CHAPTER 8

COOLING SYSTEMS

8-1. Minimum maintenance activities for cooling 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 minimum 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 8-1 provides maintenance information for diesel engine (closed water jacket) cooling systems. Table 8-2 provides maintenance information for cooling towers. Table 8-3 provides maintenance information for cooling system controls and instrumentation.

8-2. General maintenance procedures for cooling systems

This section presents general instructions for maintaining the types of components associated with cooling systems.

a. Coolant preparation and maintenance. When changing or adding coolant to an engine, observe the following guidelines.

(1) Premix the coolant in a clean tank. Never add antifreeze (ethylene glycol) directly into engine cooling system.

(2) Carefully measure additives (coolant conditioner, rust inhibitor, oxygen scavenger, antifreeze, etc.) and water. Excessive levels of some additives when combined with high concentrations of antifreeze may cause mud-like compounds to form which can block the cooling system. Antifreeze concentrations in excess of about 63 percent by volume result in reduced freeze protection. A 50 percent solution of most commercial antifreezes in water will provide freeze protection to about –32°F. (Most undiluted commercial antifreeze freezes at about –10°F.)

(3) Never add coolant to an overheated engine. Allow engine to cool and then add coolant.

(4) When filling an empty engine cooling system, do not add coolant at a rate of more than 10 gallons per minute. Slowly filling a cooling system minimizes the likelihood of air being trapped in the system.

(5) Do not switch from ethylene glycol based antifreeze to methoxypropanol based antifreeze or synthetic antifreeze compounds without verifying suitability with engine manufacturer. Methoxypropanol and synthetic antifreezes are not compatible with seal and gasket materials which are commonly used in cooling systems.

b. 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 engines 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 coolant or cooling water chemical treatment programs.

(2) The air side of air-cooled heat exchangers usually just require 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 scrappers may be used to assist in cleaning the cooling water (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.

c. Inspect engine cooling and cooling tower systems. Inspect for:

(1) Obstructions to cooling air paths

(2) Obstructions to the face area of radiators or cooling tower air inlets

(3) Dirty strainers (high pressure drop)

(4) Damage to or deterioration of equipment housings, fan housings, ducts, expansion joints, etc., that would let cooling air leak into the system between the device to be cooled and the fan. This leakage may reduce the air flow through the device being cooled which may reduce the capacity of the system.

(5) Damage to or deterioration of exhaust ducts, flexible connections, and other discharge components that would allow hot moist air to leak into occupied spaces.

(6) Obstructions in dampers, isolation valves, and device operators that would prevent free movement of the device.

(7) Deformed flexible piping connections and expansion joints

(8) Misaligned or sagging pipe and duct sections

(9) Deformed or broken pipe and duct support devices. (Verify that support devices designed to accommodate movement of the duct are free to operate.)

(10) Unusual noise, vibration, or overheating

(11) Loose mechanical or electrical connections

(12) Missing components

(13) Low lube oil levels in equipment with lube oil sumps

(14) Misalignment of drives, worn belts and pulleys, and loose drive belts on belt-driven equipment

(15) Damaged or missing equipment guards

(16) Damaged or missing insulation

(17) Damaged or missing equipment tags

d. Exercise remote operated dampers and valves. Exercise all remote operated dampers and valves.

(1) Verify free operation of dampers and valves.

(2) Inspect any packing glands and tighten as necessary.

(3) Check for leaking seals.

(4) Wipe damper and valve operators clean, apply a light coat of protective oil to exposed operating shafts, and lubricate bearings and pinned connections.

(5) Adjust operator linkages for proper valve positioning, and adjust limit switches for proper position indication.

e. 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.

f. Rotating equipment clearance adjustment. After 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.

g. 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 manufacturer's technical service manual.

h. Flexible coupling installation and alignment. These instructions cover, in general, the installation of flexible couplings of the pin, gear, or grid types.

(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 required clearance stamped on coupling unit.)

(6) When a sleeve bearing motor is used, locate 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 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 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 each 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 each 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 operating temperature, the alignment of the shafts should be checked and adjusted as required.

i. 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 8-1. Diesel engine (closed water jacket) cooling system

Diesel Engine (Closed Water Jacket) Cooling System	
Action	***Frequency***
Coolant	
Check the level of the engine coolant in the expansion tank. Add coolant as required.	day
Test coolant to determine:	
Concentration of oxygen scavengers or corrosion inhibitors. Add water treatment additives to maintain concentrations required by water treatment program. (250 hours of engine operation or monthly, whichever occurs first.)	250 hrs/mo
Freezing point (specific gravity) of coolant in engines requiring antifreeze protection. Drain coolant and add fresh coolant as required to maintain freeze protection.	mo
Drain and clean cooling system and replace engine coolant with new coolant. (At 6,000 hours of engine operation or yearly, whichever occurs first.)	6K hrs/yr
Overall Engine Cooling System	
Clean and inspect all of the components and piping associated with engine cooling system and report all discrepancies to supervisor. Inspect for:	
Leaking piping or equipment (gaskets, seals, packing, etc.)	mo
Corrosion.	mo
Sagging or misaligned piping.	mo
Damaged flexible connectors or expansion joints.	mo
Loose equipment, piping, or electrical connections. (Correct during inspection if possible).	mo
Incorrect level, temperature, or pressure gauge operation.	mo
Hot or noisy bearings, and equipment with unusual vibration or noise.	mo
Exercise all cooling system valves and perform routine maintenance as follows:	
Grease stems on OS&Y valves.	mo
Verify correct position and operation.	mo
Check for leaking seals.	mo
Wipe valve operator rods clean and apply a light coat of protective oil.	mo
Adjust operator linkages and limit switches.	mo
Keep Warm System Immersion Heater	
Remove heating element and inspect for scaling, corrosion, or excessive oxidation. Report discrepancies to supervisor.	yr

Table 8-1. Diesel engine (closed water jacket) cooling system (continued)

Diesel Engine (Closed Water Jacket) Cooling System	
Action	***Frequency***
Keep Warm Circulating Pump	
Lubricate bearings.	3 mos
Engine Driven Circulating Pump	
Inspect, repair, and maintain, in accordance with engine maintenance schedule.	as req'd
Air Separators	
Blow down separator on initial engine startup or after major cooling system maintenance. (Daily until dirt clears from system.)	day
Blow down separator during routine engine operation. (Weekly or as required by coolant treatment program.)	week
Inspect and clean strainer element.	mo
Strainers	
Remove and inspect strainers on nonoperating engines and clean as required.	mo
Coolant Heat Exchangers	
After initial engine start or after engine has been out of service for major maintenance, inspect units for leaks, and adjust and tighten gasketed joints as required. (Each 8-hour shift for 2 days following startup)	8 hrs
During operation, monitor and record engine coolant inlet and outlet temperatures (and for liquid cooled units, cooling water inlet and outlet temperatures) as a means of monitoring the condition of heat transfer surfaces.	week
Inspect, repair, and clean heat transfer surfaces of liquid-to-liquid heat exchangers (tube side and shell side).	yr
Inspect, repair, and clean heat transfer surfaces of air-cooled heat exchangers:	
Engine coolant side.	yr
Inspect unit and remove obstructions blocking air path.	day
Wash radiators on non-operating engines to remove dirt	3 mos
Radiator Propeller Fans	
Clean and inspect units and perform routine maintenance. Report all discrepancies to supervisor.	
Check and tighten set screws and bolts in fan hub and fan bearings.	week
Visually check drive alignment and clearances between fan blades and housing. Adjust as required.	week
On belt driven units, inspect belts and pulleys.	week

Table 8-1. Diesel engine (closed water jacket) cooling system (continued)

Diesel Engine (Closed Water Jacket) Cooling System	
Action	***Frequency***
When fan is operating, check for hot shafts and bearings, and any unusual noise or vibration.	week
On belt driven units, measure belt tension and adjust as required.	mo
Lubricate all bearings (except motor bearings).	
Sleeve bearings.	mo
Ball bearings.	3 mos
Roller bearings.	mo
Temperature Control Valves	
Remove from system and inspect internal components. Verify operation. Repair or replace parts as required. Perform work in accordance with manufacturer's recommendations.	yr
Alarms and Annunciators	
Verify operation of system alarms and annunciators using control system test and reset (or acknowledge) function each shift.	shift

Table 8-2. Cooling tower

Cooling Tower	
Action	***Frequency***
Spray Water System and Equipment	
Inspect and perform routine maintenance, and report all discrepancies to supervisor.	
Check water chemistry.	week
Check water level in pan and adjust makeup water valve as required.	mo
Check operation of blowdown valve. In general blowdown rate should be equal to rate of evaporation.	mo
Inspect and clean all strainer elements.	mo
Inspect spray nozzles and clean as required.	mo
Inspect spray pump(s) for leaking seals.	mo
Inspect cooling coils for scaling or corrosion. Brush exterior surfaces of coil with stiff bristle brush and flush with fresh water.	mo
Drain pan. Brush interior surfaces with stiff bristle brush and flush with fresh water.	mo
Inspect entire unit for leaks, corrosion, and cleanliness.	mo
Inspect housing and pan for corrosion or damaged coatings and repair coatings as required.	yr
All Rotating Equipment (Fans and Pumps)	
Inspect equipment and perform routine maintenance, and report all discrepancies to supervisor.	
Check for hot bearings.	week
Check for unusual noise or vibration.	week
Check tightness of fasteners (nuts, machine screws, set screws, shaft collars, etc.) and tighten as required.	mo
Visually inspect drive alignment.	mo
Lubricate bearings:	
Sleeve bearings.	mo
Ball bearings.	3 mos
Roller bearings.	mo
For units with belt drives inspect belts and pulleys.	mo
Measure belt tension and adjust as required.	mo

Table 8-2. Cooling tower (continued)

Cooling Tower	
Action	***Frequency***
Pumps	
Check packing and adjust as required.	mo
Inspect internal components, replace as required, and adjust in accordance with manufacturer's recommendations.	yr
Fans	
Inspect fan blades (or fan wheel) for buildup of dirt or scale, use soft brush or clean rages to loosen or remove dirt, and flush surfaces with clean water.	mo
CAUTION! SOME FANS MAY HAVE INTERNAL COMPONENTS PROTECTED WITH CORROSION RESISTANT COATINGS WHICH CAN BE DAMAGED EASILY. DO NOT USE CLEANING TOOLS OR MATERIALS THAT WILL DAMAGE COATINGS.	
Inspect internal components and repair or replace as required. This includes repairing defects in protective coatings. If work performed on fan wheel, check balance and rebalance as required.	yr
Dampers	
Inspect damper assemblies, and report all discrepancies to supervisor. Inspection shall include:	
Verify damper position relative to facility mode of operation. Adjust position indication switches as required.	week
Exercise dampers to verify free operation; repair or adjust as required.	mo
Inspect seals and contacting surfaces for full contact; adjust and/or repair seals and contacting surfaces as required.	mo
Wipe clean damper operator and linkages; apply a light coat of oil.	mo
Clean and inspect bearings; lubricate and adjust bearings as required.	mo
Remote Operated Valves	
Verify valve position. Adjust position indication switches as required.	week
Clean rods on valve operator and apply a light coat of protective oil.	mo
Inspect seals.	mo
Inspect and tighten packing.	mo
All Valves	
Exercise all valves and perform routine maintenance and report all discrepancies to supervisor.	

Table 8-2. Cooling tower (continued)

Cooling Tower	
Action	***Frequency***
Grease stems on OS&Y valves.	mo
Inspect packing gland and tighten as necessary.	mo
Verify correct position and operation.	mo
Check for leaking seals.	mo

Table 8-3. Cooling system instrumentation and electrical

Cooling System Instrumentation & Electrical	
Action	***Frequency***
Transmitters and Controllers	
Calibrate and adjust in accordance with the manufacturer's recommendations.	yr
Thermometers	
Check for accuracy. Remove thermometers from their wells and check against calibrated thermometer in controlled temperature bath	yr
Pressure Gauges	
Isolate pressure gauge by closing the proper valves. Remove and check in a fixture against a calibrated gauge. Adjust as required following equipment manufacturer's instructions.	yr
Motors	
Check and clean cooling airflow passages on electric motors as necessary so that nothing obstructs airflow.	6 mos
All Electrical Devices	
Check, clean, and tighten terminals at motors, starters, disconnect switches, etc.	6 mos
Wiring	
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