

5 Steps to Chiller Efficiency

Chillers represent a substantial capital investment and are a major contributor to operating costs in institutional and commercial facilities. For many organizations, chillers are the largest single energy users, and comprehensive maintenance is critical to ensure their reliability and efficient operation.

While some organizations use predictive maintenance — including vibration analysis, infrared thermography, and rotor bar testing — to diagnose problems in advance, a comprehensive preventive maintenance (PM) plan remains the key to ensuring the best performance and efficiency of a chiller.

Chiller efficiencies have improved steadily over the past decade due to advances in controls, refrigerants and equipment design. As a result, chillers now have tighter operational tolerances, and regular service and maintenance are more crucial than ever. When developing a PM plan for chilling equipment, maintenance and engineering managers should consider five essential areas.

Step 1: Maintain a Daily Operating Log

Chiller operators should document chiller performance daily with an accurate and detailed log, comparing this performance with design and start-up data to detect problems or inefficient control setpoints. This process allows the operator to assemble a history of operating conditions, which can be reviewed and analyzed to determine trends and provide advanced warning of potential problems.

For example, if machine operators notice a gradual increase in condensing pressure during a month's time, they can consult the daily operating log and systematically check and correct the possible cause of this condition, such as fouled condenser tubes or non-condensables.

Chiller manufacturers can provide a list of recommended data points specific to equipment upon request. Operators can take data readings daily, once per shift at about the same time. Today's chillers are controlled via microprocessor controls, so managers can automate this process using microprocessor-controlled building automation systems.

Step 2: Keep Tubes Clean

One large potential hindrance to desired chiller performance is heat-transfer efficiency. Chiller performance and efficiency relate directly to its ability to transfer heat, which begins with clean evaporator and condenser tubes. Large chillers contain several miles of tubing in their heat exchangers, so keeping these large surfaces clean is essential for maintaining high-efficiency performance.

Chiller efficiency deteriorates as tubes become fouled, when mud, algae, sludge, scale or contaminants accumulate on the waterside of heat-transfer surfaces. The rate of fouling depends on the system type — open or closed — as well as on water quality, cleanliness and temperature.

Most chiller manufacturers recommend cleaning condenser tubes annually, since they typically are part of an open system, and they recommend cleaning evaporator tubes once every three years for closed systems. But if the evaporator is part of an open system, they recommend periodic inspection and cleaning.

Managers can consider two primary methods for cleaning tubes:

- Mechanical cleaning removes mud, algae, sludge and loose materials from smooth-bore tubes and consists of removing the water-box covers, brushing the tubes and flushing with clean water. For internally enhanced tubes, managers should consult the chiller manufacturer for mechanical-cleaning recommendations.
- Chemical cleaning removes scale. Most chiller manufacturers recommend consulting with a local water-treatment supplier to determine the proper chemical solution required. A thorough mechanical cleaning should always follow a chemical cleaning.

New chillers feature automatic tube-brushing systems, which can be retrofit onto existing chillers. These systems use small, nylon-bristled brushes that flow through the tubes for cleaning. A custom-manufactured, four-way reversing valve is installed in condenser water-piping system, and every six hours, the system automatically reverses the flow through the condenser tubes for about 30 seconds. Coupled with proper water treatment, these systems virtually eliminate fouling within the chiller and maintain design-approach temperatures. These systems typically show payback periods of less than two years.

Step 3: Ensure a Leak-free Unit

Manufacturers recommend quarterly tests of compressors for leaks. Low-pressure chillers using either CFC-11, which has been phased out, or HCFC-123 have sections of their refrigeration systems that operate at subatmospheric pressure. Although these chillers are the most common in today's facilities, it is difficult to create a perfectly sealed machine, and leaks allow air and moisture, commonly referred to as non-condensables, to enter the unit.

Once in the chiller, non-condensables become trapped in the condenser, increasing condensing pressure and compressor-power requirements and reducing efficiency and overall cooling capacity. Low-pressure chillers have high-efficiency purge units that remove non-condensables to maintain design-condensing pressure and promote efficient operation. One chiller manufacturer estimates that 1 psi of air in a condenser equates to a 3 percent loss in chiller efficiency.

Moisture in a chiller also can create acids that corrode motor windings and bearings and create rust inside the shell. Small rust particles called fines float in the vessels and get trapped inside heat-exchanger tubes. Fines on tubes decrease the unit's heat-transfer effectiveness and overall efficiency. Left unchecked, they can lead to costly tube repairs.

The best way to monitor leaks in a low-pressure chiller is to track purge-unit runtime and the amount of moisture accumulation at the purge unit. If either of these figures is too high, the unit has leaks. Other indications of air in the system include increased head pressure and condensing temperature.

High-pressure chillers using CFC-12, HFC-134a, or HCFC-22 operate at pressures well above atmospheric pressure, and leaks in these types of chillers release potentially hazardous refrigerants into the environment. Environmental regulations limit the amount of annual refrigerant leaks.

Leaks also results in a lower refrigerant charge and other operational problems, such as lower evaporator pressure, which can cause the compressor to work harder to produce a lower cooling capacity. For positive-pressure chillers, technicians should monitor the refrigerant charge level and evaporator pressure to detect leaks.

Step 4: Sustain Proper Water Treatment

Most chillers use water for heat transfer, so the water must be properly treated to prevent scale, corrosion and biological growth. A one-time chemical treatment is required for closed-water systems, which are typical of chilled-water systems connected to the chiller evaporator.

Open systems typically are used for condenser-water systems connected to the chiller condenser. Condenser systems that use sources such as cooling towers require continuous chemical water treatment. Managers should work with a chemical-treatment vendor familiar with local water supplies and can provide full-service maintenance for all facility water systems.

Scale should not be a problem if the vendor maintains proper chemical treatment of the evaporator and condenser-water systems. The presence of scale in the condenser or evaporator tubes indicates improperly treated water. The vendor needs to test water quality every three months and correct the water treatment program, which should aid in cleaning the chiller tubes.

Also, all systems strainers should be cleaned every three months. Sand filters and side-stream filters for condenser-water systems are very effective at maintaining clean water, if properly maintained. To determine when cleaning is required, technicians should monitor pressure drop at the filters and refer to manufacturer recommendations on cleaning. Filters should be cleaned quarterly, regardless of pressure drop.

Maintenance of strainers and filters limits chiller-tube erosion caused by sand or other small particles moving at high velocities. Erosion and tube pitting decreases overall heat-transfer effectiveness and decreases efficiency. If uncorrected, these conditions can lead to plugged tubes or catastrophic tube failure.

Technicians should inspect chilled-water and condenser-water piping systems annually for evidence of corrosion and erosion. Most manufacturers recommend eddy-current inspection of heat-exchanger tubes, including an electromagnetic procedure for evaluating tube-wall thickness, every three-five years.

Step 5: Analyze Oil and Refrigerant

Annual chemical analysis of oil and refrigerant can aid in detect chiller-contamination problems before they become serious. Testing consists of spectrometric chemical analysis to determine contaminants, including moisture, acids and metals, which hamper performance and efficiency. A qualified chemical laboratory

specializing in HVAC equipment must perform the analysis. Most manufacturers provide annual oil and refrigerant analysis services.

Technicians should take an oil sample while the chiller is operating. The oil should be changed only if indicated by oil analysis. Technicians also should monitor oil filters for pressure drop and change them during a recommended oil change or if pressure drop is outside of tolerance.

Oil analysis can help detect other chiller problems. For example, high moisture content in the oil can signal problems with the purge unit, and changes in oil characteristics can signal the development of unacceptable compressor wear.

Managers use refrigerant testing to determine contaminants that might lead to reliability and efficiency problems. One main contaminant is oil that migrates into the refrigerant. One chiller manufacturer estimates there is a 2 percent loss in chiller efficiency for every 1 percent oil found in the refrigerant, and it is not uncommon to find 10 percent oil in older chillers' refrigerant. Based on this estimate, such contamination can lead to a substantial 20 percent decrease in efficiency. The bottom line — testing can pay large dividends.

Kevin M. Graham, P.E., is a project manager with 10 years' experience for [Smith Seckman Reid Inc.](#) an engineering and facility consulting firm.

