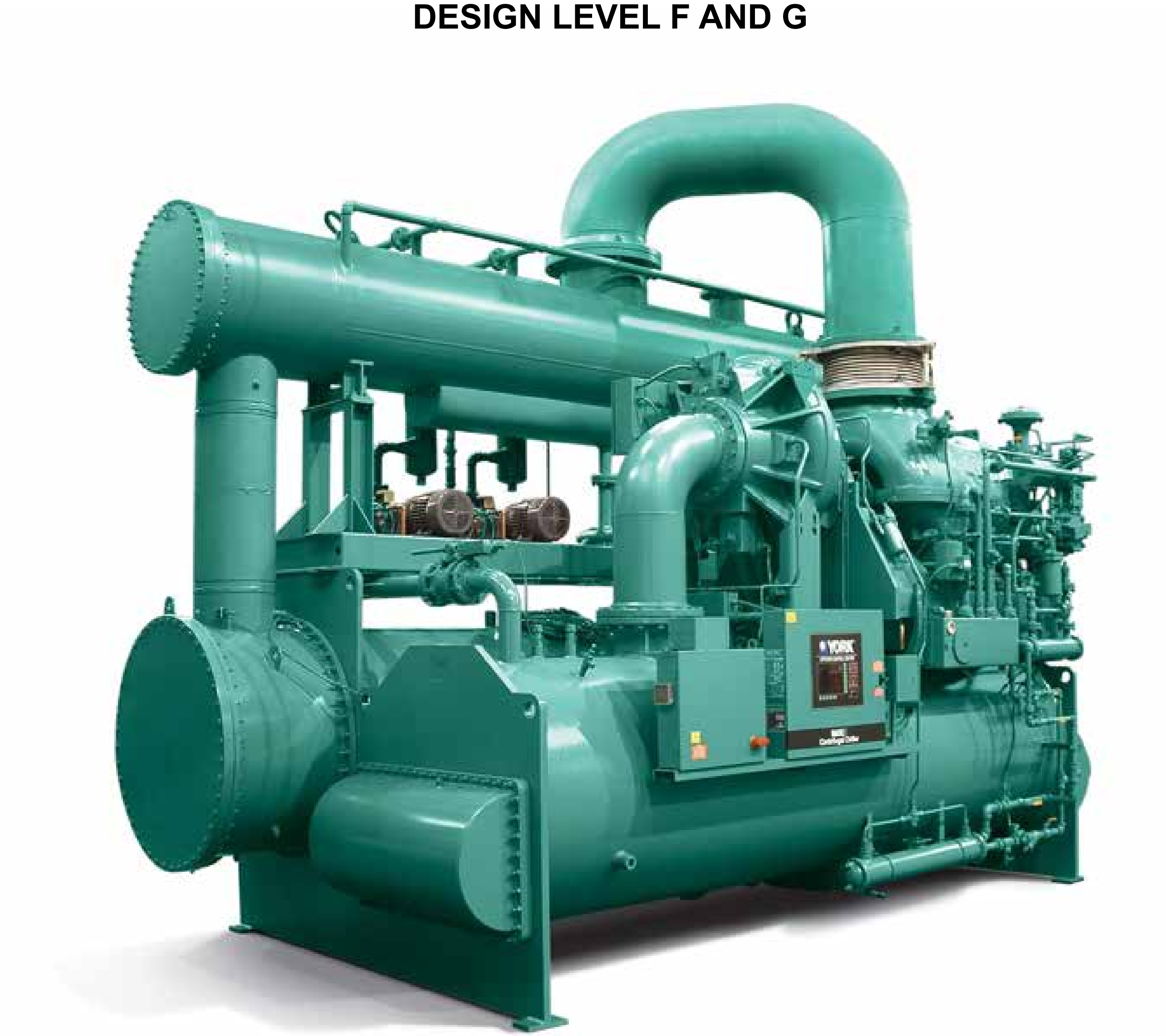
YORK
BY JOHNSON CONTROLS

STEAM TURBINE CENTRIFUGAL LIQUID CHILLERS

OPERATION & MAINTENANCE	Supersedes: 160.67-O2 (614)	Form 160.67-O2 (415)

MODEL YST
CENTRIFUGAL LIQUID CHILLER
DESIGN LEVEL F AND G



LD12189

Issue Date:
April 1, 2015

IMPORTANT!

READ BEFORE PROCEEDING!

GENERAL SAFETY GUIDELINES

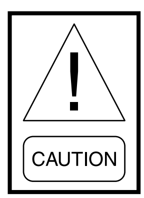
This equipment is a relatively complicated apparatus. During rigging, installation, operation, maintenance, or service, individuals may be exposed to certain components or conditions including, but not limited to: heavy objects, refrigerants, materials under pressure, rotating components, and both high and low voltage. Each of these items has the potential, if misused or handled improperly, to cause bodily injury or death. It is the obligation and responsibility of rigging, installation, and operating/service personnel to identify and recognize these inherent hazards, protect themselves, and proceed safely in completing their tasks. Failure to comply with any of these requirements could result in serious damage to the equipment and the property in which it is situated, as well as severe personal injury or death to themselves and people at the site.

This document is intended for use by owner-authorized rigging, installation, and operating/service personnel. It is expected that these individuals possess independent training that will enable them to perform their assigned tasks properly and safely. It is essential that, prior to performing any task on this equipment, this individual shall have read and understood the on-product labels, this document and any referenced materials. This individual shall also be familiar with and comply with all applicable industry and governmental standards and regulations pertaining to the task in question.

SAFETY SYMBOLS

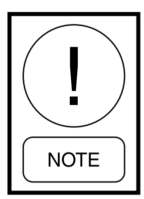
The following symbols are used in this document to alert the reader to specific situations:

Indicates a possible hazardous situation which will result in death or serious injury if proper care is not taken.



Identifies a hazard which could lead to damage to the machine, damage to other equipment and/or environmental pollution if proper care is not taken or instructions and are not followed.

Indicates a potentially hazardous situation which will result in possible injuries or damage to equipment if proper care is not taken.



Highlights additional information useful to the technician in completing the work being performed properly.

External wiring, unless specified as an optional connection in the manufacturer's product line, is not to be connected inside the control cabinet. Devices such as relays, switches, transducers and controls and any external wiring must not be installed inside the micro panel. All wiring must be in accordance with Johnson Controls' published specifications and must be performed only by a qualified electrician. Johnson Controls will NOT be responsible for damage/problems resulting from improper connections to the controls or application of improper control signals. Failure to follow this warning will void the manufacturer's warranty and cause serious damage to property or personal injury.

CHANGEABILITY OF THIS DOCUMENT

In complying with Johnson Controls' policy for continuous product improvement, the information contained in this document is subject to change without notice. Johnson Controls makes no commitment to update or provide current information automatically to the manual or product owner. Updated manuals, if applicable, can be obtained by contacting the nearest Johnson Controls Service office or accessing the Johnson Controls QuickLIT website at http://cgproducts.johnsoncontrols.com.

It is the responsibility of rigging, lifting, and operating/service personnel to verify the applicability of these documents to the equipment. If there is any question regarding the applicability of these documents, rigging, lifting, and operating/service personnel should verify whether the equipment has been modified and if current literature is available from the owner of the equipment prior to performing any work on the chiller.

CHANGE BARS

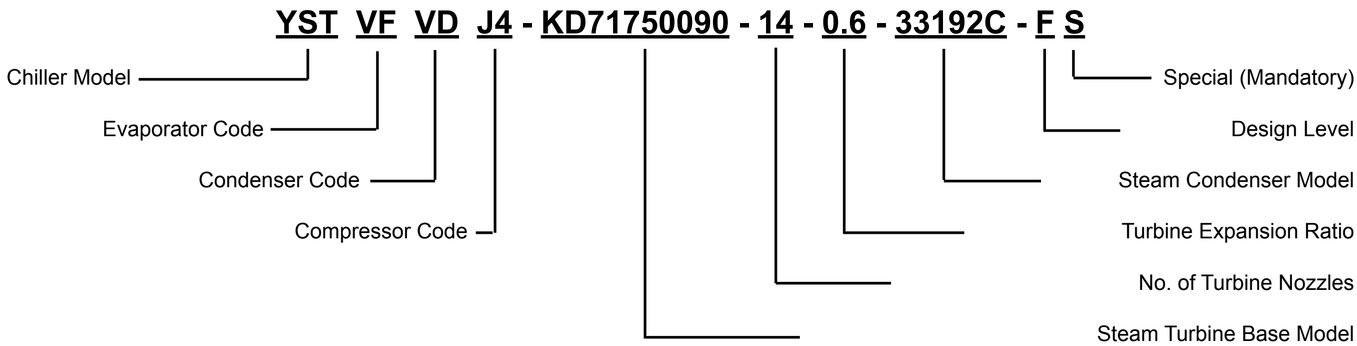
Revisions made to this document are indicated with a line along the left or right hand column in the area the revision was made. These revisions are to technical information and any other changes in spelling, grammar or formatting are not included.

ASSOCIATED LITERATURE

MANUAL DESCRIPTION	FORM NUMBER
Unit Installation Manual	160.67-N2
OptiView™ Control Center - Operation Manual	160.67-O1
Wiring Diagram - Model YST (Style F)	160.67-PW6
Renewal Parts - Unit	160.67-RP1
Renewal Parts - Controls and Instrumentation	160.67-RP2

NOMENCLATURE

The model number denotes the following characteristics of the unit.



SYSTEM DESIGN VARIATIONS

1. Steam Turbine- Smaller capacity YST chillers are fitted with a Murray Turbine design, K2G or KG, which will be referred to in this manual as KG. The larger units include a larger Murray Turbine design, KD. The speed control for the two turbine designs are similar but mechanically the two models are different not only in size and capacity but also notably the lubrication system design which is covered further in this document.
2. System Starting- The YST Chiller is available in two different starting configurations, namely manual and automatic. Both are covered in this document.
3. Hot Well Pump and Vacuum Pump for Steam System- Single pumps for both is the standard selection. An option for dual pumps, (for standby) on both hot well and vacuum service is available.

NOTE

Be sure to note which variation is furnished with your system and be guided by the sections that follow in this instruction booklet.

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SECTION 1 - DESCRIPTION OF SYSTEM AND FUNDAMENTALS OF OPERATION

GENERAL SYSTEM DESCRIPTION

The YORK Model YST Chiller is a factory assembled steam turbine driven centrifugal compressor chiller. It is commonly applied to large air conditioning systems, (700 through 2165 Tons), but may be used on other chiller applications. The YST chiller operates on Refrigerant R-134a and is designed only for NEMA 1 indoor installation or a weather protected warm environment.

The system consists of the following major equipment components:

- York® single-stage centrifugal compressor with internal speed increasing gear.
- Steam turbine, direct connected.
- Refrigerant evaporator.
- Refrigerant condenser.
- Steam condenser package.
- Lubrication systems for compressor and turbine.
- Power panel.
- Control center.

The complete chiller system can be shipped in several different arrangements, *See Form 160.67-N2.*

Typically major system components are factory-packaged including all interconnecting unit piping and wiring. The steam condenser package is shipped separately suitable for direct mounting onto the chiller or mounting along-side.

The initial charge of refrigerant and oil is supplied for each chiller. When the optional refrigerant condenser isolation valves are ordered, the unit may ship fully charged with refrigerant and oil. Actual shipping procedures will depend on a number of project-specific details.

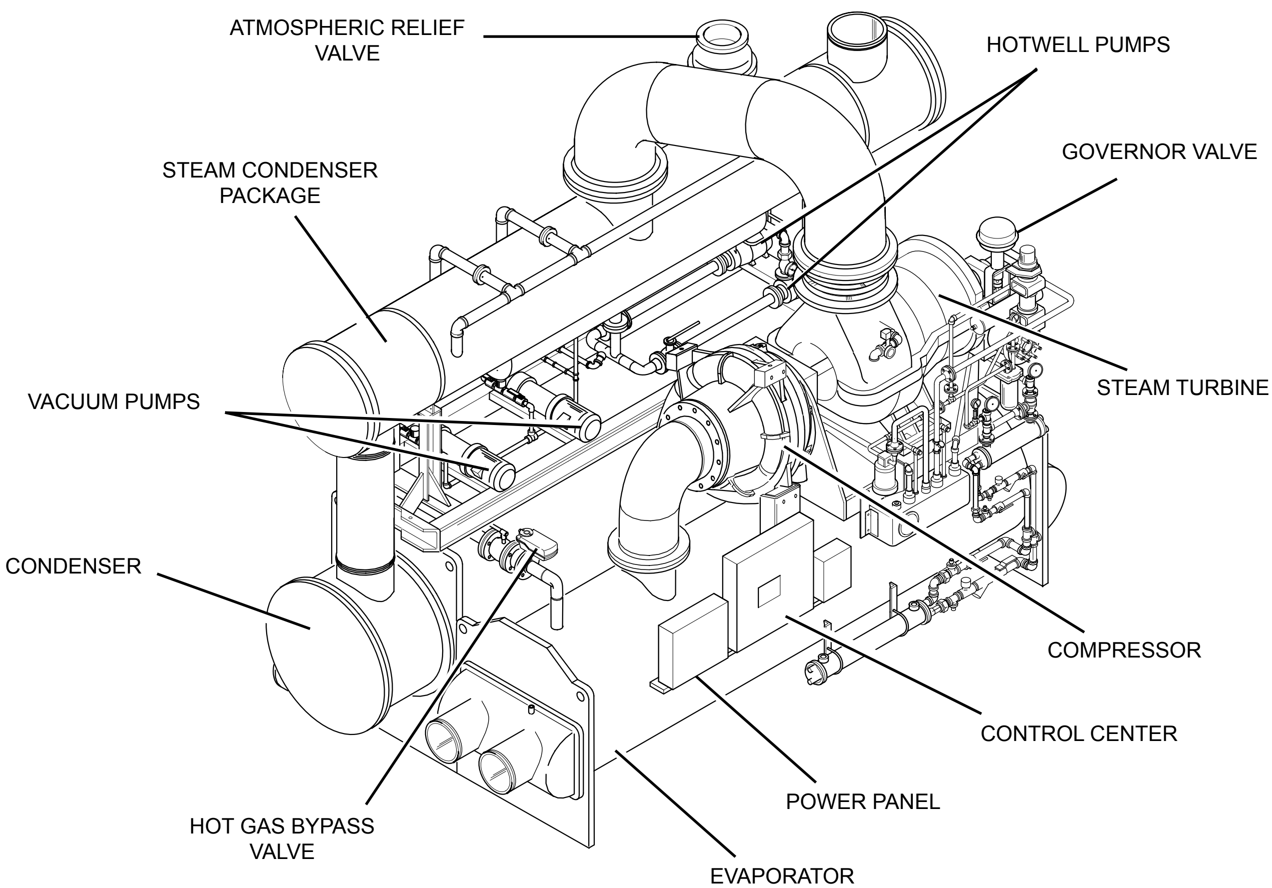

FIGURE 1 - MODEL YST CHILLER

REFRIGERATION SYSTEM OPERATION

In operation, a liquid (water or other fluid to be chilled) flows through the tubes in the evaporator , where boiling refrigerant evaporates and absorbs heat from the liquid. The refrigerant rises and passes through eliminators that remove any entrained liquid droplets. The dry refrigerant gas flows to the compressor suction. The compressor raises the temperature and pressure of the refrigerant through centrifugal force. The higher pressure refrigerant gas exits the compressor and enters the refrigerant condenser where the latent heat of the refrigerant is removed and the refrigerant condenses to a liquid by the water flowing through the tubes. The liquid refrigerant passes through a subcooling section in the bottom of the condenser where the liquid refrigerant is cooled to a lower temperature again by water inside tubes. The higher pressure refrigerant liquid then expands into the evaporator through a level control valve that is controlled by the control center based on the signal from a refrigerant level sensor located in the subcooler. The hot gas bypass is utilized during slow roll start up and also during periods of very low load operation or cold condenser water.

The open drive single impeller centrifugal compressor is direct driven by a variable speed condensing steam turbine. The reference to a condensing steam turbine indicates the exhaust steam from the steam turbine is condensed to water, which will be referred to in this manual as condensate, which is usually returned to the system boiler. The steam condenser package is furnished as an integral part of the YST system. See Steam and Condensate Flow, *Figure 4 on page 16*.

The process water or other fluid that is chilled in the evaporator is pumped to the point of use which may be air conditioning terminal units and/or central station air handling units and/or other equipment requiring cooling. The warmed liquid is then returned to the chiller to complete the chilled liquid circuit. The condenser water is supplied from a cooling tower system or sometimes other sources of water suitable for condensing service.

The chiller is controlled by a modern state of the art Microcomputer Control Center that monitors its operation. The Control Center is programmed by the operator to suit job specifications. The chiller control panel provides control of entire system, including turbine and steam condenser operation and monitoring.

The control panel includes a color liquid crystal display (LCD) surrounded by "soft" keys which are redefined based on the screen displayed at that time, mounted in the middle of a keypad interface and installed in a locked enclosure. The screen details all operations and parameters, using a graphical representation of the chiller and its major components. Panel text is in English only. Data can be displayed in either English or Metric units.

CAPACITY CONTROLS

During part load operation at off design conditions, the chiller capacity is reduced to maintain a constant leaving chilled liquid temperature by first decreasing the turbine speed, secondly closing the compressor pre-rotation vanes (PRV) (See *Figure 2 on page 12*), lastly opening the Hot Gas Bypass valve.

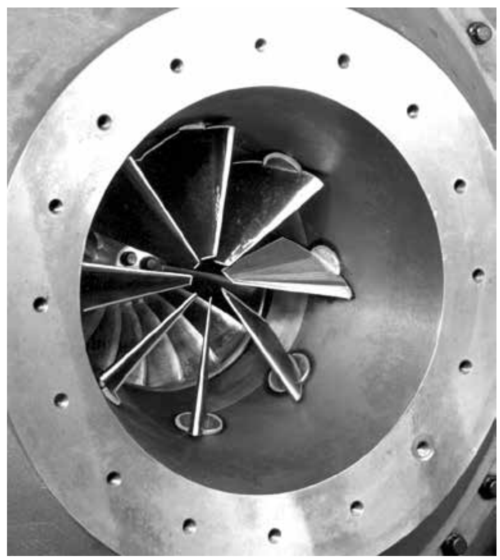

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FIGURE 2 - COMPRESSOR PREROTATION VANES

Speed is controlled automatically by a pneumatically actuated governor valve which throttles the inlet steam flow to the turbine to maintain the speed dictated by the capacity control logic.

The position of the compressor prerotation vanes is automatically controlled through a lever arm attached to an electric motor located outside the compressor housing. The automatic adjustment of the vane position in effect provides the performance of many different compressors to match various load conditions from full load with vanes wide open to minimum load with vanes completely closed. The combination of speed control and PRV control will provide capacity reduction from 100% to 15% of design for normal air conditioning applications.

If the tower water temperatures must be held above 75ºF for other chillers on the same tower circuit, the capacity control logic can be programmed to automatically limit the amount of speed reduction and PRV closure to maintain stable operation. The hot gas bypass valve is then modulated to admit condenser gas into the evaporator and reduce the cooling effect as required. This will maintain a constant leaving chilled liquid temperature with loads down to 10% of design.

REFRIGERANT FLOW DIAGRAM

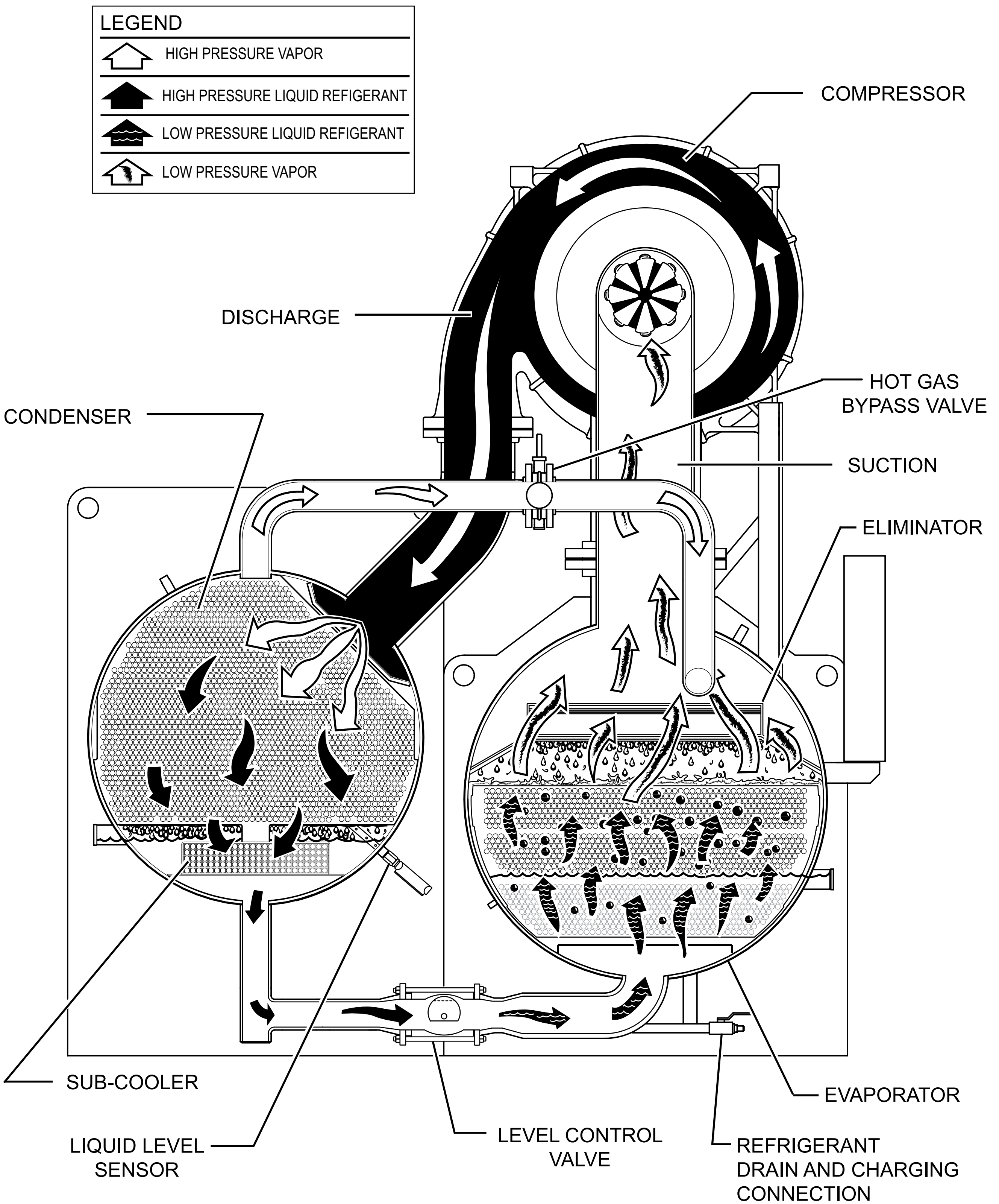

FIGURE 3 - REFRIGERANT FLOW - THRU

STEAM AND CONDENSATE FLOW

(See *Figure 4 on page 16*)

The primary function of a steam turbine is to convert thermal energy into the mechanical energy required to rotate the compressor. When the trip valve is opened and the speed setpoint is increased to open the governor valve, the high pressure and temperature steam enters the steam ring of the turbine. From the steam ring, the steam passes through some permanently open nozzles and through the number of hand valves opened depending on the load requirements. As steam passes through stationary nozzles, steam pressure decreases while steam velocity increases. Mechanical energy is produced when high velocity steam strikes the turbine blades and causes the turbine rotor to move. As the steam passes through the stages of the rotor assembly producing mechanical energy, the thermal energy of the steam is reduced. The pressure and temperature of the supply steam determines how much thermal energy is available to produce mechanical energy and therefore have a significant effect on the ability of the chiller to produce the design refrigeration capacity.

The turbine exhaust must also be held at the proper vacuum by the steam condenser in order for the turbine to produce the required mechanical energy for a given load. The turbine exhaust steam enters the steam condenser through the steam inlet connection on the top of the condenser and is distributed longitudinally over the tubes. When the steam contacts the relatively cool tubes, it condenses. This condensing effect is a rapid change in state from a gas to a liquid, which results in a great reduction in specific volume. It is this reduction in volume together with the relatively cool temperature of the cooling water that creates the vacuum in the steam condenser. The steam condenser tubes are kept cool by the circulation of liquid from the refrigerant condenser outlet, which removes the heat given up by the condensing steam. Any air that enters the steam condenser via leakage in piping, around shaft seals, valves, etc., is removed by the venting equipment consisting of the liquid ring vacuum pump.

The condensate is circulated by the hotwell pump through the recirculation and overboard valves. These valves are controlled by the chiller control panel to maintain the condensate level in the hotwell at the bottom of the steam condenser shell below the tubes. During the slow roll warm-up of the turbine, the condensate level will drop causing the overboard valve to close and the recirculation valve to open and return most of the condensate to the hotwell. As the turbine is ramped up to rated speed, more steam is condensed and the level increases causing the recirculation valve to close and the overboard valve to open thus returning more condensate to the boiler.

STEAM AND CONDENSATE FLOW DIAGRAM

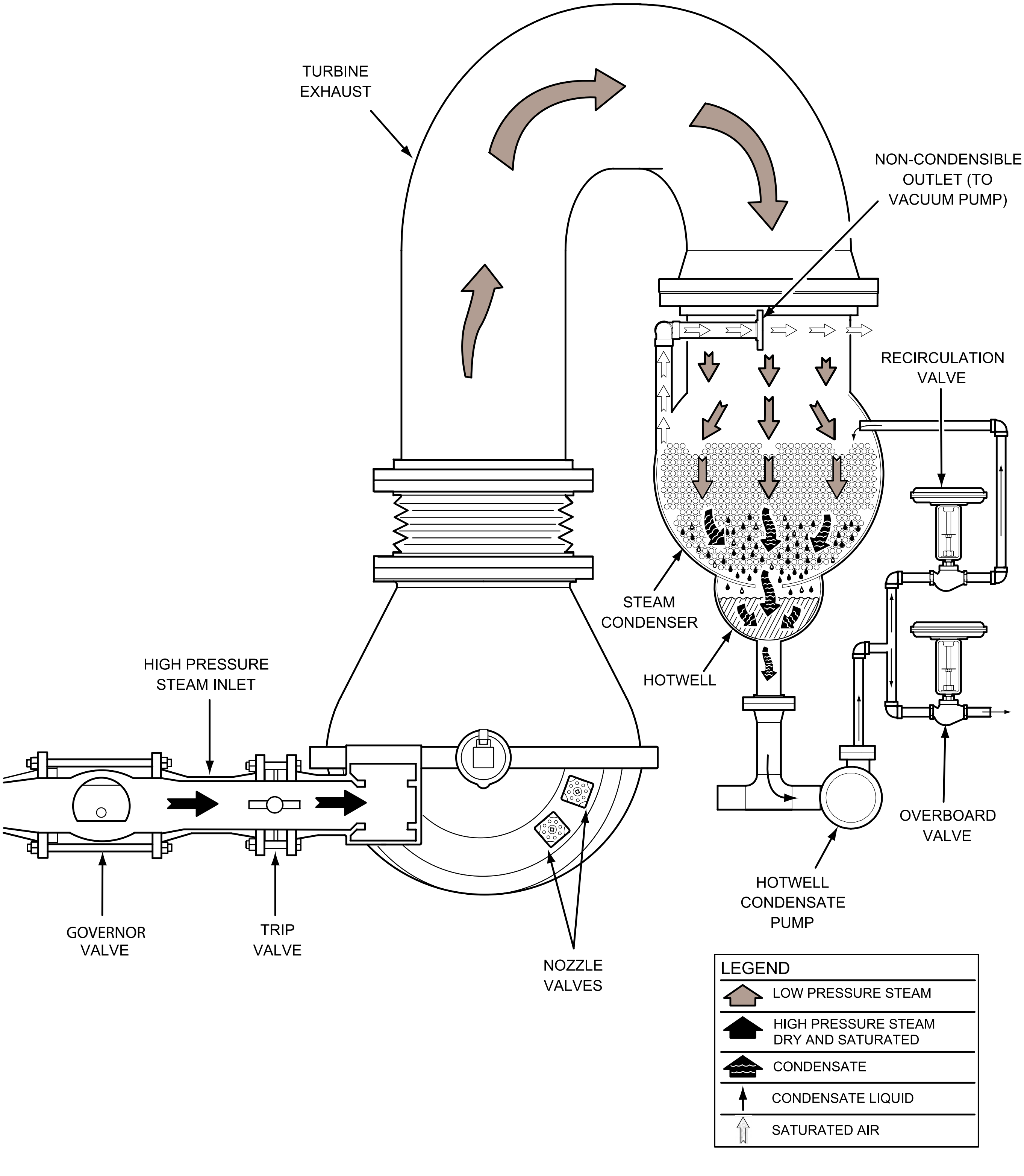

FIGURE 4 - STEAM AND CONDENSATE FLOW

STEAM CONDENSER HOTWELL LEVEL SWITCHES

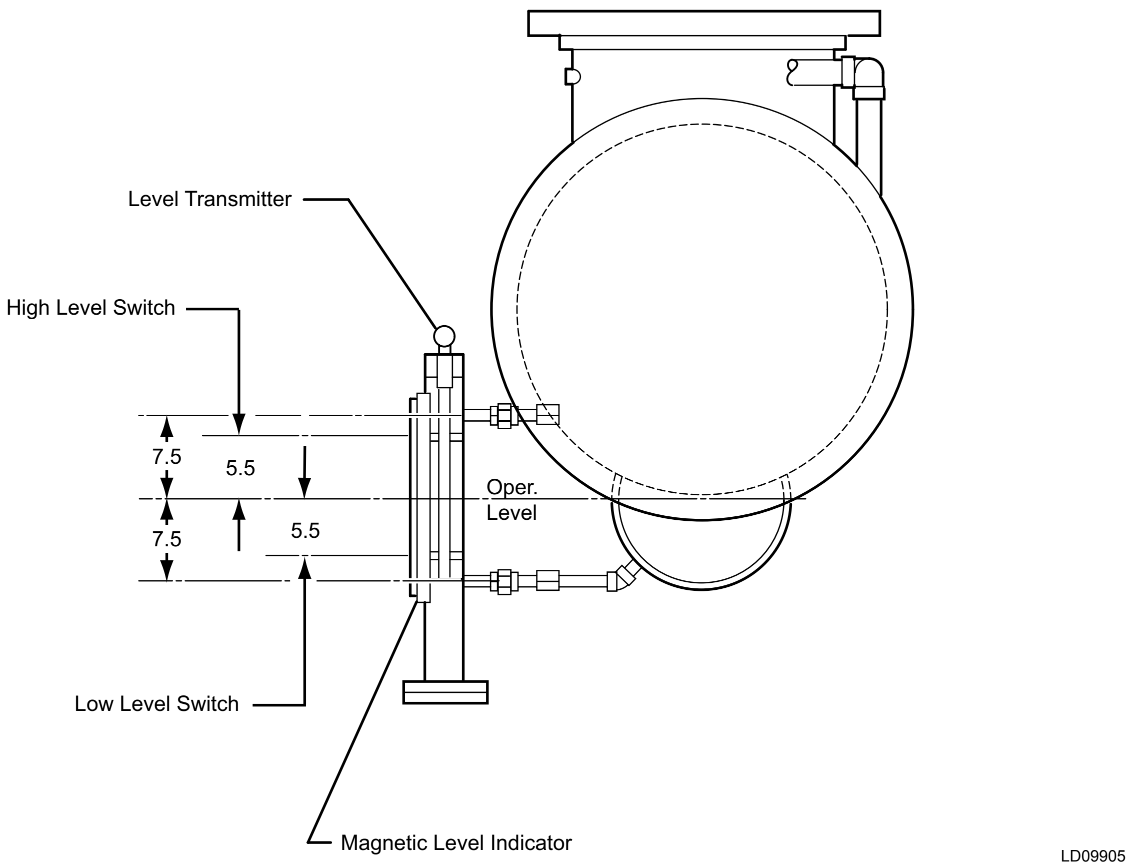

FIGURE 5 - STEAM CONDENSER HOTWELL LEVEL SWITCHES

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SECTION 2 - PRE-STARTUP AND SYSTEM OPERATING PROCEDURES

OVERVIEW

The procedures that must be completed prior to each startup depend on the extent of time the chiller has been idle and whether any maintenance has been performed on the system or piping components since the initial installation was completed. The inlet steam line blow-down should have been performed at installation *per Form 160.67-N2.* Because a clean steam supply is of utmost importance, the procedure is repeated in this manual. Refer to Sections 6 and 7 of this manual for additional procedures that should be performed periodically to ensure trouble-free operation.

CAUTION

Before applying power to the chiller, ensure that the compressor oil heater protector overload (OL1) and all motor protector overloads in the Power Panel are in the "OFF/Tripped" position. Remove fuses FU10, FU11, and FU12 to prevent premature operation of the compressor oil pump. Do not switch motor protectors on or replace fuses until instructed in the procedures below.

PRE-STARTUP PROCEDURES – INITIAL AND AFTER LONG TERM SHUTDOWN

The following procedures must be performed at the initial startup of the chiller immediately after the installation is completed as detailed in Form 160.67-N2. Some of these procedures are also required if the chiller has been shutdown for 1 month or longer or if any repairs were performed on the inlet steam piping or chiller components. Depending on the actual length of shutdown and the condition of the oil, steam strainers, etc., additional maintenance procedures may need to be performed prior to startup. Refer to Sections 6 and 7 of this manual.

Prior to and during the following procedures, all pressure and temperature displays on the OptiView™ screens should be observed to verify that the displayed values are as expected for the present ambient temperatures and condition of the chiller components (oil heater on, oil pump running etc.). If displays are not correct, perform diagnostic checks per *Form 160.67-M3* and correct the problem prior to operating the chiller.

CAUTION

Removal of foreign material from the inlet steam piping is the responsibility of the party installing the piping. Be sure to blow out and clean all steam lines before connecting to the turbine. Failure to do so may result in damage to the steam strainer screen and other internal parts. Johnson Controls accepts no responsibility for damage resulting from the entrance of foreign materials.

CHECK THE STATUS OF THE MAIN STEAM SUPPLY

Ensure that the steam supply is available at the temperature and pressure required to achieve the design capacity of the chiller. JOHNSON CONTROLS ASSUMES NO RESPONSIBILITY IN REGARD TO PRESSURE OR TEMPERATURE DROPS. THE PERFORMANCE OF THE TURBINE SPECIFIED IS BASED UPON THE INLET PRESSURE AND TEMPERATURE AS MEASURED AT THE TURBINE STEAM INLET FLANGE.

BLOW-DOWN THE INLET STEAM LINE

Newly constructed steam piping or existing piping that has been repaired or modified should be blown-down to remove scale, weld beads and any other foreign material. A blow-down should also be performed prior to starting the turbine after an extended shutdown to remove any accumulated rust. Such material can cause severe damage if it enters the steam turbine.

The blow-down connection should be as close to the turbine as possible. The diameter of the blow-down connection should be a minimum of one half the diameter of the line being blown-down to ensure that steam velocity in the piping is high enough to break loose and carry away any foreign material stuck to the inside of the piping.

Blow-down should be done before the piping is insulated. Steam at full temperature and pressure should be bled through the piping.

After the piping has been warmed up, the valve in the blow-down connection should be opened wide for about 15 seconds to allow live steam to blow out any loose material in the piping. Piping should be allowed to cool down to room temperature, about 6-8 hours.

Thermal expansion and contraction, which occurs during warming up and cooling down, helps break loose the foreign material inside the piping. Hammering around any welded joints in the piping will also help to break loose foreign material

The above procedures of warm-up, blow-down and cool-off should be repeated as many times as necessary to clean all foreign materials out of the piping. To check for clean piping, a target should be placed about two feet away from the blow-down opening so that the steam will hit the target, and any solids in the steam will become embedded in the target. Plywood, aluminum and polished stainless steel are commonly used target materials. Piping can be considered clean when no embedded particles and indentations are found in the target after a 15 second blow-down.

CAUTION

Pieces of weld metal, large pieces of scale, nuts, and other materials are commonly present in newly erected steam lines. For that reason it is necessary to emphasize the importance of blowing out all steam lines with live steam before connecting the turbine. Failure to do so may result in damage to the strainer or more serious damage such as bent or failed blades.

INSPECT AND CLEAN STEAM STRAINERS

The turbine on the standard YST chiller has a built-in type of strainer. This strainer should be inspected and cleaned periodically and checked for possible damage. A steam strainer affords some measure of protection against foreign material passing through the nozzles and blades, but it cannot be expected to stop heavy objects that move through the steam line at high velocity.

The element of the steam strainer in the steam line upstream of the governor valve should be inspected periodically, and cleaned if necessary, to avoid excessive steam pressure drop due to a clogged strainer screen. Large pressure drops may not only reduce the turbine load carrying capacity, but may result in a rupture of the strainer element.

INSPECT AND CLEAN WATER STRAINERS

Any strainers in the water inlet lines for the compressor oil cooler, turbine oil cooler (if supplied), and the steam condenser vacuum pump sealing water should be inspected and cleaned periodically and checked for possible damage.

INSPECT AND CLEAN THE TURBINE

Before a turbine is operated, certain parts must be cleaned to remove the effects of transit and storage. Protective mylar sheets installed between the journal bearing and the shaft journal MUST BE REMOVED PRIOR TO ROTATING THE SHAFT. (See FLUSH THE TURBINE LUBE SYSTEM below for instructions) Bearing caps are easily removed. The interior of the bearing cases must be inspected for dust or other grit. If any is present, the interior of the bearing cases must be flushed with kerosene or similar solvent.

Mechanical governor parts should be thoroughly washed with a spray of non-acetate solvent to remove adhering dust particles. The interior of the turbine casing should be thoroughly cleaned so the exhaust system will not become contaminated with dirt. This can be done easily with a water hose through the exhaust opening. Valve stems and other exposed machined surfaces should be cleaned with solvent to remove protective grease and/or dirt.

Exposed machined parts have been masked prior to painting. This masking serves as added protection during shipment and is not removed before shipping. MASKING SHOULD BE REMOVED DURING THE CLEANING PROCEDURE.

All loose parts (such as loose piping, etc.) should be cleaned and installed. Turbines packed for export, or protected for long storage periods may need to be completely dismantled and cleaned to remove all protective grease and flushing compound. YORK will provide specific instructions for turbines requiring complete dismantling.

FLUSH THE TURBINE LUBE SYSTEM (PRESSURE LUBRICATION TURBINE ONLY)

Flushing the oil circulation system on a turbine supplied with an auxiliary oil pump is recommended before starting a new turbine (or one that has been in storage for a long time). On a new turbine, remove the mylar protection that stabilizes the shaft during shipment. To do this, remove the upper half of the bearing housing, remove the upper half of the bearing and remove all (above and below) pieces of mylar protection (above and below) from the shaft. This must be done at both the steam and exhaust end bearings. Leave the upper halves of both bearings out to allow for more volume of oil to flow during the flush. Reseal the upper bearing housing cover and replace the bolting.

Once the mylar has been removed and you are ready to begin the oil flushing procedure, the following steps should be followed:

1. BUMP test the auxiliary oil pump to ensure that the pump is rotating in the proper direction as indicated by the rotation arrow on the pump. While viewing the TURBINE SCREEN on the OptiView™ Control Center, use the Manual Pump key and enable manual operation. Place the pump motor protector disconnect switch (OL2) in the Power Panel in the ON position and immediately back to the off position after the pump starts.
2. Install 100 mesh plain weave (.0059 opening) screen mesh ahead of all bearing cases.
3. Place the auxiliary oil pump motor protector disconnect switch (OL2) in the Power Panel in the ON position to start the auxiliary oil pump and allow it to run for two hours. Using the Manual Pump key on the TURBINE SCREEN, shut down the pump and check all screens for particles. Screens should not have any particles bigger than .01 inch in diameter and show random distribution. No metallic particles should be present. Flushing should continue until screens show no more than 6 non-metallic particles.
4. Replace screens with new ones and continue flushing in one-hour intervals until no metallic particles and no more than 6 non-metallic particles are present on any of the screens.
5. Once clean screens are present, remove all screens, service the turbine bearings and replace them in the bearing housing. Housings must be cleaned and resealed with Tite-Seal to prevent oil leaks at the case split line.
6. Check the condition and cleanliness of the oil filters furnished and replace them with new filters if needed before continuing with the start up.

CHECK THE OIL LEVEL IN THE TURBINE BEARING RESERVOIRS (RING OIL LUBRICATION)

On a new turbine, remove the mylar protection that stabilizes the shaft during shipment. To do this, remove the upper half of the bearing housing, remove the upper half of the bearing and remove all pieces of mylar protection (above and below) from the shaft. This must be done at both the steam and exhaust end bearings. Housings must be cleaned and resealed with Tite-Seal to prevent oil leaks at the case split line.

Ring Oil Lubrication

The oil level gauge on the side of the bearing housing indicates the oil level. A mark inscribed on the lower-half bearing housing indicates the proper oil level. Oil levels in both bearing housings should be checked daily. Always use a strainer when adding oil to the systems and cover the fill connection when finished. If there is any reason to suspect water in the oil, open the low point drain in each bearing housings slightly. If water is present, it will be the first thing to come out of the drain. Low point drains in the bearing housing should be checked weekly for water.

CAUTION

The presence of oil in the constant level oilers does not necessarily mean that oil in the bearing housings is at the proper level. CLEANLINESS is ESSENTIAL for long and trouble free service from the BEARINGS. Care must be taken to ensure that no foreign material enters bearing housings or constant level oilers when performing maintenance, checking oil, adding oil, or making adjustments.

CHECK THE COUPLING AND ALIGNMENT

If any maintenance or repairs have been performed on the turbine or compressor that would possibly result in a change in the shaft positions, check the alignment per Form 160.67-N2.

CHECK THE REFRIGERANT CHARGE

The refrigerant level should be visible in the evaporator sight glass at the level recorded after the chiller was initially charged. Add refrigerant if required per Section 6 of this manual.

OIL HEATERS

If the oil heater is de-energized during a shut down pe riod, it must be energized for 12 hours prior to start ing compres sor, or remove all oil and re charge com pressor with new oil. (See “Oil Charging Procedure”, Section 4 of this manual.)

OIL HEATER OPERATION

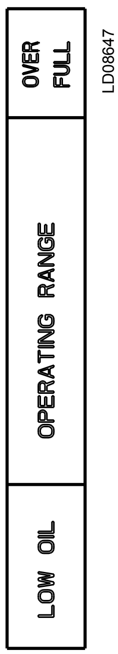
The oil heater operation is controlled by the OptiView™ Control Center. The heater is turned on and off to maintain the oil temperature differential to a val ue 50°F (27.8°C) above the condenser saturation tem per a ture. This is the target value and if the oil tem per a ture falls to 4°F (2.2°C) or more below the target, the heater is turned on. It is turned off when the oil temperature increases to 3°F (1.7°C) above the target value.

If the target value is greater than 160°F (71°C), the tar get de faults to 160°F (71°C). If the target value is less than 110°F (43.3°C), it defaults to 110°F (43.3°C).

To prevent over heat ing of the oil in the event of a control center component fail ure, the oil heat er ther mo stat (1HTR) is set to open at 180°F (82°C).

CHECK THE OIL LEVEL IN THE COMPRESSOR OIL RESERVOIR

Proper operating oil level – During operation, the oil level should fall to the "Operating Range" identified on the vertical oil level indicator label.



- If the oil level during operation is in the "Over Full" region of the oil level indicator, oil should be removed from the oil reservoir, until the oil level is to the "Operating Range".
- If the oil level during operation is in the "Low Oil" region of the oil level indicator, oil should be added to the oil reservoir. (See *SECTION 4 - OPERATIONAL MAINTENANCE* in this manual.)

CAUTION

A complete oil change may be required if the oil is dark or cloudy or an oil analysis indicates contaminated oil. Comply with EPA and Local regulations when removing or disposing of Refrigeration System oil!

CHECK THE STATUS OF ALL UTILITIES

Ensure that the correct three-phase power supply is available at the main disconnect switch in the Power Panel and that it is properly phased: Phase A-L1, Phase B-L2, Phase C-L3.

Check that a minimum of 80 PSIG pneumatic control air supply is available at the filter regulators on the turbine governor valve and steam condenser. Check the gauges to ensure that 25 PSIG is available to the steam condenser level control valve current to pneumatic (I/P) transducer. The governor valve positioner supply air gauge should read 5 PSIG above the actuator requirement.

VERIFY THE COMPRESSOR OIL PUMP OPERATION

Before applying power to the chiller, ensure that the compressor oil heater protector disconnect switch (OL1) in the Power Panel is in the "OFF" position. Close the main three-phase disconnect switch and ensure that appropriate power is available at the Power Panel. Check that the compressor oil reservoir has the proper oil level and switch the oil heater protector disconnect switch (OL1) in the Power Panel to the "ON" position to energize the oil heater.

NOTE

The oil heater is automatically controlled by the control panel at all times during shutdown and operation of the chiller to maintain the oil temperature in the oil reservoir at a target value which is 50°F above the condenser refrigerant saturation temperature. It is turned on at 4°F below the target value and off at 3°F above the target value. To prevent overheating the oil, the heater has an integral thermostat that opens at 180°F.

While viewing the compressor OIL SUMP SCREEN on the OptiView™ Control Center, verify that the compressor oil temperature is at least 110°F. Open the main three-phase disconnect switch and replace the fuses FU10, FU11, and FU12. Close the main three-phase disconnect switch and use the MANUAL key to verify that the oil pump operates properly.

VERIFY THE TURBINE GOVERNOR VALVE OPERATION

Ensure that the main steam inlet block valve, steam inlet slow roll bypass valve bypass valve, turbine pneumatic trip valve, and turbine governor valve are fully closed. While viewing the ANALOG I/O EXPANSION TEST SCREEN on the OptiView™ Control Center, manually adjust the output signal to the governor valve and verify that the valve strokes fully between 4 and 20 maDC output signals. The governor valve positioner is factory calibrated to provide the correct pressure output to the valve diaphragm with a 4-20 mA DC control signal from the OptiView™ Control Center. *See Section 24 of Form 160.67-M3* for more information.

NOTE

Chillers manufactured after December 2006 are NOT designed with separate steam inlet and slow roll bypass valves.

VERIFY THE COMPRESSOR PRE-ROTATION VANE OPERATION

The chiller cannot be started until the pre-rotation vanes have been calibrated. On standard YST chillers, the pre-rotation vanes are calibrated at the factory during functional testing. For retrofit applications, the vanes must be calibrated per the OptiView™ Control Center Service Instructions Form 160.67-M3. After completing the calibration, the operation must be verified. While viewing the AUTO/MANUAL SCREEN, place the pre-rotation vanes in Manual and manually drive the vanes fully open and then fully closed while observing the position indicator on the operating shaft. When the PRV control signal is set to 0% in the Manual mode, the vane actuator closed limit switch (VMS) may not be activated. Place the control signal back to the Auto mode to activate the switch.

VERIFY THE HOT GAS BYPASS AND SUBCOOLER LEVEL CONTROL VALVE OPERATION

While viewing the AUTO/MANUAL SCREEN, place each valve in Manual and manually drive the valve fully closed and then fully open while observing the position indicator on the operating shaft. The hot gas valve is fully closed when the flats on the valve stem are perpendicular to the pipe it is installed in.

PREPARE THE STEAM CONDENSER HOTWELL AND PUMPS

Ensure that the water level in the hotwell is at approximately 50% (refer to *Figure 5 on page 17*). If the water level is less than 50%, close the drain valve and open the main isolation valve at the edge of the base frame. Open the valve next to the fill connection on the hotwell and fill the hotwell to approximately 62%. While viewing the CONDENSATE SCREEN on the OptiView™ Control Center, verify that the condensate level display is indicating the correct level.

Ensure that the high and low level switches are secured at the correct elevations per *Figure 5 on page 17*. Check each switch function by viewing the switch indicators on the CONDENSATE SCREEN and raising and lowering the hotwell liquid level. The switch indicator will display OPEN when the level reaches the switch actuation point.

Ensure that the Hotwell Pump Motor Protector Overload Switches are both in the OFF position.

BUMP test the condensate pump and standby pump (if supplied) motors for proper rotation. The easiest way to do this is to first put the selected pump in the Manual mode using the Pump Mode key on the CONDENSATE SCREEN, and immediately place the selected hotwell pump motor protector overload switch in the Power Panel in the ON position (within 10 seconds) and immediately back to the OFF position after the pump starts. In the Manual Mode, if the pump motor does not start within 5 seconds after the pump start is initiated an alarm is sounded. Since the standby pump will not start (Overload switch is OFF), the Mode key will revert back to Auto after 5 seconds and the Pump Run Output will go off. The condensate pump should rotate clockwise when viewed from the back of the motor. If pump runs backwards, interchange two wires.

CAUTION

Reverse operation can cause extensive damage to the pump. Failure to correct the rotation could result in injury or property damage.

Before starting a condensate pump, open the suction-side isolation valve, both vent line valves and partially open the discharge valve of the selected pump and the standby pump (if supplied). Start the pump by placing the hotwell pump motor protector overload switch in the Power Panel in the ON position and using the hotwell Pump Mode key to manually start the selected pump. Slowly open the discharge valve allowing the level controller to react to the change in the level. The hotwell fill valve may be opened to make up water used to fill the condensate discharge piping. When the level appears to be stable, close the fill line valve and open the discharge valve fully.

Verify the operation of the level control system by adding water to the hot well and viewing the action of the valves. As the level in the hot well increases, the I/P transducer pneumatic output signal to the valves should decrease to open the overboard valve and close the recirculation valve. *Refer to the PID Tuning section of the OptiView™ Control Center Service Instructions Form 160.67-M3* for more details on the hotwell level control tuning parameters.

Check piping connections for leaks. Pipe unions and flanges may loosen during shipment. Retighten as necessary.

After testing, return the pump to the AUTOMATIC mode.

Test the operation of the standby pump the same as described above.

NOTE

If the chiller is equipped with an optional standby pump, in the automatic mode, the hotwell pumps will be switched-over (at each chiller start) to share operational time. If the lead pump fails to start or fails while the chiller is operating, toggle to standby pump will be done automatically. If both pumps fail, the chiller will not be allowed to start and will shutdown if operating.

The lead hotwell pump will be started automatically 50 seconds after a start is initiated if condenser cooling liquid flow is verified.

PREPARE THE STEAM CONDENSER VACUUM PUMPS

NOTE

Depending on the length of time the pump has been idle or in storage, it may be charged with a rust inhibited 50% ethylene glycol solution. This must be properly drained prior to operating the pump.

Prior to operating the pump, the housing should be drained of any storage solution. Remove the screw plug on the pump cover and allow the liquid to run out. When draining, rotate the motor occasionally in the opposite direction to the running direction (see direction arrow on the casing) by hand at the external fan until no more liquid runs out.

Reinstall the drain plug and remove the vacuum gauge to prime the pump housing with approximately 3.25 quarts (3 liters) of water via the vacuum gauge port.

CAUTION

Do not start the pump if the pump chamber is full, since this could result in the breakage of a blade or the impeller drive shaft. If the pump motor fails to start within 5 seconds after the contactor is energized, the sealing water solenoid is de-energized to stop the flow of water into the chamber. After a pump motor failure, it is recommended that some water be drained from the chamber to ensure a safe restart.

Open the main isolation valve at the edge of the base frame and all valves in the sealing water line of the selected pump and the standby pump (if supplied).

Ensure that the Vacuum Pump Motor Protector Overload switches are in the OFF position.

BUMP test the vacuum pump and standby pump (if supplied) motors for proper rotation. The easiest way to do this is to first put the selected pump in the manual mode. While viewing the VACUUM SCREEN on the OptiView™ Control Center, use the vacuum pump, Pump Mode key to put the selected pump in the Manual mode. In the Manual Mode, if the pump motor does not start within 5 seconds after the pump start is initiated an alarm is sounded. Since the standby pump will not start (Overload switch is OFF), the Mode key will revert back to Auto after 5 seconds and the Pump Run Output will go off. When a pump start is initiated, the sealing water solenoid valve is energized and when the flow switch closes, the Run Output LED is illuminated. Place the selected vacuum pump motor protector overload switch in the Power Panel in the ON position (within 10 seconds) and immediately back to the OFF position after the pump starts. The vacuum pump should rotate as indicated by the arrow on the pump. If pump runs backwards, interchange two wires.

CAUTION

Even though it is not necessary to prime the vacuum pumps, they must not be run dry after the initial startup. Normally the flow switch will prevent this from happening. However, the drain line from the separator should be checked after the initial startup and periodically thereafter to verify that the sealing water is present. If no water is coming out of the vacuum pump separator when the pump is operating, stop the pump immediately!

Place the vacuum pump motor protector overload switch in the power panel in the ON position. While viewing the VACUUM SCREEN on the OptiView™ Control Center, use the vacuum pump, Pump Mode key to manually start the selected pump. When a pump start is initiated, the sealing water solenoid valve is energized. As soon as the flow switch contacts close, the pump motor is started. In the Manual mode, if sealing water flow is not established within 10 seconds after the pump start is initiated, an alarm is sounded the mode key reverts back to Auto, and the Run Output goes OFF. Adjust the sealing water flow to the pump using the hand valve (downstream of the solenoid valve) to obtain a slight vacuum reading on the gauge down stream of the valve. When the desired vacuum is achieved, the sealing water flow may be further reduced. Gradually close the throttling valve until either a loss of vacuum (at the gauge on the pump inlet piping below the check valve) is experienced or the pump trips on low sealing water flow. This is the minimum setting and the valve should be opened slightly from this position to obtain the best vacuum. Failure to obtain the design vacuum may be due to excessive air infiltration. Check flanged connections for leaks. After testing, return the pump to the AUTOMATIC mode.

! NOTE

Test the operation of the Standby Pump the same previously described. If the chiller is equipped with an optional standby pump, in the automatic mode, the vacuum pumps will be switched-over (at each Chiller start) to share operational time. If the lead pump fails to start or fails while the chiller is operating, toggle to standby pump will be done automatically. If both pumps fail, the chiller will be not be allowed to start and will shutdown if operating.

The lead vacuum pump will be started automatically after the fifty second prelube. The vacuum pump will be stopped automatically at shutdown when the vacuum breaker solenoid is de-energized.

PREPARE THE STEAM CONDENSER ATMOSPHERIC RELIEF VALVE

Check the steam condenser atmospheric relief valve to ensure that the manual opening device is disabled. The discharge of this valve must be piped to a safe location, outdoors.

! NOTE

The relief valve hand wheel must be rotated fully counter-clockwise to prevent the valve from being manually lifted off its seat.

Open the valve supplying sealing water to the atmospheric relief valve enough to obtain a trickle flow out the overflow line. This will ensure that atmospheric relief valve sealing water is present to the proper level in the valve.

PREPARE THE CHILLED AND CONDENSER WATER PIPING AND PUMPS

Ensure that the pump motor starters and any automatic isolation valves located in the inlet/outlet piping are operable.

! NOTE

Before the initial operation of the pumps, both water circuits should be thoroughly vented of all air at the high points. Failure to do so will result in pass baffle damage.

PREPARE THE PRESSURE POWERED PUMP

If the chiller is supplied with a Pressure Powered Pump to remove condensate from the Turbine casing (Exhaust end), open the valve in the Motive Pressure Line to the pump.

VERIFY ALL USER DEFINED SETPOINTS

Using the checklist in the YST Start-up checklist Form 160.67-CL1, ensure that all setpoints are correct for the equipment supplied on the chiller and expected operating conditions. *Refer to the YST OptiView™ Control Center Operation Manual Form 160.67-O1* for a detailed explanation of all setpoints.

PRE-STARTUP PROCEDURES – AFTER SHORT TERM SHUTDOWN

A short term shutdown is defined as overnight or several days where the turbine has been allowed to cool down but the system remains in a 'READY TO START" condition. During this shutdown period, all manual valves with the exception of the steam supply valves, the atmospheric relief valve sealing water supply, and the turbine steam ring drain valve would remain in their original operating positions. The oil heater and motor protector disconnect switches in the Power Panel would remain in the "ON" position. The turbine steam ring drain valve (if NOT supplied w/

steam ring drain solenoid) should have been opened after the previous shutdown to remove any condensate as the turbine cooled down. Prior to starting the chiller, some routine checks are required to be certain plant conditions that would affect the chillers operation have not changed since the last operation. The following procedures must be performed prior to starting the chiller:

1. Check the status and availability of all utilities; electric, water, instrument air, and steam. Check that a minimum of 80 PSIG pneumatic control air supply is available at the filter regulators on the turbine governor valve and steam condenser. Check that 25 PSIG is available to the steam condenser level control valve current to pneumatic (I/P) transducer. The governor valve positioner supply air gauge should read 5 psig above the actuator requirement.
2. Ensure that all condensate is thoroughly drained from the steam supply and exhaust lines.

CAUTION

Operators must make every effort to blow the inlet steam line and turbine free of condensed steam, otherwise damage to the turbine may occur.

3. Ensure that the main steam inlet block valve, steam inlet slow roll bypass valve, bypass valve (if supplied), turbine pneumatic trip valve, and turbine governor valve are fully closed.
4. If the chiller is not supplied with at steam ring drain solenoid, open turbine steam ring drain valve (if not already open) to remove any condensate. Leave the drain valve open until the turbine has been warmed up by slow rolling it for the required time.

CAUTION

On newer chillers, the drain line will be equipped with a check valve and solenoid valve to perform the above operation at the appropriate times during the startup and shutdown sequence.

5. Ensure that the water level in the hotwell is at approximately 50%. If the water level is less than 50%, open the valve next to the fill connection on the hotwell and fill the hotwell to approximately 50%.
6. Open the valve supplying sealing water to the atmospheric relief valve enough to obtain a trickle flow out the overflow line. This will ensure that atmospheric relief valve sealing water is present to the proper level in the valve.
7. Ensure that sealing water is available for the vacuum pump(s).
8. If the OptiView™ Control Center is used to initiate the chilled and condenser liquid flow to the chiller, ensure that any manual isolation valves in the chilled and condenser liquid lines are open.
9. Check the oil levels in the compressor and turbine oil reservoirs.
10. Verify that all pressure and temperature displays on the OptiView™ screens display values as expected for the present ambient temperatures and condition of the chiller components (oil heater on, oil pump running etc.).

CAUTION

The oil heater is automatically controlled by the control panel at all times during shutdown and operation of the chiller to maintain the oil temperature in the oil reservoir at a target value which is 50°F above the condenser refrigerant saturation temperature. It is turned on at 4°F below the target value and off at 3°F above the target value. To prevent overheating the oil, the heater has an integral thermostat that opens at 180°F.

SEQUENCE OF OPERATION

NOTE

Refer to Figure 8 on page 30 Operation Sequence Timing Diagram – Manual Start/Variable Speed or Figure 8 on page 30 – Operation Sequence Timing Diagram - Automatic Start/Variable Speed along with the following paragraphs. If any of the speeds, ramp rates, or time delays described in the following paragraphs are adjustable, the factory default values are show for clarity. Refer to the OptiView™ Control Center Operation Manual Form 160.67-O1 for details on adjustable setpoints.

SLOW ROLL TIME CALCULATION

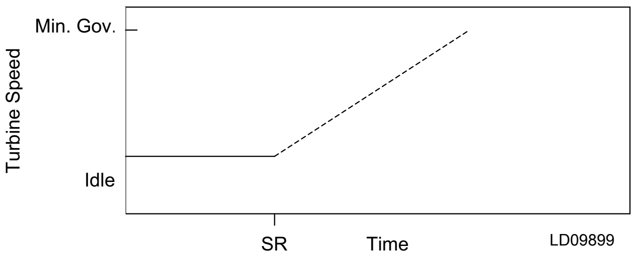


FIGURE 6 - SLOW ROLL TIME CALCULATION

A period of slow roll at idle speed is required before the turbine can be run continuously. After SLOW ROLL, the turbine speed can be increased to normal operating speed. Slow roll is shown in the above diagram as a solid line. The dotted line shows where the turbine speed is ramped up to minimum governor speed after the chilled liquid flow has been established.

The amount of time required to slow roll at idle speed varies, depending on the inlet steam temperature and the number of stages in the turbine. The following formula is used by the OptiView™ Control Center to determine the minimum slow roll time required:

$SRT = 20 + Ti - 350 / 50 + Ns$

where SRT = Slow Roll Time in minutes

Ti = Inlet Temperature in °F

Ns = Number of Turbine Stages

Example: Consider a KD71750125 turbine with an inlet temperature of 353°F.

So we know that Ti = 353, Ns = 7

$SRT = 20 + 353 - 350 / 50 + 7$

Therefore, this turbine should slow roll for a minimum of 27 minutes.

NOTE

Because steam turbines operate at relatively high temperatures which cause relatively high thermal expansion of many turbine components, a period of slow rolling startup of the turbine is necessary to avoid problems with thermal stresses and expansion. This slow roll startup is accomplished manually from the control panel on systems furnished with "Manual Startup", and is accomplished automatically on systems furnished with "Automatic Startup".

CAUTION

If the steam turbine has remained warm for some time after a shutdown because of a leaking throttle valve, or if it displays abnormal vibration during slow roll startup or at design speed, it is possible the shaft has taken a bow because of heat distortion. The shaft on the turbine design is returned to its normal shape by rotating slowly at 750-1200 RPM for 15-30 minutes with the auxiliary oil pump in operation. If the KG turbine displays the same indications it must be slow rolled for 15-30 minutes at 1200 RPM to assure a high enough speed to provide lubrication by the oil ring lubrication system. The control panel display includes a countdown timer showing the time remaining in the slow roll warm-up. Vibration on either turbine design may indicate other problems. Refer to *SECTION 5 – TROUBLESHOOTING*.

OVERVIEW

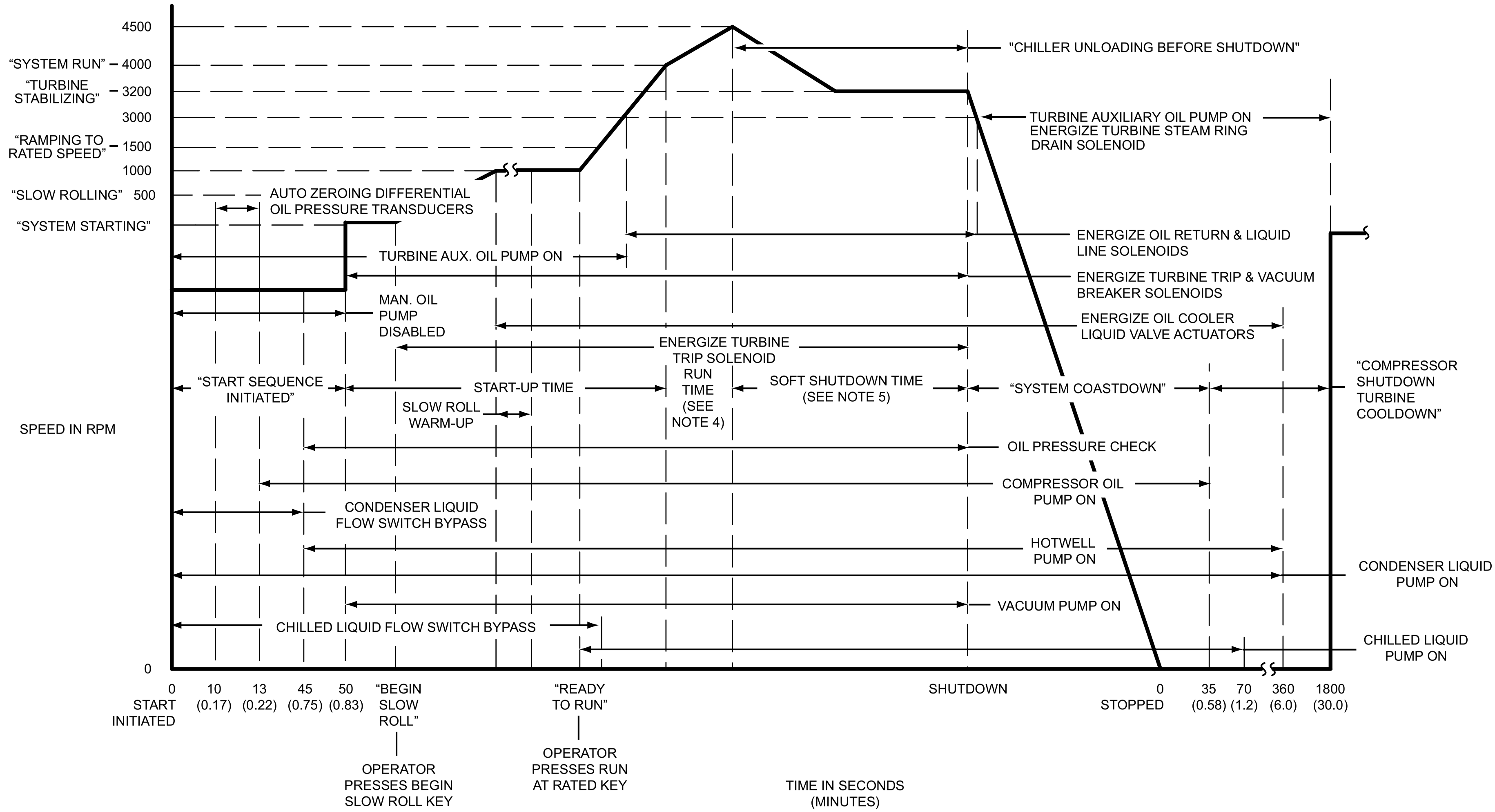
Standard YST chillers manufactured prior to December 2006 require the operator to manually open and close various steam inlet valves and drain valves at the appropriate times during the startup and shutdown of the chiller. The initiation of the slow roll warm-up and ramp to rated speed also requires operator intervention. If the chiller is supplied with the "Automatic Start" option, the chiller is supplied with solenoid valves and automatic control valves to allow a single operator action (or a remote signal) to start and shutdown the chiller. In the following steps the standard Manual Start Sequence is described. If there is a variation for "Automatic Start", it is described in the same step, following the Manual Start description with title of "Automatic Start."

YST chillers are factory configured with the Speed Control Mode set for Variable to automatically utilize the full range of the speed, compressor PRV and hot gas valve capabilities to control the capacity of the chiller and provide anti-surge and override control functions to prevent unsafe operation. The chiller may also be configured for Fixed speed as described under Capacity Controls later in this section. In the following paragraphs, variable speed control is described.

NOTE

To simplify the start up procedure and provide enhanced speed control during slow roll and low load operation, chillers manufactured after December 2006 are supplied with enhanced governor controls. The original turbine governor valve and actuator were replaced with a ball valve which is field installed in the main steam inlet line upstream of the turbine trip valve. The valve includes a Digital Valve Controller which utilizes the 4-20 mA governor output signal from the OptiView™ panel to regulate the steam flow to the turbine inlet and maintain accurate speed control. For standard chillers, the manually operated slow roll bypass valve is no longer required to be installed by the customer to provide stable slow roll operation. For chillers supplied with the Automatic Start option, the automatically operated main steam inlet and slow roll bypass valves are no longer supplied.

TIMING DIAGRAM – (MANUAL START)



NOTES:

1. Text in quotations indicates a Display Message.
2. Start-Up Time, Run Time, Soft Shutdown Time, and System Coastdown Time will vary depending on the system conditions and programmable setpoints.
3. Speeds and times shown, if programmable, are shown with default values.
4. During the Run Time, the Operating Speed may be anywhere from 3200-4500 RPM depending on Load and System Operating Conditions.
5. Only applicable to the following shutdowns: Low Water Temperature, Remote/Local Cycling (TB4-13), Remote Stop (TB4-8), Remote Stop (ISN Serial Port). Operator initiated Soft Shutdown.

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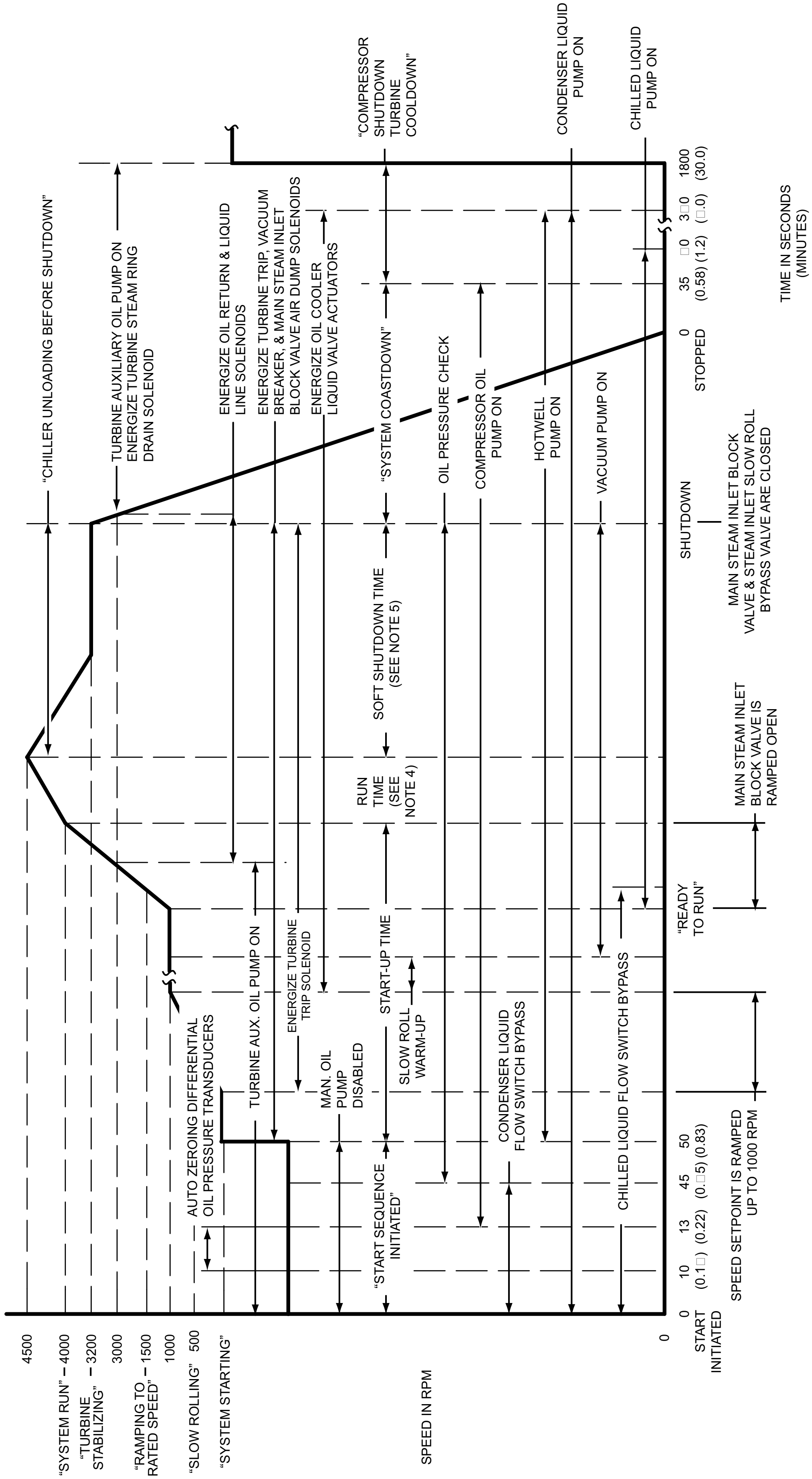
FIGURE 7 - OPERATION SEQUENCE TIMING DIAGRAM (MANUAL START)

TIMING DIAGRAM – (AUTOMATIC START)



NOTES:

1. Text in quotations indicates a Display Message.
2. Start-Up Time, Run Time, Soft Shutdown Time, and System Coastdown Time will vary depending on the system conditions and programmable setpoints.
3. Speeds and times shown, if programmable, are shown with default values.
4. During the Run Time, the Operating Speed may be anywhere from 3200-4500 RPM depending on Load and System Operating Conditions.
5. Only applicable to the following shutdowns: Low Water Temperature, Remote/Local Cycling (TB4-13), Remote Stop (TB4-8), Remote Stop (ISN Serial Port). Operator initiated Soft Shutdown.
6. Chillers manufactured after December 2006 are not supplied with separate steam inlet and slow roll bypass valves.

FIGURE 8 - OPERATION SEQUENCE TIMING DIAGRAM (AUTOMATIC START)

STARTUP SEQUENCE OF OPERATION

1. On the OptiView™ Control Center HOME screen, press the STEAM SYSTEM key to go to the STEAM SYSTEM screen.

2. On the front of the OptiView™ Control Center, place the keypad switch in the (O) STOP/RESET position to reset any previous safety trips. The message SYSTEM READY TO START is displayed.

3. On the front of the chiller panel, place the keypad switch in the (◄) "START" position and release. This starts the compressor oil pump and the turbine auxiliary oil pump (if equipped). The condenser liquid pump start contacts (terminals 150-151 on the I/O board) are closed to start the condenser liquid pump. If the operator has NOT logged in using the OPERATOR access code, the message "MANUAL START REQUIRES OPERATOR ACCESS LEVEL" is displayed. If the operator has logged in using the OPERATOR access code, the message START SEQUENCE INITIATED is displayed. The compressor oil pump is started after the 13-second delay for auto-zeroing of the differential oil pressure.

NOTE

If the condenser liquid pump contacts are not used, the plant control system or operator must ensure that the condenser cooling liquid flow is established within 45 seconds after these contacts are closed. Otherwise, the low flow switch will trip the chiller.

If for any reason, the turbine begins rotating prior to a start sequence being initiated, the oil pumps will be started automatically. The condenser liquid pump contacts are also closed and the oil cooler liquid solenoids are energized to provide oil cooling during this abnormal operation.

4. Forty-five seconds after the start is initiated, the control logic will check that adequate compressor oil pressure, turbine oil pressure (if Pump Lubrication), and condenser liquid flow are established.

5. Fifty seconds after the start is initiated, the main start relay (K18 on the I/O board) is energized. The turbine trip and vacuum breaker solenoid valves are energized, the pneumatic turbine trip valve is opened, the hotwell pump is started, and the message SYSTEM STARTING is displayed at this time.

   Automatic Start: The main steam inlet block valve and slow roll bypass valve air dump solenoids are energized to apply supply air pressure to the actuators. This enables manual operation of the valves if required.

NOTE

Chillers manufactured after December 2006 are not supplied with separate automatic main steam inlet and slow roll bypass valves. The main steam inlet supply isolation valve should be fully open at this time.

If the turbine trip valve fails to open within 10 seconds after the trip solenoid is energized, the start is aborted and the message "TURBINE MECHANICAL TRIP" is displayed.

During this period, before the turbine is started, all condensate should be returning to the hot well (recirculation valve is open, overboard valve is closed).

NOTE

If the chiller is equipped with an optional standby hotwell pump, in the automatic mode, the Hotwell pumps will be switched-over (at each Chiller Start) to share operational time. If the lead pump fails to start or fails while the chiller is operating, toggle to standby pump will be done automatically. If both pumps fail, the chiller will be not be allowed to start and will shutdown if operating.

6. After the turbine trip valve limit switch is closed, the vacuum pump sealing water solenoid valve is energized. When the sealing water flow switch contact closes, the vacuum pump is started. When the exhaust pressure has been reduced to 10 PSIA, the message "READY TO BEGIN SLOW ROLL" is displayed. Press the BEGIN SLOW ROLL key that appears on the STEAM SYSTEM screen. The message "WAITING FOR STEAM FLOW" is displayed.

NOTE

THE ACCESS LEVEL MUST BE DISPLAYED "OPERATOR" IN ORDER FOR THE BEGIN SLOW ROLL KEY TO BE DISPLAYED. If the BEGIN SLOW ROLL key is not pressed within 20 minutes after it appears, the turbine will be tripped and the message "EXCESSIVE START DELAY" is displayed.

Automatic Start: The BEGIN SLOW ROLL key does not appear and the start sequence proceeds to paragraph 7.

7. The speed controller setpoint is ramped up to 1000 RPM. This causes the output signal to the governor valve transducer to increase to open the governor valve. Open the steam inlet slow roll bypass valve to start the turbine slow rolling. The valve should be opened only far enough to achieve 1000 RPM with the governor valve at least 25-35% open. This will provide optimum speed control with less hunting.

   Chillers manufactured after December 2006 **DO NOT** require the manipulation of a slow roll bypass valve. The output signal to the valve controller automatically modulates the ball valve position to achieve and maintain the slow roll speed.

   Automatic Start: The output of the Governor (Slow Roll) PID also controls the slow roll bypass valve. As the speed setpoint is ramped up to 1000 RPM, both the governor valve and the slow roll valve open to start the turbine slow rolling. As the speed approaches set point, both valve outputs are reduced to control the slow roll at 1000 RPM.

   Chillers manufactured after December 2006 **DO NOT** use a separate slow roll bypass valve.

   After rotation begins, if 1000 RPM is not achieved in 100 seconds, the turbine will be tripped by the under speed logic and the message TURBINE UNDERSPEED is displayed. If the speed drops below 900 RPM for more than 60 seconds, the chiller will also shut down on under speed.

8. When the panel senses that the speed has increased above 500 RPM, the message "SLOW ROLLING" is displayed. If the chiller is not supplied with a solenoid in the turbine steam ring drain line, the manual valve in the steam ring drain line should be closed at this time. The evaporator low-pressure safety shutdown set point is increased to 30 PSIG. The compressor oil cooler liquid valve is opened (only if the compressor oil temperature increases above 150°F) to allow the compressor oil temperature control valve to maintain the bearing supply oil temperature at approximately 110-120°F.

   If the chiller is supplied with a check valve and solenoid valve in the turbine steam ring drain line, the solenoid valve remains energized (open) during the initial startup. The check valve in the steam ring drain line prevents air from being drawn into the turbine when the turbine steam ring drops below atmospheric pressure during the initial evacuation and while the turbine is slow rolling. When the inlet steam valves open to begin slow roll and during the ramp up to minimum speed, the steam ring will rise above atmospheric pressure and any condensate will be blown out of the turbine.

9. If the turbine is equipped with an auxiliary oil pump, the turbine oil cooler liquid valve is opened to allow the turbine oil temperature control valve to maintain the bearing supply oil temperature at approximately 110-120ºF. For turbines with Ring Lubrication, the liquid valve is opened to allow cooling liquid to flow through the bearing oil reservoir jackets. Adjust the valve in the cooling liquid outlet line to maintain a minimum oil temperature of 130°F in both bearing oil sumps.

CAUTION

Do Not Allow The Cooling Liquid To Cool The Bearing Oil Sump Temperature To Below 130°F (54°C), As This May Interfere With The Action Of The Oil Rings Or Cause Atmospheric Moisture To Condense In The Oil Reservoir.

10. A period of slow roll at 1000 RPM is required before the turbine can be run continuously. After slow roll, the turbine speed may be increased to normal operating speed. The amount of time required to slow roll varies, depending on the inlet steam temperature and the number of stages in the turbine. The chiller control logic automatically calculates the slow roll time required and displays the time remaining via a countdown timer in the status bar of the OptiView™ Control Center screens.

    If a chiller start is initiated within 15 minutes of the last trip after a ramp-to-rated speed was initiated, the calculated slow roll time is reduced to 5 minutes because the turbine rotor is still hot and the shaft has not been stationary long enough to bow.

11. During slow roll, when the turbine exhaust pressure has decreased to the PSP5-Vacuum Pump Shutdown setpoint (9 PSIA) shown on the PRESSURE SETPOINTS SCREEN , the vacuum pump is stopped. If the turbine exhaust pressure increases to the PSP6- Ready To Run Turbine Exhaust Pressure setpoint (12 PSIA) shown on the PRESSURE SETPOINTS SCREEN, the vacuum pump is restarted.

12. Perform the following while the turbine is slow rolling:
    a. Check turbine and compressor for proper operation of lubrication system.

       When starting a turbine with cold oil, the oil pressure will be somewhat higher than when the oil reaches operating temperature. This is a natural condition due to the change in oil viscosity with temperature. ANY ADJUSTMENT TO OIL PRESSURE SHOULD BE MADE WITH THE OIL AT OPERATING TEMPERATURE.
    b. Check for vibration or any unusual noise or condition.
    c. Check hotwell pump and pneumatic condensate level controls for proper operation. If the pump or level controls fail, the condensate level in the hotwell will increase. If the hotwell high level switch contacts wired to terminals 1 & 80 of the I/O board remain open for 10 seconds, the turbine will be tripped and the message HOTWELL CONDENSATE HIGH LEVEL will be displayed.
    d. Check atmospheric relief valve sealing water.
    e. Check that the automatic turbine condensate removal system is operating properly. During slow roll, the system should be cycling as required to drain the condensate from the exhaust end of the turbine.
13. During the slow roll period, the evaporator low-pressure cutout is raised to 30 PSIG. If the slow rolling produces enough flow through the compressor to reduce the evaporator pressure below this elevated pressure, the turbine will be tripped immediately. If the turbine speed increases above 1500 RPM, the chilled liquid pump contacts (terminals 44-45 on the I/O board) are closed to start the chilled liquid pump.

    If the chilled liquid pump contacts are not used, the plant control system or operator must ensure that the chilled liquid flow is established within 10 seconds after these contacts are closed. Otherwise, the low flow switch will trip the chiller.
14. After the chiller has been slow rolled for the calculated time, the message "TURBINE IDLING – INSUFFICIENT VACUUM" is displayed if the turbine exhaust pressure is not less than the PSP6- Ready To Run Turbine Exhaust Pressure setpoint (12 PSIA) and the vacuum pump is restarted. This energizes the sealing water solenoid valve. If flow is not established within 10 seconds after the pump start is initiated, an alarm is sounded. If the chiller is equipped with a standby vacuum pump, it will be started to continue with the startup, otherwise the startup will be aborted.

    If the chiller is equipped with an optional standby pump, in the automatic mode, the vacuum pumps will be switched-over to share operational time. If the lead pump fails to start or fails while the chiller is operating, toggle to standby pump will be done automatically. If both pumps fail, the chiller will be not be allowed to start and will shutdown if operating.
15. When the turbine exhaust pressure has decreased to the PSP6- Ready To Run Turbine Exhaust Pressure setpoint (12 PSIA), the turbine should be able to be safely ramped up to rated speed since there is essentially no load with the compressor pre-rotation vanes closed and the hot gas valve fully open. The message "READY TO RUN" is displayed. Slowly open the main steam inlet block valve and then press the RUN AT RATED key that appears on the STEAM SYSTEM screen.

    Chillers manufactured after December 2006 **DO NOT** require the manipulation of the main steam inlet block valve. The output signal to the valve controller automatically modulates the ball valve position to achieve and maintain the fixed rated speed.

    CAUTION

    If the RUN AT RATED button is not pressed within 20 minutes after the slow roll time has elapsed, the chiller will be tripped and the message "EXCESSIVE SLOW ROLLING TRIP" will be displayed.

    Automatic Start: The RUN AT RATED key does not appear and the start sequence proceeds to paragraph
16. The chilled liquid pump contacts (terminals 44-45 on the relay output board) are closed to start the chilled liquid pump.

    If the chilled liquid pump contacts are not used, the plant control system or the operator must ensure that the chilled liquid flow is established within 10 seconds after these contacts are closed. Otherwise, the flow switch will trip the chiller.

17. When the chilled liquid flow switch contacts close, the speed setpoint is increased to the Fixed Rated Speed of 3600 RPM at 200 RPM/second causing the governor valve to open rapidly. The governor valve will continue to open until 3600 RPM is achieved. The vacuum pump is started (if not already running) and latched on until the chiller is shutdown.

    Automatic Start: As the speed setpoint increases, the governor valve and slow roll valve both open. When the speed setpoint has increased to 500 RPM above the slow roll speed setpoint, the main steam inlet valve control signal is ramped from 0 to 100% at 5%/second to open the valve.

    Chillers manufactured after December 2006 are **NOT** supplied with separate automatic slow roll bypass and main steam inlet valves.

18. The compressor pre-rotation vane control signal is set to the PRV Minimum Open Position of 10% as soon as the ramp-to-rated speed is begun. This allows the vane actuator to begin moving the linkage so that the vanes begin to move off of their fully closed position by the time the minimum rated speed is achieved.

19. The chiller controls initiate the following actions based upon the sensed turbine speed:

    a. After the speed has increased above 1500 RPM, the message "RAMPING TO RATED SPEED" is displayed.

    b. At 2000 RPM, the under-speed trip time delay is initiated. The turbine speed must now be increased to 3200 RPM within 17 seconds or the turbine will be tripped by the under speed logic and the message "TURBINE UNDERSPEED" is displayed.

    c. If the turbine is equipped with an auxiliary oil pump, and after the speed has increased above 3000 RPM, if the turbine shaft driven oil pump is producing sufficient pressure to maintain the turbine supply oil pressure above the set point of the turbine auxiliary oil pump control set point, the turbine auxiliary oil pump will be stopped. The oil return and liquid line solenoid valves are opened. If the chiller is supplied with a solenoid valve in the turbine steam ring drain line, it is de-energized at this time.

    Whenever the turbine bearing supply oil pressure falls below the auxiliary oil pump control setting, the auxiliary pump motor will be restarted.

    d. At 3200 RPM, the under speed safety logic is enabled. If the speed falls below 3100 RPM for more than 60 seconds, the turbine will be tripped by the under speed logic and the message "TURBINE UNDERSPEED" is displayed.

    e. At the minimum rated speed, the message "TURBINE STABILIZING" is displayed and the evaporator low-pressure cutout is reduced to the normal cutout of 25 PSIG. The turbine speed will continue to increase to 3600 RPM. As the system head increases, the anti-surge logic will position the speed and vanes as required to maintain stable operation.

20. After 5 seconds, the capacity control and compressor Variable Geometry Diffuser (VGD) logic are enabled and the message "SYSTEM RUN" is displayed. The speed will decrease to the calculated anti-surge minimum speed based on the current system head. The hot gas bypass valve control signal is ramped down to 0% at 5 %/second to close the valve. When the hot gas valve (HGV) control signal is at 0%, the compressor pre-rotation vanes (PRV) control signal is ramped up to 100% at 5 %/second.

    Close the slow roll bypass valve.

    Chillers manufactured after December 2006 **DO NOT** require the manipulation of a slow roll bypass valve.

    Automatic Start: The steam inlet slow roll bypass solenoid valve is de-energized to close the bypass line.

    Chillers manufactured after December 2006 **ARE NOT** supplied with a separate automatic slow roll bypass valve.

    The PRV and HGV ramped signals are used to provide a controlled loading rate after the chiller has been ramped up to the minimum rated speed and the turbine stabilization delay has elapsed. Regardless of the ramp rate setpoints, the chiller capacity will only increase as fast as the HGV closes and the PRV open based on the stroke rate of the electric actuators. The rates shown above are increased to initiate the Capacity Ratchet Mode change to PRV before the HGV has actually closed fully and the mode change to Speed before the vanes have actually opened fully. This will allow the vanes and speed to begin increasing the capacity sooner and provide a faster pull-down to the system design conditions.

21. Under full load conditions, when the PRV control signal is at 100%, the speed setpoint is ramped up to the 4500 RPM at 10 RPM/second. If the cooling load is low, the chiller will continue to run at the calculated anti-surge minimum speed. As the system head increases, the speed will increase to the higher calculated anti-surge minimum speed. As the vanes are ramping open, if the leaving chilled liquid temperature decreases to less than 2ºF above the leaving chilled liquid temperature controller setpoint, the controls will automatically override the ramp signals to prevent over shooting the setpoint. The capacity control/anti-surge logic will always adjust the turbine speed and compressor pre-rotation vanes as required, providing stable operation and maintaining the leaving chilled liquid temperature at set point.
22. Verify general operation, oil pressures, temperatures, vibration and noise levels, and hotwell condensate level.
23. After the chiller has been running at or above the minimum rated speed for 10 minutes, the subcooler refrigerant liquid level controller setpoint is ramped up to the desired setpoint at the 0.1 %/second. This causes the subcooler level control valve to slowly close until the refrigerant level in the subcooler is at the setpoint.
24. After the chiller has achieved the SYSTEM RUN mode, if the turbine exhaust pressure increases above 3.5 PSIA for a continuous period of 10 seconds, the warning message "TURBINE EXHAUST HIGH PRESSURE" will be displayed. If the pressure remains above the set point for 10 minutes, the turbine will be tripped.

SYSTEM OPERATING PROCEDURE

General

Refer to the OPERATING INSPECTIONS in this manual for complete details on the routine operation of the equipment.

CAUTION

For turbines with pressure feed lubrication, the oil pressure should be observed frequently until the turbine has been operated for several days as failure of oil pressure can result in extensive damage. The oil reservoirs should be maintained at the proper level using oil of the recommended grade.

Hourly

Record operating readings. Walk through chiller area and perform a visual inspection of turbine, compressor, steam system and control panel. Listen for any unusual noises.

Check turbine ring pressure verses steam inlet pressure. Open or close nozzle valves to maintain ring pressure at approximately 90 percent of steam inlet pressure. If an increase in load is expected, nozzle valves may be left open to ensure reserve turbine horsepower. However, optimum turbine performance is achieved by having the least number of nozzle valves opened while maintaining the horsepower required for the load.

CAUTION

Do not partially open nozzle hand valves. Valves should be fully open or fully closed. Leaving the valves partially open could cause seat and valve damage.

Automatic Start: The nozzle valves are opened/closed automatically based on the turbine first stage pressure that varies with each application. As the load on the turbine increases, the governor valve opens and the first stage pressure increases. When the first stage pressure has been above the Turbine Nozzle Solenoid #1 Activate pressure setpoint continuously for 300 seconds, Nozzle Solenoid #1 is energized to open additional inlet nozzles and increase the horsepower output of the turbine. If the load continues to increase and the first stage pressure has been above the Turbine Nozzle Solenoid #2 Activate pressure setpoint continuously for 100 seconds, Nozzle Solenoid #2 is energized to open additional inlet nozzles. If the load decreases, the governor valve closes and the first stage pressure decreases. Each nozzle valve will be closed when the pressure decreases 5 PSIG below the respective activate setpoint.

SHUT DOWN SEQUENCE OF OPERATION

Normal (Controlled) Stop

The chiller capacity will be reduced to perform a controlled shutdown. This will slightly decrease the sudden loss of steam load when the chiller trips, thus possibly preventing boiler relief valves from lifting. The following sequence is applicable when the Speed Control Mode is set for Variable:

1. To initiate the controlled stop, push the SOFT SHUTDOWN key on the OptiView™ Control Center HOME screen or open one of the remote cycling contacts (if connected to the chiller panel). The message "CHILLER UNLOADING BEFORE SHUTDOWN" is displayed.
2. The present LCLT Controller SP (Local/Remote setpoint, whichever is selected) is ramped up to a value equal to the return chiller liquid temp +5 °F and the chiller capacity controls begin unloading the chiller. At the same time, a Soft Shutdown timer (TDSP9-Soft Shutdown Rampdown Timer, adjustable 2-20 minutes on the Time Setpoints Screen) is enabled. The unloading begins with speed reduction to the calculated anti-surge minimum speed. When the speed has decreased to the calculated anti-surge minimum speed, the PRV will close to the calculated anti-surge minimum vane position. While the vanes are closing and the head is decreasing, the speed will continue to ramp down to the lower calculated anti-surge minimum speed.

   When the PRV position feedback signal is equal to the calculated anti-surge minimum vane position, the hot gas valve will begin opening. While the hot gas valve is opening and the head is decreasing, the speed will continue to ramp down to the lower calculated anti-surge minimum speed and the vanes will continue to close to the lower calculated anti-surge minimum.
3. The chiller will be shutdown when the hot gas valve signal has increased to 95% (if HGV is Enabled) or the Soft Shutdown logic has been unloading the chiller longer than the TDSP9-Soft Shutdown Rampdown Timeout minutes entered on the Time Setpoints Screen (if HGV is Disabled).

   Automatic Start: When the Soft Shutdown is initiated, the Main Steam Inlet Valve control output is first decreased (ramped down at 5 %/second) until it is equal to or less than the current output to the Governor Valve. From this point as the chiller unloads and until it is shutdown, the Main Steam Inlet Valve output will equal the Governor Valve output. When the two valve signals are tracking, the present LCLT Controller SP (Local/Remote setpoint, whichever is selected) is ramped up to a value equal to the return chiller liquid temp +5 °F and the chiller capacity controls begin unloading the chiller as described above.

   Chillers manufactured after December 2006 **ARE NOT** supplied with a separate automatic main steam inlet valve.

   When the Speed Control Mode is set for Fixed, the unloading sequence begins with the PRV and proceeds to the hot gas valve as described above.

Immediate Stop

1. On the front of the OptiView™ Control Center, place the keypad switch in the (O) STOP/RESET position to immediately trip the turbine without the unloading delay. In the event that the STOP/RESET switch fails to trip the turbine, push the hand trip knob on the turbine.

NOTE

The oil pumps will continue to run through their normal shutdown sequence after any of the above operations. If all motors must be stopped for safety reasons, the 120 VAC power supply to the chiller panel must be shut off by an external EMERGENCY STOP switch contact (supplied by others).

Post Trip Shutdown Sequence

1. When a turbine trip is initiated, the main start relay (K18 on the I/O board) is immediately de-energized. This de-energizes the the turbine trip solenoid, which causes the pneumatic turbine trip valve to close. The compressor pre-rotation vanes are closed, the compressor Variable Geometry Diffuser (VGD) is opened, and the hot gas valve and subcooler level control valve are opened. The main steam inlet isolation valve should be closed at this time.

Automatic Start: The main steam inlet block valve air dump solenoid is de-energized to close the valve immediately and its control signal is set to 0%. The steam inlet slow roll bypass valve control signal is also set to 0% to close the valve.

NOTE

Chillers manufactured after December 2006 are not supplied with separate automatic slow roll bypass and main steam inlet valves.

The vacuum pump is stopped and the vacuum breaker solenoid valve is opened to break the vacuum in the exhaust line and slow the turbine down faster.

The speed control set point is set to 0 RPM which causes the control output signal to the governor valve to decrease to 0% and close the governor valve.

In the case of a mechanical trip, when the trip valve is actuated by hand or by an over speed condition not detected by the control panel logic, the trip valve closed limit switch is actuated for feedback to the control panel and the message "TURBINE MECHANICAL TRIP" is displayed.

2. When the speed decreases below 3000 RPM, the oil return and liquid line solenoid valves are closed and the turbine auxiliary oil pump (if equipped) is started. If the chiller is supplied with a solenoid valve in the turbine steam ring drain line, it is opened at this time.
3. During the coast down of the drive train and the compressor oil pump and turbine auxiliary oil pump (if equipped) will continue to run to maintain lubrication of the bearings and the message "SYSTEM COASTDOWN" is displayed.
4. When rotation has ceased for 35 seconds, the message "COMPRESSOR SHTDN; TURBINE COOLDOWN" is displayed if the turbine has Pump Lubrication. If the turbine has Ring Lubrication the message "SYSTEM READY TO START" is displayed.
5. When the compressor oil pump has been stopped for 35 seconds, the chilled liquid pump contacts (terminals 44-45 on the I/O board) are opened to stop the chilled liquid pump unless the cycling shutdown message "LEAVING CHILLED LIQUID – LOW TEMPERATURE" is displayed, in which case the contacts will remain closed. If the Chilled Liquid Pump Operation is set for Enhanced on the Setup Screen, the contacts will also remain closed if the cycling shutdown message "SYSTEM CYCLING – CONTACTS OPEN" is displayed.

NOTE

If the chilled liquid pump contacts are not used, the plant control system or operator should shut off the chilled liquid flow at this time.

6. The turbine auxiliary oil pump (if equipped) will continue to run for 30 minutes to remove excess heat from the turbine bearings.

CAUTION

The drive train will normally coast to a complete stop within 6 minutes after a trip. If for any reason the turbine is still rotating 6 minutes after the trip, the Oil Pumps will continue to operate. If the Turbine begins rotating again after having come to a complete stop, the message "STEAM SUPPLY VALVE MALFUNCTION" is displayed and the oil pumps will be restarted. Verify that the governor valve, pneumatic trip valve, and main steam inlet block valves are all fully closed and no steam is entering the turbine.

7. Six minutes after the turbine was tripped, if no rotation is detected, the condenser liquid and hotwell pumps are stopped and the oil cooler liquid valves are closed. If the chiller is not supplied with a solenoid in the turbine steam ring drain line and the chiller will not be restarted in a short time (the turbine will be allowed to cool down), open the manual valve in the steam ring drain line.

NOTE

If the condenser liquid pump contacts are not used, the plant control system or operator should shut off the condenser liquid flow at this time.

8. Thirty minutes after the rotation has stopped, the turbine auxiliary lube oil pump (if equipped) will be stopped and the message "SYSTEM READY TO START" is displayed.

   If the trip was caused by a power failure and the power is restored within 6 minutes of the last chiller run cycle, the oil pumps are started as soon as the power is restored. The compressor oil pump will then run for 35 seconds and stop. The turbine auxiliary oil pump (if equipped) will run for 30 minutes and stop.

The chiller may not be restarted until after the compressor coast down sequence is completed and the message "COMPRESSOR SHTDN; TURBINE COOLDOWN" (Pressure Lubrication) or "SYSTEM READY TO START" (Ring Lubrication) is displayed.

CAPACITY CONTROLS

Overview

Both fixed and variable speed modes of operation are included. The fixed speed mode would likely only be used in plants where the condensing cooling liquid is always at a high temperature so that speed reduction would not be possible due to the high system pressure differential. The Speed Control Mode is factory set for Variable (default mode) to provide the greatest efficiency of operation in plants where the condenser cooling liquid is allowed to decrease to the minimum allowed. This allows the turbine speed to be reduced to the minimum rated speed and the compressor prerotation vanes to be closed completely prior to opening the hot gas valve. In this mode, the capacity controls will automatically utilize the full range of the governor, compressor PRV and hot gas valve capabilities to control the capacity of the chiller and provide anti-surge and override control functions to prevent unsafe operation.

For easy adjustments all operating mode selections and PID tuning parameters are included on various setpoint screens on the OptiView™ Control Center graphic display.

Only a qualified YORK Service Technician should make adjustments to capacity controls.

FIXED SPEED CHILLER CAPACITY CONTROLS OPERATION

During operation at a fixed speed, the vanes and hot gas valve are controlled by the output of a single PID controller that responds to changes in the leaving chilled liquid temperature. A ratio calculation is used to position the hot gas valve after the vanes have been closed to their minimum position based on the system pressure differential (condenser minus evaporator pressure). A separate PID controller is also provided to control the hot gas valve based on leaving chilled liquid temperature if operating conditions require the vanes to be fully closed at low loads. During off design operation, the outputs of the high condenser pressure, low evaporator pressure and torque limiting override PID controllers override the output of the primary Leaving Chilled Liquid Temperature Controller to maintain stable operation and prevent the chiller from shutting down. The tuning of the primary Leaving Chilled Liquid Temperature, Evaporator Pressure and Condenser Pressure PID controllers is automatically adjusted to match the response time of the process when the hot gas valve is being controlled. To achieve maximum efficiency at part load conditions, the unloading sequence is vane closure and hot gas valve opening.

Refer to the YST OptiView™ Control Logic Diagram (Capacity Control 1, Capacity Control 2, and Capacity Control 3 Diagrams) along with the following paragraphs for a more detailed description of the operation. If any of the speeds, ramp rates, or time delays described in the following paragraphs are adjustable, the factory default values are show for clarity. *Refer to the OptiView™ Control Center Operation Manual Form 160.67-O1* for details on adjustable setpoints.

FIXED SPEED CHILLER LOADING SEQUENCE

The chiller is started with the Leaving Chilled Liquid Temperature Controller inactive and its output equal to the fixed speed tieback signal after LSR3. When the ramp-to-rated speed is initiated, the vane output signal is set to the minimum start-up value (PRVM). After the minimum rated speed of 3200 RPM has been achieved, the vanes are ramped open and the hot gas valve is ramped closed. As the system pressure differential (condenser minus evaporator pressure) increases, if the output of the Minimum Vane Position Calculation increases above the PRV ramp output signal, HSR5 will select the higher value to open the vanes farther and prevent surging. The Leaving Chilled Liquid Temperature Controller becomes active when the vane ramp signal is at 97% or the leaving chilled liquid temperature decreases to within 2°F of the Leaving Chilled Liquid Temperature Controller set point. The Leaving Chilled Liquid Temperature Controller will adjust the vanes as required to maintain the leaving chilled liquid temperature at set point.

For fixed speed operation, TDSP17 – Turbine Stabilization Delay should be set to 0 to allow loading to begin as soon as the minimum rated speed is achieved. *Refer to the OptiView™ Control Center Operation Manual Form 160.67-O1* for details on adjustable setpoints.

FIXED SPEED CHILLER UNLOADING SEQUENCE

PRV Control

If the load decreases, the output of the Leaving Chilled Liquid Temperature Controller will decrease to close the vanes to the minimum position established by the Minimum Vane Position Calculation.

As the system pressure differential falls, the compressor is capable of stable operation with less refrigerant gas flow (lower minimum compressor pre-rotation vane positions). For the greatest efficiency, the compressor pre-rotation vanes must be used for capacity control rather than hot gas bypass whenever possible. The Minimum Vane Position Calculation output signal to HSR5 provides a minimum closure of the pre-rotation vanes to suite the measured pressure differential input. This output also provides one of the input signals for the Hot Gas Ratio calculation which to use in controlling the output to the hot gas valve.

Hot Gas Ratio Control

The Hot Gas Ratio calculation controls the hot gas bypass valve at a scaled ratio to the percentage of available Leaving Chilled Liquid Temperature Controller signal below the Minimum Vane Position Calculation output, thus providing a 0-100% control signal for the hot gas bypass valve.

To provide greater stability at very low system pressure differentials when the minimum vane position calculation would normally be 0%, a minimum vane position may be entered into the HGVRAT set point. HSR1 will select this higher value to give the Hot Gas Ratio calculation a greater range of control for the hot gas valve. As long as the capacity signal from the Leaving Chilled Liquid Temperature Controller is above the Minimum Vane Position Calculation output (or the HGVRAT) signal, the hot gas valve remains closed. When the capacity signal falls below the Minimum Vane Position Calculation output, the tuning parameters for hot gas control are loaded into the Leaving Chilled Liquid Temperature Controller. The output of the Hot Gas Ratio calculation increases, which starts to open the hot gas bypass valve. Thus at low loads, the capacity is controlled by modulating the hot gas bypass valve.

HGV Temperature Controller

In some cases, it may be desirable to allow the vanes to go completely closed which would leave no signal for the Hot Gas Ratio calculation to control the hot gas valve. A separate PID controller is provided which controls at a leaving chilled liquid temperature set point that is slightly below the main Leaving Chilled Liquid Temperature Controller set point. If the load continues to decrease with the vanes fully closed, the leaving chilled water temperature will decrease below the set point of the HGV Temperature Controller causing its output to increase. HSR6 will select this higher signal and begin opening the hot gas valve to maintain the leaving chilled liquid temperature at the lower HGV Temperature Controller set point.

FIXED SPEED CHILLER OVERRIDE CONTROLLERS

High and Low Refrigerant Pressure

The Evaporator Pressure and Condenser Pressure controllers are inactive when the chiller is stopped with their outputs set to 100%. If the monitored parameter exceeds the set point of the controller during any abnormal operation when running at or above the minimum rated speed, the output of the appropriate controller is set to the tieback signal for the device currently being controlled before the controller is activated, thus providing a bumpless transfer to the override control. If the monitored parameter exceeds the set point of the controller, the controller output will decrease. LSR2 and LSR1 will select the lower signal to override the Leaving Chilled Liquid Temperature Controller output and close the compressor PRV as described above, thus preventing unsafe operation and an unnecessary shutdown.

If the override signal falls below the Minimum Vane Position Calculation output, the tuning parameters for hot gas control are loaded into the override controller. While any override controller is active, the primary Leaving Chilled Liquid Temperature Controller is inactivated and its output is set to equal the appropriate tieback, thus providing a bumpless transfer to normal leaving chilled liquid temperature control. After the override controllers monitored parameter has not exceeded the set point for 5 seconds, the Leaving Chilled Liquid Temperature Controller is reactivated and its' PID algorithm begins controlling the output at the tieback value.

Turbine Governor Position Power Limiting

In some applications, during high load/pulldown conditions, the turbine may be capable of producing more horsepower than the compressor bearings are rated for. To provide protection for retrofitted chillers that do not have the ability to monitor turbine first stage pressure, the logic monitors the governor valve actuator output from the chiller panel as done on previous chillers. The Governor Position Controller is inactive when the chiller is stopped with its' outputs set to 100%.

When the chiller is running at or above the minimum rated speed, if the integrated speed control PID attempts to open the governor valve more than a preset value (determined by field testing at start up), the output of the Governor Position Controller will decrease. LSR2 and LSR1 will select the lower signal to override the Leaving Chilled Liquid Temperature Controller output and unload the chiller as described above.

With the load reduced, the turbine will begin to speed up and the speed control PID will begin to close the governor valve, thus limiting the torque output of the turbine. While the Governor Position Controller is active, the primary Leaving Chilled Liquid Temperature Controller is inactivated and its output is set to equal the appropriate tieback, thus providing a bumpless transfer to normal leaving chilled liquid temperature control. After the load is reduced sufficiently to return the governor valve to a safe position for 5 seconds, the Leaving Chilled Liquid Temperature Controller is reactivated and its' PID algorithm begins controlling the output at the tieback value.

Turbine Horsepower Limiting

All new YST chillers are provided with a transmitter to monitor the turbine first stage pressure. This pressure is used along with the steam inlet pressure and temperature and the turbine exhaust pressure to calculate the turbines power output. A separate PID controller is provided to unload the chiller when the turbine power approaches the maximum that the compressor bearings are rated for or 115% of the turbine design horsepower, whichever is lower. The logic will calculate the actual horsepower based on the steam inlet temperature and pressure so that the override controller automatically adapts to fluctuations in the quality of the steam supplied to the turbine inlet.

If the calculated horsepower increases above the set point, the output of the Turbine Horsepower Limit Controller will decrease. LSR2 and LSR1 will select the lower signal to override the Leaving Chilled Liquid Temperature Controller output and unload the chiller as described above. With the load reduced, the turbine will begin to speed up and the speed control PID will begin to close the governor valve, thus reducing the horsepower output of the turbine. While the Turbine Horsepower Limit Controller is active, the primary Leaving Chilled Liquid Temperature Controller is inactivated and its output is set to equal the appropriate tieback, thus providing a bumpless transfer to normal leaving chilled liquid temperature control. After the turbine horsepower has not exceeded the set point for 5 seconds, the Leaving Chilled Liquid Temperature Controller is reactivated and its' PID algorithm begins controlling the output at the tieback value.

VARIABLE SPEED CHILLER CAPACITY CONTROLS OPERATION

During operation, the speed, vanes and hot gas valve are controlled by the output of a single PID controller that responds to changes in the leaving chilled liquid temperature. The Capacity Ratchet Mode Selector directs the controllers output to the appropriate controlled device depending on system load and system pressure differential (condenser minus evaporator pressure). During off design operation, the outputs of the high condenser pressure, low evaporator pressure and torque limiting override PID controllers are also directed to the appropriate device to maintain stable operation and prevent the chiller from shutting down. The tuning of the primary Leaving Chilled Liquid Temperature, Evaporator Pressure and Condenser Pressure PID controllers is automatically adjusted to match the response time of the process depending on the device being controlled. To achieve maximum efficiency at part load conditions, the unloading sequence is speed reduction, vane closure, and hot gas valve opening.

NOTE

Refer to the YST OptiView™ Control Logic Diagram (Capacity Control 1, Capacity Control 2, Capacity Control 3, and Capacity Ratchet Mode Selector Diagrams) along with the following paragraphs for a more detailed description of the operation. If any of the speeds, ramp rates, or time delays described in the following paragraphs are adjustable, the factory default values are show for clarity. Refer to the OptiView™ Control Center Operation Manual Form 160.67-O1 for details on adjustable setpoints.

VARIABLE SPEED CHILLER LOADING SEQUENCE

Hot Gas Mode

The chiller is started with the Leaving Chilled Liquid Temperature Controller inactive and the hot gas control signal at 100%. When the ramp-to-rated speed is initiated, the vane output signal is set to the minimum start-up value (PRVM). The chiller is first ramped up to the higher fixed rated speed set point to allow the speed control PID time to stabilize the speed prior to loading the chiller. This is done to avoid cycling the speed down into the critical speed range of the turbine as the governor is throttled during ramp up.

After the stabilization time delay has elapsed, the speed set point is ramped down to the minimum speed determined by the Minimum Speed Calculation to suite the measured pressure differential input. The Capacity Ratchet Mode Selector sets the Leaving Chilled Liquid Temperature Controller to the hot gas mode, the tuning parameters for hot gas control are loaded, and its output is set to the current hot gas control signal. The hot gas valve is ramped closed. As the system pressure differential (condenser minus evaporator pressure) increases, the outputs of the Minimum Speed and Minimum Vane Position Calculation will increase. The speed set point and vane control signals are immediately set to the higher values to prevent surging.

If the load is light and the leaving chilled liquid temperature decreases to within 2°F of the Leaving Chilled Liquid Temperature Controller set point, the controller becomes active, and its' PID algorithm begins modulating the hot gas valve to prevent overshooting of the set point as the chilled liquid loop is pulled down to design temperature.

PRV Mode

If the leaving chilled liquid temperature remains more than 2° F above the set point, the Leaving Chilled Liquid Temperature Controller will remain inactive and the hot gas valve will continue to be ramped closed. When the Capacity Ratchet Mode Selector detects a 0% HGV control signal to the actuator output, the tuning parameters for PRV control are loaded into the Leaving Chilled Liquid Temperature Controller and its' output is set to the current PRV control signal which will be equal to the higher of the minimum start-up value (PRVM) or the Minimum Vane Position Calculation output. The PRV will begin ramping open. As the system pressure differential increases, the output of the Minimum Speed Calculation will increase and the speed set point signal is immediately set to the higher value to prevent surging.

If the load is light and the leaving chilled liquid temperature decreases to within 2 °F of the Leaving Chilled Liquid Temperature Controller set point, the controller becomes active, and its' PID algorithm begins modulating the PRV to prevent overshooting of the set point as the chilled liquid loop is pulled down to design temperature.

Speed Mode

If the leaving chilled liquid temperature remains more than 2° F above the set point, the Leaving Chilled Liquid Temperature Controller will remain inactive and the PRV will continue to be ramped open. When the Capacity Ratchet Mode Selector detects a 97% PRV control signal, the tuning parameters for Speed control are loaded into the Leaving Chilled Liquid Temperature Controller and its' output is set to the current speed set point in % which will be equal to the higher of the minimum rated speed in % or the Minimum Speed Calculation output in %. The Leaving Chilled Liquid Temperature Controller becomes active, and its' PID algorithm begins modulating the speed set point to maintain the leaving chilled liquid temperature at set point.

VARIABLE SPEED CHILLER UNLOADING SEQUENCE

Speed Mode

If the load decreases, the output of the Leaving Chilled Liquid Temperature Controller will decrease. For the greatest efficiency, the speed must be reduced as much as possible prior to closing the compressor pre-rotation vanes. As the system pressure differential falls, the compressor is capable of stable operation with less refrigerant gas flow (lower minimum speeds). The Minimum Speed Calculation output signal to HSR4 provides a minimum speed to suite the measured pressure differential input. The Capacity Ratchet logic constantly monitors the Minimum Speed Calculation output signal to ensure that the chiller is always operating at the minimum speed possible while maintaining system stability.

PRV Mode

When the Leaving Chilled Liquid Temperature Controller output is equal to the Minimum Speed Calculation output signal, the Leaving Chilled Liquid Temperature Controller PID calculation is halted while the tuning parameters for PRV control are loaded and its' output is set to the current PRV control signal which would be 100% since the PRV signal would be at 100% while the speed is being controlled. The controller PID algorithm then begins modulating the PRV control signal to maintain the leaving chilled liquid temperature at set point. As the vanes are closed, the system pressure differential will decrease resulting in a lower output from the Minimum Speed Calculation.

The Capacity Ratchet logic will decrease the speed set point to the lower value after 30 seconds to maintain maximum efficiency of operation. If the system pressure differential increases, the output of the Minimum Speed Calculation will increase. The speed set point is immediately set to the higher value to prevent surging.

For the greatest efficiency, the compressor pre-rotation vanes must be closed as far as possible prior to opening the hot gas valve. The Minimum Vane Position Calculation output signal to HSR5 provides a minimum closure of the pre-rotation vanes to suite the measured pressure differential input. The Capacity Ratchet logic constantly monitors the Minimum Vane Position Calculation output signal to ensure that the chiller is always operating at the lowest PRV signal possible while maintaining system stability.

Hot Gas Mode

If the load continues to decrease, the output of the Leaving Chilled Liquid Temperature Controller will decrease. When the Leaving Chilled Liquid Temperature Controller output is equal to the Minimum Vane Position Calculation output signal, the Leaving Chilled Liquid Temperature Controller PID calculation is halted while the tuning parameters for HGV control are loaded and its' output is set to a value equal to 100% minus the current HGV control signal. This value would be 100% since the HGV signal would be 0% while the vanes are being controlled. The controller PID algorithm then begins modulating the HGV control signal to maintain the leaving chilled liquid temperature at set point.

If the load continues to decrease, the Leaving Chilled Liquid Temperature Controller output will begin decreasing from 100%. This signal is subtracted from 100% to provide the increasing signal required to open the HGV. As the HGV is opened, the system pressure differential will decrease resulting in lower outputs from the Minimum Speed Calculation and Minimum Vane Position Calculation. The Capacity Ratchet logic will decrease the speed set point and PRV control signals to the lower values after 30 seconds to maintain maximum efficiency of operation. If the system pressure differential increases, the outputs of the Minimum Speed Calculation and Minimum Vane Position Calculation will increase. The higher values are immediately moved into the speed set point and PRV control signal to prevent surging.

VARIABLE SPEED CHILLER OVERRIDE CONTROLLERS

High and Low Refrigerant Pressure

The Evaporator Pressure and Condenser Pressure controllers are inactive when the chiller is stopped with their outputs set to 100%. If the monitored parameter exceeds the set point of the controller during any abnormal operation when running at or above the minimum rated speed, the output of the appropriate controller is set to the tieback signal for the device currently being controlled before the controller is activated, thus providing a bumpless transfer to the override control.

If the monitored parameter exceeds the set point of the controller, the controller output will decrease. LSR1 will select the lower signal to override the Leaving Chilled Liquid Temperature Controller output and unload the chiller as described above using the Capacity Ratchet Mode Selector to direct the controllers output to the appropriate controlled device depending on system load and system pressure differential, thus preventing unsafe operation and an unnecessary shutdown.

While any override controller is active, the primary Leaving Chilled Liquid Temperature Controller is inactivated and its output is set to equal the appropriate tieback, thus providing a bumpless transfer to normal leaving chilled liquid temperature control. After the override controllers monitored parameter has not exceeded the set point for 5 seconds, the Leaving Chilled Liquid Temperature Controller is reactivated and its' PID algorithm begins controlling the output at the tieback value.

Turbine Governor Position Power Limiting

In some applications, during high load/pulldown conditions, the turbine may be capable of producing more horsepower than the compressor bearings are rated for. To provide protection for retrofitted chillers that do not have the ability to monitor turbine first stage pressure, the logic monitors the governor valve actuator output from the chiller panel as done on previous chillers.

The Governor Position Controller is inactive when the chiller is stopped with its' outputs set to 100%. When the chiller is running at or above the minimum rated speed, if the integrated speed control PID attempts to open the governor valve more than a preset value (determined by field testing at start up), the output of the Governor Position Controller will decrease.

LSR2 and LSR1 will select the lower signal to override the Leaving Chilled Liquid Temperature Controller output and unload the chiller as described above using the Capacity Ratchet Mode Selector to direct the controllers output to the appropriate controlled device depending on system load and system pressure differential. With the load reduced, the turbine will begin to speed up and the speed control PID will begin to close the governor valve, thus limiting the torque output of the turbine.

While the Governor Position Controller is active, the primary Leaving Chilled Liquid Temperature Controller is inactivated and its output is set to equal the appropriate tieback, thus providing a bumpless transfer to normal leaving chilled liquid temperature control. After the load is reduced sufficiently to return the governor valve to a safe position for 5 seconds, the Leaving Chilled Liquid Temperature Controller is reactivated and its' PID algorithm begins controlling the output at the tieback value.

Turbine Horsepower Limiting

All new YST chillers are provided with a transmitter to monitor the turbine first stage pressure. This pressure is used along with the steam inlet pressure and temperature and the turbine exhaust pressure to calculate the turbines power output.

A separate PID controller is provided to unload the chiller when the turbine power approaches the maximum that the compressor bearings are rated for or 115% of the turbine design horsepower, whichever is lower. The logic will calculate the actual horsepower based on the steam inlet temperature and pressure so that the override controller automatically adapts to fluctuations in the quality of the steam supplied to the turbine inlet.

If the calculated horsepower increases above the set point, the output of the Turbine Horsepower Limit Controller will decrease. LSR2 and LSR1 will select the lower signal to override the Leaving Chilled Liquid Temperature Controller output and unload the chiller as described above.

With the load reduced, the turbine will begin to speed up and the speed control PID will begin to close the governor valve, thus reducing the horsepower output of the turbine. While the Turbine Horsepower Limit Controller is active, the primary Leaving Chilled Liquid Temperature Controller is inactivated and its output is set to equal the appropriate tieback, thus providing a bumpless transfer to normal leaving chilled liquid temperature control.

After the turbine horsepower has not exceeded the set point for 5 seconds, the Leaving Chilled Liquid Temperature Controller is reactivated and its' PID algorithm begins controlling the output at the tieback value.

OPERATING LOG SHEET

A permanent daily record of system operating conditions (temperatures and pressures) recorded at regular intervals throughout each 24 hour operating period should be kept.

An optional status printer is available for this purpose or *Figure 9 on page 44* shows a log sheet used by Johnson Controls personnel for recording test data on chiller systems. It is available from the factory in pads of 50 sheets each under Form 160.44-F7 and may be obtained through the nearest YORK office. Automatic data logging is possible by connecting the optional printer and programming the DATA LOGGER function. *See Form 160.67-O1, Section 3 - Printers for additional information.*

An accurate record of readings serves as a valuable reference for operating the system. Readings taken when a system is newly installed will establish normal conditions with which to compare later readings.

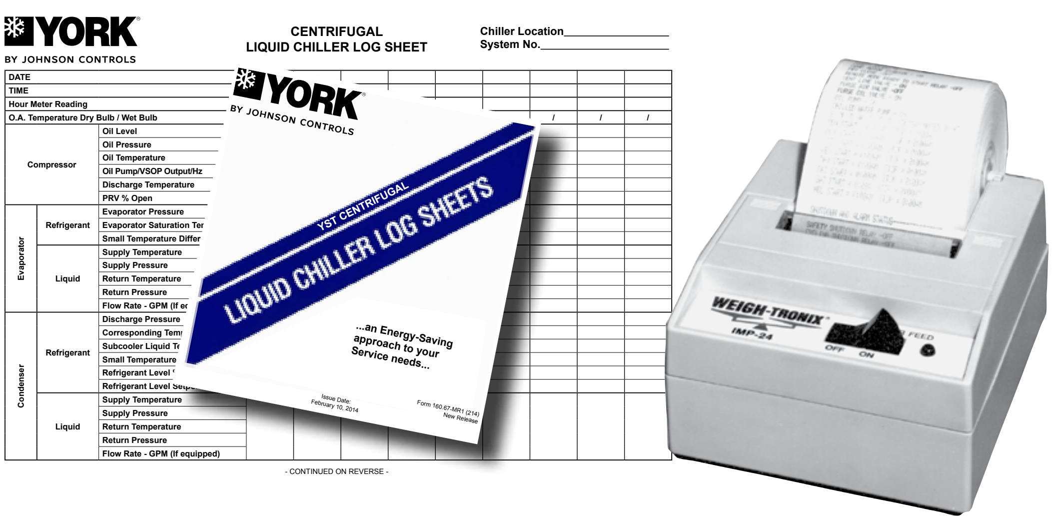
For example, an increase in condenser approach temperature (condenser temperature minus leaving condenser water temperature) may be an indication of dirty condenser tubes.

OPERATING INSPECTIONS

By following a regular inspection using the display readings of the Microcomputer Control Center, and maintenance procedure, the operator will avoid serious operating difficulty. The following list of inspections and procedures should be used as a guide.

Daily

1. Check OptiView™ Control Center displays.
2. If the compressor is in operation, check the bearing oil pressure on the **COMPRESSOR** Screen. Also check the oil level in the oil reservoir. Operating oil level should be in the "Operating Range" identified on the vertical oil level indicator label . Drain or add oil if necessary.
3. Check entering and leaving condenser cooling liquid pressure and temperatures for comparison with job design conditions. Condenser liquid temperatures can be checked on the **SYSTEM** Screen.
4. Check the entering and leaving chilled liquid temperatures and evaporator pressure for comparison with job design conditions on the **SYSTEM** Screen.
5. Check the refrigerant condenser saturation temperature (based upon condenser pressure sensed by the condenser transducer) on the **SYSTEM** Screen.
6. Check the compressor discharge temperature on the **SYSTEM** Screen. During normal operation discharge temperature should not exceed 220°F (104°C).
7. Check for any signs of dirty or fouled condenser tubes. (The temperature difference between water leaving condenser and saturated condensing temperature should not exceed the difference recorded for a new unit by more than 4°F (2.2°C).
8. Complete a visual inspection of the Turbine for external damage or leaks.
9. Inspect the Turbine for unusual vibration or noise.
10. The turbine oil temperatures should be checked several times a day. On KG turbine design oil temperature in the bearing oil should be between 130° and 180°F (54°C - 82°C). Cooling water flow should be adjusted to maintain this range. On KD turbines the oil supply from the oil cooler to the turbine bearings should be between 110° - 120°F, (38°C - 49°C). Adjust cooling water as necessary.
11. Check oil pressures on the KD turbine lubrication system every one or two hours.
12. Check The Turbine Oil Level And Oil Condition:



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*__NOTE:__ These items can be printed by an electronic printer connected to the Microboard and pressing the **PRINT** key on the Keypad, or automatically using the Data Logger feature.

FIGURE 9 - LIQUID CHILLER LOG SHEETS

Ring Oil Lubrication

The oil level gauge on the side of the bearing housing indicates the oil level. A mark inscribed on the lower-half bearing housing indicates the proper oil level. Oil levels in both bearing housings should be checked daily. Always use a strainer when adding oil to the systems and cover the fill connection when finished. If there is any reason to suspect water in the oil, open the low point drain in each bearing housings slightly. If water is present, it will be the first thing to come out of the drain. Low point drains in the bearing housing should be checked weekly for water.

CAUTION

The presence of oil in the constant level oilers does not necessarily mean that oil in the bearing housings is at the proper level. CLEANLINESS is ESSENTIAL for long and trouble free service from the BEARINGS. Care must be taken to ensure that no foreign material enters bearing housings or constant level oilers when performing maintenance, checking oil, adding oil, or making adjustments.

Pressure Lubrication

Always keep the proper oil level in the sight gauge on the oil reservoir that is an integral part of the turbine base. The system must supply continuous lubrication to all contact surfaces. **The Oil Level Should Be Checked At Least Once A Day Or Every 8 Hours If The Turbine Operates 24 Hours A Day.** Normally, a small amount of oil (of the recommended type and viscosity) should be added between oil changes to maintain the proper oil level. Always use a strainer when adding oil to the systems and cover the fill connection when finished.

CAUTION

Water gives oil a milky appearance, and it has a tendency to settle at the bottom of the reservoir when the turbine is not running. If there is any reason to suspect water in the oil, open the reservoir drain slightly. If water is present, it will be the first thing to come out of the drain. Refer to SECTION 4 - OPERATIONAL MAINTENANCE to determine the possible cause and procedure to follow.

13. Observe if steam is venting from gland leak-off line. If the amount of steam is excessive and condenssate is draining from the exhaust end gland, the seals should be replaced.
14. Observe supply pressure from pressure reducing valve for air in bearing seal air purge piping to bearing housings.

Weekly

1. Check the refrigerant charge. (See "Checking The Refrigerant Charge", Section 6 of this manual.)
2. Leak check the entire chiller.
3. Check the KD Turbine Auxiliary Oil Pump Operation.
4. Check the compressor oil pump operation.
5. Test the KD turbine manual overspeed trip valve. To do this, use the SOFT SHUTDOWN key and allow the control panel to unload the chiller. Then use the hand trip knob (See *Figure 12 on page 54*) to manually activate the 3 way Trip Valve and shutdown the turbine.
6. On KG turbines check the low point drains in the bearing housings for presence of water.
7. Check the shafts for dirt, oil, or grease buildup.
8. Check the water seal ring on the steam condenser relief valve.
9. Check the liquid ring vacuum pump on the steam condenser package.

Monthly

1. Test the turbine mechanical overspeed trip device by slowly running the turbine up to 110% of design maximum speed. See the OptiView™ Control Center Operation manual, form 160.67-O1 for the Overspeed Test Procedure using the Auto/Manual Screen.
2. On the KG steam turbine, (has no oil filter), change the oil in the bearing housings monthly, more often if oil analysis indicates a need to, or if it is suspected contaminants have gotten in the oil.
3. Check Hotwell Condensate Pump and Operation
4. Check Hotwell Condensate Pump seals.
5. Check Hotwell liquid level and operation of control valves.

Quarterly

1. Perform chemical analysis of oil for KG turbine models.

2. Clean all linkage systems and inspect for wear. On the turbine, clean and oil or grease all the moving parts (fulcrum points). For units with inlet operating temperatures above 500 F a high temperature grease (DuPont Krytox) is required for lubrication on linkage parts.

Semi-Annually (or more often as required)

1. Remove and inspect turbine journal and thrust bearings.
2. Change and inspect compressor oil filter.
3. Check controls and safety cutouts.
4. Check the steam turbine sentinel warning valve and steam condenser relief valve to ensure they are operational. The relief valve should start opening when the sentinel valve opens and should be completely open when the pressure in the turbine casing is 10% above normal pressure.
5. Inspect and clean coupling between turbine and compressor. Disassemble and inspect thoroughly if any question about reliability
6. Operate the turbine without load and inspect governor operation. Check for excessive vibrations.
7. Check the effectiveness of all steam condensate drains.
8. On compressor oil return system:

   Change dehydrator.

   Check nozzle of eductor for foreign particles.

Annually (more often if necessary)

NOTE

If quarterly inspection indicates oil is fine, replacing the oil is not necessary.

1. Drain and replace the oil in the compressor oil sump. (See "Oil Charging Procedure" Section 4 of this manual.)
2. Evaporator and Condenser.
   a. Inspect and clean water strainers.
   b. Inspect and clean tubes as required.
   c. Inspect end sheets.
3. Inspect and service electrical components as necessary.
4. Perform refrigerant analysis.
5. Remove and clean the Steam Strainer on the Turbine, refer to the product specific Service manual for instructions.
6. Inspect turbine shaft seals.
7. Check thrust bearing end play.
8. Remove and check the operation of the turbine Sentinel Warning Valve, refer to the product specific Service manual for instructions.
9. Drain and Clean KD turbine Oil Reservoir. Change oil filter with oil change.
10. Clean the steam governor valve according to product specific Service instructions.
11. Perform Oil Analysis on the KG turbine design. Change the oil.
12. Check and recalibrate pressure gauges. Check all level indicating devices and clean as necessary.
13. Inspect and Clean tubes as necessary in all water cooled heat exchangers on the system.

3 Year

1. Open and inspect turbine internals. Refer to SECTION 6 - TURBINE INTERNAL INSPECTION and SECTION 7 - STEAM PURITY/ TURBINE DEPOSITS for additional information.
2. Inspect the rotor, blades and nozzles for pitting and damage.
3. Inspect the Labyrinth Seals
4. Inspect the bearings for signs of excessive wear.
5. Inspect the End Seals

NEED FOR MAINTENANCE OR SERVICE

If the system is malfunctioning in any manner or the unit is stopped by one of the safety controls, consult the "Operation Analysis Chart", *Table 2 on page 68*, Section 5 of this manual. After consulting this chart, if you are unable to make the proper repairs or adjustments to start the chiller or the particular trouble continues to hinder the performance of the unit, please call the nearest Johnson Controls District Office. Failure to report constant troubles could damage the unit and increase the cost of repairs.

SYSTEM SHUTDOWN

The following are methods for stopping the YST system;

- Normal (Controlled) Stop - The chiller is unloaded prior to the actual de-energizing of the turbine trip solenoid to shutdown the turbine. This is done by pressing the SOFT SHUTDOWN key on the HOME screen.
- Immediate Stop - The turbine trip solenoid is de-energized as soon as the keypad switch is put in the (O) STOP/RESET position.

Refer to STOPPING THE SYSTEM in Section 2 of this manual for more detailed instructions.

PROLONGED SHUTDOWN

If the chiller is to be shut down for an extended period of time (for example, over the winter season), the following instructions outline the procedures to be followed.

1. Test all system joints for refrigerant leaks with a leak detector. If any leaks are found, they should be repaired before allowing the system to stand for a long period of time.

   During long idle periods, the tightness of the system should be checked periodically.

2. If freezing temperatures are encountered while the system is idle, carefully drain the cooling water from the cooling tower, refrigerant condenser, steam condenser, condenser water pump, and the chilled liquid system-chilled liquid pump and coils.

   Open the drains on the evaporator and condenser liquid heads to assure complete drainage.

3. On the **SETUP** Screen, disable the clock. This conserves the battery.
4. Open the main disconnect switches on the Power Panel, condenser water pump, and chilled liquid pump motor starters. Turn the compressor oil heater protector disconnect switch and all motor protector disconnect switches in the Power Panel to the "OFF" position.

Turbine Off-Season Storage

Many YST chillers are used as "seasonal machines", being out of service for as many as six to eight months of the year. During the off-season, many turbines are subjected to moisture and contaminants that will shorten the life expectancy of the machine. The turbine must be protected from corrosion internally with a vapor type of corrosion inhibitor introduced in crystal form or clean dry air/nitrogen purge.

2

The following suggested preventative maintenance procedures will greatly reduce the possibility of damage to the turbine due to off-season storage. Frequent inspections, both internal and external, for evidence of rust should be made. Cleaning and reapplication of preventatives may be necessary.

Turbine Steam Path

The following procedures are recommended to prevent off-season deterioration of the steam path:

- Gland cases should be opened, dried and inspected. If gland cases do not have removable covers, low pressure air may be blown through drain lines to assist in drying the gland area.

  The Gland leak-off connection should be capped to prevent moisture from re-entering the turbine.

  For extended storage, the carbon rings should be removed to prevent pitting of the shaft that may occur due to any condensation.

- Warm, dry air may be circulated through the turbine to remove moisture from the steam path. Air may be introduced through some other casing opening such as a hand-valve boss.

  The air can be exhausted through the exhaust flange, vacuum breaker, port or casing drains.

- Steam inlet and exhaust valves (non-condensing turbine only) must be tightly closed to provide a positive shut-off or disconnected to prevent steam entering the turbine.

NOTE

A pressure relief valve must be installed between the exhaust flange and exhaust line positive shut-off valve on non-condensing turbines.

- Several types of rust preventatives are available and can be placed into the turbine casing to help keep the turbine dry. If this type of corrosion inhibitor is used the main steam inlet and exhaust connection must be sealed off with blank flanges (wood or metal) to prevent the loss of the vapor inhibitor.

- Electric magnetic heaters can be applied to the casing to help keep the turbine dry.
- The turbine rotor should be rotated 450° once a week to eliminate any permanent bowing. Bearings must receive lubrication before this is done.
- All valves need to be exercised.

Turbine Lubrication System

The following procedures are recommended for preparing the lubrication system for off-season storage:

- The complete lubrication system must be drained and cleaned. NEVER STORE A TURBINE WITH OLD OIL IN IT. Contaminants in the oil may cause the turbine shaft to become etched under the journal bearings.
- All low points in the lubrication system should be checked for moisture and cleaned as required. Low points include bearing cases, power cylinders, drive gear cases, pilot valves, oil reservoir, etc.
- Fresh oil should be circulated through the lubrication system prior to storage.
- Cooling water to oil coolers should be positively shut off or disconnected. Drain water from cooler if freezing temperatures are expected.

Other Recommendations

If the turbine is to be idle for a period longer than eight months, Johnson Controls Service office should be consulted as to the proper storage procedures. Any other questions or concerns regarding off-season storage should be directed to the Johnson Controls Service office.

Steam Condenser Off-Season Storage

The following procedures are recommended for preparing the steam condenser system for off-season storage:

- If freezing temperatures are expected, the complete system including all pumps and piping must be drained. Fill the vacuum pump(s) with rust inhibited 50% ethylene glycol solution. Every 4 weeks, rotate the motor by hand at the external fan.
- If system is not drained and filled with a storage solution, the vacuum and condensate pumps should be run for a short period every 4 weeks during the off season. Prior to operating the pumps, prepare the valves as described above under PRE-STARTUP PROCEDURES – INITIAL AND AFTER LONG TERM SHUTDOWN.

SECTION 3 - SYSTEM COMPONENTS DESCRIPTION

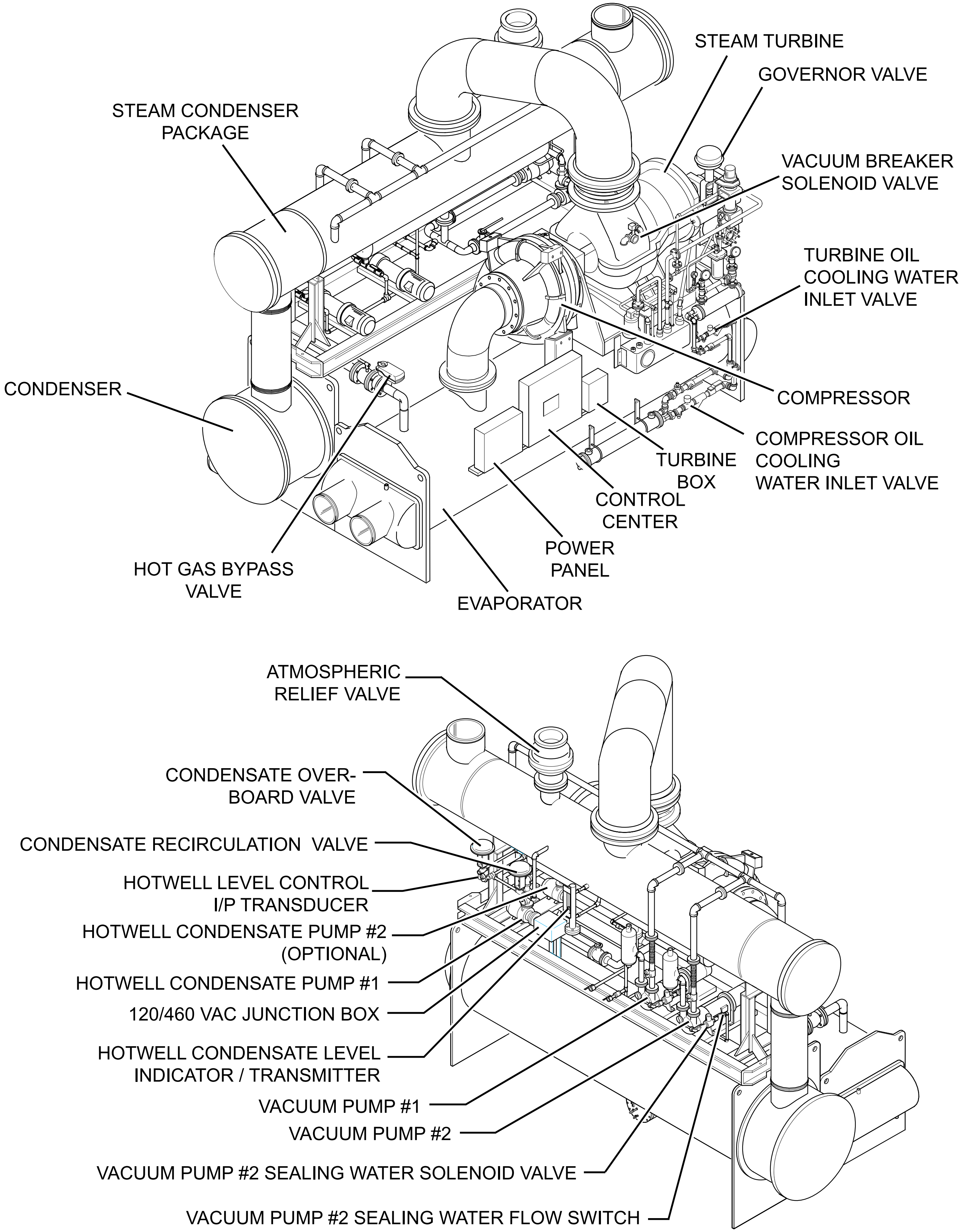


FIGURE 10 - SYSTEM COMPONENTS

GENERAL

The YORK Model YST Centrifugal Liquid Chiller Unit is completely factory-packaged including; the evaporator, refrigerant condenser, compressor, steam turbine, lubrication systems, power panel, control center, and all interconnecting unit piping and wiring. The steam condenser package is shipped separately and suitable for direct mounting onto the chiller or mounting along side the chiller. (Refrigerant and oil charges shipped separately unless optional condenser isolation valves are ordered.)

Chillers can also be shipped dismantled when required by rigging conditions, but generally it is more economical to enlarge access openings to accommodate the factory assembled unit. Chillers shipped dismantled MUST be field assembled under the supervision of a Johnson Controls representative, but otherwise installation will be as described in this instruction.

COMPRESSOR VARIABLE GEOMETRY DIFFUSER (VGD)

Certain YORK compressors are equipped with a Variable Geometry Diffuser (VGD). It is used to reduce rotating stall conditions and associated stall noise. Stall may occur at low load conditions with high head. A mechanical ring, located in the diffuser passage after the impeller discharge, is mechanically operated through linkages via an electric actuator like that used to operate the pre-rotation vanes. It is closed (extended) to narrow the diffuser gap. It is opened (retracted) to open the diffuser gap. An internal actuator end switch prevents travel beyond the fully open or closed positions. In response to a stall condition, the ring is closed as much as necessary to eliminate the stall. Since stall is caused by reduced gas flow through the compressor, narrowing the diffuser gap reduces the cross sectional area through which the gas flows, thereby increasing the gas velocity through the compressor.

A stall pressure transducer mounted in the discharge scroll of the compressor, detects the pressure pulsations created by the stall noise in the compressor discharge and outputs DC voltage pulsations to the stall detector board in the OptiView™ Control Center. This board converts the voltage pulsations into an analog voltage that represents the magnitude of the stall noise. This analog voltage is displayed on the Variable Geometry Diffuser Screen as "Stall Detector Voltage" and is input to the Microboard where it is compared to the Low Limit and High Limit setpoint thresholds to determine if the stall noise is acceptable or unacceptable. The control logic manipulates the VGD actuator as necessary to eliminate the stall noise. *Refer to the OptiView™ Control Center Service Instructions Form 160.67-M1 for additional details.*

COMPRESSOR LUBRICATION SYSTEM

To provide the required amount of oil under the necessary pressure to properly lubricate these parts, a motor driven submersible oil pump is located in a remote oil sump.

Lubrication oil is force-fed to all bearings, gears and rotating surfaces by the variable speed drive pump which operates prior to startup, continuously during operation and during coastdown.

There are main points within the unit which must be supplied with forced lubrication as follows:

1. **Compressor Drive Shaft (Low Speed)**
   a. Shaft seal.
   b. Front and rear journal bearings – one on each side of driving gear.
   c. Low speed thrust bearing (forward and reverse).
2. **Compressor Driven Shaft (High Speed)**
   a. Forward and reverse high speed thrust bearing.
   b. Two journal bearings.
3. **Speed Increasing Gears**
   a. Meshing surfaces of drive and pinion gear teeth.

There is a price option to add dual oil filters on both the compressor and KD steam turbine. (The KG turbine has no oil filter.) This provides the capability of changing the oil filters while the system is in operation. The external oil sump is vented to the compressor suction to permit refrigerant gas that is boiled off by the electric heater in the oil to equalize back to the system.

3

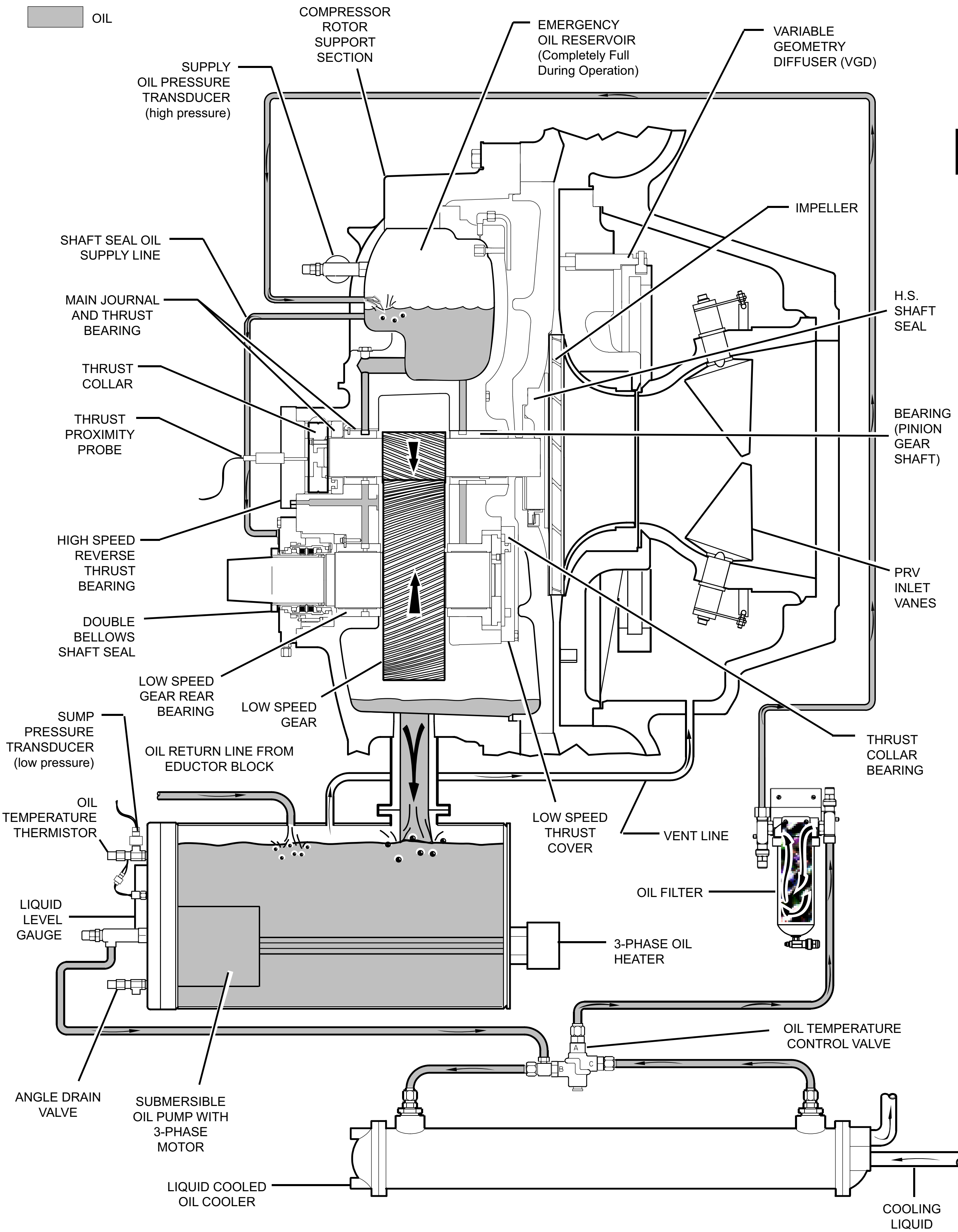


FIGURE 11 - SCHEMATIC DRAWING – (YST) COMPRESSOR LUBRICATION SYSTEM

COMPRESSOR OIL PUMP

The compressor oil pump operation is automatically controlled from the panel. On startup this pump is started automatically before the turbine is energized to establish positive lubrication and sufficient oil pressure. For normal operation the compressor oil pump should operate at all times during chiller operation. On shutdown of the system for any reason, (except power failure) the compressor oil pump will continue to run until 35 seconds after the turbine has coasted to a stop.

The submerged oil pump takes suction from the surrounding oil and discharges it to the oil cooler where heat is rejected. The oil flows from the oil cooler to the oil filter. The oil leaves the filter and flows to the emergency oil reservoir where it is distributed to the compressor bearings. The oil lubricates the compressor rotating components and is returned to the oil sump.

There is an emergency oil reservoir located at the highest point in the lubrication system internally in the compressor. It provides a gravity fed oil supply to the various bearings and gears in the event of a system shutdown due to power failure. The reservoir, located on the top of the compressor, allows the oil to be distributed through the passages by gravity flow, thus providing necessary lubrication during the compressor coastdown.

COMPRESSOR OIL HEATER

During long idle periods, the oil in the compressor oil reservoir tends to absorb as much refrigerant as it can hold, depending upon the temperature of the oil and the pressure in the reservoir. As the oil temperature is lowered, the amount of refrigerant absorbed will be increased. If the quantity of refrigerant in the oil becomes excessive, violent oil foaming will result as the pressure within the system is lowered on starting. This foaming is caused by refrigerant boiling out of the oil as the pressure is lowered. If this foam reaches the oil pump suction, the bearing oil pressure will fluctuate with possible temporary loss of lubrication, causing the oil pressure safety cutout to actuate and stop the system.

! NOTE

The oil heater is automatically controlled by the control panel at all times during shutdown, slow roll and ramp up to rated speed to maintain the oil temperature in the oil reservoir at a target value which is 50°F above the condenser refrigerant saturation temperature. It is turned on at 4°F below the target value and off at 3°F above the target value. To prevent overheating the oil, the heater has an integral thermostat that opens at 180ºF. The Heater is disabled when "SYSTEM RUN" is displayed.

STEAM TURBINE

The steam turbine is a high efficiency multistage design operating at a nominal 4500 rpm design maximum speed.

The turbine is packaged on a driveline base, completely factory piped. The driveline base has a mating flange on shaft end of the package that will bolt directly to the compressor D-flange face providing a rigid interface between turbine package and compressor. Complete turbine/compressor driveline is factory aligned prior to shipment. Turbine drive shaft is directly connected to the compressor shaft with a flexible disc coupling. Coupling is of an all metal construction with no wearing parts assuring long life and no lubrication requirements providing low maintenance.

The turbine casing is horizontally split designed to allow longitudinal thermal expansion without the affecting alignment or efficiency of the turbine. The shaft and wheels are alloy steel with the wheels shrunk and keyed to the shaft. The turbine blades are 403 grade stainless steel and the shaft is ground throughout with stainless steel sprayed in the carbon ring end gland contact area. Stainless steel nozzles are furnished throughout the turbine. Carbon ring end gland and diaphragm seals are furnished. Turbine end gland carbon ring seals (minimum five seals per end gland) are separated by partitions of stainless steel.

A stainless steel, inlet steam strainer with adequate size and mesh to minimize the pressure drop is supplied. Strainer is removable without breaking the steam piping connections.

Blanket insulation is furnished on the steam chest and barrel of the turbine for operator protection.

The turbine speed is controlled by a governor valve which is integrated with the chiller controls. The valve is made of stainless steel with stainless steel seats and designed to control flow throughout the entire operating range of the turbine. The system employs an overspeed governor designed to close an independent high performance butterfly trip valve with a pneumatic actuator when the turbine speed exceeds 110 percent of the maximum continuous operating speed of the turbine. Activation of the independent trip valve activates a limit switch on the trip valve linkage which is connected to the chiller control center to initiate a shutdown sequence and close the governor valve.

STEAM TURBINE INLET VALVES

The turbine requires a main steam block valve (supplied by others) for isolation which remains closed during the slow roll warm-up. This main block valve should also be supplied upstream of the automated valve (supplied by YORK) on Auto-Start design systems. A smaller valve called a slow roll bypass valve, bypasses the main block valve and is opened to begin the slow rolling warm-up. This valve is manual on standard systems and is an automated valve on systems with Auto Start. The main block valve is opened fully when operating speed is reached and the bypass valve is closed. See the *Sequence Of Operation on page 26* of this manual for more details.

NOTE

Chillers manufactured after December 2006 are NOT supplied with separate automatic slow roll bypass and main inlet steam valves.

For speed and overspeed control the turbine has two additional valves in the steam supply. Both are automatic valves. The governor valve is used to control the turbine speed automatically from the control panel. The other valve is the fast acting butterfly trip valve which is operated by the chiller control center, the mechanical overspeed device, or the manual trip device that can by actuated by the operator. Refer to the following TURBINE GOVERNOR AND OVERSPEED CONTROLS section in this manual for additional details.

TURBINE BEARINGS

The turbine bearings perform two functions. The journal bearings support the rotor's weight and the thrust bearings protect the turbine against any type of excessive axial displacement. These bearings are lubricated by a pressurized or ring oil lubrication system.

The journal bearings on all turbines are of the hydrodynamic type, which means they operate by means of an oil film between the contact surfaces to eliminate metal-to-metal contact. The bearings are steel backed, Babbitt lined, split sleeve type. The design is such that the bottom half is removable with the shaft in place. The normal clearances on the bearings are 0.005 to 0.007 inch for turbines with ring oil lubrication and 0.006 to 0.008 inch for turbines with pressure lubrication.

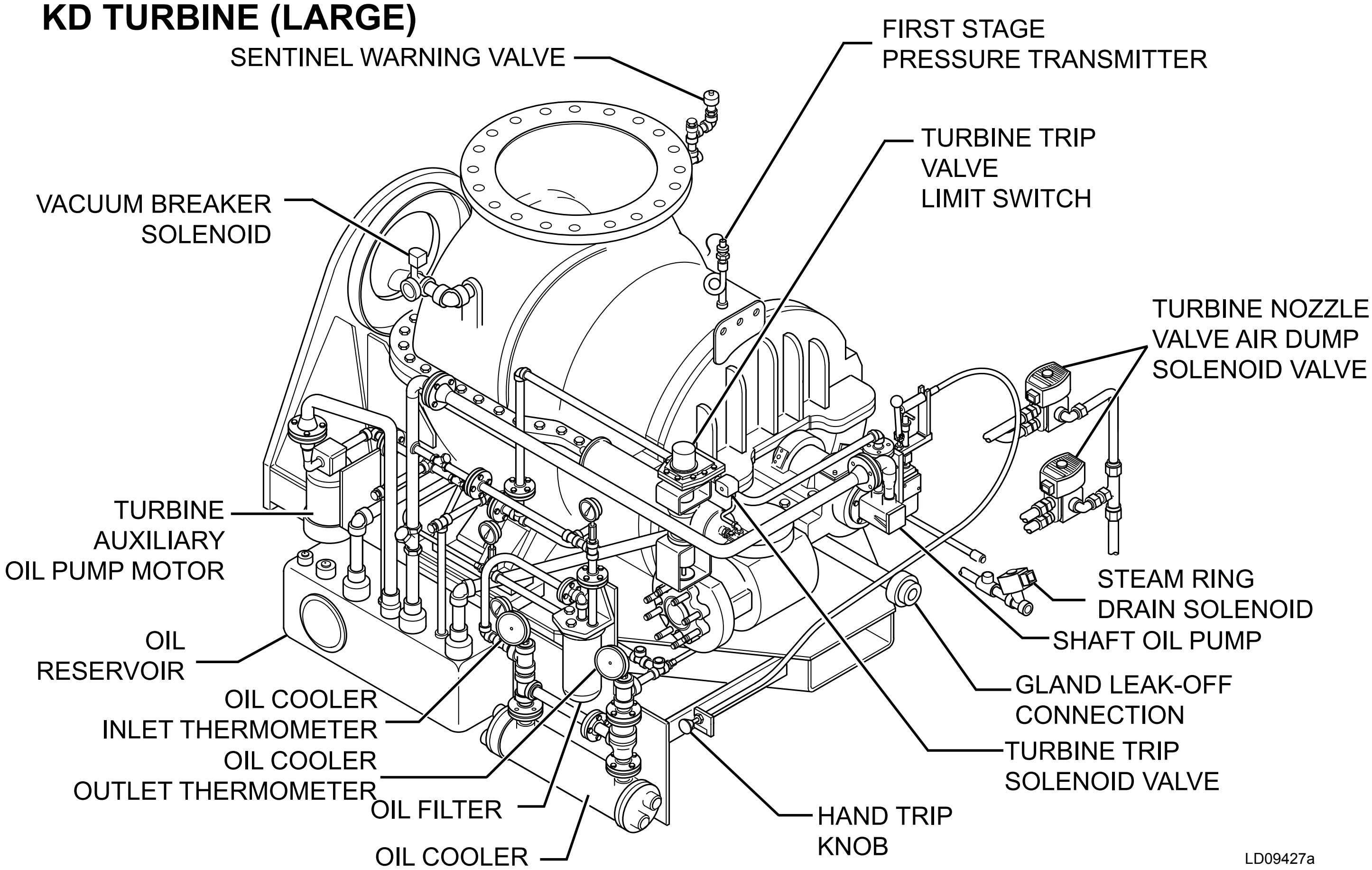
The thrust bearings on KD turbines are double acting thrust collars or multi-segmented tilting pad type. Thrust collars are simply two rings, one at each side of the journal bearing, holding the shaft in place. The multi-segmented tilting pad type is self-adjusting so that the thrust is equally divided among all the shoes on either side of the collar. The thrust bearing is accessible and removable without lifting the top half of the turbine casing.

The thrust bearings on KG turbines are antifriction ball bearings. They should be replaced each 20,000 hours or when indicated by vibrations. The thrust bearing is accessible and removable without lifting the top half of the turbine casing.

TURBINE LUBRICATION SYSTEMS

Two types of lubrication are supplied on steam turbines furnished on YST systems. The smaller turbine design, KG, has an integral lube system and is used for designs up to 1700 HP. The larger turbine design, KD, has an external lube system and is used for designs above 1700 HP.

KD TURBINE (LARGE)



KG TURBINE (SMALL)

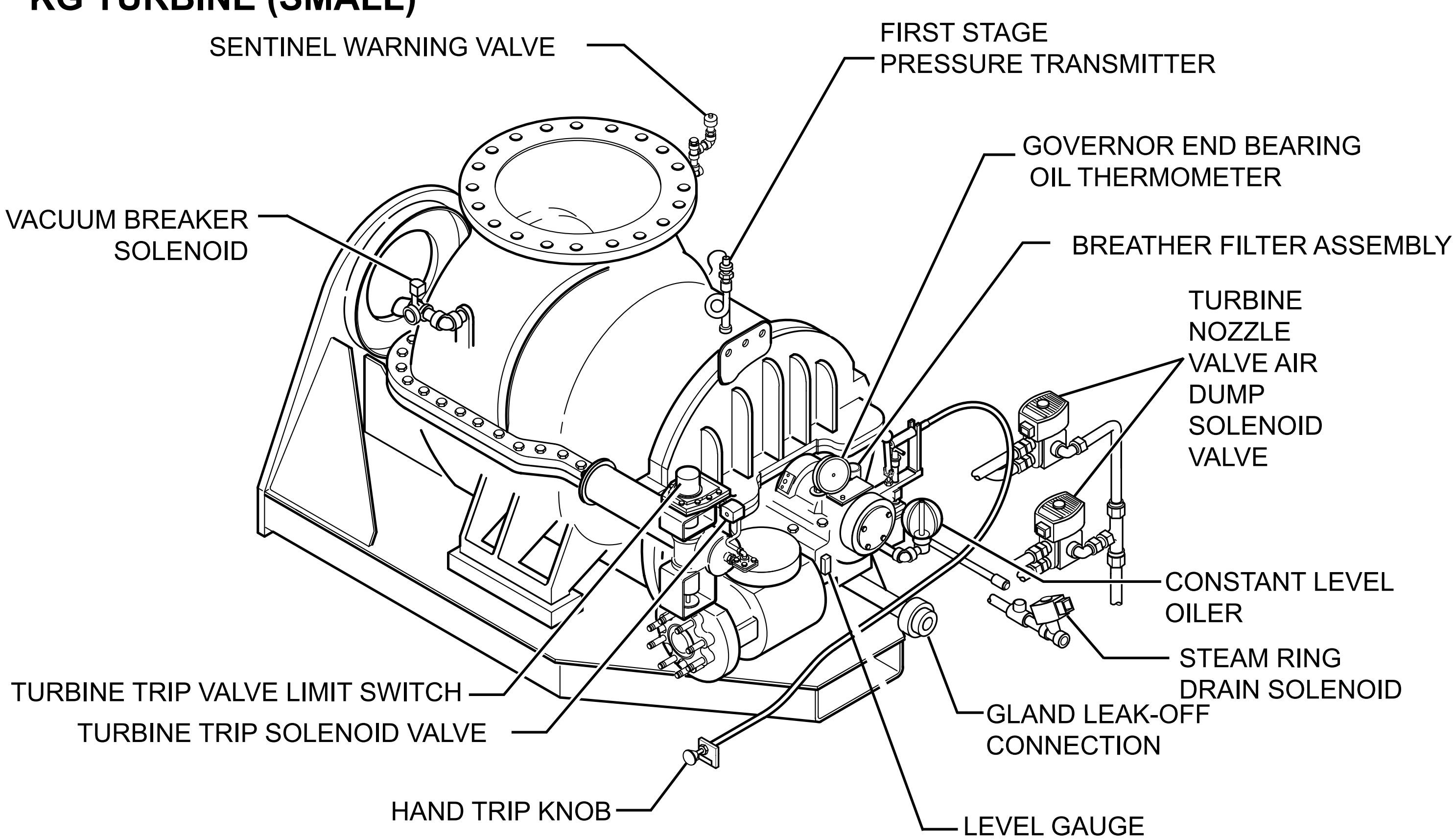


FIGURE 12 - KD & KG TURBINE DRAWING

KG Steam Turbine with Ring Oil Lubrication

The KG turbine models have an integral ring oil lubrication system built into the turbine. Brass oil rings running on the turbine shaft pick up oil from the reservoirs in the two bearing housings. As the shaft and rings rotate together, oil flows from the oil rings onto the shaft and ultimately into the bearings providing lubrication. The oil level in the bearing housing must be maintained at a sufficient level to allow the oil rings to run in the oil. An oil level that is too high results in oil leakage past the shaft seals. Oil rings cease to rotate sufficiently fast below 900 RPM to assure adequate lubrication. During startup, the automatic controls will shut the turbine down if the turbine does not achieve 1200 RPM within 100 seconds after the start is initiated, the turbine trip solenoid is energized, and rotation begins. See the *Startup Sequence Of Operation on page 31* of this manual for more details. The turbine does not have an oil pump, oil filter, external oil cooler, or an external oil reservoir. There are two bearing housings which are located on each end of the turbine shaft outboard of the gland seals. Bearing housings on the KG turbine are directly cooled with water. It is important that the valve in the cooling water outlet line be adjusted so that the temperature of the oil in the bearing housings does not drop below 130°F (54°C).

Cooling water must be supplied at 2 GPM (7.0 L/min) minimum, 90°F (32°C) maximum, and 150 PSIG (1035 kPaG) for the bearing housings.

CAUTION

Do not allow the COOLING WATER to COOL THE BEARING OIL SUMP TEMPERATURE to below 130°F (54°C), as this may interfere with the action of the oil rings or cause atmospheric moisture to condense in the oil reservoir.

The bearing housings are continuously purged during operation with instrument air that has been reduced in pressure by a pressure reducing valve. This air purge helps prevent contaminants such as steam from entering the bearing housing. The pressure reducing valve should be checked for maintenance and for outlet pressure from time to time.

KD Steam Turbine with External Pressurized Lube System

The lubrication system is external but completely factory assembled into the turbine driveline base. The KD steam turbines have a shaft mounted main oil pump. The external lubrication system includes an remote lube oil reservoir with level gauge, an open motor driven auxiliary oil pump, (not submersible as on the compressor oil pump), water cooled shell and tube oil cooler, (with copper tubes), 25 micron full flow oil filter, (dual oil filters available as a price addition). Oil temperature control is by a three way temperature control valve. The bearing housings are located on each end of the turbine shaft outboard of the gland seals. The bearing housings are continuously purged during operation with instrument air that has been reduced in pressure by a pressure reducing valve. This helps prevent contaminants such as steam from entering the bearing housing. The pressure reducing valve should be checked for maintenance and for outlet pressure from time to time.

KD Turbine Auxiliary Oil Pump

On startup, the KD turbine auxiliary oil pump is started automatically before the turbine is rotated and prior to the start of the compressor oil pump. After the turbine has been slow roll and ramped up to above 3000 RPM, if the turbine shaft driven oil pump is producing sufficient pressure above the set point of the auxiliary oil pump control logic, the auxiliary oil pump will be stopped. On shutdown for any reason, (except power failure) the auxiliary oil pump will be energized when the turbine slows to 3000 RPM and will continue to run until 30 minutes after the turbine has come to rest to remove excess heat from the bearings.

Turbine Gland Seal System

Gland seals are provided on both the high pressure inlet end and low pressure outlet end of the steam turbine to minimize the leakage of steam from the turbine or prevent the leakage of air into the turbine. The inlet steam pressure for standard YST turbines can be from 90 to 200 psig depending on the design for the particular job. The outlet steam pressure is below atmospheric, typically in the neighborhood of 1.5 PSIA. A small flow of steam through the gland seal is maintained to prevent condensation and a loss of seal in the gland. Additional details of the standard gland seal systems as well as those that could be supplied on non-standard applications such as non-condensing turbines and on turbines with inlet steam pressures above 200 PSIG are described in the following paragraphs.

Types of Gland Leak-Off Systems

Steam in non-condensing turbines tends to leak around the shaft since the pressure in the casing is greater than atmospheric. Leaks should be limited for the following reasons:

- Steam finds its way to the bearing housings, condenses there and contaminates the oil.
- Efficiency is reduced since escaped steam produces no useful work.
- Each pound of steam lost requires adding one pound of make-up water to the boiler.
- Excessive leaks cause an unpleasant working atmosphere.

The gland leak-off system for non-condensing applications and the gland seal system for condensing machines, are used to minimize leaks. This is achieved with a system that permits steam leakage where the gland seals make contact with the shaft, using the pressure differential between them as an effective seal. A leak-off connection, just before the exterior inactive seals, is designed so steam reaching that point will run through it instead of the seals.

Gland seals can either be of the segmented carbon ring type, the labyrinth type or a combination of both. Unless one of these two types is specifically mentioned in this section they will simply be referred to as “gland seals”.

NOTE

Carbon Ring Type Glands Have Excellent Sealing Capabilities When New But Are Subject To Wear. They Should Be Replaced Every One To Three Years. Note That They Lose Effectiveness When The Pressure Differential Is Excessive.

Usually, a single leak-off system is enough to seal those turbines operating with moderate temperatures and pressures. If a more effective seal is necessary, or if the working pressures are higher, a double leak-off system is used.

In these cases, leak-off connections closer to the casing (interior leak-offs) are connected to the same pipe and to a header with a steam pressure of 10-20 PSI (non-condensing turbine) or 1-5 PSI (for condensing machines). Exterior connections are either piped to the atmosphere or to an evacuation device.

The best system for any specific application depends upon the pressures involved, the required efficiency, and the availability of low pressure lines at the installation site.

Gland Seal System: Standard YST Condensing Turbines

Turbines are equipped with a gland seal system similar to that of non-condensing machines, although the function is different. The purpose of the sealing system is to keep outside air from leaking into the casing since it would reduce the vacuum and cause a loss of power. The system is not as effective when the machine is standing idle as when it is operating.

The exhaust pressure in the casing is always below atmospheric pressure. In the majority of condensing turbines, the casing pressure is also below atmospheric when operating without load but rises above atmospheric, in proportion to the increase in power, when a load is added. As load is applied, steam from the inlet gland will escape through the leak-off and supply sealing to the exhaust gland.

As the amount of steam moving through the leak-off connection rises, the excess leak-off steam is discharged to the atmosphere or some evacuation device.

Gland Seal Wear

As time goes on, the normal wear of the seals will result in more steam passing out the leak-off line to sewer. The steam required to seal the exhaust gland may go up some, but not as much as the increase in leakage from the steam gland. Eventually the seals will wear to the point where there will be more steam trying to leak to sewer than the line can handle without causing some backpressure on the seal steam header. This will cause condensate to start dripping from the exhaust gland. At that time, the leakage will be excessive from the steam gland and the seals should be replaced.

Gland Seal Leak-Off Piping

Where the rotor shaft passes through the turbine casing, packing glands of the segmented carbon ring or labyrinth type are provided. These have leak-off connections piped to a common point. **From This Point, The Customer Must Provide Suitable Piping Of A Size Indicated On The Outline Drawing.**

If it is necessary to run the pipe for a long distance the size should be increased so that back pressure does not build up on the packing gland. This pipe must slope down from the connection point to avoid forming a water trap and must not contain a shut-off valve.

A small amount of steam will pass through this line at all times. The amount of steam passing through the line will depend upon the amount of back pressure.

The leak-off steam is commonly piped to a sewer or open header. If this line becomes partially clogged, or the back pressure builds up for any reason, steam will blow out around the shaft at the packing gland.

Some machines may be equipped with an optional gland condenser which condenses the gland leakage as well as steam leaking from other leak-off connections. The condensate from this gland condenser can be returned to the feed water system.

Gland Leak-Off Condenser - Optional Supply by Special Quotation

This equipment may be specified for use on high backpressure applications, those turbines operating with a high pressure differential across the glands, and those which must operate for long periods of time between shutdowns (some low pressure turbines may also use this equipment).

The condenser is piped to the outer leak-off connections of the glands. It creates a slight vacuum on the outer leak-off areas, assuring that leakage will leave through leak-off piping and not past inactive seals.

The most common configuration is the gland condenser and ejector. The gland condenser is a shell-and-tube type heat exchanger in which cooling water is used to condense steam leakage from the glands. The ejector is a steam nozzle which creates a low pressure area to remove any air which has leaked into the system and thus maintains the vacuum in the leak-off areas.

This equipment is available for all types of leak-off flows, large or small. The condensed leakage steam and cooling water can be recovered and returned to the boiler. Note that the condenser tubes and ejector both require periodic cleaning.

Vacuum Breaker Solenoid Valve

The vacuum breaker solenoid valve is located on the turbine exhaust connection and is identified as FCV-173 on schematic drawings. This valve is closed during turbine operation and is opened at shutdown whether planned or emergency to allow air to enter the turbine exhaust piping and steam condenser to help slow the turbine more quickly by increasing the exhaust pressure on the turbine. The entrance of air into the system necessitates the operation of the vacuum pump to evacuate the air before the next startup may occur.

Steam Nozzle Valves

Steam nozzle valves are furnished to provide added efficiency as load conditions change on the turbine. The nozzle valves regulate the amount of steam and steam pressure entering the turbine. The turbine operates more efficiently at higher entering steam pressures since the flow is reduced at higher steam pressures. The turbine should not be run with the steam nozzle valves wide open all the time. This does not allow the turbine to have any backup power in case the load is increased relatively rapidly. The steam nozzle valves are manually adjustable on the standard system design with Manual Start. The valves are controlled automatically when the Auto Start design is furnished.

Sentinel Warning Valve

The sentinel warning valve is a small relief valve located on the turbine exhaust. It is not a true relief valve as it is too small but is used to provide a warning that turbine exhaust pressure has become too high. The valve is set to open at 5 psig on the standard YST Condensing Turbine. On a special non-condensing turbine it is set at 10-15 PSIG above the normal back pressure. The opening of this valve will release steam giving an indication of excessive pressure.

CAUTION

Do not under any circumstances pipe the discharge of the Sentinel Warning Valve away from the turbine.

If the valve leaks air into the system during normal operation it should be opened manually a few times to blow out any foreign material that may have collected around the seat. If this fails, the valve should be removed and repaired or replaced.

Steam Ring Drain

All YST chillers are provided with a tapped drain opening in the turbine steam ring for getting rid of excess moisture that accumulates in the steam ring when the turbine casing is cold at startup. The drain line is fitted with a check valve and solenoid valve. The line must be piped to a sewer or any other low point that permits the waste to drain off by gravity. The location of this opening is shown in top *Figure 12 on page 54*.

The steam ring drain solenoid valve remains energized (open) during the initial startup. The check valve in the steam ring drain line prevents air from being drawn into the turbine when the turbine steam ring drops below atmospheric pressure during the initial evacuation and while the turbine is slow rolling. When the inlet steam valves open to begin slow roll and during the ramp up to minimum speed, the steam ring will rise above atmospheric pressure and any condensate will be blown out of the turbine.

NOTE

On older manually started chillers, the steam ring drain is not automated. In this case, the steam ring drain valve must be manually opened at shutdown and closed after the turbine is slow rolling at initial start up.

On standard YST chillers with up-discharge turbine exhaust, an exhaust casing drain connection is supplied. The turbine must be supplied with a means of draining the casing during operation (while under vacuum). The standard Factory supplied option is an automatic pressure powered pump. Also available by special quotation is a condensate drain tank (manual or automatic). When either option is supplied, it is shipped loose for installation at the job site.

On non-condensing turbines with side-discharge turbine exhaust, there is no need for an exhaust casing drain since condensate cannot collect in the turbine exhaust end.

On any application where the exhaust piping bends upward after leaving the turbine, steam traps must be provided to keep the exhaust line drained to prevent water from building up in the exhaust pipe and turbine casing.

CAUTION

Failure to keep the exhaust line drained may result in a restriction in the exhaust line, causing a loss of power and damage to the turbine rotor.

Pressure Powered Condensate Drain Pump

A Factory supplied automatic pressure powered pump is provided for draining condensate from the steam turbine casing, during operation. The pressure power pump is shipped loose and all piping and installation is provided by others.

NOTE

An automatic pressure powered pump is supplied by Johnson Controls when the Auto-Start option is ordered.

Liquid enters the pump body through the inlet check valve causing the float to rise. As the chamber fills the valve changeover linkage is engaged opening the motive supply valve and closing the equalizing valve. As motive pressure is above the total back pressure, condensate is forced out through the outlet check valve into the return system.

CAUTION

Motive pressure for automatic pressure powered pumps cannot exceed a maximum of 200 PSIG (steam or air may be used). Application with higher pressure motive supply must use custom selected condensate drain equipment suitable for higher pressures.

As the liquid level falls within the pump, the float re-engages the valve changeover linkage causing the motive supply valve to close and the equalizing valve to open allowing condensate to re-enter through the inlet check valve and the cycle is repeated. Refer to YORK standard flow diagram for typical pressure pump piping installation.

All the piping associated with the installation of the Automatic Pressure Powered Pump is field provided and installed .

Condensate Drain Tank – Optional Supply by Special Quotation

When ordered, a Factory supplied condensate drain tank is provided for draining the condensate from the exhaust end of the steam turbine during operation. The tank is shipped loose and all piping and installation is provided by others.

The tank is provided with a high level alarm switch which is connected to the OptiView™ Control Center to signal the operator that the tank must be manually drained by closing and opening the appropriate valves to isolate the tank from the turbine during the draining process and allow the condensate to drain into the sewer. If the tank is automated, the tank is provided with a self contained control panel, float switches, and solenoid valves to control the draining isolation/draining process.

TURBINE GOVERNOR AND OVERSPEED CONTROLS

Protection from turbine overspeed is an important consideration and the following are four methods of protection against overspeed:

- Protection against overspeed is built into the automatic speed control for the chiller system. The turbine operating speed for capacity control is controlled by a governor valve that is integrated with the chiller controls. The governor valve is designed to control flow throughout the entire operating range of the turbine. If the speed sensed by the automatic controls exceeds the maximum speed of 4500 RPM it will automatically begin closing the governor valve. If the speed should continue to increase the controls will continue to send a signal to close the governor valve.
- If the automatic speed controls should fail to slow the turbine by closing the governor valve in an overspeed condition, the software overspeed logic will de-energize the turbine trip solenoid at a programmable setpoint that is usually set 50 RPM below the mechanical trip activation speed.
- A mechanical spring loaded overspeed device will trip at 110% of maximum design speed. This mechanical overspeed trip mechanism will immediately close the overspeed trip butterfly valve. The mechanical overspeed device is connected by mechanical linkage to a normally open 3 way trip valve in the instrument air supply to the actuator on the overspeed trip butterfly valve. The valve, a normally closed valve, will close when the supply air pressure is relieved.
- There is an overspeed trip that can be used by the operator in an emergency. This manual trip is activated by an emergency trip knob at the base of the turbine, that is connected to the same linkage as the mechanical overspeed trip. See *Figure 13 on page 60*.

HEAT EXCHANGERS

Evaporator and refrigerant condenser shells are fabricated from rolled carbon steel plates with fusion welded seams.

Heat exchanger tubes are internally enhanced type.

The evaporator is a shell and tube, flooded type heat exchanger. A distributor trough provides uniform distribution of refrigerant over the entire shell length. Stainless steel mesh eliminators or suction baffles are located above the tube bundle to prevent liquid refrigerant carryover into the compressor. A 2" liquid level sight glass is located on the side of the shell to aid in determining proper refrigerant charge. The evaporator shell contains dual refrigerant relief valves.

The refrigerant condenser is a shell and tube type, with a discharge gas baffle to prevent direct high velocity impingement on the tubes. A separate subcooler is located in the condenser to enhance performance. Dual refrigerant relief valves are located on condenser shells with optional isolation refrigerant isolation valves.

The removable compact water boxes are fabricated of steel. The design working pressure is 150 PSIG (1034 kPa) and the boxes are tested at 225 PSIG (1551 kPa). Integral steel water baffles provide the required pass arrangements. Stub-out water nozzle connections with Victaulic grooves are welded to the water boxes.

These nozzle connections are suitable for Victaulic couplings, welding or flanges, and are capped for shipment. Plugged 3/4" drain and vent connections are provided in each water box.

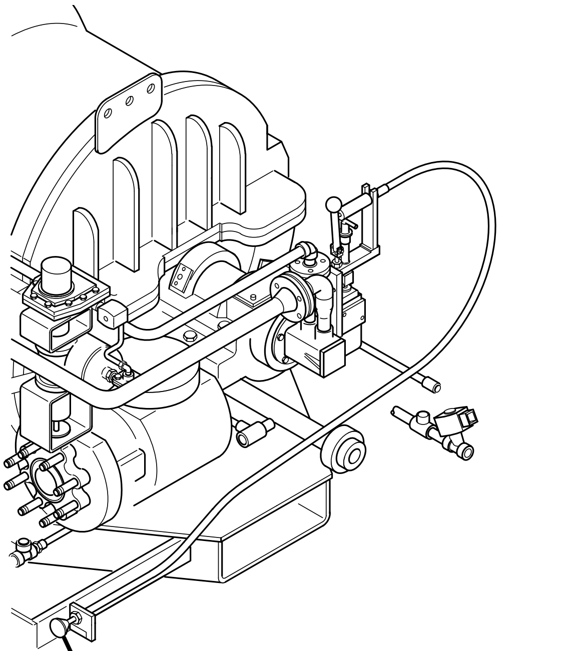


FIGURE 13 - OVERSPEED PROTECTION KNOB ASSEMBLY

REFRIGERANT FLOW CONTROL

Refrigerant flow to the evaporator is controlled by the Subcooler Level Control Valve.

A level sensor senses the refrigerant level in the condenser and outputs an analog voltage to the Microboard that represents this level (0% = empty; 100% = full). Under program control, the Microboard modulates an electrically actuated valve to control the condenser refrigerant level to a programmed setpoint. Other setpoints affect the control sensitivity and response. These setpoints must be entered at chiller commissioning by a qualified service technician. Only a qualified service technician may modify these settings.

When the chiller is shut down, the Subcooler Level Control Valve will be in the fully open position causing the sensed level to be approximately 0%. When the chiller is started the valve will remain fully open until the chiller has been running at or above the minimum rated speed for 10 minutes. At that time the subcooler refrigerant liquid level controller setpoint is ramped up to the desired setpoint at a rate of 0.1% per second. This causes the Subcooler Level Control Valve to slowly close until the refrigerant level in the subcooler is at the setpoint.

OPTIONAL SERVICE ISOLATION VALVES

If the chiller is equipped with optional service isolation valves on the compressor discharge and main liquid line to the evaporator, these valves must remain open during operation. These valves are used for isolating the refrigerant charge in either the evaporator or condenser to allow service access to the system. A separate refrigerant pump-out unit will be required to isolate the refrigerant.

NOTE

Isolation of the refrigerant in this system must be performed by a qualified service technician.

HOT GAS BYPASS

The hot gas bypass feature is furnished as a standard item. The hot gas bypass consists of a control valve in piping that conveys warm gas from the refrigerant condenser to the evaporator. The purpose of the hot gas is to provide the compressor with sufficient gas to operate smoothly at times when normal refrigerant gas flow is too low. The hot gas bypass is 100% open before startup and during the slow rolling operation to permit the compressor to operate smoothly as the system is being brought up to speed. The hot gas is also used during operation when loads are very light or when compressor head becomes too high. The OptiView™ control panel will automatically modulate the hot gas valve open and closed as required. Adjustment of the setpoints used by the hot gas bypass control logic must be performed by a qualified technician.

CAUTION

Changes in the minimum and maximum condenser water inlet temperature after initial commissioning of the chiller will require readjustment of the anti-surge setpoints to ensure proper operation of the Hot Gas Bypass Valve.

OPTIVIEW™ CONTROL CENTER

The OptiView™ Control Center is factory-mounted, wired and tested. The electronic panel automatically controls the operation of the unit in meeting system cooling requirements while minimizing energy usage. For detailed information on how the Control Center controls the start-up and shutdown of the chiller, refer to *Sequence Of Operation on page 26* of this manual and the *OPERATION MANUAL, Form 160.67-O1.*

POWER PANEL

All motor contactors and circuit protectors, the compressor oil pump variable speed drive and the control power transformer are contained in an enclosure installed adjacent to the OptiView™ control center. A main power disconnect switch is supplied which provides the termination points for customer's single point power supply wiring.

STEAM CONDENSER PACKAGE

The steam condenser system is furnished fully packaged. It consists of a steam condenser, single hotwell (condensate) pump and single vacuum pump which are standard, (with an option for standby pumps for both with automatic switchover controls), hotwell condensate level control system, and an atmospheric steam relief valve. The hotwell is the collection well under the steam condenser where condensate collects and serves as a reservoir for the hotwell pump. Condensate level in the hotwell is controlled by a level control system with two (2) pneumatic automatically controlled valves located in the hotwell pump discharge piping. One valve, (named as recirculation valve on drawings), is for recirculation back to the steam condenser and the other, (named as overboard valve on drawings), is for removal of condensate from the hotwell. This condensate is typically piped back to the boiler feedwater circuit.

The recirculation valve is used primarily during startup since very little steam is condensed and it is necessary to recirculate the condensate to ensure stable operation of the hotwell pump. As the turbine comes up to speed more and more condensate will be produced until at some point the operating level set point will be exceeded and the level control will modulate the overboard valve open and modulate the recirculation valve closed. Because the condensate in the hotwell is at saturation steam temperature/pressure the hotwell pump is subject to possible cavitation if the condensate level in the hotwell becomes too low. The hotwell pump requires a Net Positive Suction Head, (NPSH) of at least 2 feet. For this reason the level in the hotwell is very important. If the level is too low the pump will cavitate. If the level is too high some of the tubes in the condenser will be covered with condensate which will reduce the capacity of the condenser causing the exhaust pressure of the turbine to rise.

All key control and monitoring parameters are integrated with the chiller control panel. In addition, auxiliary pressure gauges are located at the condenser steam inlet and hotwell pump discharge piping. Temperature gauges are located at the steam inlet, cooling water inlet and outlet, and the hotwell.

Piping is fitted with unions at suitable break-points.

Steam Condenser

A steam condenser is provided to condense the steam exhausted from the steam turbine. Cooling water supply for the steam condenser is piped from the outlet of the refrigerant condenser. This eliminates the need for a separate water supply and is designed to minimize water pressure drop for energy savings. The steam condenser is a shell and tube heat exchanger with 3/4" OD (19mm) prime surface copper tubes. Steam condenses on the outside of the tubes. Condensing water flows inside the tubes. Tubes are roller-expanded into the tube sheets. Subcooling sections in both ends of the condenser cool non-condensibles, (mainly air), sufficiently below the condensing temperature thereby reducing the required capacity of the vacuum pump. Water side is suitable for a maximum working pressure of 150 psig, (1030 kPA). Cooling water end plates are provided on each end of the steam condenser so that tubes may be accessed without having to disturb the water piping connections.The steam side of the system is protected by an atmospheric relief valve. Refer to the following "Atmospheric Relief Valve section."

Atmospheric Relief Valve

The steam side of the system is protected by an atmospheric relief valve mounted on the steam condenser. Since there is no valve in the steam discharge piping this relief valve provides protection not only to the steam condenser but the turbine as well. The relief valve is sized per HEI and is mounted on the shell side of the steam condenser. It is set to open at 1-2 psig, (7-14 kPA), and will prevent the system pressure from exceeding 10 psig, (69 kPA). The relief valve is a water seal type relief valve. Water is used to cover and seal the closed port of the relief valve during operation. The relief valve is furnished with water supply and an overflow connection that assures the correct depth of water is maintained. During operation a small trickle of water should be maintained to ensure that the water that seals the closed relief port on the valve does not evaporate over a period of time. The steam condenser operates under a high vacuum pressure. Any leaks, even very small, through the relief port would cause air to leak into the steam condenser causing the condensing pressure to rise, reducing efficiency and power of the turbine and eventually shutting the system down.

Hotwell (Condensate) Pump

The hotwell pump(s) is a 5 HP, 3600 RPM motor driven direct connected pump with a maximum suction pressure of 5 psig. The pumps have a minimum NPSH requirement of 2 feet. The hotwell pump is automatically controlled during operation to remove condensate as it builds up in the condenser. Concurrently it maintains a constant level in the hotwell for proper operation of the steam condenser through automatic modulation of both the recirculation valve and overboard valve located in the hotwell pump discharge piping.

Vacuum Pump

The vacuum pump(s) is a 7.5 HP, 1800 RPM motor driven direct connected single stage liquid ring type pump designed for continuous operation. An impeller is located in a cylindrical casing and is offset from the rotor axis. The impeller transmits the driving power to the water liquid ring which forms concentrically to the casing when the pump is started. As the liquid moves outwards, non-condensible gas, (air), is drawn into the pump, compressed and expelled through the discharge port into a discharge separator that separates the water from the air. Water is drained and not recirculated to the pump. Approximately 3.5 GPM of make-up water is required to maintain the liquid seal ring while the vacuum pump is in operation.

Level Control

The condensate level in the hotwell is controlled automatically during operation by a level control system. The level measurement transmitter senses the condensate level in the hotwell and sends a 4-20 mA signal to the OptiView™ control center which in turn sends a control signal to position the condensate recirculation valve and the condensate overboard valve. The level control system includes a visual magnetic level gauge. High level trip and low level alarm switches are wired to the control center to provide the safety functions required.

SECTION 4 - OPERATIONAL MAINTENANCE

COMPRESSOR OIL RETURN SYSTEM

The oil return system continuously maintains the proper oil level in the compressor oil sump.

High pressure condenser gas flows continuously through the eductor inducing the low pressure, oil rich liquid to flow from the evaporator, through the dehydrator to the compressor sump.

CHANGING THE DEHYDRATOR

To change the dehydrator, use the following procedure:

1. Shut the stop valves on the condenser gas line, oil return line to the oil sump and inlet end of the dehydrator.
2. Remove the dehydrator.
3. Assemble the new filter-drier.
4. Open condenser stop valve and check dehydrator connections for refrigerant leaks.
5. Open all the dehydrator stop valves to allow the liquid refrigerant to flow through the dehydrator and condenser-gas through the eductor.

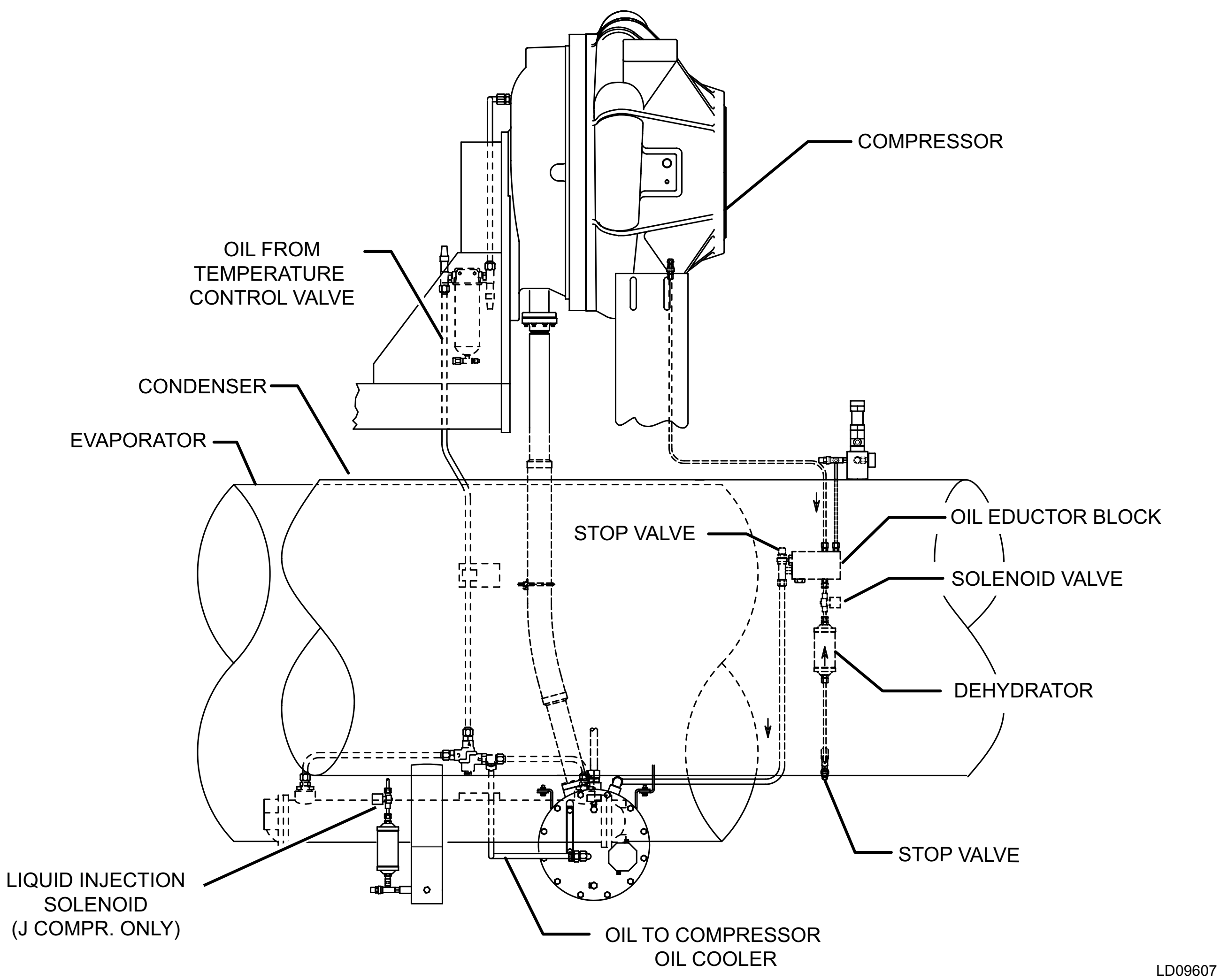


FIGURE 14 - OIL RETURN SYSTEM

THE COMPRESSOR OIL CHARGE

The nominal oil charge for all YST compressors is 20 gallon, type “York K”.

New YORK Refrigeration oil must be used in the centrifugal compressor. Since oil absorbs moisture when exposed to the atmosphere, it should be kept tightly capped until used.

COMPRESSOR OIL CHARGING PROCEDURE

During operation the compressor oil level must be maintained in the "Operating Range" identified on the vertical oil level indicator. If the oil level falls into the lower sight glass, it is necessary to add oil to the compressor oil reservoir. The oil should be charged into the oil reservoir using the YORK Oil Charging Pump – YORK Part No. 070-10654. To charge oil into the oil reservoir, proceed as follows:

1. The unit must be shut down.
2. Immerse the suction connection of the oil charging pump in a clean container of new oil and connect the pump discharge connection to the oil charging valve (A) located on the remote oil reservoir cover plate. Do not tighten the connection at the charging valve until after the air is forced out by pumping a few strokes of the oil pump. This fills the lines with oil and prevents air from being pumped into the system.
3. Open the oil charging valve and pump oil into the system until oil level in the compressor oil reservoir is in the “Over Full” region of the oil level indicator label. Close the charging valve and disconnect the hand oil pump.
4. As soon as oil charging is complete, ensure that the power is available to the control center and power panel to energize the oil heater. This will keep the concentration of refrigerant in the oil to a minimum.

When the oil reservoir is initially charged with oil, the oil pump should be started manually to fill the lines, passages, oil cooler and oil filter. This will lower the oil level in the reservoir. It may then be necessary to add oil to bring the level back into the “Operating Range” of the oil level indicator label.

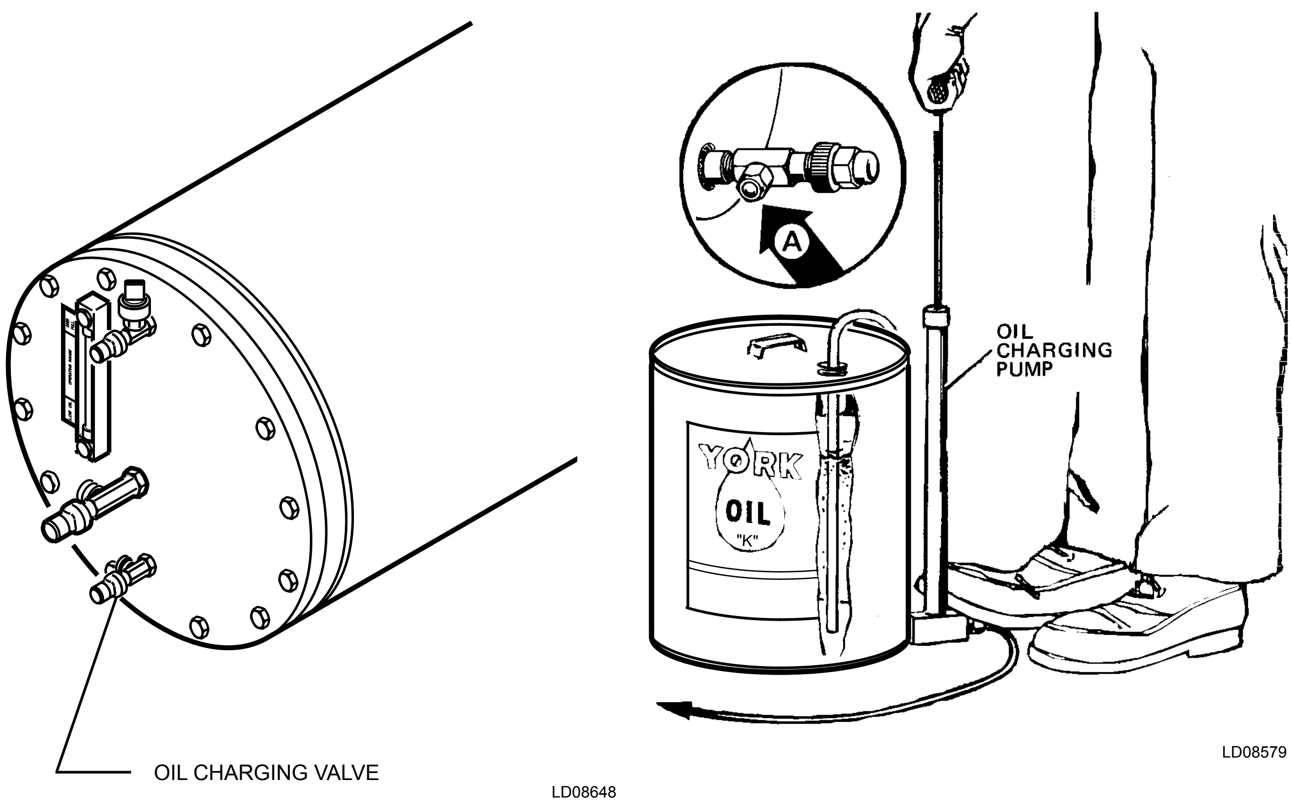


FIGURE 15 - CHARGING OIL RESERVOIR WITH OIL

COMPRESSOR OIL FILTER

A single oil filter is provided as standard equipment and dual oil filter arrangements are available as optional equipment. The oil filter(s) are a replaceable 3 micron cartridge type oil filter. Use only YORK approved oil filter elements.

The oil filter element should be changed after the first 200 hours of operation and then as necessary thereafter. Always replace the oil filter element and O-ring on a yearly maintenance schedule.

NOTE

When the Compressor Oil Pump VSD frequency increases to 55 Hz to maintain the target oil pressure, the Compressor Oil Filter is dirty and needs to be replaced.

Single Oil Filter Replacement

The chiller must be OFF. Place the Keypad control switch to the OFF position; turn the main disconnect switch on the power panel to the OFF position to prevent the chiller from being accidentally started.

1. Close the hand isolation valves on the inlet and outlet oil lines going to and from the oil filter.
2. Relieve the refrigerant pressure and oil in the oil filter and the oil lines through the pressure access port fitting, located on the top of the filter housing. Connect a refrigeration pressure hose to the pressure access port and drain the oil and refrigerant into a suitable refrigerant recovery container.
3. Position a container to collect the oil (less than 2 quarts, 1.9 liters). Loosen and remove the drain nut at the bottom of the oil filter housing; drain the oil into the container.
4. Unscrew the oil filter bowl locking nut.
5. Remove the oil filter element.
6. Install a new element.
7. Install a new O-ring on the top of the oil filter bowl.
8. Tighten the oil filter bowl locking nut.
9. Open the hand isolation valves.
10. The chiller is ready to be restarted.

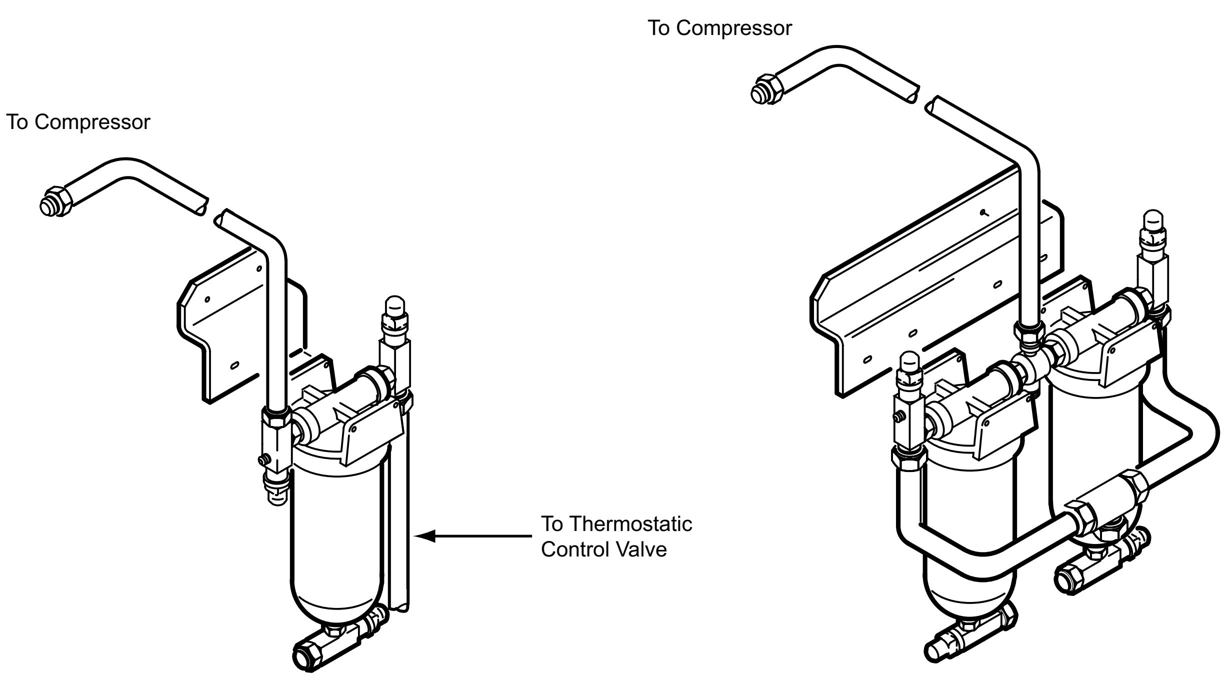


FIGURE 16 - STANDARD SINGLE OIL FILTER AND OPTIONAL DUAL OIL FILTER

Dual Oil Filter Replacement

The dual oil filter option allows one oil filter to be isolated and changed with the chiller in operation.

1. Isolate the left hand filter by turning the valve stem parallel with the valve body. 90º counter clockwise.
2. Isolate the right hand filter by turning the valve stem 1/4 turn clockwise.

CAUTION

Do not force the valve stem past the stop. Damage to the Isolation Valve will occur.

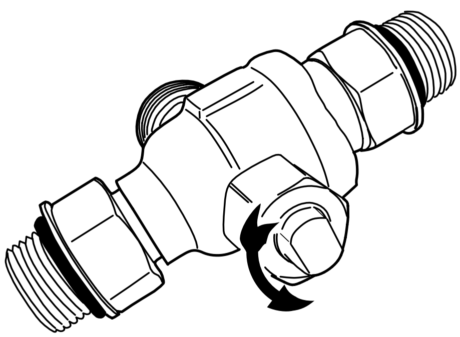


FIGURE 17 - DUAL OIL FILTER ISOLATION VALVE

TURBINE OIL MAINTENANCE

Ring Oil Lubrication

Turbines lubricated with oil rings are equipped with constant level oilers. The purpose of these oilers is to maintain the correct oil level in the bearing housings. The oil level within bearing housings must be maintained at a sufficient level to allow the oil rings to run in the oil. An oil level that is too high results in oil leakage past the shaft seals. The oil level gauge on the side of the bearing housing indicates the oil level. A mark inscribed on the lower-half bearing housing indicates the proper oil level. Oil levels in both bearing housings should be checked daily. Always use a strainer when adding oil to the systems and cover the fill connection when finished. If there is any reason to suspect water in the oil, open the low point drain in each bearing housings slightly. If water is present, it will be the first thing to come out of the drain. Low point drains in the bearing housing should be checked weekly for water.

CAUTION

The presence of oil in the constant level oilers does not necessarily mean that oil in the bearing housings is at the proper level. CLEANLINESS is ESSENTIAL for long and trouble free service from the BEARINGS. Care must be taken to ensure that no foreign material enters bearing housings or constant level oilers when performing maintenance, checking oil, adding oil, or making adjustments.

Cooling of the bearing oil is accomplished by water jackets integral to the bearing housings. Verify that the cooling water supply is being maintained at 2 GPM (7.0 L/min) minimum, 90°F (32°C) maximum, and 150 PSIG (1035 kPaG) for the bearing housings. Cooling water flow should be adjusted by partially closing the valve in the cooling water outlet line while observing the thermometers on the bearing housings to maintain the bearing oil sump temperature in the normal range as shown in the Table 1 below.

CAUTION

Do not allow the COOLING WATER to COOL THE BEARING OIL SUMP TEMPERATURE to below 130°F (54°C), as this may interfere with the action of the oil rings or cause atmospheric moisture to condense in the oil reservoir.

TABLE 1 - RECOMMENDED MAXIMUM TURBINE BEARING, OIL SUMP, AND METAL TEMPERATURES

RECOMMENDED MAXIMUM TURBINE BEARING, OIL SUMP, AND METAL TEMPERATURES				
	Bearing Oil Sump Temperature		**Bearing Metal Temperature**	
Operating Status	**°F**	**°C**	**°F**	**°C**
Normal Operation	130-180	54-82	150-200	66-93
Alarm	200	93	210*	99
Trip	210	99	220*	104

* Bearing alarm & trip values should be set at 10 °F (5.5 °C) to 15 °F (8.4 °C) above operating temperature when running at unit design conditions. Maximum alarm setting of 210 °F (99 °C) and 220 °F (104 °C) trip.

Establish an oil change frequency based on oil tests. Otherwise, oil in bearing housings should be changed monthly; or earlier, if there is reason to believe that the oil has been contaminated with water, dirt, or by overheating. The basic turbine oil for new units is a #68 which has an average viscosity of 319 SSU @ 100°F. If there are any doubts about the particular oil for turbine use, consult the YORK Service Department.

Pressure Lubrication

Turbines supplied with pressure lubrication consist of a main oil pump powered by the turbine shaft and a motor driven auxiliary oil pump. Both pumps draw oil from the oil reservoir that is an integral part of the turbine base. Pressure relief valves are used in the pressure lubricating system to control pressures through the oil filter, oil cooler, piping, and auxiliary oil pump. Always keep the proper oil level in the sight gauge. The system must supply continuous lubrication to all contact surfaces. THE OIL LEVEL SHOULD BE CHECKED AT LEAST ONCE A DAY OR EVERY 8 HOURS IF THE TURBINE OPERATES 24 HOURS A DAY. Normally, a small amount of oil (of the recommended type and viscosity) should be added between oil changes to maintain the proper oil level. Always use a strainer when adding oil to the systems and cover the fill connection when finished.

If an elevation in the oil level is observed in the sight gauge when no oil has been added, water is probably collecting in the oil. If an abnormal decrease is observed, there are oil leaks in the system. If an unexplained rise or drop in oil level is observed in the sight gauge, investigate immediately and stop the chiller if necessary.

The tendency of oil to oxidize and deteriorate increases with temperature. A rise in oil temperature also decreases viscosity, which progressively lowers the ability of oil to lubricate the turbine properly.

The operator should frequently observe the temperatures at the inlet and outlet of the oil cooler. Any drastic change should be investigated. Keeping a record of temperatures is advisable since it provides a good base for comparison.

Take readings from the pressure gauges every one or two hours and investigate any change (gradual or sudden). The most frequently encountered difficulty is pressure drop, and the most common causes are clogged oil filter, worn pump, faulty relief valves, insufficient oil in the reservoir, clogged piping, entrained air, and temperature elevation.

The most common sources of oil contamination are impurities picked up during storage, shipping, or adding of the lubricant, dirt in the entrained air, water in the oil reservoirs, leaks in the oil cooler, or condensation of gland leakage.

Always use a strainer when adding oil to the systems and cover the fill connection when finished. Make sure the gland system works properly. For details, see *Turbine Gland Seal System on page 55* for details.

Water gives oil a milky appearance, and it has a tendency to settle at the bottom of the reservoir when the turbine is not running. If there is any reason to suspect water in the oil, open the reservoir drain slightly. If water is present, it will be the first thing to come out of the drain.

The oil in the turbine should be inspected while the equipment is standing idle. If the turbine operates constantly, take a small sample of oil from the reservoir and let it sit a few hours. If any water is present it will settle to the bottom of the container.

The probability of oil contamination will increase if:

- Gland seals are allowed to become excessively worn, if obstructions are allowed to develop in leak-off piping
- If the turbine is allowed to stand idle with back pressure in the casing of a non-condensing turbine.
- If there is too much sealing pressure on a condensing turbine.

Care should be taken to avoid these conditions.

When oil is agitated it mixes with air and produces foam. Foam inhibits the ability of oil to lubricate properly by reducing the oil pressure and causing excessive wear of moving parts, rapid oil deterioration and oxidation, and loss of oil through seepage. The problem is usually solved with oil additives, lowering water flow to the cooler and circulating the oil at a slightly higher (not to exceed 120°) temperature, lowering the oil circulation pressure (not less than 13 PSIG), and maintaining the proper oil level.

Sludge impairs oil circulation and causes oil temperature elevation, which accelerates oxidation and reduces lubricant life. Any sludge should be removed as soon as it is found. Using high quality oil and keeping the system free of impurities can minimize sludge formation.

Establish an oil change frequency based on oil tests. Otherwise, the oil reservoir should be drained and cleaned yearly; or earlier, if there is reason to believe that the oil has been contaminated with water, dirt, or by overheating.The basic turbine oil for new units is a #32 which has an average viscosity of 162 SSU @ 100°F. If there are any doubts about the particular oil for turbine use, consult the YORK Service Department.

Lube Oil Flushing

If the lube system has been contaminated, the oil should be changed and the entire system should be flushed. To do this, remove the upper half of the bearing housing, remove the upper half of both bearings to allow for more volume of oil to flow during the flush. Reseal the upper bearing housing cover and replace the bolting.

The following steps should be followed:

1. Install 100 mesh plain weave (.0059 opening) screen mesh ahead of all bearing cases.
2. While viewing the TURBINE SCREEN on the OptiView™ Control Center, use the Manual Pump key and enable manual operation and allow it to run for two hours. Using the Manual Pump key on the TURBINE SCREEN, shut down the pump and check all screens for particles. Screens should not have any particles bigger than .01 inch in diameter and show random distribution. No metallic particles should be present. Flushing should continue until screens show no more than 6 non-metallic particles.
3. Replace screens with new ones and continue flushing in one-hour intervals until no metallic particles and no more than 6 non-metallic particles are present on any of the screens.
4. Once clean screens are present, remove all screens, service the turbine bearings and replace them in the bearing housing. Housings must be cleaned and resealed with Tite-Seal to prevent oil leaks at the case split line.
5. Check the condition and cleanliness of the oil filters furnished on the set and replace them with new filters if needed before continuing with the start up.

DETERMINING CORRECT REFRIGERANT CHARGE LEVEL

The refrigerant charge level is correct when the measured evaporator approach and discharge refrigerant gas superheat are within the values listed in *Table 2 on page 68*.

IMPORTANT: The chiller must be at design operating conditions and full load operation before the correct refrigerant charge level can be properly determined.

Liquid refrigerant will be visible in the evaporator sight glass. The refrigerant level cannot be properly determined by viewing the liquid refrigerant level in the evaporator sight glass.

All YST Chillers shipped Form 1 are charged with the correct amount of refrigerant. Under some operating conditions the chiller may appear to be overcharged or undercharged with refrigerant. Consult with the YORK Factory prior to removing or adding refrigerant. The liquid line isolation valve may have to be partially throttled to prevent overfeeding the evaporator in some applications and under certain operating conditions.

Definitions:

Evaporator Approach = (S.E.T) - (L.E.L.T)

Discharge Superheat = (C.D.G.T) - (S.C.T)

Where:

S.E.T. = Saturated Evaporator Temperature

L.E.L.T. = Leaving Evaporator Liquid Temp.

C.D.G.T. = Compressor Discharge Gas Temp.

S.C.T. = Saturated Condensing Temperature

These values can be obtained from the OptiView™ Control Center. Refer to OptiView™ Control Center Operation Manual, Form 160.67-O1.

TABLE 2 - REFRIGERANT CHARGE LEVEL

CONDITION	R-134A REFRIGERANT
COMFORT COOLING APPLICATIONS	
Evaporator Approach	1°F-5°F
Discharge Superheat	12°F-18°F
BRINE (ICE MAKING) APPLICATIONS	
Evaporator Approach	4°F-8°F
Discharge Superheat	24°F-36°F

Refrigerant Charging

Should it become necessary to add refrigerant charge to a YORK YST Chiller; add charge until the evaporator approach and refrigerant gas discharge superheat are within the temperature values listed in *Table 2 on page 68*.

A charging valve is located in the liquid line below the evaporator (See *Figure 3 on page 14*). The size of the charging connection is 3/4 inch male flare. Purge air and non-condensables from the charging hose. Only add new refrigerant, or refrigerant that has been tested and certified to meet American Refrigeration Institute Standard (ARI-700).

REFRIGERANT LEAK CHECKING

Periodic refrigerant leak checking must be part of a comprehensive maintenance program. Leak check the entire chiller using a calibrated electronic leak detector.

Use a soap solution to confirm leaks that are found using the electronic leak detector.

Check refrigerant relief valve piping and tube rolled joints as part of the comprehensive refrigerant leak checking program.

Repair leaks before adding refrigerant.

PRESSURE CONNECTIONS

All threaded pressure connections used on the YORK YST Chillers are SAE straight thread, O-ring face seal type fittings or Primore Rotalock® fittings.

The O-ring straight thread fittings and O-ring face seal fittings are designed and used in accordance with SAE J1926 and J1453. Should it become necessary to remove a fitting, the O-ring(s) should be replaced. Make certain to use only neoprene replacement O-rings. O-rings can be ordered from the local Johnson Controls Service Office.

Pipe sealant compounds are not required with SAE type O-ring fittings. The O-ring seal accomplishes the pressure sealing. Lubricate the O-ring with compressor oil prior to assembly.

All filter driers and angle shut off valves use Primore Rotalock® fittings. These fittings use a Teflon® fiber seal washer. The Teflon® fiber seal washers should be replaced each time the filter driers are changed.

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SECTION 5 – TROUBLESHOOTING

TABLE 3 - OPERATION ANALYSIS CHART

RESULTS	POSSIBLE CAUSE	REMEDY
1. Symptom: Abnormally High Discharge Pressure		
Temperature difference between condensing temperature and water off condenser higher than normal	Air in Condenser	
High discharge pressure	Condenser tubes dirty or scaled	Clean condenser tubes. Check water conditioning
	High condenser water temperature	Reduce condenser water inlet temperature. (Check cooling tower and water circulation.)
Temperature difference between condenser water on and water off higher than normal, with normal evaporator pressure	Insufficient condensing water flow	Increase the quantity of water through the condenser to proper value.
2. Symptom: Abnormally Low Suction Pressure		
Temperature difference between leaving chilled liquid and refrigerant in the evaporator greater than normal with normal discharge temperature.	Insufficient charge of refrigerant	Check for leaks and charge refrigerant into system,
	Subcooler level valve problem	Remove obstruction
Temperature difference between leaving chilled liquid and refrigerant in the evaporator greater than normal discharge temperature	Evaporator tubes dirty or restricted	Clean evaporator tubes
Temperature of chilled liquid too low at minimum rated speed	Insufficient load for system capacity	Check prerotation vane and Hot gas valve operation and setting of low liquid temperature cutout
3. Symptom: High Evaporator Pressure		
High chilled liquid temperature	Prerotation vanes fail to open	Check the prerotation vane motor positioning circuit
	System overload	Be sure the vanes are wide open, Hot gas valve is fully closed, and speed us at maximum. System conditions may dictate that the override controls limit the chiller capacity until the load decreases.
4. Symptom: Compressor or Turbine (KD Model) Oil Pressure		
Low Oil pressure displayed on control center; chiller will not start.	Oil pump running in wrong direction	Check rotation of oil pump (Electrical Connections).
	Oil pump not running.	Troubleshoot electrical problem with pil pump motor and/or VSD on compressor oil pump or turbine auxiliary oil pump contractor.
5. Symptom: Compressor or Turbine (KD Model) High Oil Pressure		

TABLE 3 - OPERATION ANALYSIS CHART (CONT'D)

Unusually high oil pressure is displayed when the oil pump is running.	High oil pressure. Transducer/ Transmitter defective.	Replace low or high oil pressure transducer or turbine supply oil pressure transmitter
6. Symptom: Compressor or Turbine (KD Model) Oil Pump Vibrates or is Noisy		
Oil pump vibrates or is extremely noisy with some oil pressure NOTE ***When oil pump is run without an oil supply it will vibrate and become extremely noisy.***	Oil not reaching pump suction inlet in sufficient quantity	Check oil level
	Worn or failed oil pump	Repair/Replace oil pump
7. Symptom: Compressor or Turbine (KD Model) Reduced Oil Pump Capacity		
Oil pump pumping capacity.	Excessive end clearance pump. Other worn pump parts.	Inspect and replace worn parts
	Partially blocked oil supply inlet.	Check oil inlet for blockage.
8. Symptom: Compressor or Turbine (KD Model) Oil Pressure Gradually Decreases (Noted by Observation of Daily Lot Sheets)		
When compressor oil pump VSD frequency increases to 55 + hz to maintain target oil pressure. Turbine supply pressure gradually drops as noted by log sheets	Oil filter is dirty.	Change oil filter.
9. Symptom: Compressor Oil Pressure System Ceases to Return Oil/Refrigerant Sample		
Oil refrigerant return not functioning.	Filter-drier in oil return system dirty.	Replace old filter-drier with new.
	Jet or orifice of oil return jet clogged	Remove jet, inspect for dirt. Remove dirt using solvent and replace.
10. Symptom: Compressor or Turbine (KD Model) Oil Pump Fails to Deliver Oil Pressure		
No Oil pressure registers when oil pump runs.	Faulty oil pressure transducer/ transmitter Faulty wiring/connections.	Replace oil pressure transducer/ transmitter
11. Symptom: Turbine Is Still Warm After Prolonged Shutdown		
Turbine shaft may have taken a bow during shutdown.	Turbine inlet valves have leaked during shutdown.	Slow roll turbine as noted is Startup Section. Check valves for tightness and leakage. Repair/replace as necessary.
12. Symptom: Excessive Vibration of Drive Line During Operation		
Possible damage to compressor or turbine	Misalignment of coupling	Stop the system and investigate the cause.
	Damage or worn bearings in compressor and/or turbine.	
	Bowed turbine shaft (See item 11)	

SECTION 6 - MAINTENANCE

RENEWAL PARTS

For any required Renewal Parts, *refer to YORK Renewal Parts Unit Components Manual 160.67-RP1.*

CHECKING SYSTEM FOR LEAKS

Leak Testing During Operation

The refrigerant side of the system is carefully pressure tested and evacuated at the factory.

After the system has been charged, the system should be carefully leak tested with a R-134a compatible leak detector to be sure all joints are tight.

If any leaks are indicated, they must be repaired immediately. Usually, leaks can be stopped by tightening flare nuts or flange bolts. However, for any major repair, the refrigerant charge must be removed. (See *Handling Refrigerant For Dismantling And Repairs on page 76* in this Section.)

EVACUATION AND DEHYDRATION OF UNIT

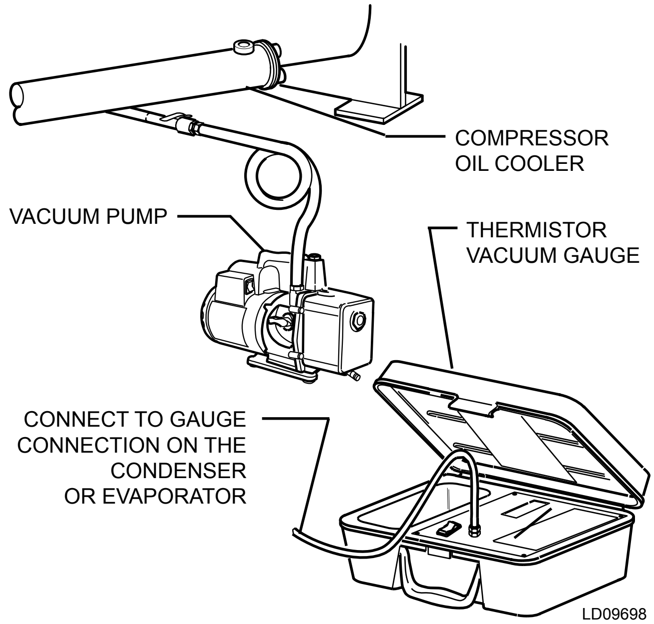

FIGURE 18 - EVACUATION OF CHILLER

TABLE 4 - SYSTEM PRESSURES

*Gauge	Absolute			Boiling Temperatures of Water °F
Inches of Mercury (HG) Below One Standard Atmosphere	PSIA	Millimeters of Mercury (HG)	Microns	
0	14.696	760.	760,000	212
10.24"	9.629	500.	500,000	192
22.05"	3.865	200.	200,000	151
25.98"	1.935	100.	100,000	124
27.95"	.968	50.	50,000	101
28.94"	.481	25.	25,000	78
29.53"	.192	10.	10,000	52
29.67"	.122	6.3	6,300	40
29.72"	.099	5.	5,000	35 WATER FREEZES
29.842"	.039	2.	2,000	15
29.882"	.019	1.0	1,000	+1
29.901"	.010	.5	500	-11
29.917"	.002	.1	100	-38
29.919"	.001	.05	50	-50
29.9206"	.0002	.01	10	-70
29.921"	0	0	0	

*One standard atmosphere = 14.696 PSIA
= 760 mm Hg. absolute pressure at 32°F
= 29.921 inches Hg. absolute at 32°F

NOTES: PSIG = Lbs. per sq. in. gauge pressure
= Pressure above atmosphere
PSIA = Lbs. per sq. in. absolute pressure
= Sum of gauge plus atmospheric pressure

CONDUCTING R-22 PRESSURE TEST

With the R-134a charge removed and all known leaks repaired, the system should be charged with a small amount of R-22 mixed with dry nitrogen so that an electronic leak detector can be used to detect any leaks too small to be found by the soap test.

To test with R-22, proceed as follows:

1. Valve off the water side of the evaporator and refrigerant condenser and blow down the bundle pressure to 0 PSIG.
2. With no pressure in the system, charge R-22 gas into the system through the charging valve to a pressure of 2 PSIG.
3. Build up the system pressure with dry nitrogen to approximately 75 to 100 PSIG (517 to 690 kPa). To be sure that the concentration of refrigerant has reached all parts of the system, slightly open the oil charging valve (If oil charge is not present) and test for the presence of refrigerant with a leak detector.

CAUTION

Do not open the oil charging valve if oil charge has not been drained. Test for R-22 at the condenser service valve if oil charge is present.

4. Test around each joint and factory weld. It is important that this test be thoroughly and carefully done, spending as much time as necessary and using a good leak detector.
5. Check if any pressure buildup has occurred in the water side of the evaporator and condenser. Open the vents in the evaporator and condenser heads and test for the presence of refrigerant. If no refrigerant is present, the tubes and tube sheets may be considered tight. If refrigerant is detected at the vents, the heads must be removed, the leak located (by means of soap test or leak detector) and repaired.

VACUUM TESTING

After the pressure test has been completed, the vacuum test should be conducted as follows:

1. Connect a high capacity vacuum pump, and an indicator to the system as shown in FIG. 15 and start the pump. (See "Vacuum Dehydration".)
2. Open wide all system valves. Be sure all valves to the atmosphere are closed.
3. Operate the vacuum pump in accordance with **VACUUM DEHYDRATION** until a wet bulb temperature of +32°F or a pressure of 5 mm Hg is reached. See Table 4 for corresponding values of pressure.
4. To improve evacuation circulate hot water (not to exceed 125°F, 51.7ºC) through the evaporator and condenser tubes to thoroughly dehydrate the shells. If a source of hot water is not readily available, a portable water heater should be employed. **DO NOT USE STEAM**. A suggested method is to connect a hose between the source of hot water under pressure and the evaporator head drain connection, out the evaporator vent connection, into the condenser head drain and out the condenser vent. To avoid the possibility of causing leaks, the temperature should be brought up slowly so that the tubes and shell are heated evenly.
5. Close the system charging valve and the stop valve for the vacuum indicator. Then disconnect the vacuum pump leaving the vacuum indicator in place.
6. Hold the vacuum obtained in Step 3 in the system for 8 hours; the slightest rise in pressure indicates a leak or the presence of moisture, or both. If, after 24 hours the wet bulb temperature in the vacuum indicator has not risen above 40°F (4.4°C) or a pressure of 6.3 mm Hg, the system may be considered tight.

NOTE

Be sure the vacuum indicator is valved off while holding the system vacuum and be sure to open the valve between the vacuum indicator and the system when checking the vacuum after the 8 hour period.

7. If the vacuum does not hold for 8 hours within the limits specified in Step 6 above, the leak must be found and repaired.

VACUUM DEHYDRATION

To obtain a sufficiently dry system, the following instructions have been assembled to provide an effective method for evacuating and dehydrating a system in the field. Although there are several methods of dehydrating a system, we are recommending the following, as it produces one of the best results, and affords a means of obtaining accurate readings as to the extent of dehydration.

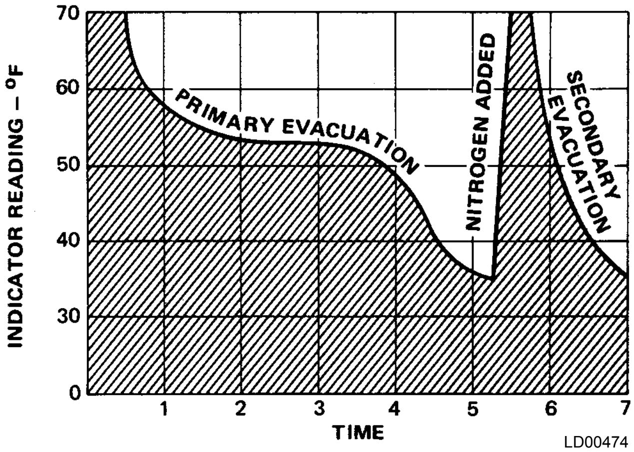

FIGURE 19 - SATURATION CURVE

The equipment required to follow this method of dehydration consists of a wet bulb indicator or vacuum gauge, a chart showing the relation between dew point temperature and pressure in inches of mercury (vacuum), (See *Table 4 on page 73*) and a vacuum pump capable of pumping a suitable vacuum on the system.

OPERATION

Dehydration of a refrigerant system can be obtained by this method because the water present in the system reacts much as a refrigerant would. By pulling down the pressure in the system to a point where its saturation temperature is considerably below that of room temperature, heat will flow from the room through the walls of the system and vaporize the water, allowing a large percentage of it to be removed by the vacuum pump. The length of time necessary for the dehydration of a system is dependent on the size or volume of the system, the capacity and efficiency of the vacuum pump, the room temperature and the quantity of water present in the system. By the use of the vacuum indicator as suggested, the test tube will be evacuated to the same pressure as the system, and the distilled water will be maintained at the same saturation temperature as any free water in the system, and this temperature can be observed on the thermometer.

If the system has been pressure tested and found to be tight prior to evacuation, then the saturation temperature recordings should follow a curve similar to the typical saturation curve shown as *Figure 19 on page 75*.

The temperature of the water in the test tube will drop as the pressure decreases, until the boiling point is reached, at which point the temperature will level off and remain at this level until all of the water in the shell is vaporized. When this final vaporization has taken place the pressure and temperature will continue to drop until eventually a temperature of 35°F (1.6°C) or a pressure of 5 mm Hg. is reached.

When this point is reached, practically all of the air has been evacuated from the system, but there is still a small amount of moisture left. In order to provide a medium for carrying this residual moisture to the vacuum pump, nitrogen should be introduced into the system to bring it to atmospheric pressure and the indicator temperature will return to approximately ambient temperature. Close off the system again, and start the second evacuation.

The relatively small amount of moisture left will be carried out through the vacuum pump and the temperature or pressure shown by the indicator should drop uniformly until it reaches a temperature of 35°F (1.6°C) or a pressure of 5 mm Hg.

When the vacuum indicator registers this temperature or pressure, it is a positive sign that the system is evacuated and dehydrated to the recommended limit. If this level cannot be reached, it is evident that there is a leak somewhere in the system. Any leaks must be corrected before the indicator can be pulled down to 35°F or 5 mm Hg. in the primary evacuation.

During the primary pulldown, keep a careful watch on the wet bulb indicator temperature, and do not let it fall below 35°F (1.6°C). If the temperature is allowed to fall to 32°F (0°C), the water in the test tube will freeze, and the result will be a faulty temperature reading.

REFRIGERANT CHARGING

To avoid the possibility of freezing liquid within the evaporator tubes when charging an evacuated system, only refrigerant vapor from the top of the drum or cylinder must be admitted to the system pressure until the system pressure is raised above the point corresponding to the freezing point of the evaporator liquid. For water, the pressure corresponding to the freezing point is 8.54 PSIG (58.9 kPa) for R-134a (at sea level).

While charging, every precaution must be taken to prevent moisture laden air from entering the system. Make up a suitable charging connection from new copper tubing to fit between the system charging valve and the fitting on the charging drum. This connection should be as short as possible but long enough to permit sufficient flexibility for changing drums. The charging connection should be purged each time a full container of refrigerant is connected and changing containers should be done as quickly as possible to minimize the loss of refrigerant.

CHECKING THE REFRIGERANT CHARGE DURING UNIT SHUTDOWN

The refrigerant charge is specified for each chiller model on the unit data plate. Charge the correct amount of refrigerant and record the level in the evaporator sight glass.

The refrigerant charge should always be checked and trimmed when the system is shut down.

The refrigerant charge level must be checked after the pressure and temperature have equalized between the condenser and evaporator. This would be expected to be 4 hours or more after the compressor and water pumps are stopped. The level should visible in the sight glass.

Charge the refrigerant in accordance with the method shown under the “Refrigerant Charging”, above. The refrigerant level should be observed and the level recorded after initial charging.

HANDLING REFRIGERANT FOR DISMANTLING AND REPAIRS

If it becomes necessary to open any part of the refrigerant system for repairs, it will be necessary to remove the charge before opening any part of the unit. If the chiller is equipped with optional valves, the refrigerant can be isolated in either the condenser or evaporator / compressor while making any necessary repairs.

REFRIGERANT CONDENSERS AND EVAPORATORS

General

Maintenance of the refrigerant condenser, steam condenser, and evaporator shells is important to provide trouble free operation of the chiller. The water side of the tubes in the shell must be kept clean and free from scale. Proper maintenance such as tube cleaning, and testing for leaks, is covered on the following pages.

CHEMICAL WATER TREATMENT

Since the mineral content of the water circulated through evaporators and condensers varies with almost every source of supply, it is possible that the water being used may corrode the tubes or deposit heat resistant scale in them. Reliable water treatment companies are available in most larger cities to supply a water treating process which will greatly reduce the corrosive and scale forming properties of almost any type of water.

As a preventive measure against scale and corrosion and to prolong the life of evaporator and condenser tubes, a chemical analysis of the water should be made preferably before the system is installed. A reliable water treatment company can be consulted to determine whether water treatment is necessary, and if so, to furnish the proper treatment for the particular water condition.

CLEANING EVAPORATOR AND CONDENSER TUBES

Evaporator

It is difficult to determine by any particular test whether possible lack of performance of the water evaporator is due to fouled tubes alone or due to a combination of troubles. Trouble which may be due to fouled tubes is indicated when, over a period of time, the cooling capacity decreases and the split (temperature difference between water leaving the evaporator and the refrigerant temperature in the evaporator) increases. A gradual drop-off in cooling capacity can also be caused by a gradual leak of refrigerant from the system or by a combination of fouled tubes and shortage of refrigerant charge. An excessive quantity of oil in the evaporator can also contribute to erratic performance.

Condenser

In a condenser, trouble due to fouled tubes is usually indicated by a steady rise in head pressure, over a period of time, accompanied by a steady rise in condensing temperature, and noisy operation. These symptoms may also be due to foul gas buildup. Purging will remove the foul gas revealing the effect of fouling.

TUBE FOULING

Fouling of the tubes can be due to deposits of two types as follows:

1. **Rust or sludge** – which finds its way into the tubes and accumulates there. This material usually does not build up on the inner tube surfaces as scale, but does interfere with the heat transfer. Rust or sludge can generally be removed from the tubes by a thorough brushing process.
2. **Scale** – due to mineral deposits. These deposits, even though very thin and scarcely detectable upon physical inspection, are highly resistant to heat transfer. They can be removed most effectively by circulating an acid solution through the tubes.

TUBE CLEANING PROCEDURES

Brush Cleaning of Tubes

If the tube consists of dirt and sludge, it can usually be removed by means of the brushing process. Drain the water sides of the circuit to be cleaned (cooling water or chilled water) remove the heads and thoroughly clean each tube with a soft bristle bronze or nylon brush. DO NOT USE A STEEL BRISTLE BRUSH. A steel brush may damage the tubes.

Improved results can be obtained by admitting water into the tube during the cleaning process. This can be done by mounting the brush on a suitable length of 1/8" pipe with a few small holes at the brush end and connecting the other end by means of a hose to the water supply.

The tubes should always be brush cleaned before acid cleaning.

Acid Cleaning Of Tubes

If the tubes are fouled with a hard scale deposit, they may require acid cleaning. It is important that before acid cleaning, the tubes be cleaned by the brushing process described above. If the relatively loose foreign material is removed before the acid cleaning, the acid solution will have less material to dissolve and flush from the tubes with the result that a more satisfactory cleaning job will be accomplished with a probable saving of time.

WARNING

Acid cleaning should only be performed by an expert. Please consult your local water treatment representative for assistance in removing scale buildup and preventative maintenance programs to eliminate future problems.

COMMERCIAL ACID CLEANING

In many major cities, commercial organizations now offer a specialized service of acid cleaning evaporators and condensers. If acid cleaning is required, YORK recommends the use of this type of organization. The Dow Industries Service Division of the Dow Chemical Company, Tulsa, Oklahoma, with branches in principal cities is one of the most reliable of these companies.

TESTING FOR EVAPORATOR AND CONDENSER

Tube Leaks

Evaporator and condenser tube leaks in R-134a systems may result in refrigerant leaking into the water circuit, or water leaking into the shell depending on the pressure levels. If refrigerant is leaking into the water, it can be detected at the liquid head vents after a period of shutdown. If water is leaking into the refrigerant, system capacity and efficiency will drop off sharply. If a tube is leaking and water has entered the system, the evaporator and condenser should be valved off from the rest of the water circuit and drained immediately to prevent severe rusting and corrosion. The refrigerant system should then be drained and purged with dry nitrogen to prevent severe rusting and corrosion. If a tube leak is indicated, the exact location of the leak may be determined as follows:

1. Remove the heads and listen at each section of tubes for a hissing sound that would indicate gas leakage. This will assist in locating the section of tubes to be further investigated. If the probable location of the leaky tubes has been determined, treat that section in the following manner (if the location is not definite, all the tubes will require investigations).
2. Wash off both tube heads and the ends of all tubes with water.

NOTE

Do not use carbon tetrachloride for this purpose since its fumes give the same flame discoloration that the refrigerant does.

3. With nitrogen or dry air, blow out the tubes to clear them of traces of refrigerant laden moisture from the circulation water. As soon as the tubes are clear, a cork should be driven into each end of the tube. Pressurize the dry system with 50 to 100 PSIG (345 to 690 kPa) of nitrogen. Repeat this with all of the other tubes in the suspected section or, if necessary, with all the tubes in the evaporator or condenser. Allow the evaporator or condenser to remain corked up to 12 to 24 hours before proceeding. Depending upon the amount of leakage, the corks may blow from the end of a tube, indicating the location of the leakage. If not, if will be necessary to make a very thorough test with the leak detector.

4. After the tubes have been corked for 12 to 24 hours, it is recommended that two men working at both ends of the evaporator carefully test each tube – one man removing corks at one end and the other at the opposite end to remove corks and handle the leak detector. Start with the top row of tubes in the section being investigated. Remove the corks at the ends of one tube simultaneously and insert the exploring tube for 5 seconds – this should be long enough to draw into the detector any refrigerant gas that might have leaked through the tube walls. A fan placed at the end of the evaporator opposite the detector will assure that any leakage will travel through the tube to the detector.
5. Mark any leaking tubes for later identification.
6. If any of the tube sheet joints are leaking, the leak should be indicated by the detector. If a tube sheet leak is suspected, its exact location may be found by using a soap solution. A continuous buildup of bubbles around a tube indicates a tube sheet leak.

COMPRESSOR MAINTENANCE

Maintenance for the compressor assembly consists of checking the operation of the oil return system and changing the dehydrator, checking and changing the oil, checking and changing the oil filters, checking the operation of the oil heater, checking the operation of the oil pump, and observing the operation of the compressor.

Internal wearing of compressor parts could be a serious problem caused by improper lubrication, brought about by restricted oil lines, passages, or dirty oil filters. If the unit is shutting down on COMPR OIL - HIGH TEMPERATURE or COMPR OIL - LOW DIFFERENTIAL PRESSURE, change the oil filter element. Examine the oil filter element for the presence of aluminum particles. Aluminum gas seal rings can contact the impeller and account for some aluminum particles to accumulate in the oil filter, especially during the initial start up and first several months of operation. However, if aluminum particles continue to accumulate and the same conditions continue to stop the unit operation after a new filter is installed, notify the nearest Johnson Controls office to request the presence of a Johnson Controls Service Technician.

STEAM CONDENSER CONDENSATE PUMP MAINTENANCE

While the pump is running, re-grease the pump bearing with #2 lithium base petroleum grease. This should be done after every 2500 hours of operation or every 6 months, whichever occurs first. Lubricate the motor per the instructions on the nameplate.

STEAM CONDENSER VACUUM PUMP MAINTENANCE

After approximately 3 years of operation, the rolling-contact bearings and the adjacent spaces should have the spent grease and other dirt deposits removed and be repacked with fresh grease. The pump must be disassembled for this procedure. UNIREX N3 or equivalent grease per DIN51825-K3N must be used. Different types of grease should not be mixed. Fill 50% of the free hollow space in the deep-groove ball bearing at the impeller end with grease. Fill the deep-groove ball bearing at the motor end flush. Do not fill the bearing caps as his could result in an excessive amount of grease. When re-lubricating or replacing rolling-contact bearings, inspect and replace any worn seals such as the V ring.

TURBINE INTERNAL INSPECTION

To perform the thorough periodic inspections, it will be necessary to remove the turbine cover. Housed under that cover are diaphragms, the turbine rotor, nozzle block, shaft seals, the stationary blade segment, and the casing interior. Refer to SECTION 7 - STEAM PURITY/TURBINE DEPOSITS for additional information.

Inspection of other parts, such as bearings, governor and linkage, oil pump drive assembly, governor valve and trip valve, can be accomplished without casing cover removal.

Where turbines have a top exhaust, the inspection procedure is more involved since the exhaust pipe must first be removed to provide the necessary free space above the turbine. The casing cover can then be removed by the following procedure:

It should be remembered that the casing assembly is a pressure tight vessel and that all joints are necessarily sealed to prevent steam leakage. These include the main horizontal casing flange, gland case splits and vertical surfaces.

These joints have been kept in contact by the bolts while under prolonged exposure to heat and moisture. Even though joint compounds have been used at the factory, which assist sealing and help prevent sticking, it is to be expected that more or less sticking may occur from corrosion at one or more of these points. **It is therefore necessary to proceed with care in order to avoid damage to the rotor and other stationary parts.**

First, remove sheet metal covering, if provided, insulation and piping as required, then all horizontal joint bolts. There are four tapped holes in the horizontal flange. These are provided for the use of jack-bolts in order to "break" the main casing joint.

Insert bolts and apply reasonable torque to part the joint. In some cases, it may be necessary to use penetrating oil and tap on the casing barrel while jack-bolts are fully tightened. After the joint separates, continue to raise the casing cover with the jack-bolts. The rotor must remain free and bearing caps must not lift as the cover is raised.

Rotating the shaft while raising the cover will assure that the rotor is not in contact with any parts being raised. If the rotor rises with the cover, it indicates that either the lower half of a diaphragm or a carbon ring retaining plate is rising with the cover. This situation is brought about by diaphragm halves sticking together in or by retainer plates sticking in the casing cover and being free in the base. In either case, the cover should be lifted with the jack-bolts only until all the clearance (1/6 to 1/8 inch) is taken up and the rotor starts to rise. Do not lift beyond this point, but retract two diagonally opposite jack-bolts and rock the cover back and forth.

Try to determine where the sticking is occurring so that if the rocking does not release the stuck joint, the use of penetrating oil and tapping on the outside of the casing will. **Do not use wedges or pry bars between the joint as this will damage the surface and cause leakage.**

If there is persistent sticking of these parts, considerable care must be exercised to free them. Tapping and rocking as described above should be continued; possibly tapping directly on the circumference of the diaphragm or retainer plate by inserting a flat bar between the casing flanges (against the diaphragm or plate) and tapping on the exposed end.

After the parts are free, a chain hoist can be used to remove cover and rotor. The lower diaphragm portion cannot rise and the upper portion is fastened to it.

No difficulty should be encountered in lifting the casing cover. The packing cases employ stainless steel carbon ring retainer plates. Should the plates stick in the packing case, screw an eyebolt in the horizontal flange and impose a lift strain by means of a hand operated chain hoist while tapping on the upper portion of the packing case near the centerline.

If it is found that any retainer plates are stuck in the lower portion, these should be freed up with penetrating oil. After the retainer plates are all free, the rotor, with retainer plates, may be lifted out with a chain hoist.

The diaphragms are removed by rolling out, assisted by pulling on a clamp fastened on one corner with a chain hoist. It may be necessary to free-up the diaphragms with penetrating oil before they can be rolled out.

Before re-assembly, the pressure joints must be completely cleaned to the bare metal. The joints must then be re-coated with sealing compound using a type that will not harden in service. Murray joint compound is available for this purpose and will not "freeze" the joints.

The joint compound is also suitable as an anti-seize compound or pipe thread sealant. The compound must be kept absolutely clean and free of metal particles that might interfere with proper sealing.

Apply a light even coat, leaving about ¼ inch of the joint surface on the inside and outside uncoated to avoid surplus squeeze-out. Coat only the casing joints and the packing case joints of bolted type packing case. Do not apply closer than ¼ inch to carbon rings.

Do not coat diaphragm joints or grooves. Bearing caps should not be sealed with high temperature joint compound. Instead, use a material intended for oil tight joints such as "Tite-Seal" or a similar non-hardening Teflon-based paste compound.

Refer to the Turbine Tightening Torque Specifications at the end of this section when reassembling the turbine.

CHECK THE CASING INTERIOR FOR FOREIGN MATERIAL BEFORE CLOSING.

The casing cover should be carefully lowered. If it appears to "hang up", use a slight rocking motion to assist proper mating of parts. Use the dowels on guide rods to assist positioning. The bolting should be tightened uniformly, in about three stages, finally achieving approximately uniform torque on all bolts of the same size. If the joint has been properly serviced, it should be as tight as before the inspection.

ELECTRICAL CONTROLS

Periodically check that all pressure and temperature data fields on the OptiView™ Control Center screens display values as expected for the present ambient temperatures and operating conditions.

The following torques are to be applied to socket head and hex head capscrews, bolts and nuts of SAE grade 8, alloy steel and 17-4 Ph stainless steel.

TABLE 5 - TURBINE TIGHTENING TORQUES (WITHOUT WASHERS)

SIZE	FINAL TORQUE
1/4"	130 in.- lbs.
5/16"	275 in.- lbs.
3/8"	490 in.- lbs.
7/16"	70 ft.- lbs.
1/2"	100 ft. - lbs.
9/16"	145 ft.- lbs.
5/8"	200 ft. - lbs.
3/4"	350 ft. - lbs.
7/8"	570 ft. - lbs.
1"	850 ft. - lbs.
1-1/8"	1210 ft. lbs.
1-1/4"	1700 ft. - lbs.
1-3/8"	2225 ft. - lbs.
1-1/2"	2950 ft. - lbs.

The following torques are to be applied to socket head and hex head capscrews, bolts, and nuts of SAE Grade 8, alloy steel and 17-4 Ph stainless steel.

TABLE 6 - TURBINE TIGHTENING TORQUES (WITH WASHERS)

SIZE	FINAL TORQUE
1/4"	120 in.- lbs.
5/16"	250 in.- lbs.
3/8"	445 in.- lbs.
7/16"	60 ft.- lbs.
1/2"	90 ft. - lbs.
9/16"	130 ft.- lbs.
5/8"	180 ft. - lbs.
3/4"	315 ft. - lbs.
7/8"	515 ft. - lbs.
1"	770 ft. - lbs.
1-1/8"	1100 ft. lbs.
1-1/4"	1545 ft. - lbs.
1-3/8"	2025 ft. - lbs.
1-1/2"	2685 ft. - lbs.

SECTION 7 - PREVENTIVE MAINTENANCE

It is the responsibility of the owner to provide the necessary daily, monthly and yearly maintenance requirements of the system.

NOTE

IMPORTANT – If a unit failure occurs due to improper maintenance during the warranty period; YORK will not be liable for costs incurred to return the system to satisfactory operation.

In any operating system it is most important to provide a planned maintenance and inspection of its functioning parts to keep it operating at its peak efficiency. Therefore, the following maintenance should be performed when prescribed.

COMPRESSOR

1. **Oil Filter** – Change when oil pump VSD frequency increases to 55 hz to maintain target oil pressure.

   When the oil filter is changed, it should be inspected thoroughly for any aluminum particles which would indicate possible bearing wear. If aluminum particles are found this should be brought to the attention of the nearest YORK office for their further investigation and recommendations.

2. **Oil Changing** – The oil in the compressor must be changed annually or earlier if it becomes dark or cloudy. However, quarterly oil analysis can eliminate the need for an annual change provided the analysis indicates there is no problem with the oil.

LEAK TESTING

The unit should be leak tested quarterly. Any leaks found must be repaired immediately.

EVAPORATOR AND REFRIGERANT CONDENSER

The major portion of maintenance on the condenser and evaporator will deal with the maintaining the water side of the condenser and evaporator in a clean condition.

The use of untreated water in cooling towers, closed water systems, etc. frequently results in one or more of the following:

1. Scale Formation.
2. Corrosion or Rusting.
3. Slime and Algae Formation.

It is therefore to the benefit of the user to provide for proper water treatment to provide for a longer and more economical life of the equipment. The following recommendation should be followed in determining the condition of the water side of the condenser and evaporator tubes.

1. The refrigerant condenser tubes should be cleaned annually or earlier if conditions warrant. If the temperature difference between the water off the condenser and the condenser liquid temperature is more than 4°F (2°C) greater than the difference recorded on a new unit, it is a good indication that the condenser tubes require cleaning. Refer to the Maintenance section of this manual for condenser tube cleaning instructions.

2. The evaporator tubes under normal circumstances will not require cleaning. If however the temperature difference between the refrigerant and the chilled water increases slowly over the operating season, it is an indication that the evaporator tubes may be fouling or that there may be a water bypass in the water box requiring gasket replacement or refrigerant may have leaked from the chiller.

OIL RETURN SYSTEM

1. Change the dehydrator in the oil return system semiannually or earlier if the oil return system fails to operate.

2. When the dehydrator is changed, the nozzle of the eductor should be checked for any foreign particles that may be obstructing the jet.

ELECTRICAL CONTROLS

1. All electrical controls should be inspected for obvious malfunctions.

2. It is important that the factory settings of controls (operation and safety) not be changed. If the settings are changed without YORK's approval, the warranty will be jeopardized.

YORK BY JOHNSON CONTROLS

MAINTENANCE REQUIREMENTS FOR YORK YST CHILLERS

	PROCEDURE	DAILY	WEEKLY	MONTHLY	YEARLY
CHILLER	Record Operating Conditions (On Applicable Log Form)	X			
	Check Oil Levels	X			
	Check Refrigerant Levels		X		
	Check Oil Return System Operation			X	
	Check Sump Heater And Thermostat Operation			X	
	Check Three-Phase Voltage And Current Balance			X	
	Verify Proper Operation/Setting/Calibration Of Safety Controls[1]			X	
	Verify Condenser And Evaporator Water Flows			X	
	Leak Check And Repair Leaks As Needed[1]			X	
	Check And Tighten All Electrical Connections				X
	Replace Oil Filter And Oil Return Filter/Driers				X
	Clean Oil Cooler Heat Exchanger Tubes				X
	Perform Oil Analysis On Compressor Lube Oil[1]				X
	Perform Refrigeration Analysis[1]				X
	Perform Vibration Analysis				X
	Clean Heat Exchanger Tubes				X[2]
	Perform Eddy Current Testing And Inspect Tubes				2-5 Years
	Check Operation of all Shutdowns (History Print)		X		
	Conduct Panel Overspeed Test			X	
	Check Operation of Motor Contactors in Power Panel			X	
STEAM CONDENSER	Visually Inspect For Leaks / Abnormal Noise	X			
	Check Liquid Ring Seal On Relief Valve & Liquid Ring Vacuum Pumps		X		
	Check Conedsate Pump Operation / Seals			X	
	Check Hotwell Liquid Level / Pump			X	
	Lubricate The Hotwell Pump Bearing			6 Months	
	Check And Tighten All Electrical Connections				X
	Check Three-Phase Voltage And Current			X	
	Inspect / Clean Tubes With Chiller Heat Exchangers				X
	Clean And Grease Vacuum Pump Bearings				3 Years

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	PROCEDURE	DAILY	WEEKLY	MONTHLY	YEARLY
TURBINE	Visual Inspection (external damage, leaks)	X			
	Check Oil Level in Reservoir (and Governor If Applicable)	X			
	Check for Unusual Vibration / Noise	X			
	Check Oil Temperature and Pressure	X			
	Observe seal steam venting	X			
	Check Aux. Oil Pump Operation (KD Only)		X		
	Check Shafts (free of Oil and Grease)		X		
	Exercise Trip Valve Remote Knob Operation		X		
	Check Oil System Operation			X	
	Verify Operation / Setting / Calibration of Safety Controls[1]			X	
	Leak Check and Repair Leaks as Needed[1]			X	
	Check Oil and Filter			X	
	Remove / Clean Steam Strainer				X
	Check Thrust Bearing End Play				X
	Remove / Check Operation Sentinel Warning Valve				X
	Drain / Clean Oil Reservoir				X
	Drain / Clean Governor (If Applicable)				X
	Change Filter with Oil Change				X
	Check / Recalibrate Gauges				X
	Open / Inspect Turbine / Replace as Required				3 Years
	Rotor				3 Years
	Labyrinth Seals				3 Years
	Bearings				3 Years
	Gland Seals				3 Years

For operating and maintenance requirements listed above, refer to appropriate service literature, or contact your local Johnson Controls Service Office.

[1] This procedure must be performed at the specified time interval by an Industry Certified Technician who has been trained and qualified to work on this type of Johnson Controls equipment. A record of this procedure being successfully carried out must be maintained on file by the equipment owner should proof of adequate maintenance be required at a later date for warranty validation purposes.

[2] More frequent service may be required depending on local operating conditions.

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BY JOHNSON CONTROLS

CENTRIFUGAL
LIQUID CHILLER LOG SHEET

Chiller Location__________________
System No.________________________

DATE											
TIME											
Hour Meter Reading											
O.A. Temperature Dry Bulb / Wet Bulb			/	/	/	/	/	/	/	/	/
Compressor		Oil Level									
		Oil Pressure									
		Oil Temperature									
		Oil Pump/VSOP Output/Hz									
		Discharge Temperature									
		PRV % Open									
Evaporator	**Refrigerant**	Evaporator Pressure									
		Evaporator Saturation Temperature									
		Small Temperature Difference									
	Liquid	Supply Temperature									
		Supply Pressure									
		Return Temperature									
		Return Pressure									
		Flow Rate - GPM (If equipped)									
Condenser	**Refrigerant**	Condenser Pressure									
		Corresponding Temperature									
		Subcooler Liquid Temperature									
		Small Temperature Difference									
		Refrigerant Level %									
		Refrigerant Level Setpoint									
	Liquid	Supply Temperature									
		Supply Pressure									
		Return Temperature									
		Return Pressure									
		Flow Rate - GPM (If equipped)									

- CONTINUED ON REVERSE -

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YORK®
BY JOHNSON CONTROLS

CENTRIFUGAL
LIQUID CHILLER LOG SHEET

Chiller Location________________

System No.________________

DATE										
TIME										
Hour Meter Reading										
O.A. Temperature Dry Bulb / Wet Bulb		/	/	/	/	/	/	/	/	/
Turbine	Oil Level									
	Oil Pressure *(KD Only)									
	Oil Temperature									
	Bearing Temp. DE & NDE									
	Inlet Steam Pressure									
	Inlet Steam Temperature									
	First Stage Pressure									
	Exhaust Pressure									
	Vibration Level DE & NDE									
	Gov. & Trip Valve Supply Air Press.									
Steam Condenser	Hotwell Level %									
	Hotwell Level Setpoint									
	Leaving Water Temperature									

Remarks: ____
____

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7

STEAM PURITY/TURBINE DEPOSITS

Overview

It is generally recognized that the performance and reliability of a steam turbine can be adversely affected by the admission of contaminated steam. When contaminants enter the turbine with the steam supply, the usual result is the accumulation of deposits, either inert or highly reactive, depending on the contaminants present. If the contaminants are reactive, they can cause serious damage by corrosive attack on the turbine materials.

To avoid these deposits, adequate boiler water chemistry control and other precautions are required along with the need for constant surveillance during operation and inspections. When deposits or material attack are noted during inspections, investigations into the nature and origin of contaminants should be conducted and a program for corrective action begun

STEAM PURITY

Deposits and harmful ions come from additive chemical elements in boiler feedwater. Make-up water for many steam systems utilizing Murray turbines is industrial grade water which contains dissolved and suspended contaminants which must be removed prior to use in the steam system.

To avoid the likelihood of adverse effects from deposits and harmful ions, limits shown in Table 7 are established for steam turbines. These limits are based on operating history and recommendations from various consultants. Their maintenance will ensure protection of the turbine.

NOTE

Warranty may be void in the event operational failure is attributed to inadequate boiler feed water treatment.

EFFECTS OF DEPOSITS AND HARMFUL IONS ON TURBINE

Efficiencies in a steam turbine are sensitive to surface finish because of the high velocities and sharp turning that are required by the design. While corrosion and stress corrosion problems are unusual in steam plants, such problems can result from boiler carry-over due to inadequate de-aeration and boiler feed-water treatment.

The chloride ion that is present in most industrial water, can cause stress corrosion problems, but most typically it is associated with the pitting of turbine blades and nozzles, especially in the presence of oxygen.

DETECTION OF DEPOSITS

Indication of the accumulation of deposits in the steam path could include:

- Increased stage pressure.
- Reduced power output.
- Increased active thrust with increased oil or bearing temperatures in the thrust bearing.
- Excessive vibration

If deposits are observed in the turbine during inspection, samples should be taken and submitted for chemical analysis by a laboratory to determine their make-up and what action is required to remove them from the system.

DETECTION OF CORROSION

Indications of corrosion may be difficult to determine. A steam turbine's efficient performance dictates that it's steam path possess tight corners and crevices. These areas can be susceptible to pitting due to the collection of condensate that possesses harmful ions.

The turbine's blade and first stage nozzles should be inspected during scheduled shutdown using a bore scope. If possible the upper half casing should be removed, under supervision of a YORK Service Representative for better inspection.

Pitting of the blades and nozzles is evidence of a corrosive attack, making them susceptible to stress corrosion cracking. YORK Service should be consulted prior to the restart of the turbine. If residue or condensate is present in the turbine and corrosion is present, samples of the residue or condensate should be submitted for chemical analysis to determine the presence of excessive chlorides and other harmful ions.

TABLE 7 - RECOMMENDED LIMITS FOR BOILER WATER (BASED ON DRUM WATER ANALYSES).

PRESSURE AT OUTLET OF STEAM GENERATING UNIT, PSIG	TOTAL SOLIDS PPM	OH ALKALINITY PPM	SILICA PPM	PHOSPHATE PPM	SULFITE PPM	HARDNESS PPM	CHLORIDES PPM
0-150	2,000	200	50	50	30	0	250
151-450	1,500	100	35	50	30	0	200
451-750	1,000	60	25	25	25	0	150
751-900	750	55	10	25	20	0	50

The following factors can be used to convert from English to the most common SI Metric values.

TABLE 8 - SI METRIC CONVERSION

MEASUREMENT	MULTIPLY ENGLISH UNIT	BY FACTOR	TO OBTAIN METRIC UNIT
Capacity	Tons Refrigerant Effect (ton)	3.516	Kilowatts (kW)
Power	Horsepower	0.7457	Kilowatts (kW)
Flow Rate	Gallons / Minute (gpm)	0.0631	Liters / Second (l/s)
Length	Feet (ft)	0.3048	Meters (m)
	Inches (in)	25.4	Millimeters (mm)
Weight	Pounds (lbs)	0.4538	Kilograms (kg)
Velocity	Feet / Second (fps)	0.3048	Meters / Second (m/s)
Pressure Drop	Feet of Water (ft)	2.989	Kilopascals (kPa)
	Pounds / Square Inch (psi)	6.895	Kilopascals (kPa)

TEMPERATURE

To convert degrees Fahrenheit (°F) to degrees Celsius (°C), subtract 32° and multiply by 5/9 or 0.5556.

Example: (45.0°F - 32°) x 0.5556 = 27.2°C

To convert a temperature range (i.e., a range of 10°F) from Fahrenheit to Celsius, multiply by 5/9 or 0.5556.

Example: 10.0°F range x 0.5556 = 5.6 °C range

NOTES

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