UNIT NOT OPERATING

1. Control power is available to the control panel.

2. Compressor sump oil heaters are energized.

3. The capacity controls are disabled; compressor pre-rotation vanes and the interstage control valve are closed. The hot gas valve is open.

SYSTEM STARTUP

1. All chiller safeties must be satisfied prior to starting, with the exception of the compressor and gear low oil pressure switches. The oil pressures are bypassed initially, until the auxiliary oil pumps can establish pressures. The "RESET" button must be pushed to clear any previous power failures (if any).

2. Select the "Main" screen and enable the chiller start by pressing the "Enable Start" button.

   NOTE: In order to start the chiller, cooler and condenser water flows must be established. The actual flows (in GPM) are displayed on the "Main" screen. The cooler and condenser on the CRT lube system screen change from white to blue when sufficient flows are established to satisfy the alarm switches FSL-601 and FSL-604.

   The cooler water flow must be established remotely or locally (using the "Main" screen keypad button F5) by manually opening the cooler water outlet valve (PCV-706).

3. With the above Enable Start signal, the chiller controls start the compressor and gear auxiliary oil pumps. The "Pre-Lube" text in the lower left corner of the screen changes to yellow indicating that pre-lube timer is timing and the seconds display in incremented. The respective pump symbols on the CRT "Lube System" screen change from green to red. The condenser water outlet valve (PCV-102) control signal is slowly increased to open the valve and establish water flow.

4. Twenty-five seconds after the "Enable Start," the compressor and gear low oil pressures are checked.

SYSTEM STARTUP (Continued)

If the minimum oil pressures are not established, startup will be prevented and an alarm signal will be transmitted to the CRT for indication and recording. The chilled and condenser water flow alarms are also enabled at this time.

5. At 30 seconds after the "Enable Start," with the oil pressures and water flows established:

   a) A signal is provided to energize the compressor drive motor starter interposing relays R4 and R5 and the message "Compr Stopped" (green) text changes to "Compr Ready" (yellow) on the CRT "Lube System" and "Main" screens.

   b) The compressor pre-rotation vanes are opened to their minimum position necessary to prevent "surging."

   c) At this time the chiller must be manually started using the "Compressor Start" pushbutton on the front of the panel.

6. When the feeder breaker is closed an auxiliary contact closes to signal the chiller microprocessor to operate the following:

   a) Enable the capacity control circuit. Compressor pre-rotation vanes, hot gas bypass valve and interstage valve will now begin to ramp open/closed at a predetermined rate. See Panelview Operator Terminal Description (Screen #12: PID Tune) for further details on ramp tuning.

   b) De-energize the compressor oil heaters.

   c) When the shaft pumps maintain the gear and compressor oil pressure for a 100 second time period (through the respective auxiliary pump pressure control software switch), the auxiliary motor driven oil pumps will be stopped.

   NOTE: Whenever either the gear or compressor oil pressure falls below the auxiliary oil pump control software switch setting, the auxiliary pump motors will be restarted.

SYSTEM STARTUP (Continued)

d) When the compressor auxiliary oil pump stops, solenoid valve SV-401 is energized allowing the sump vent FCV-401 to slowly open at a rate determined by the needle valve FCV-001 in the supply air line. The sump vent valve will be closed any time the compressor auxiliary oil pump is re-started.

7. 100 Seconds after the motor feeder breaker auxiliary contact closes the oil separator heaters are energized. When the oil temperature level in the separator reaches approximately 110°F, the temperature control switch (TS-140) closes to actuate the solenoid valve in the high pressure gas supply line to the eductor. The eductor will then pull a fresh oil and refrigerant mixture from the bottom of the evaporator, into the separator. The Refrigerant is boiled off and returned to the evaporator. The oil level increases and flows out of the separator, to return to the compressor. Refer to the Flow Diagram drawing 076-73763E (Sht.2) for further details

8. After ramp-up is completed the capacity controls operate to control chiller capacity in response to chilled water outlet temperature. See Panelview Operator Terminal Description (Screen #5: Capacity Controls) for further details on ramp-up features.

SYSTEM SHUTDOWN

1. The chiller may be shutdown normally by depressing the CRT keypad STOP pushbutton or the hardwired "Compressor Stop" pushbutton on the front of the panel. Also, the chiller may be stopped via a safety control, in which event the CRT displays and records the cause of shutdown. On any shutdown, the sequence is as follows.

2. The chiller motor starter interposing relays R4 and R5 are de-energized to stop the motor if the CRT stop pushbutton is used. If the hardwired pushbutton is used, these relays remain energized.

3. The compressor pre-rotation vanes and the interstage gas valve are closed to minimize back flow of gas through the compressor. The hot gas valve is opened to equalize the condenser pressure with the evaporator. These actions are taken to reduce backspin of the compressor on shutdown.

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SYSTEM SHUTDOWN (Continued)

4. The oil separator heaters are de-energized, and the oil return ejector gas supply solenoid valve is de-energized.

5. The compressor and gear auxiliary oil pump motors are started when the shaft pump pressures fall below the setting of the software control switches PDS-401 and PCS-502.

6. The solenoid (SV-401) is de-energized to close the compressor sump vent valve (FCV-401).

7. The low water flow and low oil pressure alarm circuits to the CRT are inactivated to prevent nuisance alarms when these switches later open as a normal occurrence.

8. The chilled water flow may be shutoff at this time.

   The condenser water outlet valve PCV-102 is automatically closed.

9. The anti-recycle timer is activated at this time. The anti-recycle (cool down) time depends on the down time of the motor prior to starting and the number of previous starts attempted as described below.

   During this time, further restarts of the motor are prevented. The "Anti-recycle" text on the screen is yellow and the time to next allowable start is displayed.

10. Five seconds after the shutdown, the compressor oil sump heaters are energized.

11. 120 Seconds after the shutdown, the drive components will have coasted to a stop and the auxiliary oil pumps will be turned off.

    If the hardwired stop pushbutton was used to stop the unit, the pumps will continue to run the operator presses the CRT stop pushbutton, and then continue to run for 120 seconds.

ANTI-RECYCLE OPERATION

Cold Starts

If the chiller has been shutdown for 2 hours prior to the first start, the cool down (anti-recycle) time will be 3 minutes for the first and second cold start.

To start a third time, the chiller must be off for 22 minutes.

Any additional starts would be considered hot starts.

Hot Starts

If the chiller has been running for 30 minutes at 50-100% FLA or has been restarted 3 times per the cold start procedure, the cool down time will be 30 minutes.

Excessive Starts Lockout

If an attempt is made to start the chiller more than 10 times in a 24 hour period, further starts will be prevented until after 24 hours time has elapsed from the time of the first start, or until after a minimum 2 hour cool down period.

An alarm message will also be displayed on the CRT if the chiller start is inhibited due to excessive starts.

Capacity Controls Operation

MAJOR CAPACITY CONTROL DEVICES

1. **Compressor Pre-rotation Vanes:**

   The compressor pre-rotation vanes (PRV's) are internal guide vanes in the suction flow path to the first stage impeller wheel. The PRV's are used to throttle the Refrigerant flow through the system as a means of controlling capacity. The PRV's control capacity in response to the leaving chilled water temperature. If the leaving chilled water setpoint falls below the setpoint, the PRV's are partially closed until the net cooling is reduced and the leaving chilled water returns to setpoint.

   In the event of high motor current, the capacity control signal is over-ridden and the compressor PRV's are closed to keep the motor current down. On start-up, the PRV's are closed to reduce the starting load torque of the compressor.

   The compressor pre-rotation vanes are closed on shutdown to reduce backflow of high pressure gas from the condenser which might otherwise cause the compressor to spin backwards at a high rate of speed.

   The mechanical pre-rotation vane linkage at the compressor is operated by a Conoflow piston operator, which has a pneumatic 3-15 psig direct acting positioner (increasing air signal opens the PRV's). The capacity control signal from the Allen Bradley PLC-5 microprocessor is converted from 4-20 maDC to a 3-15 psi pneumatic signal by an I/P transducer TY-601A.

2. **Hot Gas Bypass Valve:**

   The hot gas bypass valve is used primarily at low loads to maintain a minimum suction gas flow required by the compressor for stability. When the compressor has reduced capacity to its minimum flow (via pre-rotation vane throttling), further capacity reductions are accomplished by opening the hot gas bypass valve. This maintains the flow to the compressor by bypassing the discharge gas back to the compressor suction. However, the hot gas flow replaces the useful evaporation in the cooler since the compressor flow is at minimum. Thus, the net chilling capacity is reduced (albeit not efficiently).

Capacity Controls Operation

Hot Gas Bypass Valve: (Continued)

The minimum suction flow or minimum compressor PRV position will vary. As the differential "head" pressure is lowered (due to colder condenser water) the compressor is capable of stable operation at lower loads. The programming in the chiller panel thus uses the differential "head" pressure to establish when the hot gas may be needed.

The hot gas valve is a Posi-Seal butterfly valve with Fisher actuator and 3620J electro-pneumatic positioner. This positioner has a direct input of 4-20 maDC, which is converted to pneumatic within the positioner (TY-601C).

3. **Interstage Gas Valve:**

The interstage valve controls Refrigerant flash gas, from the intermediate chamber of the intercooler to the second stage compressor impeller wheel when capacity must be reduced below 50% vane position. At normal high "head" conditions, the interstage valve operates from the same signal as the compressor pre-rotation vanes (multiplied by 2): Throttling to control capacity; closing on startup for reduced load torque; and closing on shutdown to reduce compressor backspin.

When the Differential "HEAD" pressure (R-134a Compr. discharge minus evaporator pressure) falls below 23 PSID (due to cold condenser water temperatures) the interstage valve is driven closed by the "Low Head" pressure controller in software. This maintains a minimum pressure in the intercooler and ensures that the intercooler lowest stage R-134a float valve will have sufficient pressure drop to accommodate the design flow of liquid being expanded to the evaporator.

4. **Manual Override (M/A) Stations:**

The CRT Screen No. 4 provides for manual/auto control of: pre-rotation vane, interstage valve, and hot gas bypass valve. Normally these should be left in the "Auto" mode.

If during manual operation, the unit is started or stopped, the M/A stations are returned to "Auto" mode so that the PRV and valves return to their safe positions.

5. **Temperature (Capacity) Control (TC-601):**

The temperature control is a programmed control function. Using the input signal from a temperature sensor in the leaving chilled water line, the control provides a proportional plus reset output signal which decreases as water temperature drops below set point to reduce the capacity of the chiller.

This control is forced to "manual" operation with is setpoint tracking the chilled water temperature when the chiller shutdown, during ramp-up, and whenever the vane are manually controlled. See Panelview Operator Terminal Description (Screen #5: Capacity Controls) for further details.

6. **Current Override (IC-551):**

The current override control function uses the motor current input signal to limit capacity. When the motor current exceeds normal, the controller puts out a decreasing signal. The LSR-2 will then pass this lower signal on to close the PRV's and interstage valve whenever the motor current is high.

Since the vanes are fully closed at a 25% control signal, the minimum output signal for this controller is set at 35%. This will prevent the vane signal (after CR-2) from going below 13% on a high motor amps condition. This is to prevent a potential low oil pressure trip problem on start-up.

7. **Initial Pulldown (Low Evap. Pressure Override)(PC-101):**

During startup, the condensing pressure may initially be low. This can cause the refrigerant to back up ahead of the intercooler expansion float valves. If this occurs, the low level of evaporator liquid uncovers a portion of the tube bundle, thereby reducing the heat exchanger performance, and lowering the evaporator pressure.

The Initial Pulldown Evaporator Pressure Controller provides a proportional output signal which decreases as the evaporator falls below a set point which is slightly below design. When a low evaporator pressure is sensed, the lower output signal overrides the capacity signal and is passed on by LSR-1 to keep the PRV's and Interstage valve closed.

The minimum output signal for this controller is set at 35% to prevent a low oil pressure trip problem on a low pressure override condition.

When the pressure returns to a safe operating condition, the controllers increasing signal is passed through a ramp (CR-5 and SS-5) to slowly bring the signal to LSR-1 up to 100% (the signal will increase at a rate of 1% per second) and prevent cycling of the controls.

8. **Low Head Override Controller (PDC-102):**

This programmed control function senses when the differential "Head" pressure is low, and through the low select relay LSR-3 acts to close the interstage valve at "Head" pressures below 23 psid. This raises the interstage pressure, and ensures that any refrigerant collects in the condenser upstream of the first intercooler float valve. Otherwise, if the refrigerant were to back up in the intercooler ahead of the lower stage float valve, large amounts of liquid could enter the compressor interstage connection causing potential damage.

9. **Anti-surge Controller (Min. Vane Position) (PDC-102A):**

As the differential "Head" pressure falls, the compressor is capable of stable operation at lower minimum PRV settings. From an energy standpoint, it is wise to use the PRV's for capacity control rather than hot gas bypass whenever possible. The Anti-surge controller output signal to HSR provides a minimum closure of PRV's and interstage valve to suit the measured "Head" pressure input. This output also provides the setpoint for the hot gas controller.

See Panelview Operator Terminal Description (Screen #12: PID Tune) for procedure to determine tuning values for most efficient operation.

10. **Hot Gas Controller (TC-601C):**

This controller modulates the hot gas valve when the capacity control signal reaches the minimum signal established by PDC-102A. As long as the control signal from the temperature controller TC-601 (PV) is above the anti-surge controller output signal (SP) the hot gas valve remains closed.

When the capacity signal PV falls below the SP setpoint, the output of TC-601C is increased above minimum, which starts to open the hot gas bypass valve. Thus at low loads, the capacity is controlled by modulating the hot gas bypass valve.

11. Minimum Condensing Pressure Controller (PC-102)

The minimum entering condenser water temperature at design flow (9000 GPM) is 55°F. At temperatures below this the flow must be reduced to maintain the condenser pressure above the minimum (approximately 57 PSIG).

The controller (PC-102) provides a proportional output signal which decreases as the condensing pressure falls below a set point which is slightly above the minimum condensing pressure.

This causes the condenser water outlet valve (PCV-102) to close, reducing flow through the condenser and prevents the condensing pressure from falling below the minimum allowed.

12. Condenser Water Flow Controller (FC-604)

The flow control is a programmed control function. Using the input signal from a flow sensor in the entering condenser water line, the control provides a proportional plus reset output signal which decreases as flow increases above set point to close the water outlet valve PCV-102.

The control is forced to "manual" operation with its setpoint tracking the condenser water flow when the chiller is shutdown, during start-up, whenever PC-102 is controlling the valve, and whenever the valve is manually controlled. See Panelview Operator Terminal Description (Screen #13: Condenser Controls) for further details.