load at which the ramp begins.

When optional hot gas bypass has been supplied, an output from the computer controls the solenoid. The solenoid is turned on if the target percent capacity of the compressor drops below the hot gas bypass set point. If the target percent capacity then climbs above the hot gas bypass set point, the solenoid is turned off.

If desired, the chilled water temperature can be (optionally) raised by a 0-5 VDC analog signal provided by an external controller. The reset signal must be between 0 VDC and 5 VDC, with 0 VDC being no reset and 5 VDC being maximum reset. The maximum temperature reset (increase) desired must be stored in CWR MAX. For example, to raise the chilled water set point from 44°F (6.7°C) to 50°F(10°C) with a 5 VDC input, 6.0(3.3) is stored in CWR MAX.

If (optional) demand limiting is desired, a 0 to 5 VDC signal must be supplied to the Demand Limit terminals shown on the wiring diagram. Supplying 0 volts will have no effect, and 5 volts will have maximum limiting. The demand limit works automatically by lowering the HOLD and UNLOAD amp limits for the compressor. This does not change the amp limit set points.

If the condenser water control option is furnished, the analog output signal is changed based on discharge pressure. If below the set point (typically 160 psig), the output will stay at OVDC. As pressure rises above the set point, the voltage increases linearly until the output reaches maximum (5VDC or 10VDC) at the high set point (typically 190 psig).

### 3.9.1 Control Center

3.9.1.1 Control Center is NEMA 12 (4, 4XSS, 7) fully enclosed, baked powder coated steel control panel with hinged access doors. Dual compartments, separating the safety and operating controls from the power controls, are provided. Controls include:

1. Separate terminal blocks for main power, and 115 VAC control power.
2. Optional Remote or Unit mounted Solid State Starters 460/3/60, 575/3/60 or 400/3/50 operation with control power transformer.
3. (Optional remote or Unit mounted WYE-Delta Starters 460/3/60, 575/3/60 or 400/3/50 operation with control power transformer).
4. Optional Remote mounted Across-The-Line Starters for 2300/460/3/60, 4160/460/3/60, 3300/400/3/50 operation.
5. Complete labeling of all control components.
6. Numbering of wires and terminal strips for easier wire tracing.
7. Terminals for customer digital input to enable/disable unit.
8. Dry contacts for chiller water and condensing water pump control.
9. Dry contacts for pre-alarm warning.
10. Dry contacts for unit alarm.
11. Over/under voltage relay-optional.
12. Operation and safety lights visible from unit exterior including: power on; alarm; compressor switch on.
13. Optional Control panel door latch solenoid to prevent door opening before turning off power to the unit.
14. Optional Analog ammeter with 3-phase selector switch.
15. Optional Analog voltmeter with 3-phase selector switch.
16. Optional via micro Compressor elapsed time meter.
17. Optional via micro Compressor cycle counter.
18. Entering and leaving chilled fluid temperature sensor.
19. Optional entering and leaving condenser water temperature sensor.

3.9.1.2 Control Center's individual Microcomputer provides compressor loading based on leaving fluid temperature throughout the full range of operation. It has a two-line 80 character alphanumeric Liquid Crystal display utilizing an easy-to-understand menu-driven software. It is proactive in control and accommodate system anomalies such as high condensing pressure, low suction pressure, and high compressor motor amp draw by controlling loading to keep the unit running, but at reduced capacity, until the fault is fixed. Battery backed-up real time clock and memory with over 10 years life and automatic recharge of lithium ion battery that requires no service.

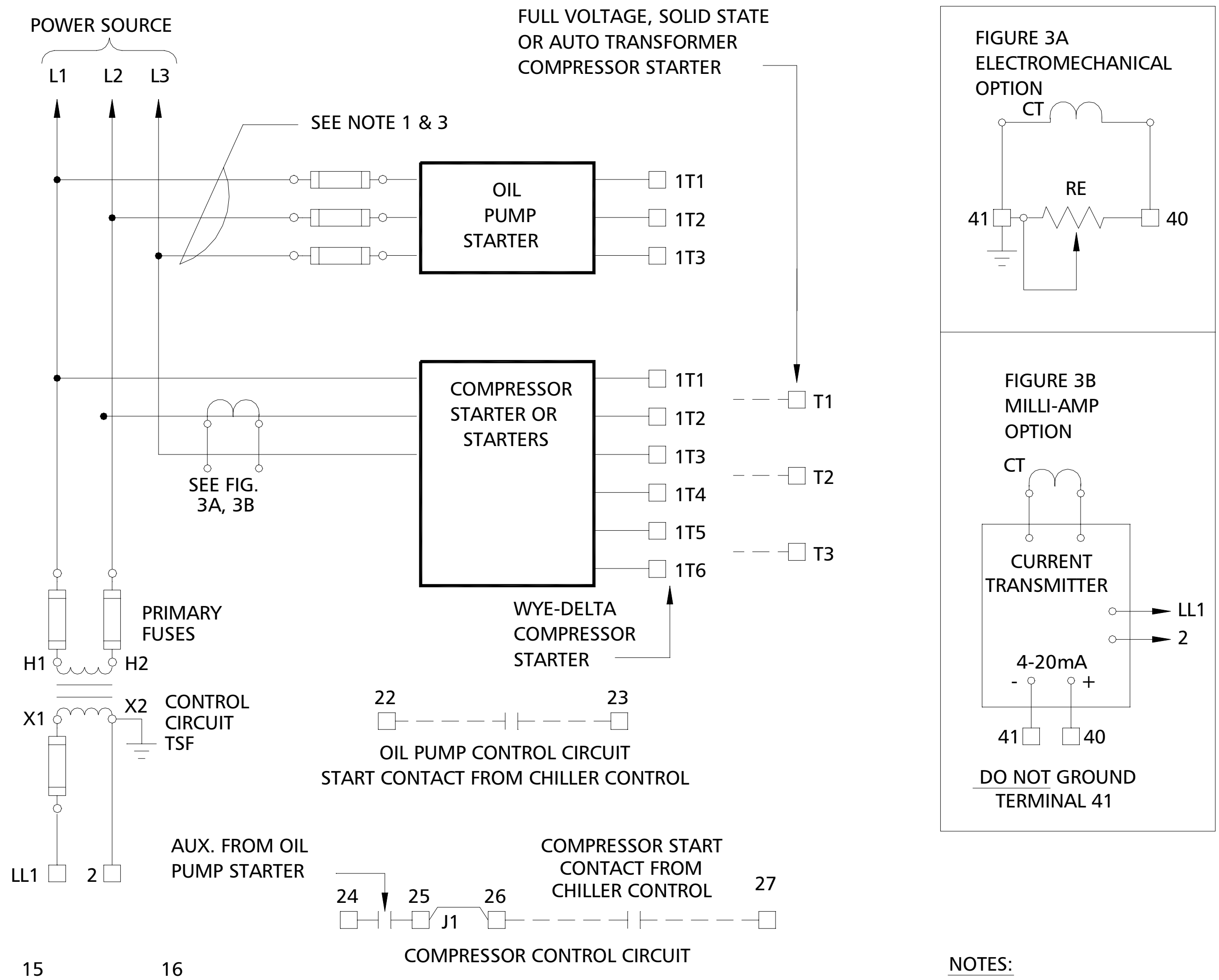
3.9.1.3 Microcomputer: individual chiller controller provides for:

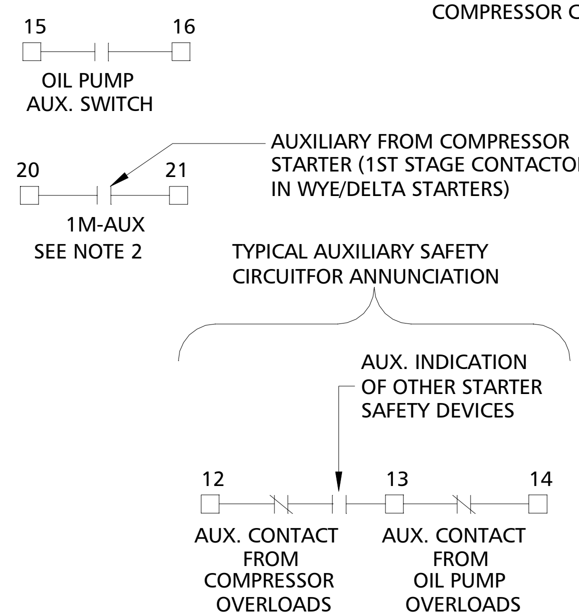
1. Unit control:
   a. Loading and unloading of the compressor based on leaving fluid temperature.
   b. Seven-day time clock with schedules for machine control.
   c. Proactive control to unload the compressors based on high pressure, low pressure, and high amp draw to reduce nuisance trips.
   d. Control of hot gas bypass circuit.
   e. Dry contact for cooler pump interlocks.
   f. Dry contact for condenser pump interlocks.
   g. Terminals for customer enable/disable of unit.
   h. Dry contact for unit pre-alarm warning.
   i. Dry contact for unit alarm.
2. Unit Protection:
   a. Low refrigerant suction pressure and temperature
   b. High refrigerant discharge pressure and temperature
   c. Automatic restart from power outage.
   d. Cooler freeze protection
   e. Compressor current limiting
   f. Anti-recycling protection
   g. Sensor error
   h. Cooler-(condenser-option) water flow loss
   i. Low oil differential pressure
   j. Low oil temperature
   k. Over current protection.
   l. Phase loss, phase reversal and phase imbalance.
   m. Ramp control for timed unit loading when the return fluid temperature is 5°F above leaving fluid set point
   n. Starter fault
   o. Oil pump starter fault
3. Microcomputer - Readouts provide the following:
   a. Compressor run time and cycles
   b. Leaving liquid temperature
   c. Compressor motor ampere draw
   d. Suction pressure and temperature
   e. Discharge pressure and temperature

f. Unit control contacts
g. Chilled fluid flow switch
h. Chilled fluid reset
i. Digital Outputs
j. Compressor control status
k. Unloader control status
l. Liquid line valve control status (on flooded systems)
m. Alarm control status
n. Control power status
o. (Condenser water flow indication)
p. Utility demand limit
q. Percent slide valve loading
r. Oil pressure
s. Oil sump temperature
t. Oil seal temperature

4. Microcomputer - Set-points provide the following:
   a. High discharge pressure
   b. Low suction pressure
   c. Freeze protection temperature
   d. Leaving cooler fluid temperature
   e. Low suction unload
   f. High discharge unload
   g. High & low compressor amperes
   h. Chilled fluid reset
   i. Demand limit reset
5. Microcomputer - Alarm History provides the following:
   a. The 8 most recent alarms can be displayed
   b. Low suction pressure
   c. High discharge pressure
   d. Freeze protection cutout
   e. No run
   f. No stop
   g. Loss of cooler fluid flow
   h. Power failure
   i. Temperature sensor error
   j. Low oil pressure
   k. Optional refrigerant leak detector
   l. Refrigerant valve control fault (on flooded systems)
   m. Pressure sensor error
   n. Compressor start fault
   o. Compressor slide valve error
   p. Low discharge superheat
   q. High sump temperature
   r. High oil seal temperature
   s. Oil pump starter fault
6. Microcomputer Remote Monitoring Capabilities:
   a. Optional Telephone Modem:
      The microcomputer is complete with an RS232 communications port and all hardware and software necessary to remotely monitor and control the packaged chiller through the optional phone modem. A dedicated phone line is required.
   b. Optional Remote Monitor Display Terminal:
      The Remote Monitor Display Terminal is supplied with a 14" monitor, two (2) RS232 serial ports, 6 foot 115 volt power cord and an enhanced PC keyboard. The RMDT can be hard wired up to 50 feet away from the chiller for remote monitoring and operating of the one or multiple units.
      This option allows remote start-stop, chilled fluid set-point changes, and reading of all microcomputer screens including operating condition, faults, and fault history.
   c. BMS - Building Management System Terminal:
      A BMS (Building Management System) interfaces with the chiller microcomputer and provides the same level of monitoring and operating control as above, when the BMS company has implemented the communications protocol.
      Dunham-Bush has an open communications protocol policy with most BMS companies.
   d. Optional ChillerLINK:
      The ChillerLINK is supplied for communication from the Chiller to the BMS through BACnet or MODBUS communicating systems.

### 3.9.2 Starter Connections

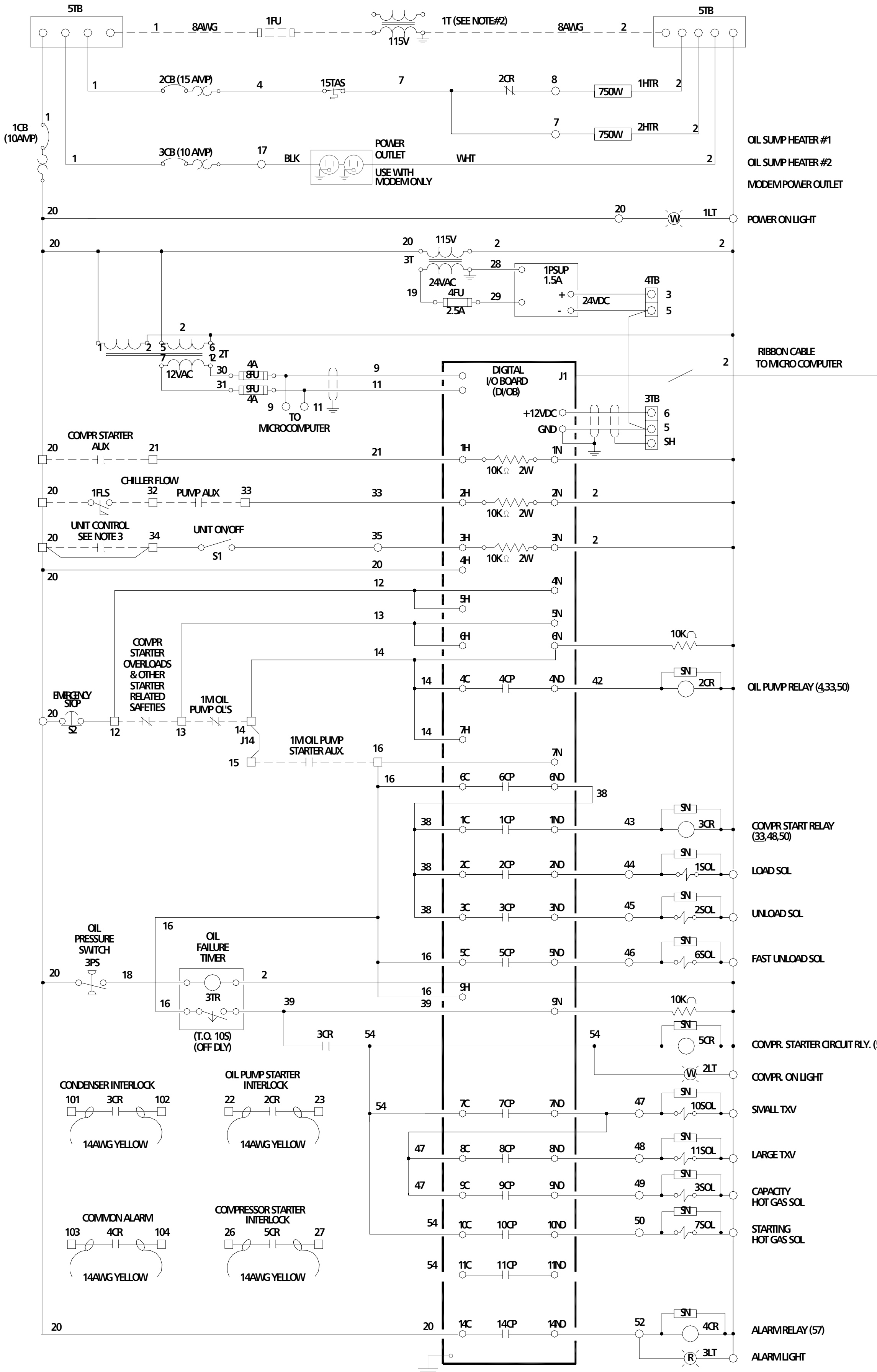


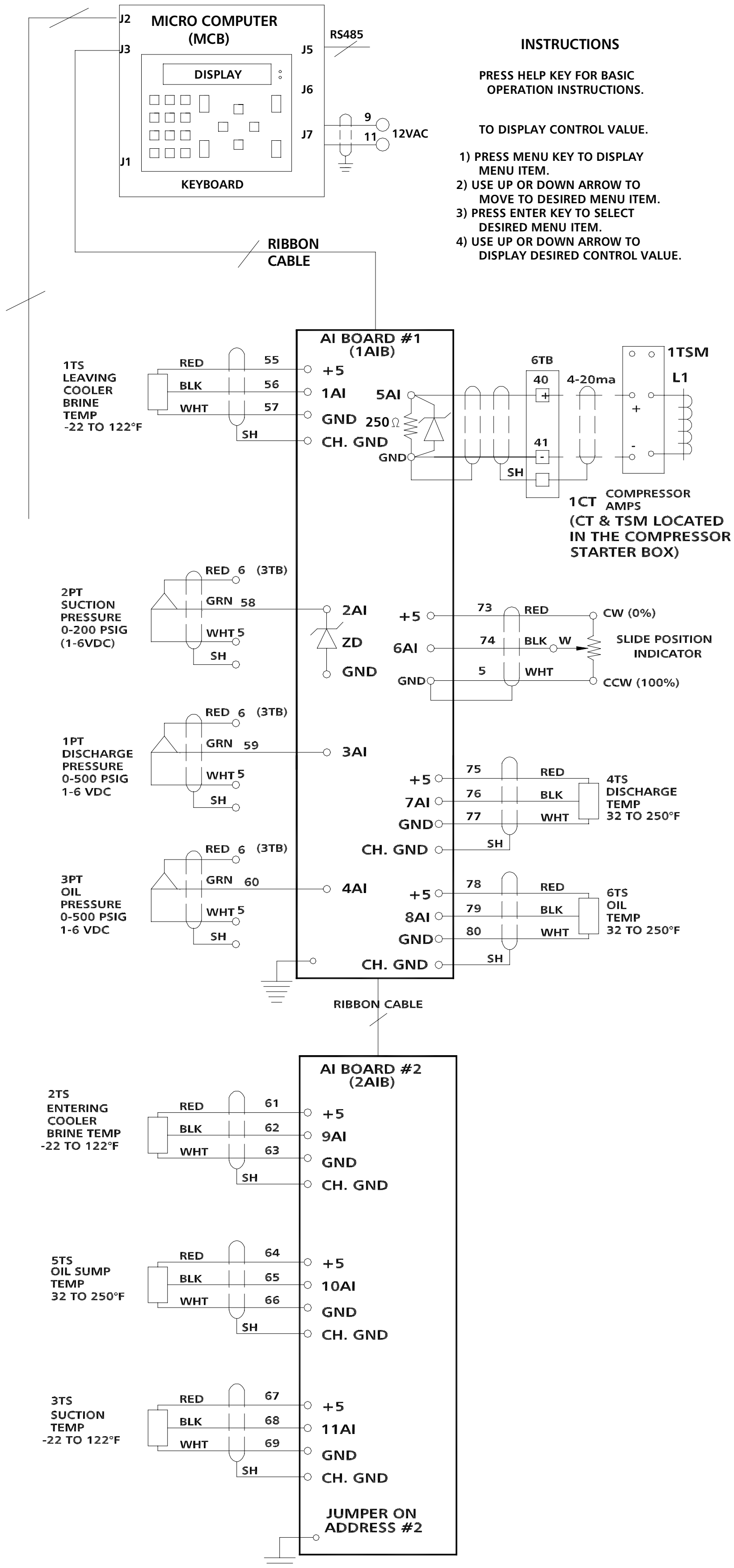

NOTES:

1. OIL PUMP BRANCH CIRCUIT, SHORT CIRCUIT AND GROUND FAULT PROTECTION IS REQUIRED. DUAL ELEMENT FUSES OR CIRCUIT BREAKERS MAY BE USED AS DESIRED, UNLESS OTHERWISE SPECIFIED.
2. COMPRESSOR STARTER AUXILIARY SWITCH (1M-AUX) MUST CLOSE WITHIN 1 SECOND OF ENERGIZATION OF COMPRESSOR STARTER.
3. A SEPERATE 460V OIL PUMP CIRCUIT IS REQUIRED FOR 2300V AND 4160V PACKAGES. REFERENCE N.E.C. REQUIREMENTS FOR MEDIUM VOLTAGE APPLICATIONS.
4. OVERLOAD RELAYS AND OTHER SAFETY DEVICES WIRED BETWEEN TERMINALS 12 & 13 MAY BE THE EXTRA CONTACTS FROM THE ACTUAL DEVICES, OR MAY BE RELAY OR OTHER TYPE OF CONTACTS THAT REPRESENT THE ACTION OF THESE DEVICES, FOR ANNUNCIATION PURPOSES. THE PRIMARY SET MUST BE FACTORY WIRED INTO THE COMPRESSOR STARTER CIRCUIT.

## 3.10 Typical Electrical Schematic



### 3.10 Typical Electrical Schematic (cont.)



# 4.0 Maintenance

## 4.1 General

Maintenance personnel should become thoroughly familiar with the unit and the contents of this manual in order to properly diagnose and rapidly correct and prevent minor difficulties. Routine or periodic maintenance should be followed to insure a comprehensive preventative maintenance program minimizing costly repairs. Service Bulletins as referenced in this section, may be obtained from North American Service Department.

**CAUTION:** All valve caps, packing glands and pipe plugs must be tightened securely after performing maintenance and/or periodically, to prevent refrigerant leakage.

**WARNING:** All inspection, maintenance, or repairs should be done by an authorized, qualified, Dunham-Bush, Inc., Service Representative as listed in the latest edition of Form No. 9822. Failure to comply may jeopardize the warranty.

## 4.1 Periodic Maintenance

### 4.1.1 Pre-Initial Start-Up Maintenance

a. Insure unit is level.

b. Check for any piping stresses on unit.

c. Check coupling alignment. (Direct drive compressor and oil pump motors)

d. Tighten all wiring connections.

e. Check tripping of safety controls for grounding. (See Typical System Tests Section)

f. Check oil sump heaters for proper operation.

g. Check all control and starter wiring connections for grounding.

h. Sump oil level must be visible in sump sight glass, sump oil temperature must be at a minimum of 100°F (37.8°C).

j. Hydronic system must be vented free from entrapped air, and the piping properly supported to the unit.

k. All satellite equipment and associated control devices must be operationally checked and capable of handling their design capacities.

m. Inspect for external refrigerant leaks with an electronic leak tester or halide torch.

o. Check refrigerant indicators for evidence of moisture.

NOTE: If moisture is evident prior to initial start-up, the refrigerant indicators should be monitored after start-up to insure that the moisture is removed. If moisture is evident after minimal running time, the unit must be shut-down and the filter drier elements replaced. (See Component Maintenance Section)

p. Adjust limit switches.

### 4.1.2 Post Initial Start-up And Daily Maintenance

NOTE: A log of daily readings should be maintained. (Refer to Maintenance Records Section)

a. Check suction superheat conditions after start-up for proper adjustment at thermal expansion valve. (Refer to Component Maintenance Section)

b. Inspect sight glasses for the following:

- Liquid Line, Inlet Side of Pilot Valve - Inspect for a full glass free from bubbles.
- Condenser Sight Glass (if equipped) - Inspect level to be visible.
- Liquid Injection Line Sight Glass (if equipped Sight glass (downstream of solenoid) will be nearly empty if liquid injection solenoid is off. Sight glass will be full of liquid refrigerant, (if located upstream of TX valve) or flashing refrigerant (if located downstream of TX valve).

c. Check and record the following:

- Suction, discharge and oil pressures.
- Condenser inlet and outlet water temperatures.
- Chiller inlet and outlet cooling medium temperatures.
- Compressor motor amps.
- Oil Temperature.
- Compressor motor voltage.
- Discharge Temperature

d. Initial seal drainage collection (direct drive compressor) can be 0.31 cubic inches per hour (5 cc per hour) after start-up. After the unit has run a seven day break-in period, the normal seal drainage is 0.06 to 0.24 cubic inches per hour (1 cc to 4 cc per hour).

e. Check evaporator oil return (if equipped) to be at liquid level. (Refer to Component Maintenance Section)

f. Rotate capacity control hot gas bypass (optional) throttling valve to proper adjustment after initial start-up. (Refer to Sub-System Maintenance Section)

g. Check refrigerant indicators for evidence of moisture. Change filter drier elements if required. (Refer to Component Maintenance Section)

### 4.1.3. 1000 Hr. (Monthly) Interval Maintenance

NOTE: A log of 1,000 hour readings should be maintained, and the data compared to daily values for evidence of operational changes, i.e. condensing pressure, superheat temperatures, compressor/oil pump motor current amps, etc. (refer to maintenance records).

a. Check oil sump sight glass to be at proper level.

b. Check oil filter pressure drop and replace filter elements if necessary. A clean filter will have 1 to 2 psid (6.9 to 13.8 kPa). The oil filter should be changed at 6 psid (41.4 kPa) pressure drop across the filter.

c. Check gages and controls for proper operation and calibration.

d. For other than water chiller applications, field test chiller cooling medium for proper freeze point. (Brine applications, check pH)

e. Inspect all motor starter control relay contacts for arcing and replace if required. Check thermal switch heaters and starter linkages for proper operation.

f. Check oil sump heaters for proper operation.

g. Check and record the following additional items:
   - Oil temperature at manifold
   - Oil pump motor current
   - Oil pump motor voltage
   - Suction superheat
   - Discharge superheat
   - Chiller and condenser pressure drop

h. Check filter drier pressure drop. (Maximum operational pressure drop across filter is 5 psid (34.5 kPa)

j. Check unloaders for proper loading and unloading speed. For a full stroke a maximum of two (2) minutes should elapse.

k. Check all sub-systems for proper operation, i.e. seal oil cooler, evaporator oil return, vapor injection, liquid injection, water cooled oil cooler. (Refer to Oil Cooling System Maintenance Section and SubSystem Maintenance Section)

m. Check condenser water regulating valve(s) for proper adjustment.

### 4.1.4 3,000 Hour Interval Maintenance

a. Check coupling alignment (direct drive compressors, oil pump).

b. Field test oil for acidity. Take action if required. Low temperature and heat reclaim require professional analysis at 3,000 interval. Refer to North American Service Bulletin SR96.

   NOTE: PH factor and total acid number (TAN) are highly responsive to moisture.

### 4.1.5 Annual Maintenance

a. Send sample of oil to laboratory for thorough analysis. Records of the analyses will provide a continuous case history, and insight, as to what system components have contributed to the quality of the oil. Refer to North American Service Bulletin SR-96 for analyses information. Change oil if required.

b. Send sample of chiller medium and condenser water to laboratory for analysis. This will provide insight as to what maintenance may be performed to prevent corrosive chemical activities. (See component maintenance)

c. Send sample of refrigerant to manufacturer for professional analysis of contamination. Water content should not exceed 20 PPM.

d. Check, recalibrate operating and safety controls. Design settings are noted on the particular job wiring diagram. (See system tests)

e. Inspect and clean all satellite equipment per manufacturer's recommendations.

f. Check compressor seal for refrigerant and excessive oil leakage. If a maintenance action is necessary, refer to the latest edition of the LSC Compressor Manual 6136. If necessary, an update to the latest seal design is recommended.

g. Check compressor thrust bearings by loosening coupling center and checking male rotor for axial float. If axial float exists, refer to Compressor Service Manual 6136 for thrust bearing service/ replacement.

h. Insure compressor coupling is aligned.

j. Lubricate compressor motor (direct drive) per manufacturer's recommendations.

k. Remove condenser heads, and have tubes inspected for corrosion by a professional agency. Clean condenser and heat exchanger(s) as outlined in this manual. Failure to comply may result in system problems. Plug or replace tubes if required.

m. Check, re-adjust oil pump end clearance. Align oil pump motor coupling (direct drive oil pump).

### 4.1.6 25,000 Hour Maintenance

a. Perform annual maintenance.

b. Replace compressor shaft seal with latest version.

c. Inspect/replace compressor unloader, injection tube, and slipper seal parts if abnormal operation exists.

d. Inspect/replace compressor unloader guide block if wear is evident. Check slide valve guide and spindle snap rings for security.

e. Check compressor balance piston/sleeve clearance. Replace if beyond limits or if there has been any changes in unit oil pressure.

f. Check rotors for radial and lateral movement. If movement is beyond pre-selected limits, take appropriate action or consult North American Service.

### 4.1.7 50,000 Hour Maintenance

a. Repeat 25,000 hour maintenance.

b. Replace thrust bearing.

### 4.1.8 75,000 Hour Maintenance

A major disassembly and inspection of the compressor is to be made. The compressor condition will determine if it should be field rebuilt or scheduled for a factory exchange rebuild.

### 4.1.9 Seasonal Shut-Down Maintenance

a. Shut down IPCX Unit in normal manner and partially pumpdown system.

b. Perform annual maintenance.

c. If unit is located where ambient temperature will be below freezing, drain all water thoroughly and blow out tubes (flooded chiller) or vessel (direct expansion chiller) with compressed air.

   NOTE: Simply draining is not sufficient.

d. Open disconnect switches.

e. Run the oil pump periodically to fill the pump seal cavity with oil. This will prevent refrigerant from leaking. (Direct Drive Units)

## 4.2 Maintenance Records

### 4.2.1 Logs

It is recommended that permanent daily records of system operating conditions be recorded at least once a day. The records should be retained as they are invaluable in determining patterns of operational change that will indicate the need for maintenance or service. System design conditions are established by the readings entered when the unit is first installed. Dunham-Bush, Inc., Form No. 9181 Log Sheet (See Appendix A), will serve this function admirably.

NOTE: In addition to the Daily/Monthly Log sheets, annual and seasonal maintenance is required. (See Periodic Maintenance Section)

The locations on the unit from which data may be obtained are shown in Figures 17 thru 20 for a typical unit.

The log sheets should be reviewed and evaluated periodically to determine operational trends.

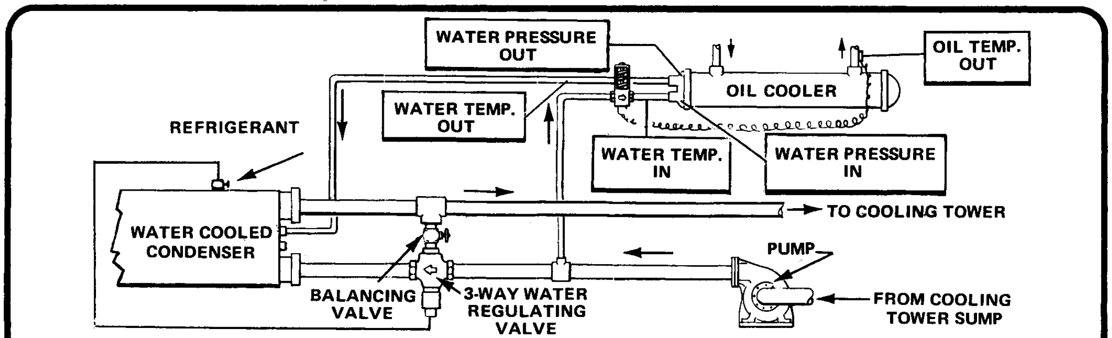



FIG. 17 TYPICAL WATER COOLED OIL COOLER (LOW TEMPERATURE APPLICATIONS)

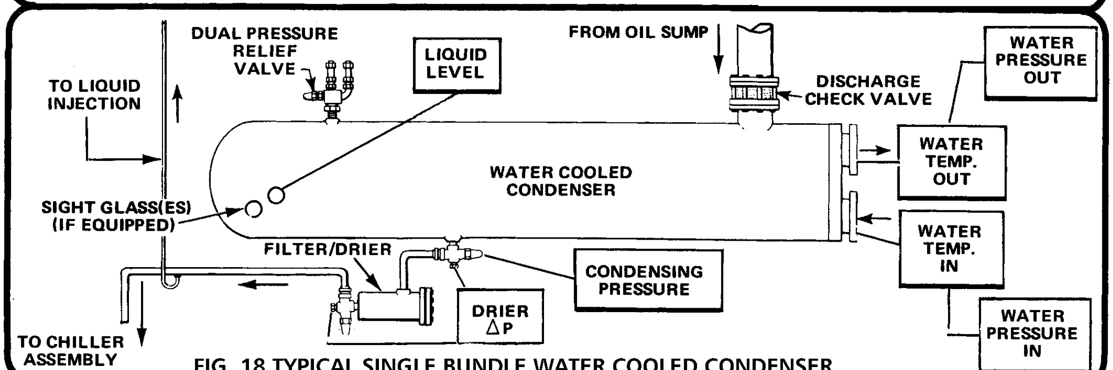



FIG. 18 TYPICAL SINGLE BUNDLE WATER COOLED CONDENSER

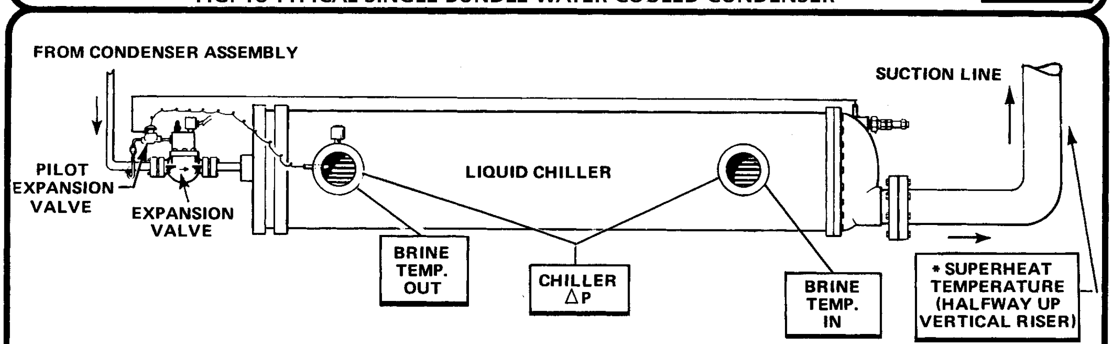



FIG. 19 TYPICAL DIRECT EXPANSION CHILLER

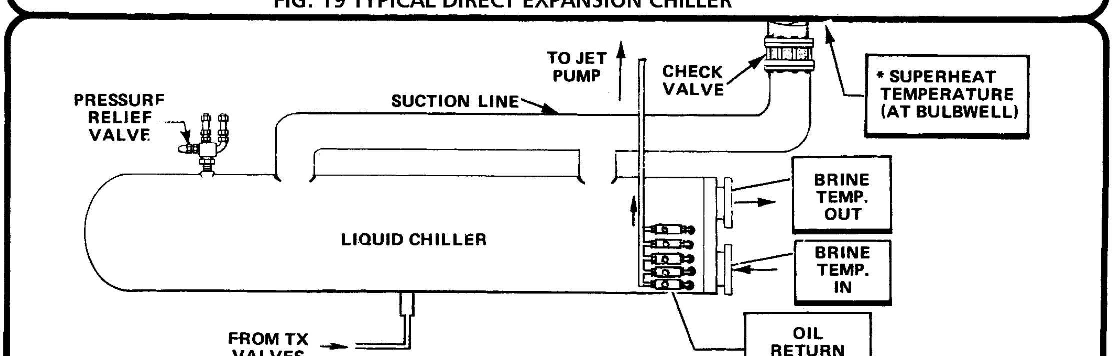



FIG. 20 TYPICAL FLOODED CHILLER

## 4.3 Oil Removal/Addition

### 4.3.1 Recommended Oils

Dunham-Bush uses various oil viscosities. Typical viscosity classifications: 150 SUS (Saybolt Universal Seconds) measured at 100°F for low temperature applications and 300 SUS measured at 100°F for high and commercial temperature applications. Other oil viscosities must be approved for use in Dunham-Bush compressors.

NOTE: Mixing of oil is not recommended. Oil should be thoroughly drained and replaced when changing oil brands. Consult factory for any other oil types.

The following Napthenic base oils are recommended.

| | SST* | |
|---|---|---|
| | Low Temp | Commercial or High Temp. |
| | (-40°F to 0°F) (-40°FC to -17.8°C) | (+1°F to +50°F) (-17.2°C to +10°C) |
| Company † | 150 SUS (31.8 Cst) | 300 SUS (64.6 Cst) |
| Sun Oil Company | Suniso 3GS | Suniso 4GS |
| Texaco | Capella B | Capella D |

*Saturated Suction Temperature

† These oils are subject to periodic change. Consult the latest edition of North American Service Bulletin SR42.

### 4.3.2 Approximate Oil Charges For Standard Packages

NOTE: Packages with non-standard vessel selections may have different oil charges. The oil capacities listed are for purchasing purposes only. Refer to Oil Replenishment Section for proper oil level.

| | Approximate Oil Charge | | | |
|---|---|---|---|---|
| | Direct Drive | | Direct Drive Heat Reclaim | |
| Model PCX | U.S. Gallons | Liters | U.S. Gallons | Liters |
| 120 | 21 | 79.5 | 24 | 90.8 |
| 150 | 21 | 79.5 | 24 | 90.8 |
| 180 | 21 | 79.5 | 24 | 90.8 |
| 230 | 24 | 90.8 | 28 | 106.0 |
| 290 | 24 | 918 | 28 | 106.0 |
| 350 | 24 | 918 | 28 | 106.0 |
| 400 | 35 | 132.5 | - | - |
| 450 | 44 | 166.5 | - | - |
| 500 | 44 | 166.5 | - | - |
| 580 | 45 | 1113 | - | - |
| 630 | 45 | 1703 | - | - |
| 700 | 46 | 174.1 | - | - |
| 750 | 47 | 177.9 | - | - |

### 4.3.3 Oil Removal

NOTE: If oil from sump has been tested and evaluated to be reusable, ensure that the container is clean and can be properly sealed to prevent entry of contaminants.

**SP-1 (Oil Removal)**

1. Attach hose between oil sump drain valve and a clean, vented, 55 gallon (200 liters) drum.
2. Drain oil slowly until oil ceases to flow. Oil will foam up.
3. Change oil filter(s) (Refer to SP-17)

### 4.3.4 Oil Replenishment

NOTE: It is desirable to coordinate oil addition with system evacuation so that oil can be drawn in utilizing the partial vacuum. Oil should be drawn into the oil sump during the final stages of evacuation. (Refer to Evacuation/Dehydration Procedures)( SP-7 thru SP-12)

**SP-2 (Oil Replenishment, Partial Vacuum Method)**

1. Connect a service hose to the oil sump drain valve and to a vented container of new or reusable oil.

**CAUTION:** Hose should be purged with oil and care must be exercised not to incorporate air into the system.

2. Charge sump until oil level in sump is 113 to 112 of the (top) sight glass. Continue evacuation procedures.

**SP-3 (Oil Replenishment Portable Pump Method)**

**CAUTION:** For adding oil to a system under pressure, the portable pump should have a design working pressure of 150 to 200 PSIA, (1034.2 to 1379 kPa), and a capability to pump to 150 PSI (1034.2 kPa) from atmospheric pressure. Recommended capacity is 2 to 3 GPM (76 to 114 liters/min.)

NOTE: To facilitate sight glass inspection, a flashlight may be used.

1. With unit off and oil at normal temperature (100°F to 150°F), (37.8°C to 65.6°C), inspect for proper oil level to be at 113 to 112 of the (top) sight glass; normal level will vary from 112 full to just visible at the bottom of the glass.
2. Connect an adequately sized portable oil pump to oil sump drain valve, add oil from vented drum and insure absolutely no air enters the system.
3. Stop pump and close shut off valve when oil level in sump reaches 113 to 112 of (top) sight glass.
4. Disconnect pump and start-up IPCX unit. If oil fails to return to sump causing shutdown due to loss of oil pressure, add additional oil and restart unit.

CAUTION: Do not overcharge system. System problems could result. Added oil must be removed once oil charge is returned to sump.

5. Shut down unit and observe sight glass after unit has stabilized. Drain off excess oil slowly.

## 4.4 Transferring/Evacuating/ Charging Refrig.

**CAUTION:** All charging/evacuating procedures must only be performed by qualified commercial and industrial refrigeration personnel.

### 4.4.1 Charging/Evacuating Stations

Adequate accessibility is provided on all packaged units for charging and evacuating. Careful consideration of the refrigerant state or quality must be employed before opening the valve for charging and evacuating procedures. Access may be obtained to the high and low side through:

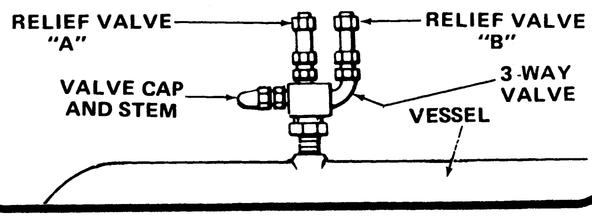
- Dual pressure relief valve(s)
- Service shut-off valves (King, Queen Valve)
- Charging valves

**CAUTION:** Valve caps must be tightened when replacing to prevent refrigerant leakage.

#### 4.4.1.1 Dual Pressure Relief Valve

Vessels equipped with dual pressure relief valves enable service personnel to obtain access to the refrigerant vapor portion of the chiller or condenser.

FIG. 21 DUAL PRESSURE RELIEF VALVE




**SP-4 (Relief Valve Access)**

1. Isolate relief valve 'B' by closing off the three way valve stem clockwise until it seats. (See Figure 21)
2. Remove relief valve 'B'.
3. Install a charging hose adaptor in place of the removed relief valve. (adapter not supplied)
4. Connect one end of the hose to the adaptor insuring the hose is purged with refrigerant.
5. Return 3 way valve to original position and follow charging evacuating procedures.

#### 4.4.1.2 Service Valves

Service valves are located at the filter drier outlet (Queen Valve), and condenser outlet (King Valve) and may be used to obtain access for charging or transferring liquid refrigerant, and evacuating procedures.

**SP-5 (Service Valve Access)**

1. Backseat the valve to isolate plug tap from system.
2. Remove appropriate plug and attach hose.
3. Reposition valve stem and follow Charging/Evacuating Procedures as outlined in this manual
4. Backseat the valve and plug taps.

#### 4.4.1.3 Charging/Evacuating Valves

Units are equipped with charging valves located either on the suction line or directly on the compressor housing, as noted on the unit piping schematic.

**SP-6 (Charging Valve Access)**

1. Attach hose and purge by opening manual valve.
2. Follow Charging/Evacuating Procedures as outlined in this manual.

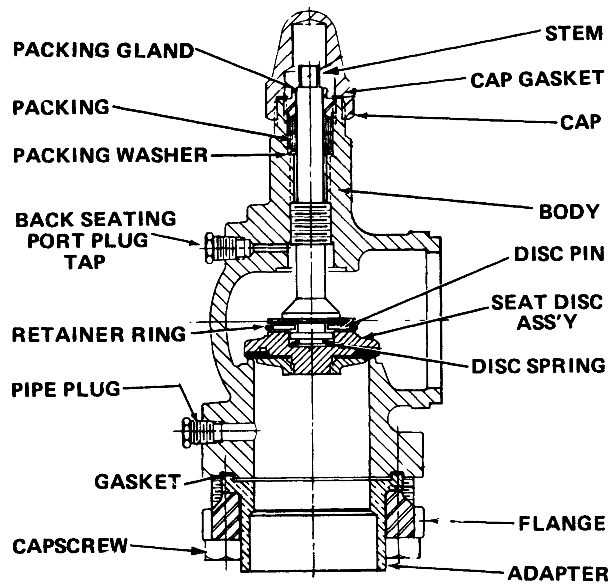



FIG. 22 TYPICAL SERVICE VALVE

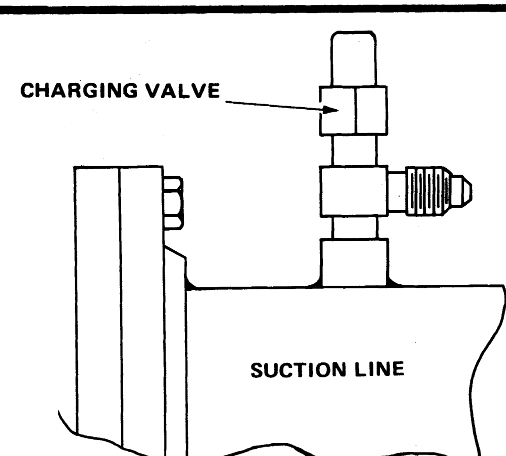



FIG. 23 TYPICAL CHARGING VALVE

### 4.4.2 Transfer (Pumpdown) Of Refrigerant Condenser Or External Containers

Most service work can be executed by isolating the component to be repaired from the system. However, it may be required to pump and temporarily store the refrigerant in the condenser, or remove the charge completely. How the refrigerant is handled is dependent upon equipment, time available, and the type of maintenance performed. The succeeding procedures SP-7 thru SP-11 must be executed in the order presented. The following must be adhered to for all transfer procedures:

**CAUTION:** Continuously weigh receiving container to be certain it is not filled more than 85% of its volumetric capacity to allow for thermal expansion.

NOTE: When removing refrigerant to external containers, it is recommended to pack the containers in dry ice.

#### 4.4.2.1 Partially Pumpdown System

Partially pumping down the system serves to transfer most of the refrigerant from the chiller to the condenser.

**CAUTION:** Safety controls are not to be defeated or readjusted during pumpdown. Compressor motor starts are limited to 3 starts per hour.

**SP-7 (Partial Pumpdown)**

1. With the unit operating, and a partial load available, set the slide valve at minimum load position. Close the condenser shut-off valve (King Valve). If hot gas bypass is installed, close hot gas bypass manual valve recording number of turns.
2. After unit shuts down due to low pressure cut-out, restart unit after 20 minutes elapsed.
3. Unit will cycle off again on low pressure cut-out The unit is now partially pumped down.

#### 4.4.2.2 Transfer Liquid Refrigerant From Chiller to Condenser or Containers (Flooded Type Chiller)

The remaining liquid refrigerant and residual oil must be transferred out of the chiller barrel before the gas is transferred.

**CAUTION:** The chiller pressure must not go below the corresponding freezing point of water, or the brine being used. Approximately 65 to 75 psig (R-22) (448.2 to 517.1 kPa), should be maintained inside the vessel, until it is certain all liquid refrigerant has evaporated. Rapid removal of liquid refrigerant will cause the chiller tubes to freeze and the possibility of bursting them exists. Rapidly boiling refrigerant also foams up the oil, which can freeze lower tubes.

NOTE: It may be helpful to monitor D-X chiller shell temperature with a thermocouple. Another precaution (flooded chiller models) to avoid freezing is to remove the heads of the chiller and have the tubes fully blown out with compressed air, prior to refrigerant removal.

**SP-8 (Liquid Transfer, Flooded Chiller)**

1. Remove oil (refer to SP-1).
2. Connect a hose to the liquid connection at the bottom of the chiller vessel. Attach in line, a strainer liquid refrigerant pump, and a sight glass.
3. Purge hose, and connect to the receiver (i.e. condenser, containers). Commence draining, maintaining pressure as much as possible until all the liquid is removed.

#### 4.4.2.3 Transfer Gas Refrigerant From Chiller to Condenser or Containers

**SP-9 (Gas Transfer From Chiller)**

1. Manually unseat the main expansion valve(s) and open hot gas bypass (if equipped) recording number of turns.
2. Connect the suction side of a portable condensing unit to the low (vapor) side of the system. Connect the discharge hose to the condenser vessel through the dual pressure relief valve (see SP-4) or to an external container.
3. Commence removal of the refrigerant until the suction pressure (chiller pressure) is slightly above atmospheric pressure.

#### 4.4.2.4 Transfer Liquid Refrigerant from Condenser to External Containers

**SP-10 (Transfer Liquid Refrigerant from Condenser)**

1. Connect a hose to the service valve at the condenser outlet. (See SP-5) Attach an in-line strainer, refrigerant pump and sight glass. Purge line and attach to a clean empty refrigerant container which is marked with the correct type of refrigerant.
2. Commence draining until the first cylinder is 85% full.
3. Remove container and repeat until all liquid refrigerant is removed, without dropping pressure below the corresponding freezing temperature of water.

#### 4.4.2.5 Transfer Gas Refrigerant From Condenser to External Containers

**SP-11 (Transfer Gas Refrigerant from Condenser)**

1. Connect the suction side of a portable condensing unit through the condenser relief valve access. (See SP-4) Connect the discharge hose of the portable condensing unit to an external container.
2. Commence removal of refrigerant gas until the condenser vessel pressure is slightly above atmospheric pressure.

### 4.4.3 Complete System Evacuation & Dehydration

For a complete system evacuation, it will be necessary to make up a manifold and evacuate from three evacuating stations simultaneously.

NOTE: It is absolutely necessary to use a true micron gauge. An ordinary compound gauge is not acceptable.

**SP-12 (Evacuation/Dehydration)**

1. Drain oil (refer to SP-1).
2. Transfer refrigerant to external containers (refer to SP-7 thru SP-11)
3. Pressure test the unit with dry nitrogen and R-22 to insure no leaks exist. (Refer to SP-37)
4. With the unit at atmospheric pressure, connect a vacuum pump to the system. Manually unseat the main expansion valve(s) and open hot gas bypass valve (if equipped).
5. Evacuate to 1,000 microns and break vacuum with dry nitrogen and R-22.
6. Change filter drier elements. (Refer to SP-29)

NOTE: To achieve best results, warm water or warm air should be recirculated through the water side of the evaporator and condenser.

7. System must be dehydrated down to 1,000 micron level at least three times, initially leaving vacuum pump on system at least 12 hours. Break vacuum twice with dry nitrogen. On final pull down to 1,000 microns, or lower, system pressure must not rise above 2,000 microns in four hours with vacuum pump isolated from system.
8. Fill oil sump with clean oil after third pull down utilizing the partial vacuum to draw in the oil. (Refer to SP-2)
9. Turn on oil heaters upon completion of dehydration. Break vacuum with dry refrigerant vapor.

### 4.4.4 Charging the Refrigerant System

When charging a fully evacuated system, the unit must be 1) gas charged initially, 2) liquid charged to 90% of design charge capacity and 3) charged under operation to full design charge capacity, as noted on the nameplate located at the control panel.

#### 4.4.4.1 Initial Gas Charging the Refrigerant System

NOTE: This is the initial procedure for charging a fully evacuated system, with the oil at the proper level.

**CAUTION:** Refrigerant gas must be charged until the internal system pressure corresponds to an evaporating temperature above freezing (R-22, 70 PSIG) (482.6 kPa), before liquid is charged. This will prevent freeze-up and bursting of tubes.

**CAUTION:** Chiller and condenser water pumps must be running and must maintain a minimum of 50% water flow.

**SP-13 (Initial Gas Charging)**

1. Manually unseat the main thermal expansion valve(s).
2. Slowly gas charge (2 PSI/minute) (13.79 kPa/min) at:
   a. Condenser vessel
   b. Chiller vessel
3. Continue gas charging until the pressure is stable throughout the system at a safe level. (R-22:70 PSIG 482.6 kPa).

#### 4.4.4.2 Liquid Charging the Refrigerant System

NOTE. This procedure is for charging a unit that has a system pressure above the corresponding freezing temperature of water. Liquid refrigerant can be charged directly into an evacuated system only if water is drained thoroughly and the tubes (flooded chiller) or the shell (direct expansion chiller) have been fully blown out with compressed air.

**CAUTION:** Chiller and condenser water pumps must be running and must maintain a minimum of 50% water flow.

**SP-14 (Liquid Charging the System)**

1. Purge and connect a charging hose from refrigerant containers to the King valve (refer to SP-5).
2. Liquid charge condenser, exchanging containers until 90% of design charge is in the system. A liquid refrigerant pump may be employed. Insure a liquid seal exists in the liquid line to the thermal expansion valve(s) by observing the sight glass.
3. The remaining refrigerant must be charged while the system is operating (refer to SP-15).

#### 4.4.4.3 Adding to Refrigerant Charge

This procedure is used when an inadequate charge is suspected. Typical indications of an inadequate charge are bubbles in sight glasses (vaporized refrigerant), high suction pressure, high oil temperature, etc. Indications of an adequate charge at 100% load are:

- Discharge Superheat - Must maintain between 25°F (13.9°C) and 30°F (16.7°C) above saturated conditions.
- Refrigerant Quality - Moisture indicator sight glasses should be clear of bubbles when system is fully charged.
- Condenser Outlet Temperature (Subcooling) - System will maintain approximately 8°F to 10°F (4.4°C to 5.6°C) below saturated conditions when refrigerant charge is adequate.
- Oil Temperature (Water Cooled Oil Cooler, if equipped) - Oil temperature must be maintained at 110° F to 120°F (43.3°C to 48.9°C) entering compressor.
- Liquid Injection Feed (if equipped) - Liquid seal exists in feed line at sight glass.

  NOTE: It may be helpful to liquid charge the liquid injection line independently to initiate normal operation.

- Seal Oil Cooler Feed (Direct Drive Models) - Liquid seal exists in feed line entering cooler.

  NOTE: It may be helpful to liquid charge the feed line to the seal oil cooler independently to initiate normal operation.

**SP-15 (Adding to Refrigerant Charge)**

1. Manually set and hold compressor slide valve at 25% position using temperature load control (TLC) manual control selection switch.

CAUTION: Partial cooling load must be available to manually position slide valve to prevent shut-down from safety controls.

2. Connect container of the design refrigerant to the low side of the system.
3. Start-up IPCX unit, open drum, valve and gas charge system until above conditions are met.

## 4.5 Component Maintenance

### 4.5.1 Compressor/Motor Assembly

#### 4.5.1.1 Compressor

All inspection, maintenance, or repairs of the compressor, must be done by an authorized, qualified Dunham-Bush, Inc. Service Representative as listed in the latest edition of Form Number 9822. If the customer has any reason to suspect a problem, he should contact the Dunham-Bush Service Representative for assistance. Failure to comply may jeopardize the warranty. Repair information may be found in the latest edition of the LSC Compressor Service Manual, Form No. 6136.

#### 4.5.1.2 Compressor Motor

Direct drive motors must be lubricated per manufacturer's specifications and periodic insulation resistance tests are also recommended.

#### 4.5.1.3 Coupling Alignment

Shafts become misaligned as a result of many natural and unavoidable causes. Heat, vibration, bearing wear, the settling of foundations, etc., all tend to alter alignment. Periodic checks of the compressor coupling is recommended.

NOTE: The coupling should be hot when making alignment adjustments. Also the motor should be aligned to the compressor.

**SP-16 (Compressor Coupling Alignment)**

1. To check angular misalignment (Figure B) mount indicator (as shown on left flange) with stem on face of right flange. Rotate equipment noting maximum and minimum indicator reading. Move equipment as necessary to reduce the total indicator reading to that shown below.
2. To check parallel misalignment (Figure C) set indicator stem on outer surface of flange. Rotate equipment noting maximum and minimum indicator reading. Move equipment as necessary to reduce indicator reading to that shown below. Be careful not to disturb the setting of Step 1.

   NOTE: If it is necessary to remove the motor alignment pins, the motor should be repinned after the alignment corrections are made.
3. Repeat Steps 1 and 2 as necessary.
4. Coupling hubs to be spaced to dimension C, as shown in the table below.
5. This coupling should be rotated several revolutions to make sure no "endwise creep" in connected shafts is measured.
6. Tighten all bolts as shown in chart below.
7. When operating at full speed, both laminated rings should have a distinct and clearly defined appearance not blurred when viewed from top and side.

**FIG. 24 - COUPLING ALIGNMENT**

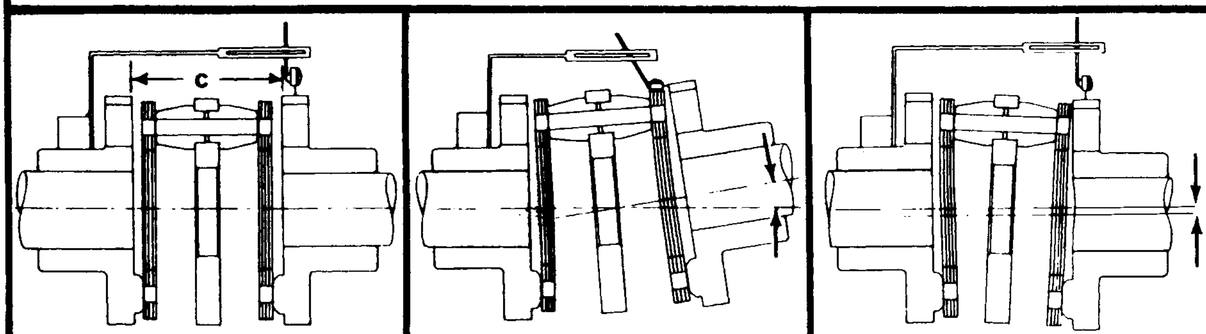



**FIGURE 24A** *COUPLING IN ALIGNMENT*

**FIGURE 24B** *TEST FOR ANGULAR MISALIGNMENT*

**FIGURE 24C** *TEST FOR PARALLEL MISALIGNMENT*

| THOMAS COUPLING SERIES | FORM-FLEX COUPLING SERIES | BOLT TORQUE | | | | MISALIGNMENT (TIR) | | | | DIMENSION C (SEE FIG. A) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | THOMAS | | FORM-FLEX | | PARALLEL | | ANGULAR | | | |
| | | (Ft.-Lb.) | (kg-m) | (Ft.-Lb.) | (kg-m) | (In) | (mm) | (In) | (mm) | (In) | (cm) |
| 163 DBZ-B | - | 13 | 1.8 | - | - | 0.003 | 0.376 | 0.003 | 0.076 | 2 7/16 | 6.19 |
| 201 DBZ-B | - | 25 | 3.5 | - | - | 0.005 | 0.127 | 0.005 | 0.127 | 2 15/16 | 7.46 |
| 226 DBZ-B | AK 30 | 43 | 6.0 | 40 | 5.5 | 0.005 | 0.127 | 0.005 | 0.127 | 3 13/16 | 9.68 |
| 263 DBZ-B | AK 35 | 63 | 8.7 | 40 | 5.5 | 0.007 | 0.178 | 0.007 | 0.178 | 4 5/16 | 11.0 |
| 301 DBZ-B | AK 40 | 95 | 13.1 | 80 | 11.1 | 0.007 | 0.178 | 0.007 | 0.178 | 4 7/8 | 12.38 |
| 351 DBZ-B | AK 45 | 175 | 24.2 | 80 | 11.1 | 0.007 | 0.178 | 0.007 | 0.178 | 5 7/8 | 14.90 |
| 350 - 51 | - | 95 | 13.1 | - | - | 0.007 | 0.178 | 0.007 | 0.178 | 6 | 15.24 |

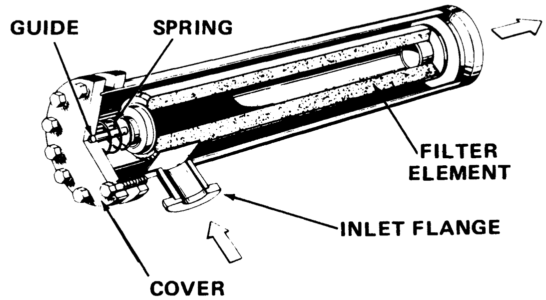
1. Consult factory for complete engineering specification ASY-ES-1, if additional information is required.
2. TIR = Total Indicator Reading.
3. Compressor alignment data is subject to periodic change. Consult latest North American Service Bulletin SR-109.

### 4.5.2 Oil System Component Maintenance

#### 4.5.2.1 Oil Filter Replacement

The need for replacement of the oil filter may be determined by measuring the pressure drop across the filter (6 psid [41.4 kPa] maximum). The normal pressure drop with a new element is 1 to 2 psid (6.9 to 13.8 kPa). Some units are equipped with an indicator for this purpose.

FIGURE 25 HORIZONTAL TYPE OIL FILTER




**SP-17 (Oil Filter Replacement)**

1. With the unit off, close the oil filter service valves at the inlet and outlet sides of the oil filter assembly to be serviced.
2. Vent filter housing into a gallon (3.8 liters) container. Oil will foam up.
3. Remove cover, (enclosure; vertical type), by evenly backing out the bolts.

NOTE: Do not cock cover (enclosure). Spring is in compression with the filter elements.

4. Remove filter element guide. Remove and inspect oil filter cartridge for metallic particles, babbitt or unusual amounts of dirt or sludge. Remove old gaskets (O-Ring).
5. Clean interior of oil filter housing with a lint free wiping cloth.
6. Inspect new oil filter element to ensure that the element is free from damage, and install new oil filter element, Ensure that the element is seated properly.
7. Install cover (enclosure) with new gasket or "O" Ring if necessary. Torque bolts evenly.
8. Purge oil filter thoroughly and open isolation shut off valves.
9. With unit operating, test for any leakage.

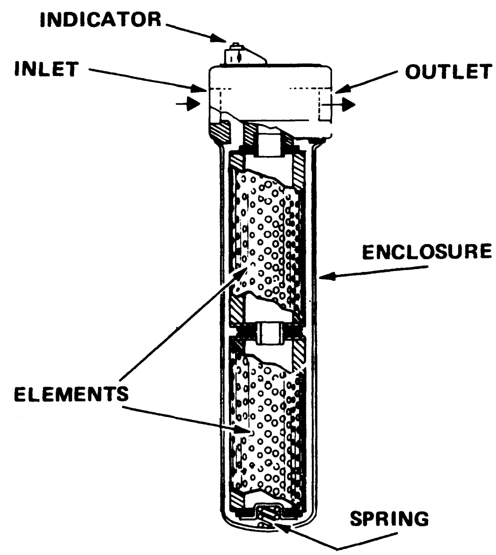



FIGURE 26 VERTICAL TYPE OIL FILTER

**SP-18 (Coupling Alignment)**

1. Disconnect electrical service
2. Check parallel alignment by placing a straight-edge across the two coupling flanges and measuring the maximum offset at various points around the periphery of the coupling. Do not rotate the coupling. If the maximum offset exceeds the figure shown under parallel, realign the coupling.
3. Check angular alignment with a micrometer or caliper. Measure from the outside of one flange to the outside of the other at intervals around the periphery of the coupling. Determine the maximum and minimum dimensions. Do not rotate the coupling, the difference between the maximum and minimum must not exceed the figure given under "angular". If a correction is necessary, be sure to recheck the parallel alignment.

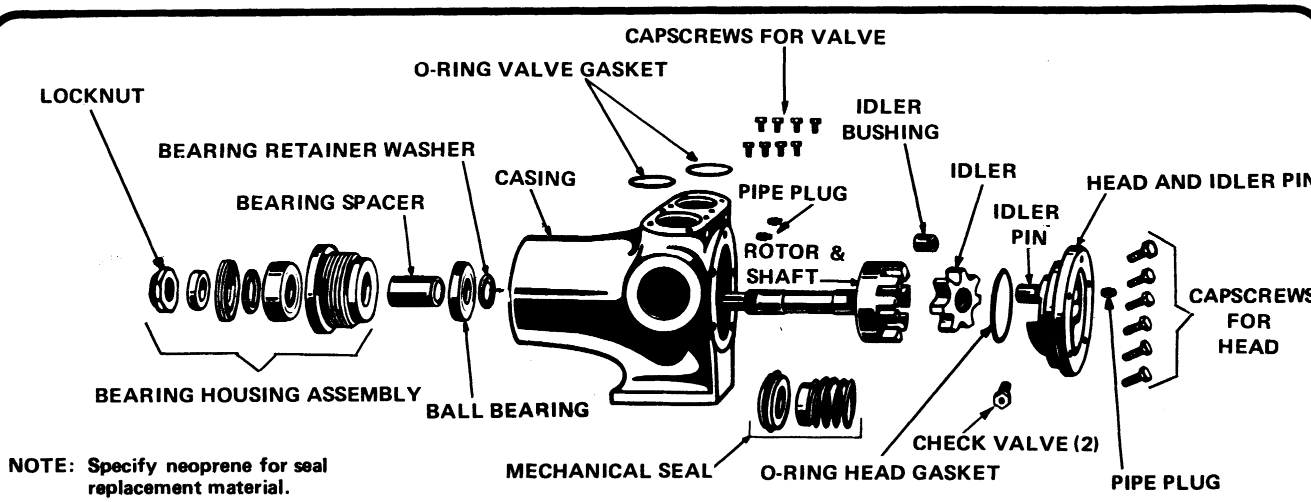



FIGURE 27 TYPICAL EXTERNAL TYPE OIL PUMP

NOTE: For maximum life, keep misalignment values as near to zero as possible.

| Net Max. Alignment Values (External Oil Pump) | | | | |
|---|---|---|---|---|
| (Type N) Sleeve Size | Parallel | | Angular | |
| | In. | cm | In. | cm |
| 6 | 0.015 | 0.038 | 0.070 | 0.178 |
| 7 | 0.020 | 0.051 | 0.081 | 0.206 |
| 8 | 0.020 | 0.051 | 0.094 | 0.239 |
| 9 | 0.025 | 0.064 | 0.109 | 0.277 |

**SP-19 (End Clearance Adjustment, Direct Drive Oil Pump)**

1. Disconnect electrical service to oil pump.
2. Loosen set screws on bearing housing.
3. Counterclockwise rotation of the bearing housing will increase end clearance. Two notches on the bearing housing represent approximately 0.003 in. (0.076mm).

CAUTION: Be sure the shaft can be rotated freely and the set screws are tightened securely.

4. Align coupling and reconnect electrical service.

#### 4.5.2.2 Oil Pressure Relief Valve

**CAUTION:** Problems seeming to require oil pressure relief valve adjustments can usually be traced to other items, such as plugged oil filters, worn pump, improper pump end clearance, a plugged or dirty seat, and/or a damaged seat.

- External Type - The external type in-line oil pressure regulating valve is factory set to crack at 35 to 42 psig (2413 to 289.6 kPa) (pressure at compressor, 100% load).

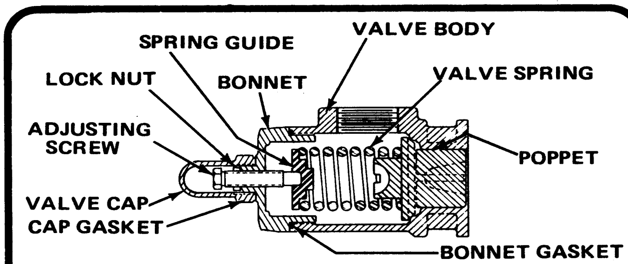



FIGURE 28 TYPICAL EXTERNALLY LOCATED PRESSURE RELIEF VALVE

**SP-21 (Oil Pressure Relief Valve Adjustment)**

1. Remove the valve cap which covers the adjusting screw, and loosen the locknut(s), which locks the adjusting screw so the pressure setting will not change.
2. The adjusting screw should be turned in for increasing the pressure that the relief valve will open.
3. Adjust to design conditions.

**SP-22 (Oil Pressure Relief Valve Disassembly)**

1. Remove valve cap.
2. Measure and record length of extension of the adjusting screw.
3. Loosen the locknut(s) and back out adjusting screw until spring pressure is released.
4. Remove part components, clean and inspect for wear or damage. Repair or replace as necessary.

#### 4.5.2.3 Oil Sump Heaters

No maintenance is required on oil sump heaters, except for replacement, if the heater element should fail. The heater may be removed from its well without disturbing the oil or charge.

**SP-23 (Replacement of Oil Sump Heaters)**

1. With the power off, disconnect electrical cable and wiring.
2. Remove the oil sump heater element from the oil sump flange.
3. Install new oil sump heater element to the oil sump well.
4. Reconnect wiring and electrical cable.

#### 4.5.2.4 Evaporator Oil Return (Flooded Chiller, Low Temp. Direct Expansion Chiller)

The jet pump oil return taps on the chiller vessel are factory pre-set to design conditions. However re-adjustment may be needed after installation.

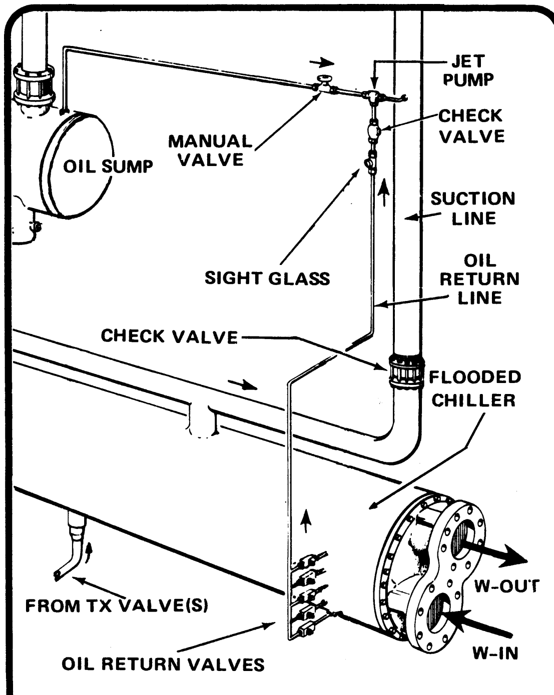


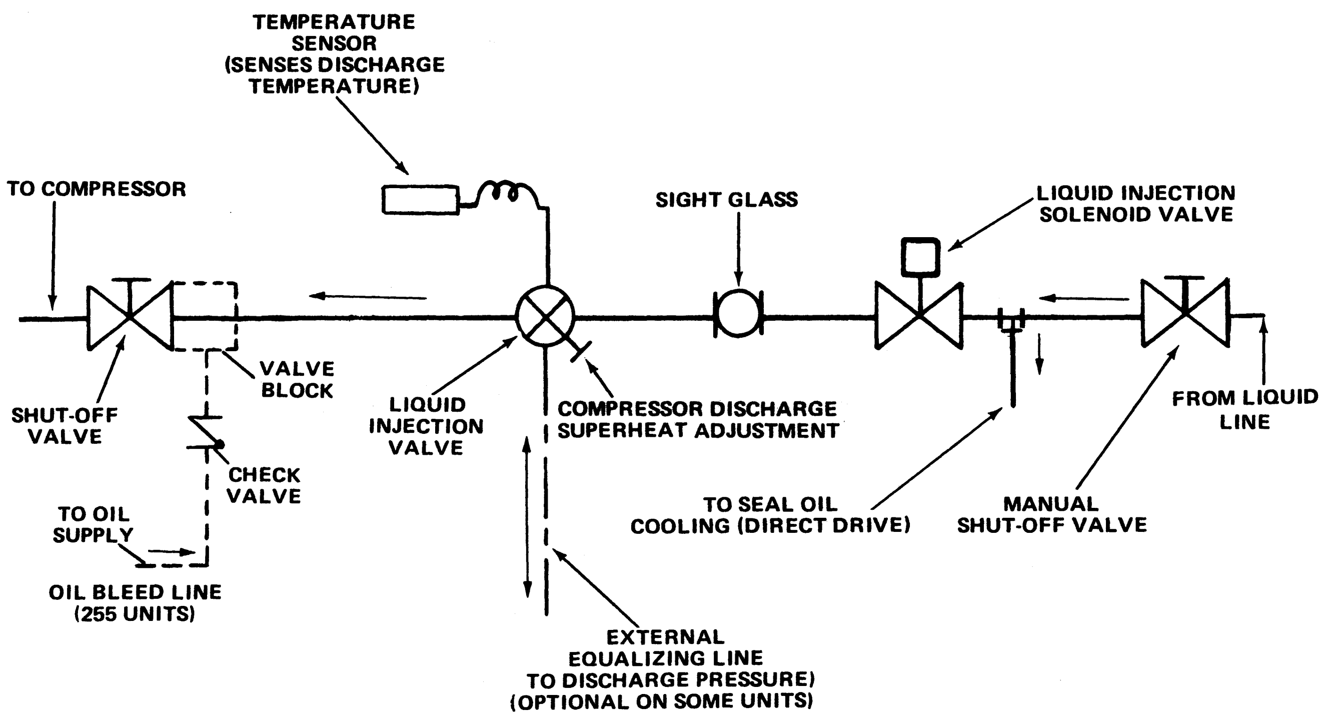

FIGURE 29 TYPICAL EVAPORATOR OIL RETURN

- **Adjustment (Flooded Type)** - Once the maximum and minimum liquid refrigerant levels are established, adjustment may be made. All dip tubes that are within the liquid operating range are to remain fully open. All dip tubes that are never exposed to liquid refrigerant are to remain closed to prevent capacity reduction. If extended pulldown is anticipated, the lowest dip tube should remain fully open.
- **Adjustment (Direct Expansion Type)** - Valve is to remain fully open on dip tube.

### 4.5.3 Oil Cooling System Maintenance

#### 4.5.3.1 Liquid Injection Oil Cooling System

FIGURE 30 TYPICAL LIQUID INJECTION OIL COOLING SCHEMATIC




- **Normal Operation** - This system is designed to hold the oil temperature to the compressor inside the 135°F to 200°F (57°C to 93°C) range under all conditions of operation. This is done by a combination of controls. The liquid injection valve is factory adjusted to provide 40°F to 50°F (22°C to 28°C) discharge superheat at 100% load and design head pressure. That is the discharge temperature that will be controlled at 40°F to 50°F (22°C to 28°C) above saturated discharge temperature.

**EXAMPLE:** At 105°F (41°C) condensing temperature and 100% load, the discharge temperature will be controlled at 145°F to 155°F (63°C to 68°C) at 100% load. At 115°F (46°C) condensing temperature the discharge temperature will be controlled at 155°F to 165°F (68°C to 74°C) at 100% load.

At low loads, the superheat provided by the liquid injection valve will decline to approximately 25°F (14°C) and in the usual system the head pressure will also rebalance lower.

**EXAMPLE:** 10% load, 90°F (32°C) C.T. the liquid injection valve will control at 115°F (46°C). It is preferable to maintain a higher value to prevent oil dilution, so under these conditions, the thermostat will cycle the solenoid valve to maintain 140°F ± 5°F (60°C ± 3°C) oil temperature.

**CAUTION:** The thermostat setting should not be altered in the field. If the unit is stopped by the thermostat, the cause should be determined and corrected.

- **Abnormal Operation** - If the liquid injection valve fails in the closed position the unit will cycle off on the oil temperature thermostat, or the oil pump motor thermostats. If the liquid injection valve fails in the open position, the thermostat and solenoid will take over control until the liquid injection valve can be repaired.

- **Control Settings:** As noted on the unit job wiring diagram. TX Valve: Adjusted to maintain 40°F to 50°F (22°C to 28°C) above saturated discharge temperature (100% load, design conditions) minimum.

**NOTE:** Heat transfer paste must be used in the bulbwell.

#### 4.5.3.2 Liquid Injection Oil Cooling System

The water cooled oil coolers require periodic cleaning of the water side to assure maximum efficiency. It is recommended that the tubes are cleaned out at the same time that the condenser is cleaned. (Refer to Condenser Maintenance)

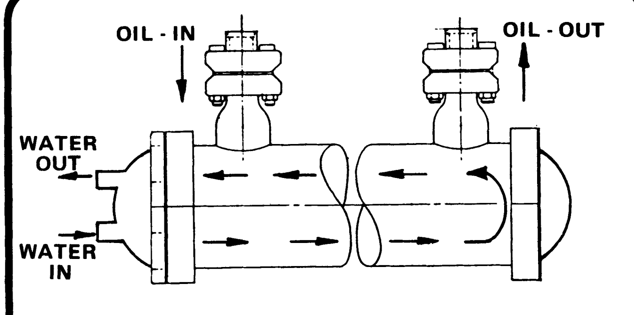



FIGURE 31 TYPICAL TWO-PASS WATER COOLED OIL COOLER

- **Oil Cooler Water Regulating Valve** - These valves are factory adjusted but may require periodic readjustment if too high an oil temperature occurs that is not attributed to oil cooler fouling or oil pump problems. This valve should also be flushed out when the oil cooler is cleaned.

**SP-24 (Oil Cooler Water Regulating Valve Adjustment)**

1. To raise the temperature opening point, turn adjusting screw counterclockwise; to lower the temperature opening point, turn adjusting screw clockwise.

**NOTE:** Temperature closing point of valve is non-adjustable. Temperature actuated valves close approximately 3°F to 5°F (1.7°C to 2.8°C) below opening point.

**SP-25 (Oil Cooler Water Regulating Valve Flushing)**

1. Lift range spring follower with screwdrivers at two sides of lower spring cap to open valve.
2. Backflush oil cooler, holding valve open (this procedure should not affect valve adjustment).

#### 4.5.3.3 Seal Oil Cooler System (Direct Drive Models)

CAUTION: The thermostat setting should not be altered in the field. If the unit is stopped by the thermostat, the cause should be determined and corrected.

- **Normal Operation** - This system is designed to hold the temperature of the oil being pumped to the seal to 115°F ± 5°F (46°C ± 3°C), under all conditions of operation by adjustment of its thermal expansion valve.

- **Abnormal Operation** - If the temperature operated expansion valve fails in the closed position, the unit will cycle off from the oil temperature thermostat, which senses the oil temperature out of the seal oil cooler. If the temperature operated expansion valve fails in the open position, the heat exchanger may flood through and the oil will be overcooled. The seal oil cooling system in conjunction with the liquid injection system will not perform properly if flashing liquid is supplied to the expansion valves.

- **Settings - Thermostat:** 130°F (54.4°C) cut out, 127°F (52.8°C) cut in. Temperature operated expansion valve: 115°F ± 5°F (46.1°C ± 2.7°C) oil temperature at bulbwell.

**SP-26 (Seal Oil Temperature Adjustment)**

**NOTE:** When adjusting the temperature setting on the thermal expansion valve to maintain seal oil temperature time must be allowed for the system to react and stabilize before further adjustment.

1. With a thermo-couple properly insulated and orientated at the thermal expansion valve bulbwell (on oil line) monitor the oil temperature.
2. Clockwise rotation of the temperature adjustment will lower oil temperature. Adjust accordingly.

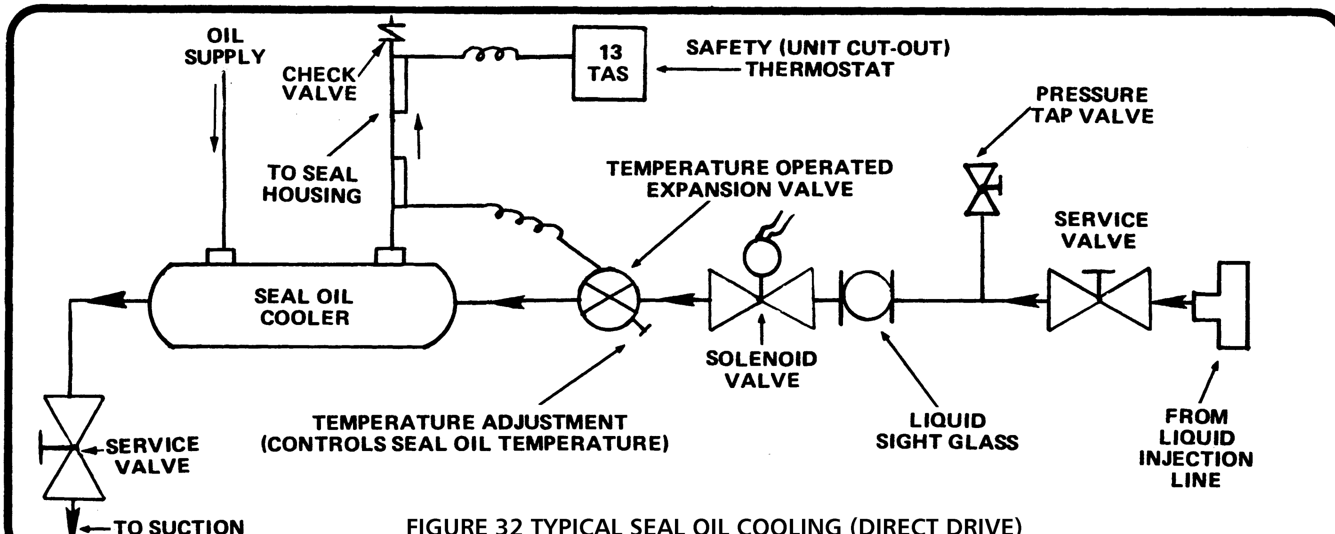



FIGURE 32 TYPICAL SEAL OIL COOLING (DIRECT DRIVE)

### 4.5.4 High/Low Side Component Maintenance

#### 4.5.4.1 Condenser Cleaning

To assure optimum efficiency, the condenser water tubes should be cleaned of scale, sludge, and slime deposits. Individual water conditions will determine how often the tubes are cleaned. One indication of tube fouling, is rising condensing pressures not attributed to air or other causes. There are two methods of tube cleaning.

1. Mechanical - Using brushes to remove loose material deposits.
2. Chemical - Flushing solvent to remove scale deposits.

NOTE: It is recommended that only a reputable professional chemical cleaning organization be used for the cleaning of the condenser. Damage could result to the heat exchanger from the use of an improper, solution or from exposure for too long a period.

**SP-27 (Mechanical Cleaning of Condenser)**

NOTE: Head gaskets need not be renewed after each head disassembly operation. Gasket must to replaced if it is physically disfigured or otherwise deteriorated.

1. Isolate water side of condenser, vent, drain and remove heads.
2. Remove loose material which has settled in the tubing with brushes. Flush thoroughly with fresh water, drain and restore heads and piping to vessel, torquing nuts evenly. Insure no entrapped air exists by venting high points of water system.

#### 4.5.4.2 Condenser Tube Plugging

Plugging has long since been accepted as standard service procedure. A maximum 5% of the total number of tubes may be plugged. The recommended method of repair can be performed without pumping out the refrigerant if due care is exercised.

**SP-28 (Tube Plugging)**

1. With unit off, shutdown the condenser water flow.
2. Drain condenser water supply and return piping and remove both heads.
3. Conduct leak test (refer to SP-37)
4. Drill and tap tube sheet for 112 inch pipe plug or tapered plug and plug accordingly.
5. Install heads, with new gaskets if required. Connect water piping and fill condenser water supply.
6. Start pump and vent water system of entrapped air at high points of piping, and at vessel heads.
7. Add to refrigerant charge if necessary. (Refer to SP-15)
8. Check moisture indicators for evidence of water and change filter drier elements if necessary.

- **Condenser Relief Valves** - The condenser relief valve is adjusted and sealed at the factory. No maintenance is anticipated. However, if the relief valves do blow off at the design pre-set pressure, the cause should be determined and the relief valves should be replaced if they do not properly re-seat.

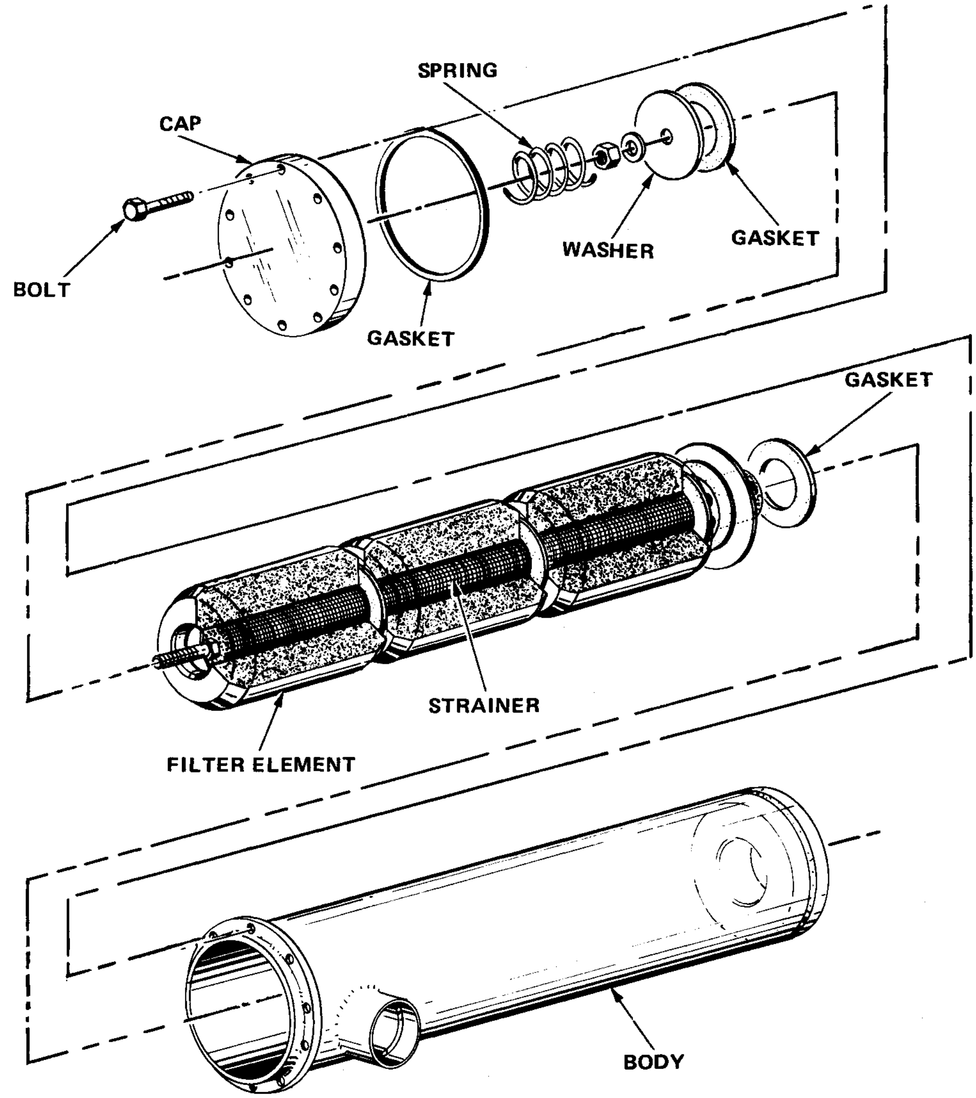



FIG. 33 TYPICAL REFRIGERANT FILTER DRIER

### 4.5.4.3 Filter Drier Replacement

The filter drier elements should be replaced at scheduled intervals, when a specific maintenance action requires, or when moisture is evident in the system. The maximum operational pressure drop across the filter drier is 5 PSI (34.5kPa).

**SP-29 (Filter Drier Replacement)**

1. Partially pumpdown system (Refer to SP-7),
2. Close both manual shut-off valves to isolate the filter drier.
3. Slowly vent enclosure to atmospheric pressure by opening plug.
4. Disassemble the drier assembly, discarding the cartridge elements and gaskets. Remove bolts evenly as spring is in compression to flanged cover.
5. Clean the housing and internal parts thoroughly. Inspect for damaged or deteriorated parts. Replace as needed.
6. Assemble the filter drier and torque bolts evenly.
7. Purge drier assembly and open isolation valves.
8. With the unit operating, check for leaks with a leak tester.

Once every two years, an inspection of the chiller tubes should be made, and the tubes cleaned if necessary. (flooded chiller models, clean inside tubes; direct expansion chiller models, clean outside of tubes).

### 4.5.4.4 Cleaning Chiller

Because the chiller water or brine is a closed system, less frequent cleaning of the chiller tubes is required.

NOTE: It is recommended that only a reputable professional chemical cleaning organization be used for the cleaning of the chiller. Damage could result to the heat exchanger from the use of an improper solution, or from exposure for too long a period.

- **Chiller relief valve(s)** - The chiller relief valve is adjusted and sealed at the factory, no maintenance is anticipated. However, if the relief valve does blow-off at the design pre-set pressure, the cause should be determined and the relief valve should be replaced if it does not properly re-seat.

#### 4.5.4.5 Brine Maintenance

The chiller cooling medium must be periodically checked and maintained at design percent concentration, for a freeze point at least 10°F (6°C) below minimum saturated evaporator temperature. The actual freeze point may be determined by obtaining the specific gravity (with a hydrometer) and the temperature of the brine. With this data obtained, the percent concentration and freeze point may be determined from curves available from the brine manufacturer.

**WARNING**: The factory is not responsible for damage due to chiller freeze-up as a result of negligent periodic maintenance of brines.

- **Chloride Brines** - In addition to proper freeze point, chloride brines require special precautions. A rust inhibitor must be used in adequate quantity and the brine PH must be checked and adjusted periodically to prevent potential chiller corrosion. Brine PH must be maintained between 7.5 and 8.0 and must be adjusted before filling chiller.

**NOTE:** Consult brine manufacturer or a professional agency for mixing the solution, adjusting PH, and proportioning the rust inhibitor.

#### 4.5.4.6 Pilot Thermo Valve

The pilot thermo valve is located on a branch liquid line and is used in conjunction with the pilot operated solenoid thermal expansion valve. The pilot thermo valve is factory pre-set to maintain 10°F to 15°F (5.6°C to 8.3°C) superheat (direct expansion chillers) or 0 to 5°F (0 to 2.8°C) superheat (flooded chillers). Superheat is the temperature increase of the refrigerant gas above the saturation temperature at the existing pressure. The superheat setting can be re-adjusted, if required, to improve system performance.

- **Pressure and Temperature Measurement** - The suction gas temperature should be measured on the suction line at the pilot thermo valve bulbwell and must be insulated from ambient air temperature. Units that locate the bulb in the leaving chilled water or brine flange require temperature measurement on the suction line halfway up the vertical riser on the side of the pipe.

**CAUTION:** The orientation of the thermocouple is critical for temperature measurement. Do not locate the thermocouple on any elbows.

The pressure may be measured by installing a calibrated gage at a gage connection closest to the temperature measurement. Both pressure and temperature measurements must be taken either upstream or downstream of the check valve.

**SP-30 (Superheat Adjustment)**

1. To increase superheat (decreases flow and reduces suction pressure), turn adjustment screw clockwise two full turns. Allow time for the system to react.

NOTE: As measured superheat decreases with a partial load, these adjustments should be made at 60% load or above. (With a dual pilot thermo valve arrangement, the load must be manipulated for each setting.)

2. Observe for increased superheat; adjust accordingly until design superheat is obtained.

- **Maintenance** - The only maintenance required for the pilot thermo valve is inspection, cleaning or replacing the cage assembly, and/or replacing the power assembly.

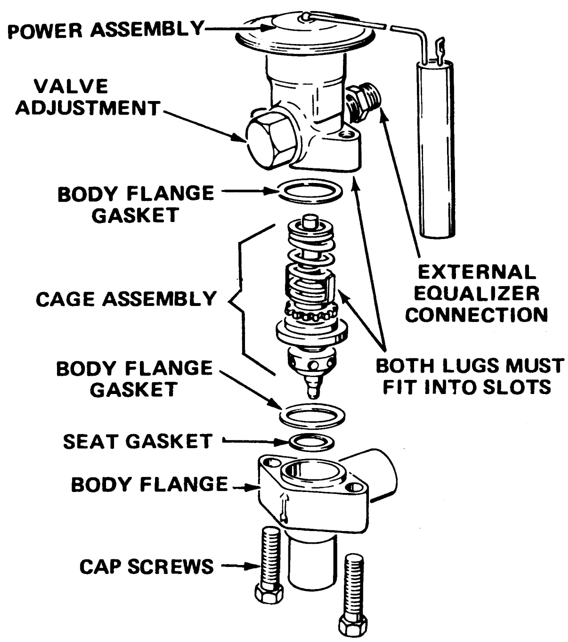
**SP-31 (Thermo-Expansion Valve Disassembly)**

NOTE: The liquid line must be at atmospheric pressure before disassembly.

1. Remove the two cap screws, lift off the power assembly and remove the cage assembly.
2. Compress the cage spring to inspect pin and seat. If either are worn or eroded, replace cage assembly.
3. Check power assembly by pressing finger against buffer plate; replace assembly if plate is easy to move or depress.

CAUTION: Be sure all three gaskets are replaced in their proper places on the cage; that the two lugs on the cage assembly feed into their grooves in the power assembly; and that valve parts are not forced together.

FIG. 34 TYPICAL PILOT THERMO VALVE




### 4.5.4.7 Pilot Operated Solenoid Thermal Expansion Valve(s) (Main)

No adjustment of the pilot operated solenoid TX valve is necessary. This valve may be manually unseated by turning the manual opening stem beneath the seal cap on the top of the valve in a clockwise direction, until a stop position is reached.

NOTE: Always return the manual stem to the original position before starting the unit.

- **Maintenance**

NOTE: The most expedient method for inspection, cleaning or replacing parts would be to repair them in place.

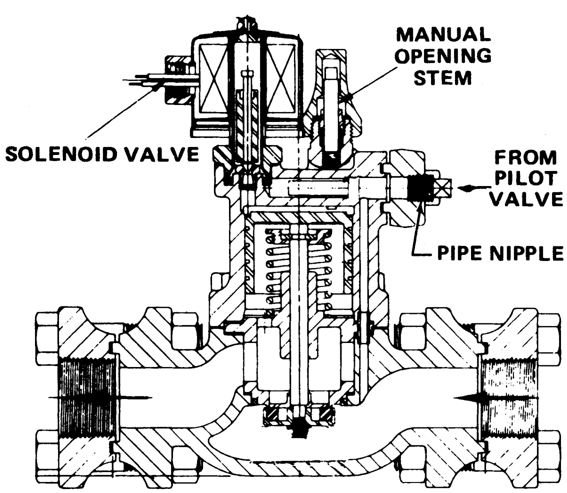
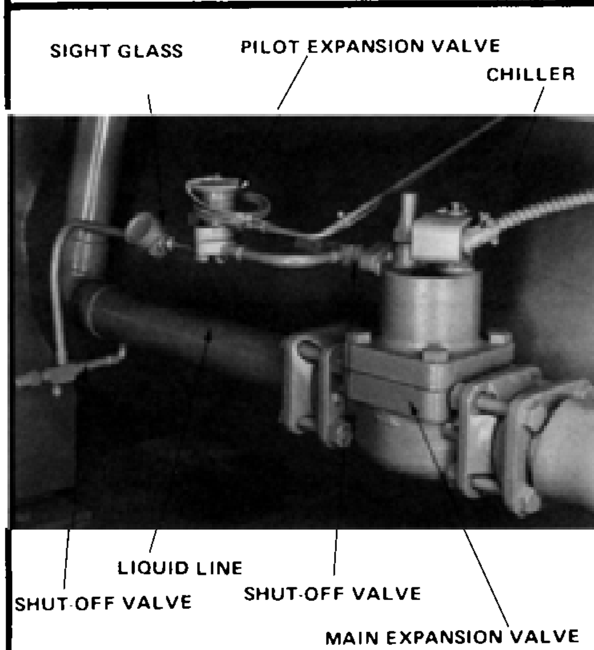



FIG. 35 TYPICAL P.O.S. THERMAL EXPANSION VALVE

**SP-32 (Disassembly/Maintenance P.O.S. Valve)**

1. Remove the solenoid coil.
2. Remove four cap screws, lift off upper body. Remove piston, inspect piston, rings, cylinder wall; check for free movement of piston in cylinder; wipe clean, oil all surfaces. Clean bleed port in top of piston.
3. Remove cage assembly, compress cage spring and examine valve disc, restrictor plug and seat; replace cage assembly if valve disc or seat are cut or eroded.
4. Re-assemble, insert cage with gaskets. Carefully place piston with rings in upper body. Re-assemble unit and tighten cap screws evenly. Replace pilot line connection, test for leaks and re-install.
5. Take apart the solenoid valve assembly. Check seat for wear, dirt, rust, etc. Replace if required.

TYPICAL THROTTLING ARRANGEMENT (1) PILOT, (1) MAIN EXPANSION VALVE



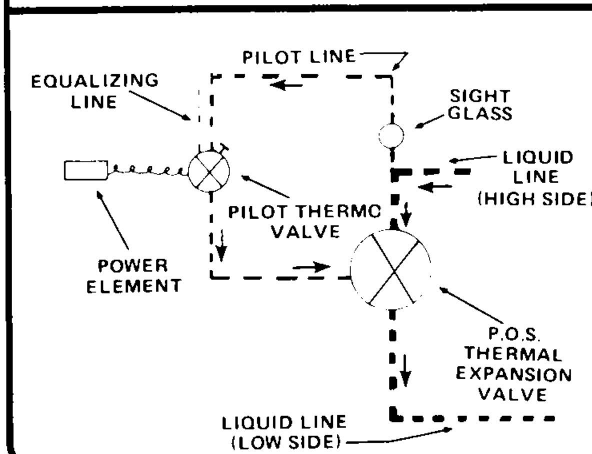
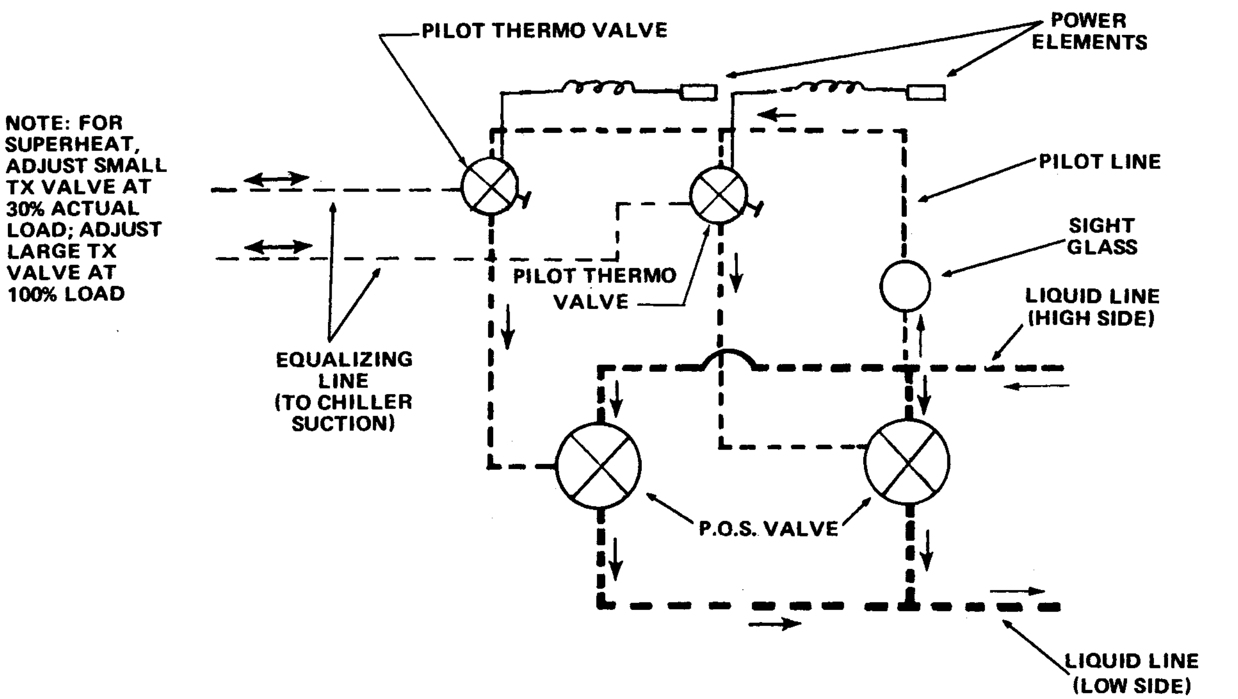
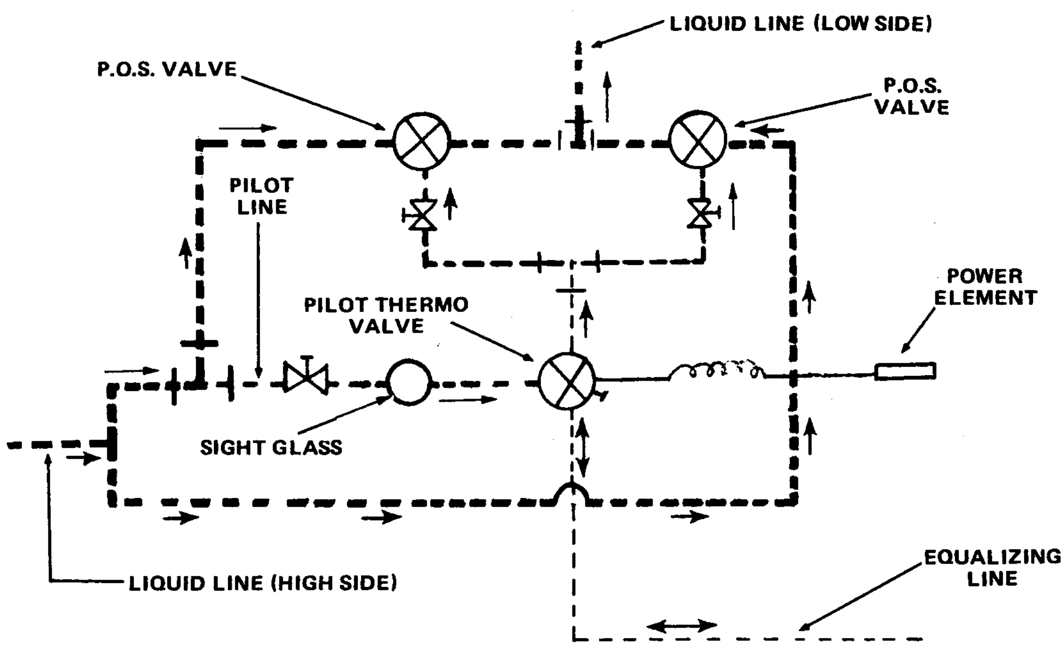



FIG. 36 TYPICAL THROTTLING ARRANGEMENTS




SCHEMATIC - (2) PILOT THERMO VALVES AND
(2) PILOT OPERATED SOLENOID THERMAL EXPANSION VALVES.




SCHEMATIC - (1) PILOT THERMO VALVE AND
(2) PILOT OPERATED SOLENOID THERMAL EXPANSION VALVES

FIG. 37 TYPICAL SUCTION FILTER - IN LINE TYPE

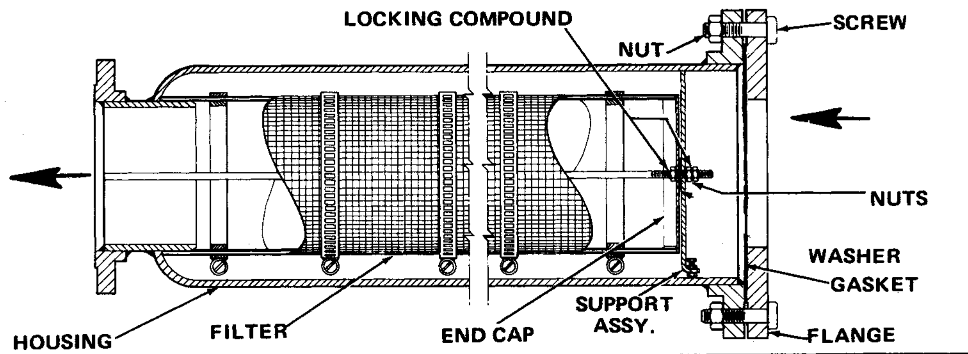
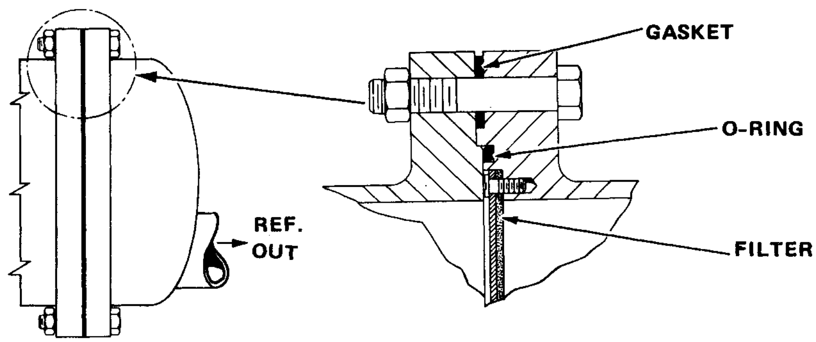



FIG. 38 TYPICAL SUCTION FILTER - CHLLER HEAD TYPE




### 4.5.4.8 Option A Suction Filter

The suction filter should normally be inspected, cleaned or the element replaced only when a major overhaul is performed. Both type chiller units have the filter located in the suction line near the compressor.

**SP-33 (Suction Filter Maintenance In-Line Type)**

1. Transfer refrigerant to the condenser or remove the charge completely. (Refer to SP-7 thru SP-12) Isolate suction line and insure this portion of the system is at atmospheric pressure.
2. Remove insulation over suction filter.
3. Remove flange bolts, lift and remove housing weldment from piping. Remove old gaskets.
4. Remove support assembly and filter element and replace element.

NOTE: A locking compound has been applied on the nuts, when re-installing, be sure the compound is suitable for the refrigerant used and compatible with the refrigerant oil.

5. Position filter over support pipe. Install nut on center rod and push against end of filter.

NOTE: Adjusting screw on support assembly may be loosened for clearance.

6. Install second nut on center rod. Push support assembly hard against filter to crush overhanging media. Tighten outer nut against support assembly to secure it in place against filter core. Apply locking compound, then turn inner nut outward until it contacts inside surface of support assembly. Inner nut should now be in correct position.
7. Remove outer nut and support assembly. Install end cap, and position over filter. Install washers, support assembly and apply locking compound. Install outer two nuts. Tighten nut to clamp parts in place.
8. Adjust screw on support assembly to prevent end movement of filter. Apply locking compound to jam nut (on housing weldment) then tighten.
9. Re-install into piping using new gaskets, and torque bolts evenly. Epoxy insulation over housing weldment. Add refrigerant as required and test for any refrigerant leakage. (Refer to SP-15)

**SP-34 (Suction Filter Maintenance-Head Type)**

1. Transfer refrigerant to the condenser or remove the charge completely. Isolate the chiller and insure chiller is at atmospheric pressure (Refer to SP-7 thru SP-12).
2. Remove insulation at chiller suction head and suction flange. Remove flange bolts at chiller head and suction piping flange.
3. Remove chiller head and pipe assembly, head flange O-Ring and suction pipe flange gasket.
4. Disassemble filter element and inspect. Clean filter element with R-11 or replace if necessary.
5. Reassemble filter element to head with felt facing chiller.
6. Install chiller head assembly using new flange gaskets and head O-ring.
7. Add refrigerant as required and test for any refrigerant leakage.

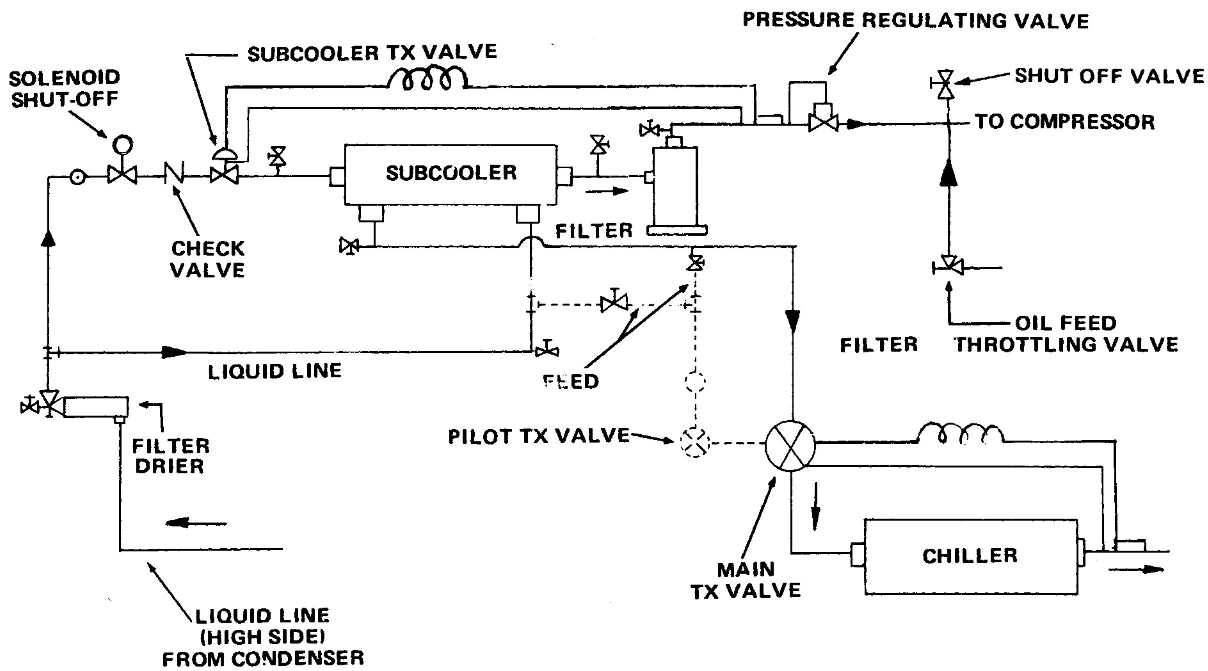



FIG. 39 TYPICAL VAPOR INJECTION SUBSYSTEM SCHEMATIC

## 4.6 Optional Subsystem Maintenance

### 4.6.1 Vapor Injection

NOTE: It is necessary to have a load available that is sufficient to run the machine at full load at design conditions for the proper adjustment of the vapor injection system.

- **Adjustments**

- Subcooler TX Valve - Adjust superheat to 8°F to 12°F (4.4°C to 6.7°C) as measured at the subcooler outlet.
- Evaporator Pressure Regulator - Adjustment must beset at 10% below design conditions.
- Feed Lines to Pilot TX Valve - Use the warm liquid normally unless job conditions are such that unit operation is improved using cold liquid.
- Oil Feed Valve - Close valve until noise level increases; then back off 90° rotation.
- Vapor Injection Shut-Off - Normally set 65% slide valve travel to open solenoid. A can be adjusted from 40% to 75% to suit job conditions.

### 4.6.2 Hot Gas Bypass (Unloaded Start)

The only periodic maintenance required on the unloaded start gas bypass is to insure the solenoid valve is operational and the timer maintains a 10 second timing period. The voltage supplied to the solenoid must not exceed ± 10% of the rated nameplate voltage. If the valve sticks or chatters, it should be disassembled and cleaned or replaced if required.

### 4.6.3 Hot Gas Bypass (Capacity Control)

The capacity control hot gas bypass requires a throttling valve adjustment upon installation and may require periodic readjustment. The throttling valve (located on the hot gas bypass line) should be adjusted at design percent slide valve activation as noted on the unit wiring diagram. The voltage supplied to the solenoid must not exceed ± 10% of the rated nameplate voltage. If the valve sticks or chatters, it should be disassembled and cleaned or replaced if required.

**SP-35 (Hot Gas Bypass Adjustment)**

1. Position slide valve at design percent slide valve activation by manipulating the load to the chiller.

NOTE: Do not position slide valve by means of the temperature load controller. This will not reflect an accurate valve adjustment.

2. Monitor the temperature of the leaving chilled water or brine. If the temperature approaches the corresponding low pressure cut-out, open the throttling valve to avoid shut-down of the unit
3. Rotating valve in the clockwise direction will lower leaving brine temperature, and may cycle off the unit Rotating valve in the counter clockwise direction may load the compressor or may cycle the hot gas bypass solenoid on and off. Neither of these extremes are desirable. Adjust valve between these actions.

## 4.7 Typical System Tests

### 4.7.1 Refrigerant Leak Test

Pressure leak testing may be performed on either a component of the refrigerant system, or on the entire system.

CAUTION: All gages must be valved off to avoid damage under high test pressure.

**SP-37 (Refrigerant Leak Test)**

1. Complete System (Remove refrigerant charge and have sample tested for quality.
   a. Open all line valves and manually unseat the expansion valves.
   b. Add 25 psig of refrigerant R22. Back this up with dry nitrogen bringing the pressure up in steps to 90% of the relief valve setting for the chiller.
   c. Isolate the vessel, (King Valve)
   d. Bring up the pressure in the remainder of the unit to 90% of relief valve setting for the condenser.
   e. Check all vessels, valves and joints with an electronic leak detector, or halide torch. If leaks are found, isolate them and make repairs.
2. Partial System

When the charge is pumped into the condenser a low side pressure leak check can be made using refrigerant R-22.

CAUTION: If nitrogen is used the low side test pressure must be kept 20 psig below the condenser pressure to prevent nitrogen from contaminating the charge.

   a. Open all refrigerant valves on the low side and unseat the expansion valves.
   b. Check all vessels, valves and joints with an electronic leak detector or halide torch. If leaks are found, Isolate them and make repairs.

### 4.7.2 Checking Phasing Of Motors For Proper Direction Of Rotation

   a. Start-up unit in normal manner.
   b. When the compressor starts to accelerate immediately check the suction pressure gage. If the pressure is dropping, the compressor is wired correctly and turning in the proper direction. If the suction pressure is rising, the motor is wired incorrectly and the control circuit breaker should be turned off immediately. Operation of the compressor in the wrong direction at full speed can damage the compressor and system.

# 5.0 TROUBLESHOOTING

## 5.1 General

Operating personnel must be completely familiar with the equipment and this manual. This will be necessary for correct diagnosis of any troubles and will permit immediate correction of minor difficulties. It is important that operators be able to quickly distinguish conditions requiring expert service in order to minimize down-time and maintenance expense. Comparison of the readings entered in the current Daily Log with those entered immediately following installation of the unit will be of considerable assistance in locating trouble areas.

To determine and isolate common problems which might occur, the following chart was made which lists symptoms, possible causes and remedies.

| SYMPTOM | POSSIBLE CAUSE | REMEDY |
|---|---|---|
| A. Unit shuts down on compressor starter overload | 1. Faulty compressor or motor<br>2. Overloads trip below 105% of full load amperage<br>3. Low voltage<br>4. Load limit relay out of adjustment<br>4. Check and adjust for proper operation | 1. Contact Dunham-Bush Service Representative<br>2. Install properly sized overloads<br>3. Check line voltage. Must be ± 10% of rated voltage |
| B. Unit shuts down on oil pump starter overload | 1. Cold oil<br>2. Low voltage<br>3. Bound Pump<br>4. Plugged oil filter<br>5. Faulty motor<br>6. Closed service valve | 1. Check oil sump heaters for proper operation, repair and replace as necessary<br>2. Check line voltage must be ± 10% of rated voltage<br>3. Clean and repair as necessary<br>4. Clean and replace as necessary<br>5. Repair or replace as necessary<br>6. Open service valve |
| C. Unit shuts down on High-Low pressure switch | 1. High Discharge Pressure<br>a. Poor or no condensing water flow<br>b. Condenser tubes fouled<br>c. Refrigerant overcharge<br>d. Air or noncondensables in refrigerant system<br>e. Water supply to condenser is too warm<br>f. Pressure switch out of calibration<br>2. Low Suction Pressure<br>a. Plugged filter/drier<br>b. Low refrigerant charge<br>c. Low water flow thru chiller<br>d. Fouled chiller<br>e. Frozen chiller<br>f. Pressure switch out of calibration<br>g. Low condenser water temperature | 1.<br>a. Clean strainers, check setting of flow valve, check condenser pump - clean and repair as necessary<br>b. Clean tubes, have water checked by water treatment specialist<br>c. Remove excess refrigerant<br>d. Purge air or non condensables<br>e. Check, repair and adjust condenser water cooling facilities<br>f. Reset or replace as necessary<br>2.<br>a. Replace elements if pressure drop is above limits<br>b. Check sight glass for flashing gas, check for leaks, repair leaks. Add refrigerant as necessary<br>c. Check control valves for proper settings, check for dirty strainer, adjust clean and repair as necessary<br>d. Clean chiller, consult water treatment specialist<br>e. Check and reset or replace freeze-up switch as necessary, check brine for proper % solution<br>f. Reset or replace as necessary<br>g. Adjust condenser water regulating valve (if applicable). Check tower temperature controls |
| D. Shutdown of unit on seal oil temp. | 1. Low refrigerant charge<br>2. Inoperative TX valve<br>3. Inoperative seal oil cooler solenoid<br>4. Filter drier plugged | 1. Check sight glass for flashing gas, check for leaks. Repair leaks add refrigerant as necessary<br>2. Replace valve<br>3. Check coil for burnout<br>4. Clean or replace as necessary |

# 5.0 Troubleshooting

| SYMPTOM | POSSIBLE CAUSE | REMEDY |
|---|---|---|
| E. Shutdown on high oil temp. | **Units with Liquid Injection:**<br>1. Low refrigerant charge<br>2. Inoperative liquid injection TX valve<br>3. Inoperative liquid injection solenoid<br>4. Discharge temperature thermostats out of adjustment<br>**Units with Water Cooled Oil Cooler:**<br>5. Oil cooler water valve out of adjustment<br>6. Inadequate water supply to oil cooler<br>7. Dirty oil cooler | 1. Check sight glass for flashing gas, check for leaks, repair leaks and add refrigerant as necessary<br>2. Replace valve<br>3. Check coil for burnout<br>4. Reset to lower temperature<br>5. Readjust<br>6. Check condenser water pump and clean strainer<br>7. Check and clean tubes if necessary, check condenser water treatment installation |
| F. Unit shuts down on freezestat | 1. Inadequate flow of chilled water<br>2. Malfunctioning freezestat<br>3. Incorrect TLC temperature setting | 1. Check settings of valves, clean strainers, check chiller pump, clean and repair as necessary<br>2. Reset or replace as necessary<br>3. Readjust to desired leaving chilled water temperature |
| G. Unit shuts down on flow switch | 1. Pump malfunctioning<br>2. Strainers plugged<br>3. Valves not set properly<br>4. Air in system<br>5. Flow switch inoperable | 1. Check pump, clean and repair as necessary<br>2. Clean strainers<br>3. Reset valves<br>4. Bleed system<br>5. Replace |
| H. Unit shuts down on chilled water pump | 1. Overload on pump | 1.<br>a. Pump malfunctions, repair or replace as necessary<br>b. Plugged<br>c. Closed system valves, reset as necessary |
| J. Low discharge/oil temperature | 1. Sump heaters not functioning during off period<br>2. Maladjusted expansion valves<br>3. Discharge temperature thermostat out of adjustment<br>**Water Cooled Oil Coolers**<br>4. Oil cooler water valve out of adjustment<br>5. High water pressure | 1. Repair and replace as necessary<br>2. Readjust superheat settings of main expansion valves, liquid injection and seal oil cooler expansion valves<br>3. Reset to lower temperature<br>**Water Cooled Oil Coolers**<br>4. Readjust<br>5. Readjust water pressure regulator |
| K. High discharge/ oil temperature | 1. Maladjusted expansion valve<br>2. Discharge temperature thermostat out of adjustment<br>3. Liquid injection solenoid valve malfunction<br>**Water Cooled Oil Coolers**<br>4. Oil cooler water valve out of adjustment<br>5. Inadequate water supply to oil cooler<br>6. Dirty oil cooler | 1. Readjust superheat settings of main expansion valves, liquid injection and seal oil cooler expansion valves<br>2. Reset to lower temperature<br>3. Check coil for burnout.<br>**Water Cooled Oil Coolers**<br>4. Readjust<br>5. Check condenser water pump and clean strainer<br>6. Check and clean tubes |
| L. Unit periodically running low or losing oil | 1. External oil leak<br>2. Low discharge superheat and or suction superheat<br>3. Units with jet pump not picking up oil - clogged lines or maladjusted valves<br>4. Discharge temperature thermostat out of adjustment<br>5. Liquid injection solenoid valve malfunction<br>6. Liquid injection TX valve malfunction | 1. Check unit visually for leaks, repair as necessary<br>2. Readjust superheat as necessary<br>3. Repair or readjust as necessary<br>4. Reset to lower temperature<br>5. Repair or readjust as necessary<br>6. Repair or readjust as necessary |
| M. Shut down on low oil pressure | 1. Oil filter plugged<br>2. Low oil pressure safety switch malfunction<br>3. Low discharge superheat and/or suction superheat | 1. Clean and replace as necessary<br>2. Repair or readjust as necessary<br>3. Readjust superheat as necessary |

# 6.0 Appendix

## 6.1 Typical Daily Operating Log

**DUNHAM-BUSH**

DAILY OPERATING LOG
ROTARY SCREW COMPRESSOR PACKAGED CHILLER (IPCX)

UNIT MODEL ____________ MONTH ____________

UNIT SERIAL NUMBER ____________ YEAR ____________

| | | DATE | | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY | SUNDAY |
|---|---|---|---|---|---|---|---|---|---|---|
| TIME | | CHECK | | ☐AM ☐PM | ☐AM ☐PM | ☐AM ☐PM | ☐AM ☐PM | ☐AM ☐PM | ☐AM ☐PM | ☐AM ☐PM |
| ELAPSED TIME INDICATOR READING | | HR | | | | | | | | |
| SLIDE VALVE INDICATOR POSITION | | % | | | | | | | | |
| MOTOR CURRENT (COMPRESSOR) | | AMPS | | | | | | | | |
| MOTOR VOLTAGE (COMPRESSOR) | | VOLTS | | | | | | | | |
| REFRIGERANT SUCTION PRESSURE | | PSIG | kPa | | | | | | | |
| REFRIGERANT SUCTION TEMPERATURE | | °F | °C | | | | | | | |
| REFRIGERANT DISCHARGE PRESSURE | | PSIG | kPa | | | | | | | |
| REFRIGERANT DISCHARGE TEMPERATURE | | °F | °C | | | | | | | |
| NET OIL PRESSURE (GAGE MINUS DISCHARGE) | | PSI | kPa | | | | | | | |
| SEAL DRAINAGE (DIRECT DRIVE ONLY) | | CC/HR. | | | | | | | | |
| SEAL OIL TEMPERATURE (DIRECT DRIVE ONLY) | | °F | °C | | | | | | | |
| OIL TEMPERATURE ENTERING COMPRESSOR | | °F | °C | | | | | | | |
| OIL SUMP SIGHT GLASS LEVEL | | % | | | | | | | | |
| WATER TEMPERATURES (CONDENSER) | ENTERING | °F | °C | | | | | | | |
| | LEAVING | °F | °C | | | | | | | |
| OUTSIDE AMBIENT AIR TEMPERATURE | WET BULB | °F | °C | | | | | | | |
| | DRY BULB | °F | °C | | | | | | | |
| REFRIGERANT INDICATORS | | WET/DRY | | | | | | | | |
| TRANSFER MEDIUM (BRINE, WATER) TEMPERATURES (CHILLER) | ENTERING | °F | °C | | | | | | | |
| | LEAVING | °F | °C | | | | | | | |
| CHILLED (AIR) MEDIUM (SYSTEM) | IN DRY BULB | °F | °C | | | | | | | |
| | IN WET BULB | °F | °C | | | | | | | |
| | OUT DRY BULB | °F | °C | | | | | | | |
| | OUT WET BULB | °F | °C | | | | | | | |
| RECORDED BY | | | | | | | | | | |

COMMENTS ________________________________________

________________________________________

## 6.2 Typical Monthly Operating Log

**DUNHAM-BUSH**

MONTHLY OPERATING LOG

ROTARY SCREW COMPRESSOR PACKAGED CHILLER (IPCX)

UNIT MODEL ____________ DATE ____________

UNIT SERIAL NO. ____________ RECORDED BY ____________

☐ 1000 HOUR INTERVAL

| | | | | | |
|---|---|---|---|---|---|
| LUBRICATION | OIL FILTER PRESSURE DROP | | PSI | kPa | |
| LUBRICATION | OIL PUMP MOTOR CURRENT | | AMPS | | |
| LUBRICATION | OIL PUMP MOTOR VOLTAGE | | VOLTS | | |
| LUBRICATION | OIL SUMP HEATER OPERATION | | — | | |
| LUBRICATION | LOAD/UNLOAD SPEED (FULL STROKE) | | MINUTES | | |
| LUBRICATION | OIL PUMP MOTOR STARTER AND RELAY CONTACTORS | | — | | |
| LUBRICATION | SEAL OIL COOLER OPERATION (DIRECT DRIVE ONLY) | | — | | |
| LUBRICATION | EVAPORATOR OIL RETURN VALVE (IF EQUIPPED) | | — | | |
| REFRIGERANT | COMPRESSOR MOTOR STARTER AND RELAY CONTACTORS | | — | | |
| REFRIGERANT | CONTROL AND GAGE CALIBRATION | | — | | |
| REFRIGERANT | REFRIGERANT LEAKAGE | | — | | |
| REFRIGERANT | FILTER DRIER PRESSURE DROP | | PSI | kPa | |
| REFRIGERANT | LIQUID INJECTION OPERATION | | — | | |
| REFRIGERANT | DISCHARGE SUPERHEAT | DISCHARGE TEMP. | °F | °C | |
| | | DISCHARGE PRESSURE | PSIG | kPa | |
| | | SUPERHEAT | ΔF° | ΔC° | |
| REFRIGERANT | SUCTION SUPERHEAT | SUCTION TEMPERATURE | °F | °C | |
| | | SUCTION PRESSURE | PSIG | kPa | |
| | | SUPERHEAT | ΔF° | ΔC° | |
| HYDRONIC | CHILLER COOLING MEDIUM | FREEZE-POINT | °F | °C | |
| | | PH (BRINE ONLY) | — | | |
| HYDRONIC | CONDENSER PRESSURE DROP (WATER SIDE) | | PSI | kPa | |
| HYDRONIC | CHILLER PRESSURE DROP (BRINE SIDE) | | PSI | kPa | |

COMMENTS ____________

☐ 3000 HOUR INTERVAL

| | | | | |
|---|---|---|---|---|
| COMPRESSOR COUPLING ALIGNMENT (DIRECT DRIVE MODELS ONLY) | | CM | INCH | |
| OIL PUMP COUPLING ALIGNMENT (DIRECT DRIVE OIL PUMP ONLY) | | CM | INCH | |
| OIL ACIDITY (TOTAL ACID NUMBER) | | | TAN | |
| INSULATION RESISTANCE TEST | TEMP. SENSOR READINGS | | OHM | |
| | MEG OHM READINGS | | MEG OHM | |

## 6.3 Typical Condenser Water Piping

### 6.3.1 Condenser Water Piping

A relatively constant condensing temperature (compressor head pressure) should be maintained. The supply water temperature and flow rate must, therefore, be controlled to maintain this constant condensing temperature over the wide load and operating range of the packaged chiller. Valve manufacturers recommendations for piping should be followed.

If a cooling tower is supplying the condenser water, then some means to maintain a constant water supply temperature should be employed.

There are a number of different methods; e.g., cycling the tower fan off and on through a thermostat sensing the cooling tower sump water; temperature dampers controlling air flow (may also be used in conjunction with fan cycling) or by-passing all or part of the return water directly to the sump via a 3-way valve actuated by a controller sensing sump temperature.

The most stable compressor operation can be obtained with a water regulating valve modulating the water flow to the condenser, controlled by condensing pressure.

Heat reclaim units condense refrigerant at higher pressures while operating in the heat reclaim mode. However, this is justified by the amount of heating and cooling performed per kilowatt input. Controlling head pressures for heat reclaim units is highly specialized depending on the system application and is not included in this discussion.

The following are typical valving arrangements with suggested guidelines for the piping configurations. The cooling source is applicable to cooling tower, evaporative water coolers and natural sources.

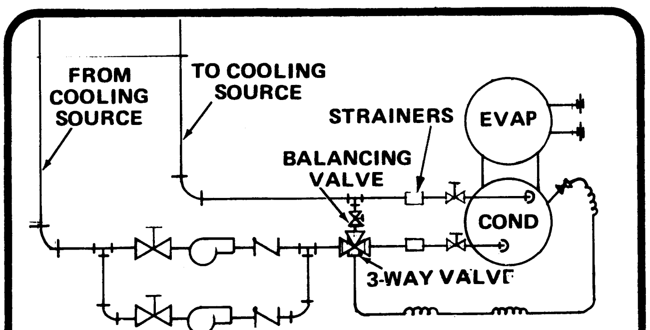



**FIG. 40 TYPICAL DIVERSION OF ENTERING CONDENSER WATER**

1. **Typical Diversion of Entering Condenser Water with Three-Way Valve. (Fig. 40)**

   Stable packaged chiller operation can be obtained by diverting a percentage of the entering water to bypass the condenser as a function of condensing pressure.

   With a diverting system, entering condenser water is regulated by a three-way valve sensing refrigerant condensing pressure. The water valve therefore maintains constant refrigerant head pressure in the condenser.

- **Oil Cooler Piping** -Units that are equipped with a water cooled oil cooler have a two-way water regulating valve.(Fig. 41)

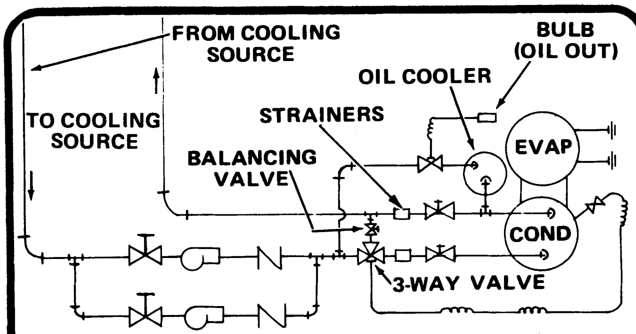



**FIG. 41 TYPICAL DIVERSION OF ENTERING CONDENSER WATER WITH OIL COOLER**

With this configuration, the piping must be designed to have an uninterrupted water supply flow to the oil cooler. The supply to the oil cooler must be located upstream of the condenser water regulating valve.

2. **Cool Weather Package Operation**

   Any application of condenser water regulating valves with an anticipated entering water temperature of below 50°F (10°C) requires additional considerations. A minimum condensing pressure must be maintained to insure proper operation of the thermal expansion valves. If entering condenser water is not effectively regulated, proper operation of the packaged chiller may be jeopardized. Consult factory for parameters concerning your application.

3. **Cold Weather Operation (Cooling Towers)**

   If a system is to be operated in a cold climate [below 32°F (0°C)] some provision must be made to keep the cooling tower from freezing. Sump heaters or an indoor sump are two examples of how this can be accomplished. Consult the tower manufacturer for recommendations.

## 6.4 Compressor Lubrication Requirements

The purpose of this chart is to define the type of oil used with large screw compressors (163, 204, 255mm) for various fluorocarbon applications.

**TYPE OF OIL**

| TEMPERATURE | | REFRIGERANT |
|---|---|---|
| EVAPORATOR | CONDENSING | R-22 |
| Above 20°F | Below 135°F | Oil 4 |
| Above 20°F | Above 135°F | NA |
| Below 20°F | All | Oil 3 |

This chart is used to define the oil pressure and oil failure switch settings for various applications.

**REQUIRED OIL PRESSURE**

| TYPE SYSTEM | MINIMUM OIL FAILURE CUT-OUT SETTING (PSID) | | FULL LOAD OIL PRESSURE (PSID) | |
|---|---|---|---|---|
| | BELOW 20° ET | ABOVE 20°ET | BELOW 20° ET | ABOVE 20° ET |
| IPCX | 20 | 20 | 40 | 40 |
| Heat Recovery | 35 | 35 | 65 | 65 |

DUNHAM-BUSH
USA

101 Burgess Road
Harrisonburg, VA 22801
540-434-4010, FAX 540-434-4595
www.dunham-bush.com

May 2001

Form No. 6139D