

## CHAPTER 11

# CHILLED WATER SYSTEMS

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### 11-1. Minimum maintenance activities for chilled water systems

The tables located at the end of this chapter indicate items which must be performed to maintain systems and equipment at a minimum level of operational readiness. The listed action items should be supplemented by manufacturer-recommended maintenance activities and procedures for specific pieces of equipment. Maintenance actions included in this chapter are for various modes of operation, subsystems, or components. Table 11-1 provides maintenance information for chilled water system centrifugal chillers. Table 11-2 provides maintenance information for chilled water system pumps. Table 11-3 provides maintenance information for chilled water system piping. Table 11-4 provides maintenance information for refrigerant compressors used in thermal storage systems. Table 11-5 provides maintenance information for refrigerant piping and accessories of thermal storage systems. Table 11-6 provides maintenance information for chilled water system instrumentation and electrical systems.

### 11-2. General maintenance procedures for chilled water systems

This section presents general instructions for maintaining various components for a typical chilled water system.

*a. Tubular heat exchanger maintenance.* Since heat exchangers have no moving parts, heat exchanger maintenance problems generally result from poor coolant maintenance or poor quality cooling water. Another cause of maintenance problems is temperature and pressure cycling as chillers/compressors are started and stopped.

(1) Heat exchangers are subject to fouling or scaling. A light sludge or scale coating on heat transfer surfaces can greatly reduce the effectiveness of the heat exchanger. This loss of performance may show up as higher than design temperatures or higher than design pressure drops through the heat exchanger unit. Units require periodic cleaning to maintain performance. Sludge or similarly soft deposits on the interior of radiator tubes and both sides of shell and tube heat exchangers may be removed by circulating a hot wash oil or a light distillate through the tubes at a good velocity. Salt deposits may be removed by circulating hot, fresh water through the tubes at a good velocity. If the above methods are not effective, there are many commercial chemical cleaning programs available. Carefully follow the manufacturer's instructions as these programs generally use an acid or caustic wash that must be neutralized to prevent long-term attack on heat transfer surfaces or interference with chilled water chemical treatment programs.

(2) The air side of air-cooled heat exchangers usually requires cleaning to remove buildups of dirt and grime. Satisfactory cleaning can usually be accomplished by rinsing the outside of tubes with a high-pressure stream of fresh water.

(3) When opening or disassembling a heat exchanger for inspection or maintenance:

*(a)* Do not open inspection ports until all pressure is off the equipment. Do not begin disassembly until the unit has been drained (both sides of a liquid-to-liquid heat exchanger).

(b) Exercise care in handling tube bundle to avoid damaging the tubes. Do not handle tube bundles with hooks or other sharp tools which might damage tubes. A skid, cradle, or other protective device should be used when available.

(c) Thoroughly clean tubes at each cleaning. Leaving any film on the tubes only decreases the time interval to the next cleaning. Avoid using mechanical devices to clean the coolant side (usually the inside) of tubes. Wire brushes and scrapers may be used to assist in cleaning the cooling water side (usually the outside) of tubes. Exercise care to minimize damaging the tube surfaces.

(d) Inspect heads for damage and repair as required. On units with tubes rolled into the tube sheet, tighten loose tubes using a suitable roller type tube expander. Only roll loose or leaking tubes, as rolling thins the tube walls. Routine rolling of all tubes may result in early failure of the entire tube bundle.

(e) When reassembling the unit, do not tighten bolts on gasketed connections until the gasket has been properly seated. Replacing the gaskets when the unit is reassembled can eliminate having to schedule another shutdown to replace a leaking gasket. Composition gaskets become brittle and dried out and do not provide an effective seal when reused. Metal or metal-jacketed gaskets when compressed initially tend to match the gasket contact surfaces and become work-hardened. When reassembled, the joint may not make up the same and a work-hardened gasket will not conform to the mating surfaces. The joint may leak and the mating surfaces may be damaged.

(f) When a new or repaired unit is placed in service, frequently inspect all gasketed joints during the first two days of operation for leaking joints or loose bolts. Tighten and adjust as required.

*b. Test alarms.* Verify operation of system alarms and alarm system by actuating appropriate system test push buttons. Verify that the audible alarm sounds and that all warning and annunciator lights operate.

*c. Rotating equipment clearance adjustment.* After a long service, the running clearances in some types of rotating equipment (fans, pumps, compressors, etc.) may increase to the point where the device is losing capacity or pressure. Resetting the clearances will normally improve performance. Check clearances during annual inspections, and adjust as required. Refer to the manufacturer's technical service manual.

*d. Examine internal parts of rotating equipment.* Periodically (at least annually), remove casing access covers and inspect components for wear. Replacing a relatively inexpensive part after only moderate wear can eliminate the need to replace more expensive parts at a later date. Refer to the manufacturer's technical service manual.

*e. Flexible coupling installation and alignment.* The following instructions cover, in general, the installation of flexible couplings of the pin, gear, or grid type.

(1) Verify that equipment the coupling is serving is completely assembled and adjusted before installing drive coupling.

(2) Install each half cover with seals on its shaft. Consult coupling manufacturer's data to determine proper orientation of long and short shanks of coupling.

(3) For non-taper lock hub units, heat coupling to approximately 300°F by means of a hot oil bath or oven. **Do not apply flame to hub teeth.**

(4) Install coupling hubs on motor and driven shafts. Install shaft keys while hubs are still hot. Face of hub should be flush with end of shaft.

(5) Adjust clearance between the coupling faces. Consult manufacturer's data for proper clearance. (Some coupling units may have the required clearance stamped on the coupling unit.)

(6) When a sleeve bearing motor is used, locate the motor so that when the motor rotor is closest to the driven shaft, the motor shaft will not touch the driven shaft. If the motor shaft has a magnetic center marked, base clearance between coupling faces on magnetic center. Otherwise, determine maximum motor shaft movement and base clearance between coupling faces on one half of the motor shaft movement.

(7) With tapered wedge, feeler gauges, or dial indicator, verify that faces of coupling hubs are parallel.

(8) Using a straightedge or dial indicator, verify that motor and driven shafts are parallel. Shim and adjust as required.

(9) After alignment of shafts is obtained, recheck spacing between hub faces and verify that faces are parallel to within 0.001 inch.

(10) When alignment is complete, thoroughly clean both sides of the coupling and inspect all parts for damage. Install the gasket and draw the coupling flanges together keeping gasket holes in line with bolt holes. Insert and tighten bolts, lock washers, and nuts. Lubricate coupling in accordance with the manufacturer's data. When aligning shafts, a general rule is to align large motor shafts so the center of the motor shaft is 0.001 inch lower than the driven shaft for every 1 inch of motor shaft diameter. Turbine shafts or similar large rotating equipment, as a general rule, are set 0.001 inch lower than the driven shaft for every 1 inch of height from the mounting feet to the center of the shaft. This initial offset provides for thermal expansion of the equipment. After the equipment has been in operation long enough to reach the operating temperature, the alignment of the shafts should be checked and adjusted as required.

*f. Clean all equipment.* Clean all equipment regularly. Clean equipment is easier to inspect, lubricate, and adjust. Clean equipment also runs cooler and looks better.

Table 11-1. Chilled water system (centrifugal chillers)

<b>Chilled Water System (Centrifugal Chillers)</b>	
<i>Action</i>	<i>Frequency</i>
<b>Centrifugal Chiller (Operating)</b>	
Check control center gauges and lights, excess purge light, and remote start operations.	shift
Record the bearing oil pressure and check oil level in the oil sump. Drain or add oil as required.	shift
Check the inlet and outlet water pressures and temperatures for variations with normal values.	shift
Record liquid refrigerant temperature leaving the condenser.	shift
Record the compressor discharge temperature (should not exceed 220 F).	shift
Check for signs of dirty or fouled condenser tubing (the temperature difference between the water outlet and refrigerant outlet should not be larger than 4 F).	shift
Record the compressor motor voltage and amperage at the starter.	shift
<b>Centrifugal Chiller (Off-Line)</b>	
Clean and wipe down the condenser, compressor, motor control panel, and associated pumps and piping. Inspect the unit and motor base. Tighten all loose bolts, fasteners, and anchors.	week
Check for oil, refrigerant, and/or water leaks. Verify proper water treatment.	week
Check the refrigerant charge.	week
Check the drive coupling on the motor/compressor unit. Realign as required.	mo
Inspect the electrical wiring, connections, control switches, switch contacts, starter contacts, and fuses. Repair or replace as required.	mo
Change the purge filter drive.	3 mos
Inspect and clean the purge foul gas strainer and check valve.	3 mos
Perform chemical analysis of the oil. Record results.	3 mos
Change compressor oil filter element.	3 mos
Change oil system return filter.	3 mos
Inspect the nozzle and the oil return eductor for foreign particles.	3 mos
Check controls for safety cutouts. Confirm the integrity of the high- and low-pressure bellows of the oil pressure cutout system.	6 mos
Drain and replace oil in the compressor sump.	yr
Inspect and clean cooler, condenser, strainers, tubes, and end sheets.	yr

Table 11-1. Chilled water system (centrifugal chillers) (continued)

<b>Chilled Water System (Centrifugal Chillers)</b>	
<i>Action</i>	<i>Frequency</i>
Inspect and clean purge unit valves and orifices in the liquid feed line to the cooling coil and in the line connecting the purge exhaust line to the pressure switch. Drain and flush purge shell.	yr
Perform chemical analysis of the entire system.	yr
Megger compressor motor windings.	yr

Table 11-2. Chilled water system (pumps)

<b>Chilled Water System (Pumps)</b>	
<i>Action</i>	<i>Frequency</i>
<b>Pumps (Off-Line)</b>	
Clean and wipe down pump unit.	mo
Lubricate all operating equipment fitted with grease fittings.	mo
Inspect pump and seals for leaks. If leaking, repack (replace seals if mechanical type).	mo
Inspect valves and piping for leaks and corrosion. Repair leaks. Corroded surfaces shall be cleaned and repainted.	mo
Adjust valve stem packing if leaking. Replace packing as required.	mo
Inspect electrical wiring, connections, switches, and switch contacts. Repair or replace defective items as required. Tighten all connections. Check pump (motor) rotation.	mo
Inspect and repair damaged pipe insulation adjacent to pump installation.	mo
Tighten or replace loose, missing, or damaged nuts, bolts, or screws.	mo
<b>Pumps (Operating)</b>	
Upon energizing pump unit, observe and record suction and discharge pressures. Verify proper pump rotation and record data.	mo
Observe pump and motor operation. Note and record any undue vibration and noises that could indicate prospective malfunctions.	mo
Observe and record electrical load data on motor when under full load.	mo
Inspect shaft alignment and clearances of impeller and shaft. Readjust as required.	3 mos
Inspect drive couplings for wear and alignment.	3 mos
Adjust as required. Ensure that couplings are tight on shafts and are in alignment. Ensure coupling and shaft guards are in place.	as req'd
Replace mechanical pump seal.	yr

Table 11-3. Chilled water system (piping)

<b>Chilled Water System (Piping)</b>	
<i>Action</i>	<i>Frequency</i>
<b>General</b>	
Drain collecting tees and strainers.	mo
Check piping connections for leaks. Repair if needed.	mo
Check piping and equipment for rust spots. Determine cause of rust and repair as required. Clean and paint as required.	mo
Check for missing identification tags on equipment and piping.	mo
Check insulation to make sure it is not torn, missing, or degraded, and that it is still fastened to piping.	yr
Check pipe supports, hangers, and straps to make sure the piping is properly supported.	yr
<b>Valves</b>	
Check water valves for leaks. Correct defective conditions. Lubricate and tighten packing as necessary.	mo
Exercise all valves and grease stems (on os&y valves).	mo
<p><b>CAUTION!</b></p> <p>BEFORE OPENING OR CLOSING ANY VALVE FOR MAINTENANCE, CONTACT YOUR AREA SUPERVISOR. BE SURE THAT THE VALVE CAN BE EXERCISED WITHOUT CAUSING ANY DAMAGE TO IT OR OTHER COMPONENTS.</p>	
<b>Control Valves</b>	
Check for correct positioning and operation.	mo
Wipe valve operator rods clean and apply a thin coat or light oil.	mo
Adjust operator linkages and limit switches.	mo
Check electrical connections for loose, cracked, or frayed wires where applicable. Repair as required.	yr
<b>Expansion Tanks</b>	
Check tank for correct water level and air pressure charge. Check all fittings for leaks.	mo
<b>Indicators</b>	
Inspect all temperature and pressure indicators for cracked or broken covers, insecure mounting, and defective operation.	mo
Remove all indicators and test the accuracy.	yr

Table 11-3. Chilled water system (piping) (continued)

<b>Chilled Water System (Piping)</b>	
<i>Action</i>	<i>Frequency</i>
<b>Strainers</b>	
Check strainer for clogging. Clean if necessary.	week
Inspect strainer internals for wear. Replace if necessary.	yr
<b>Chemical Pot Feeders</b>	
Check operation of shutoff, bypass, and drain valves. Clean, repair, or replace as necessary.	3 mos
Close shutoff valves, open drain valve, and flush feeder with fresh water.	3 mos

Table 11-4. Refrigerant compressors used in thermal storage systems

<b>Refrigerant Compressors Used In Thermal Storage Systems</b>	
<i>Action</i>	<i>Frequency</i>
<b>General</b>	
Check oil levels both during operation and shutdown. Mark oil level on sight glass for reference.	day
Check sight glass for water accumulation.	day
Check the operating oil pressure and temperature. Adjust these as required to the compressor manufacturer's specifications.	week
Check suction and discharge pressures and temperatures.	week
Listen for unusual starting and operation noises.	week
Inspect all compressor gaskets for leaks. Be sure to open hermetic terminal box to check for leaks into the box. Check bolt torque or replace gaskets if you find any leaks.	week
Stop the compressor and inspect the oil level and condition of crankcase oil. Refill or replace oil when necessary. If the compressor has force-feed lubrication, check the oil pump pressure gauge.	mo
Inspect compressor motor for cleanliness, proper operation, and lubrication. When necessary, clean motor housing and lubricate motor bearings.	mo
Inspect the electrical circuit (including starter, controls, and compressor terminal box) for dirt and moisture. Clean and dry out if necessary.	3 mos
Inspect the condition of starter contacts and terminals. Dress or replace worn contacts. Clean and tighten terminals.	3 mos
Measure line voltage to compressor motor and balance between phases. Report abnormal conditions due to power source.	3 mos
Measure motor amperage draw. If above motor nameplate amperage, determine cause and repair.	3 mos
Test compressor protection devices for proper setting and operation. Adjust, repair, or replace if necessary.	3 mos
Check all compressor joints for refrigerant leaks, and check the purge unit for air and water leaks.	3 mos
Check the oil temperature and pressure cutouts for proper operation.	6 mos
Check safety controls for proper operation, including the chilled water and refrigerant low-temperature cutouts, condenser water high-pressure cutout, oil low-pressure cutout, and condenser water flow switches.	6 mos
Change the oil. If it becomes contaminated during machine repairs, it should be replaced. Replace the oil filter each time the oil is changed.	yr

Table 11-4. Refrigerant compressors used in thermal storage systems (continued)

<b>Refrigerant Compressors Used In Thermal Storage Systems</b>	
<i>Action</i>	<i>Frequency</i>
Inspect the bearings and replace them as necessary.	yr
Remove samples of refrigerant from the unit and have it analyzed by a competent laboratory. If the refrigerant is contaminated, consult with the unit's manufacturer for recommendations.	2 yrs
<b>Centrifugal Compressors</b>	
Keep the oil heater on during all compressor shutdowns.	as req'd
Check purge unit and its controls for proper operation, corrosion, and wear. Repair or replace as required.	3 mos
<b>Reciprocating Compressors</b>	
Keep the crankcase heater on during all compressor shutdowns.	as req'd
Inspect compressor drives for pulley alignment, belt tension, and condition of belts. Replace defective belts.	mo
Test for leaking compressor discharge and suction valves. Repair leaky valves.	3 mos
Disassemble compressor as necessary. Clean and repair parts. Replace defective parts. Regrind suction and discharge valves. Change the oil.	as req'd

Table 11-5. Refrigerant piping and accessories of thermal storage systems

<b>Refrigerant Piping and Accessories of Thermal Storage Systems</b>	
<i>Action</i>	<i>Frequency</i>
<b>Refrigerant Piping</b>	
Check the refrigerant piping for leaks and proper support. Repair defective connections.	3 mos
Check piping insulation to make sure the insulation is still wrapped around piping. Repair or replace if needed.	3 mos
Check piping for dents and frosting. Replace piping section if dents are found.	3 mos
Check piping for unnecessary vibration, noise, and wear. Repair and eliminate vibration and wear.	3 mos
<b>Automatic Expansion Valves</b>	
Check pressure on low side of valve to test for proper operation. Adjust valves when necessary.	3 mos
<b>Thermostatic Expansion Valves</b>	
Check the superheat of the expansion valve to see that it gives the proper control. Adjust, repair, or replace if necessary.	3 mos
<b>Flooded Evaporator Float Valve</b>	
Check the operation of the float valve to see that it gives the proper refrigerant level control in the evaporator. Repair or replace if not operating properly.	3 mos
<b>Refrigerant Receivers</b>	
Check the level of the refrigerant charge. Replenish the charge when necessary.	mo
Check the safety pressure relief valve or fusible safety plug to ensure that it is present and not damaged.	mo
<b>Oil Traps and Separators</b>	
Inspect the operation of the float valve. Clean the float assembly and adjust the float valve needle when necessary.	3 mos
<b>Oil Receivers</b>	
Check the operation of the float valve. Clean the float assembly and adjust when necessary.	3 mos
Take the receiver apart and clean the interior and exterior. Replace gaskets and worn or defective parts.	3 mos
<b>Solenoid Valves</b>	
Check the operation of the valve. Repair or replace if necessary.	mo
Check electrical connectors for loose, cracked, or frayed wires.	yr

Table 11-5. Refrigerant piping and accessories of thermal storage systems (continued)

<b>Refrigerant Piping and Accessories of Thermal Storage Systems</b>	
<i>Action</i>	<i>Frequency</i>
<b>Suction Pressure Regulator, Hot Gas Bypass Valve, or Head Pressure Control Valve</b>	
Test the regulator or valve for proper operation. Adjust regulator or valve as required. Repair or replace if inoperative.	mo
<b>Filter-Dryers and Strainers</b>	
Check strainers for clogging. Clean and replace if necessary.	mo
Replace filtering and drying material in filter-dryers that can be changed without taking the unit out of service.	yr
<b>Refrigerant Valves</b>	
Check refrigerant valves for leaks. Correct defective conditions. Lubricate packing when necessary.	mo
Check relief valve to be sure it is clean, unobstructed, and sealed properly.	mo
<b>Sight Glass and Moisture Indicator</b>	
Check the sight glass for signs of bubbles, indicating improper refrigerant charge. Add refrigerant if needed.	mo
Check the moisture indicator for signs of moisture, which is indicated by a color of the indicator. Install or replace dryer.	mo
Check for leaks around connectors. Repair if necessary.	mo
<b>Hot Gas Muffler</b>	
Check hot gas muffler for excessive noise or vibration. Replace if necessary.	mo
<b>Pressure Gauges</b>	
Inspect pressure gauges for cracked or broken covers, insecure mounting, and defective operation. Replace damaged or defective gauges.	mo
Remove pressure gauges and test accuracy.	yr

Table 11-6. Chilled water system instrumentation and electrical

<b>Chilled Water System Instrumentation &amp; Electrical</b>	
<i>Action</i>	<i>Frequency</i>
<b>Pneumatic Control Systems</b>	
Check for air leaks in joints of piping and at control devices using soapy water, with control air compressor operating. Repair or replace parts as required.	3 mos
Check the contact surfaces and condition of all transmitters, sensing elements, temperature indicators, and pressure gauges.	3 mos
Check the operation of all control devices.	yr
Calibrate all controllers as recommended by the manufacturer of the control. Set the control point(s), sensitivity, range, proportional band, etc., to the correct values.	yr
Check the calibration of all transmitters, sensing elements, switches (temperature, pressure, flow, etc.), time delay relays, temperature and pressure indicators, and recorders. Clean, repair, or replace parts as needed. Calibrate the devices as necessary according to the manufacturer's instructions. Set the cut-in and cut-out points of all switches and time delay relays to the right value.	yr
<b>Electronic and Electric Control Systems</b>	
Check the main control panels for broken or frayed wires or loose connections.	3 mos
Check the contact surfaces and condition of all transmitters, sensing elements, temperature indicators, and pressure indicators.	3 mos
Check the contact and switch points in motor starters, relays, and switches to be sure that they are clean and meet properly. Clean or replace contacts and switches as needed.	6 mos
Check the operation of all control devices.	yr
Calibrate all controllers as recommended by the manufacturer of the control. Set the control point(s), sensitivity, range, etc., to the correct setting.	yr
Check the calibration of all transmitters, sensing elements, switches (temperature, pressure, flow, etc.), time delay relays, temperature and pressure indicators, and recorders. Clean, repair, or replace parts as needed. Calibrate the devices as necessary according to the manufacturer's instructions. Set the cut-in and cut-out points of all switches and time delay relays to the right value.	yr
<b>Motors</b>	
Check and clean cooling airflow passages on electric motors as necessary so that nothing obstructs airflow.	6 mos
<b>All Electrical Devices</b>	
Check, clean, and tighten terminals at motors, starters, disconnect switches, etc.	6 mos
<b>Wiring</b>	

Table 11-6. Chilled water system instrumentation and electrical (continued)

<b>Chilled Water System Instrumentation &amp; Electrical</b>	
<i>Action</i>	<i>Frequency</i>
Check insulation on conductors in starters, switches, and junction boxes at motors for cracks, cuts, or abrasions. Replace wiring as required and correct cause of damage.	6 mos