CHILLER MAINTENANCE FOR RECIPROCATING, ABSORPTION, SCREW, AND CENTRIFUGAL MACHINES

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INTRODUCTION

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Careful attention to details promotes efficient chiller operation, lower operating cost, and increased uptime.

With larger reciprocating chillers being installed, many in critical process applications, the importance of good maintenance cannot be overstated. Some of these chillers have more than 100 tons of refrigeration capacity. Careful maintenance attention can pay big dividends in efficient operation, lower operating cost, and reduced downtime.

Here are some chiller maintenance tips that can help improve efficiency and reliability.

MAINTAIN AN OPERATING LOG

An accurate log is the number one tool for keeping chillers running at peak performance. Recording day-to-day changes in chiller operation allows current performance to be compared to design specifications so maintenance needs can be detected early.

Items to check and log include voltage, current, and motor power; temperatures and pressures for the compressor, condenser, and evaporator; and cooling tower temperatures. Whenever problems are suspected, several checks should be made each day.

An analysis of variations shown in the log can reveal potential problems and allow corrective action to be taken quickly. For example, a decrease in evaporator pressure and an increase in leaving chilled water temperature would indicate a loss of refrigerant or dirty evaporator tubes. Correct preventive maintenance in the early stages would prevent these conditions from becoming a major problem. The result is a more efficient, trouble-free chiller performance.

The recent addition of smart electronic control panels on many reciprocating chillers has greatly simplified the logging of chiller operating data. Maintaining equipment logs should be viewed as the basic task upon which all other maintenance routines are built. The importance of keeping a log cannot be overemphasized.

CHECK CHILLER STARTER AND CONTROLS

Before starting a chiller system, after a seasonal or service-related shutdown, mechanics should make sure the starter and control center are operating properly. Electrical overload settings on the starter should be checked to make certain that the chiller will shut off promptly if the current exceeds safe limits. The starter’s interior should be inspected and vacuumed to remove dust and dirt.

Starter wire connections should be checked for tightness, and electromechanical linkages examined for loose contacts or obstructions. The starter must disengage properly when necessary for the chiller to operate safely.
Contacts should be checked for pitting, and replaced when necessary. Pitted contacts can arc and eventually weld shut. Then the chiller may ignore its own safety cut-outs, and keep the compressor in operation beyond safety limits.

The control center should also be inspected. Controls will typically show some stiffness and corrosion after having been idle, for example, over the winter months.

Control panel and unit controls should be checked for proper calibration, and all safety shut-offs and flow switches should be examined for proper operation. This inspection will help ensure proper chiller operation and minimize the risk of catastrophic failure. All indicator lights and gauges should be inspected.

CHECK THE COMPRESSOR

Discoloration in the compressor cylinder heads or discharge manifold indicates overheating, most likely caused by malfunctioning or broken valves. Not only will valve problems hamper proper operation, but they can also lead to serious chiller damage. If discoloration exists, check the valves for proper operation.

A simple, yet vital, task is checking the compressor oil (and external oil filter, where applicable) of each chiller. Every chiller manufacturer recommends annual oil sampling and filter inspection, with replacement as needed.

The oil sample and filter should be chemically analyzed for the presence of destructive acids and corrosive materials. Also, metal deposits in the filter indicate abnormal parts wear.

Oil sampling and analysis provide clear evidence of chiller condition, allowing maintenance personnel to schedule necessary repairs when cooling demand is low. Change the oil and filters regularly as recommended by the manufacturer. Adjust the frequency of service as operating conditions dictate.

CHECK REFRIGERANT CHARGE

An insufficient refrigerant charge starves the chiller’s evaporator, causing loss of cooling and possibly freezing of water. An overcharge raises discharge pressure, causing lower efficiency, greater compressor wear, and possibly compressor failure.

If the refrigerant charge is too low, there will be bubbles in the liquid sightglass when the chiller is operating under full-load conditions. If the refrigerant charge is too high, the compressor discharge pressure will be higher than normal and there will be excessive subcooling.

The amount of subcooling can be calculated by subtracting the liquid line temperature at the outlet of the condenser from the compressor discharge pressure. This pressure is converted to a temperature using a refrigerant temperature/pressure chart. For example: Discharge pressure of

202 psig converted to 102°F

Liquid line temperature -87°F

Amount of subcooling 15°F

Typically, the subcooling temperature range is 8 to 12°F for water-cooled chillers and 10 to 15°F for air-cooled chillers.
ENSURE PROPER SUPERHEAT

Superheat is the difference between the actual temperature of the suction gas entering the compressor and the suction pressure, converted to a temperature using a temperature/pressure chart. For example:

Suction temperature 44°F

Suction pressure of 60 psig converted to -34°F

Amount of superheat 10°F

A high enough superheat should be maintained to keep the refrigerant in a gaseous state as it enters the compressor. A low superheat temperature could result in liquid refrigerant reaching the compressor, leading to damage.

The superheat should be reset only after steady operation of the chiller has been established and the leaving chilled water temperature has been reduced to the proper level. Again, the correct superheat temperature depends on the chiller, typically 8 to 12°F for water-cooled chillers and 10 to 15°F for air-cooled chillers.

ENSURE PROPER SUPERHEAT

For air-cooled chillers, make sure fans work properly and coils are clean on the condenser side of the system.

For water-cooled chillers, ensure that all flow rates and pressure drops on the waterside of the chiller are within recommended limits. Restricted condenser flow rate, for example, increases head pressure, causing the compressor to work harder and use more electricity to produce the same amount of cooling. A 20 percent reduction in condenser water flow rate will increase full-load energy consumption by 3 percent.

Reduced flow rates are caused by scale buildup on the condenser tubes, partially closed valves, clogged nozzles in the cooling tower, dirty strainers and filters, and air in the water piping. Flow rates can usually be maintained within design limits by adjusting condenser pump discharge valves. If not, determine and correct the cause of the reduced flow.

Although the tips presented here do not cover every facet of reciprocating chiller maintenance, they touch on primary areas for maintenance attention.

Low cooling demand periods are the best times to fine-tune chillers to ensure maximum efficiency and reduce the chance of downtime or failure. During low demand periods, maintenance personnel should become familiar with all areas of chiller care and operation. In the long run, careful and complete startup and maintenance, provide benefits far beyond the time and costs involved.

1. Condenser coil free from debris
2. Fans rotate freely
3. Motor brackets tight
   1. Compressor lubrication circuit primed
   2. Oil shows in crankcase sightglass
   3. Crankcase heater energized
4. Discoloration of cylinder heads

5. Discoloration of discharge manifold

1. Flow rate across cooler

2. Flow rate across condenser

3. Pressure drop across cooler

4. Pressure drop across condenser

5. Clean chilled water strainer

6. Clean condenser water strainer

1. Flow switches operate properly

2. Check and calibrate control panel

3. Check and calibrate unit controls

1. Change filter drier core

2. Check system refrigerant charge

3. Check subcooling

4. Check superheat

5. Make sure line voltage is same as nameplate

Procedures to improve reliability, reduce operating costs, prevent costly repairs, and eliminate downtime for HVAC equipment.

Like all HVAC equipment, chillers should have an active maintenance program designed to uncover potential problems before they become serious. Maintenance needs left unattended can result in loss of efficiency or sudden breakdown, with serious damage to key chiller components.

Specifically, a predictive maintenance program for a chiller system involves nondestructive testing of heat exchangers, periodic analysis of chiller fluids, electronic surveillance of equipment, and a record keeping program to log key operating parameters.

In addition to reducing HVAC operating costs and improving reliability, these procedures also establish a baseline of information which managers can use to predict future maintenance needs.

**EDDY-CURRENT TUBE TESTING**

One of the most costly problems in a water-chiller heat exchanger is tube failure. When a tube develops a leak, water and refrigerant mix in the chiller system to form hydrochloric and hydrofluoric acids.
These acids erode metal parts and components, resulting in extensive damage throughout the system. In the worst case, involving a hermetic motor cooled by refrigerant, the acids attack the insulation on the motor windings. The result is catastrophic, a hermetic-motor burnout, requiring repairs that can cost $50,000 or more, and take several weeks to complete.

Eddy-current tube testing is one of the most effective ways to check the condition of the tubes. Among the common types of damage it can identify are:

- **Internal pitting**, caused by abrasive or corrosive elements in the condenser water loop.
- **Freeze damage**, which occurs when controls fail to sense that the temperature of the heat exchanger has dropped below freezing, allowing water in the tubes to freeze and rupture tube walls.
- **Support wear**, caused by the vibration of the tubes resulting from the boiling action of the refrigerant.
- **Zipper cracks**, tiny tube defects that are difficult to detect.
- **Corrosion**, occurring as acids erode the chiller shells and deposit residue onto the tubes.

To conduct the test, a trained operator inserts a specially-designed electronic probe to induce a small electrical current through the tube being tested. Any variation from normal tube structure will cause a change in the flow of electrical current, which can be observed on an oscilloscope or chart recorder.

In addition to its value as a method of detection, eddy-current tube testing can help identify corrective action, including plugging or replacing faulty tubes, and lead to measures which will prevent future tube problems.

Eddy-current tube testing should be performed every 3 to 5 years, although some maintenance departments request the test annually.

The process can be completed in a day or two, at a cost of less than $2000-an attractive alternative to a major repair bill and several weeks of downtime during the peak cooling season.

**OIL AND REFRIGERANT ANALYSIS**

Periodic analysis of oil and refrigerant samples is another important predictive maintenance technique that can reveal information on the condition of your chiller equipment.

Different kinds of metal particles in the oil, for instance, may indicate mechanical wear. Detecting an increase in the amount of tin may mean the chiller is experiencing Babbitt bearing wear or bearing corrosion. High copper levels can indicate corrosion in evaporator or condenser tubing, or oil pump bearing wear. And a close analysis of the oil itself can reveal oil degradation.

Analysis of refrigerant would be directed at detection of excessive amounts of moisture, acidity, and rust, which could accelerate the corrosion of chiller components, and reduce efficiency.

If moisture is present, it can combine with the refrigerant to form hydrochloric acid, which will attack the metal surfaces in the chiller.

Analysis of oil and refrigerant should be completed by a laboratory familiar with the testing of chiller fluids; results should be interpreted by trained HVAC professionals. Samples should be collected carefully, according to standards outlined and defined by the laboratory and the chiller manufacturer.
Most HVAC manufacturers recommend that an oil sample be analyzed annually, and that the filter be replaced (and sent out for inspection) at the same time. Refrigerant analysis should be done whenever excess rust or other contaminants are suspected in the refrigerant system.

ELECTRONIC PREDICTIVE MAINTENANCE

Electronics have created an entirely new arena of predictive maintenance, in which key operating parameters are monitored constantly by microprocessor-driven controls.

This new technology detects a chiller anticipatory alarm or shutdown immediately, when symptoms occur. The electronic guardian greatly extends the maintenance professional’s ability to predict maintenance needs and react to problems promptly.

If the system is connected to an electronic watchdog service, the problem can be detected immediately, and service technicians can be dispatched to intervene. The electronic hookup, accomplished through telephone lines, can also allow service technicians from a remote location to coach on-site maintenance personnel through a corrective procedure.

In addition to identifying an anticipatory alarm or shutdown, the new technology fully documents events leading up to the problem, and thus makes a solution more apparent. It can also help service technicians determine whether corrective actions have been effective.

Electronically-enhanced service programs have been embraced enthusiastically by industries such as color printing, textiles, and certain manufacturing atmospheres where a host of environmental factors, including temperature, pressure, and humidity, must be scrupulously controlled. Currently, there appears to be a growing need for this electronically-enhanced maintenance capability in buildings with comfort cooling requirements.

IMPORTANCE OF SERVICE LOGS

Perhaps the easiest predictive maintenance procedure is the process of completing a daily operating log. The accurate recording of daily operating parameters is the best reference point that maintenance personnel or service technicians can use to interpret day-to-day changes in chiller operation.

At the very least, chiller operators should keep a daily log of motor voltage, current, and power; oil, condenser, and evaporator temperatures and pressures; and cooling tower temperatures. These key indicators should be checked frequently if an operating problem is observed.

KEYS TO PREDICTIVE MAINTENANCE

Applied to chillers, predictive maintenance represents that proverbial stitch in time which can reduce operating costs and detect problems before they result in equipment damage or shutdown.

The techniques covered in this article are major predictive maintenance procedures for chillers, whether used in process or comfort cooling. Although specific routines will vary by type and model of chiller, a comprehensive approach to predictive maintenance protects the building owner’s investment in cooling equipment, and keeps it operating reliably and efficiently.

Absorption chillers require very little attention, but if they are ignored they will eventually break down. These tips will help you get years of trouble-free operation.

Absorption chillers can be their own worst enemy. Because they are relatively simple devices and easy to operate, some operators feel that they require no maintenance at all. As a result, building owners and maintenance managers tend to ignore them entirely. Eventually, they begin to operate inefficiently and break down, sometimes with serious consequences. But with a little care, absorption chillers can provide years of trouble-free operation.
Absorption chillers differ significantly from other types of chillers, such as centrifugal and reciprocating. Centrifugal and reciprocating chillers rely on electricity as a power source, operating a mechanical compressor to move a specialized refrigerant at above-atmospheric pressures.

In contrast, absorption chillers operate at vacuum pressures, using steam or hot water as the power source. Water is the refrigerant and it is "moved" by a specialized salt solution. Because they operate differently, absorption chillers require special maintenance attention. Operators can get the most from absorption equipment by following these eight tips:

1. **MAINTAIN THE PURGE UNIT**

   Perhaps the most critical part of the system’s operation is the purge unit, which maintains the vacuum within the chiller shell by expelling any air that leaks in. Chiller systems that do not have air leaks are usually trouble free, efficient, and reliable. The pump should be operated at least once a week, even when the system is not in use.

   Each time the pump is operated, check its effectiveness by isolating it from the system and see if it will pull sufficient vacuum on gauge. If the pump is not effective, change the oil. If changing the oil does not correct the deterioration in pump performance, inspect the discharge valve, the oil distributor, and the shaft seal. If these components are cracked or scored, they should be replaced.

   If pump condition is satisfactory, purge the unit and check the leak rate by measuring how much air is removed. This task can be accomplished by connecting a hose to the purge pump and immersing the other end in oil. Determine the leak rate by counting the bubbles that surface over a given period. (See manufacturer’s instructions for this calculation and for acceptable rates.)

   If a high leak rate is indicated, leak-test the unit.

2. **LEAK-TEST THE UNIT REGULARLY**

   Because an absorption chiller system requires vacuum conditions to generate cooling, air leaks sharply reduce system performance and reliability. Performance deteriorates because the water refrigerant evaporates more slowly. Reliability suffers because the air leaking into the system can combine with water to cause rust damage.

   If the system requires frequent purging, it should be pressure-tested as soon as possible to check for air leaks. Remove all refrigerant, and remove and save the salt solution. Next, fill the inside of the chiller with dry nitrogen and a trace of R-22 refrigerant, raising its pressure to above atmospheric, according to manufacturer’s instructions. Use a leak detector on the outside to see if R-22 is leaking anywhere, but especially at the joints. Leaks should be repaired promptly. Evacuate the system with a service vacuum pump and refill with the salt solution and water refrigerant.

3. **TEST FOR TUBE LEAKS**

   If leaks are detected at the head of the generator, evaporator, condenser, or absorber, there may be a leak in one of the tubes. To leak-test the tubes, leave the R-22/nitrogen charge in place and plug the tube ends with corks (after blowing nitrogen or air through the tubes to remove moisture).

   Leave the corks in for at least 12 to 24 hours. If the tube has a large leak, the pressure buildup will blow out the cork plug. If the cork does not blow out, each tube should be tested for a smaller leak, using a leak detector. Replace faulty tubes as necessary.

   As an alternative, eddy current testing can be used. In this procedure, a small electrical current is induced through a tube using a specially designed electronic probe. Deviations in normal tube structure change the flow of current. Changes are displayed on an oscilloscope or chart recorder. A trained operator should perform the test so results can be interpreted properly.
4. CHECK FOR TUBE FOULING AND SCALING

A drop in capacity may indicate that the tubes need to be cleaned. Many maintenance managers ask how often they have to clean tubes, and the only appropriate answer is, “It depends.” Cleaning frequency is influenced by local water characteristics, atmospheric contamination, operating conditions, and other local conditions.

Most major cities have reliable commercial organizations that offer specialized cleaning services for the water sides of pressure vessels. They will analyze the type of dirt or scale present in the tubes and use the proper cleaning solutions to remove the contaminants.

Two types of deposits can cause tube fouling:

- Dirt, rust, and sludge do not coat the entire tube surface but lie in the bottom of the tubes. These deposits accumulate and restrict the flow of water through the tubes, thereby reducing the heat-transfer surface. Tube fouling of this type is easily visible and can be removed by a thorough brushing with a soft-bristle bronze brush.

- Scale, a hard coating of mineral deposits, resists heat transfer on the inside surface of the tube. Scale is usually invisible when the tubes are wet. Therefore, the tubes in most cases must be emptied and thoroughly dried to detect it. Common scales such as calcium carbonate and calcium sulfate can be observed as a white coating inside the tube. Silica scale may not be visible, but it can be flaked off the tube with a small knife. Other types of scale can also develop, depending on local water conditions. Most can be removed with commercial cleaning agents (available for specific kinds of scale) or with acid cleaning.

Condenser tubes should be cleaned annually, at least, and more often if necessary. If the temperature difference between the refrigerant condensate and the water off the condenser is greater than 10°F at full load, condenser tube cleaning is indicated.

5. MAINTAIN THE PUMPS

Absorption chillers have one or more pumps to circulate internal fluids. Seals on both solution and refrigerant pumps should be replaced when a leak is evident.

Because most pumps on absorption chillers have hermetic motors, it is not necessary to lubricate the bearings. If bearing problems occur, the entire motor must be replaced.

When the system is pressurized for other maintenance functions, the operator should clean the motor coolant system strainer, which removes particles that could harm the motor.

If the system has a float switch that trips when motor coolant runs low, it should be checked for proper operation.

6. MAKE SURE THE LITHIUM BROMIDE IS PROPERLY CONDITIONED

For maximum protection, the system must have the proper lithium bromide salt concentration and inhibitor to prevent the salt solution from causing internal corrosion on the shell and tubes.

The system should be operated for at least 2 weeks before sampling, and for several hours on the day when the sample is to be removed. (These requirements are impractical during winter shutdown periods.)

Withdraw a sample of the salt solution, following the manufacturer’s instructions to avoid getting air in the system. Test the sample, either by using a test kit supplied by the manufacturer or by sending it to the manufacturer for evaluation. Add inhibitor if needed. Consult the manufacturer if alkalinity is too high.
7. INSPECT AND VERIFY THE CALIBRATION OF CONTROLS

All operating and safety controls should be inspected for proper setting and operation by simulating operating conditions. Check indicator lights and gauges for accuracy and make sure all wire connections are tight. Other procedures include the following:

- Inspect steam valve and make sure it is closing properly. Adjust actuator and linkage, if necessary. Make sure the steam valve is delivering enough steam to the generator flange. If steam pressure is too high, check the setting of the pressure-reducing valve, if used, and adjust the steam valve to reduce maximum opening.

- Check power supply and unit fuses and replace if necessary.

- Review the temperature readings of cooling tower water. If they fluctuate rapidly, adjust the setting or replace the controller and fan thermostats, if necessary. Check the settings of tower fans and adjust if indicated.

8. MAINTAIN A DATA LOG

Record operating conditions after startup to establish a data log for future comparison. A good log may help an operator recognize early symptoms that could result in poor performance or damage to the unit. Progressive deterioration in unit performance, for instance, may indicate scaling, a buildup of non-condensables, or a malfunction in controls.

By following these tips—and by having equipment serviced regularly by a qualified HVAC professional—operators will find that absorption chiller equipment provides relatively trouble-free service.

Screw and centrifugal chillers have enough similarities to provide some common guidelines for keeping them operating at their optimum.

Proper maintenance of electrically driven screw and centrifugal water chillers has a big impact on energy efficiency and operating costs. Therefore, it pays to take the time for regular maintenance and to involve experienced personnel or an HVAC contractor, engineer, or manufacturer to make sure the job is done right.

To make the task easier, it helps to have some understanding of screw and centrifugal chillers. Both chillers consist of a compressor, condenser, expansion device, evaporator, refrigerant and water loops, motor, and controls. The main difference lies in the compressor.

A screw chiller’s compressor commonly uses two intermeshed “screws.” The refrigerant gas is trapped between them. As they turn, the decreasing volume between the screws compresses the refrigerant. Screw chillers are available from 50 to 1250 tons of refrigeration, but their greatest use presently is between 100 and 400 tons.

A centrifugal compressor rotates at high speed, using velocity pressure to compress the refrigerant. It handles varying refrigerant flows easily. If a bigger chiller is required, the compressor can be geared up to run faster or its diameter can be increased. Centrifugal chillers presently claim 98 percent of the market from 200 to 10,000 tons.

Because of the fundamental differences between the two types of compressors, screw and centrifugal chillers present minor differences in design and operation too numerous to detail here. But there are enough similarities beyond the compressor to provide some common guidelines for keeping screw and centrifugal chillers operating at their optimum. The following 10 maintenance steps address these common areas.

1. MAINTAIN EQUIPMENT LOGS

An operating log is an essential part of an effective maintenance program. Operators should understand that filling out the log twice each 8 hour shift (for example) is a central and required part of the job.
Continual recording of pressures, temperatures, and other pertinent information enables an operator or service technician to recognize deviations from normal operating conditions immediately. This information is the key to maintaining peak chiller performance and solving problems. By analyzing log readings, the technician can spot a variety of potential problems, making it possible for corrective action to be taken early, rather than later when it is more expensive.

2. GET OFF TO A GOOD START

For most maintenance procedures, proper compressor shutdown and startup routines must be followed. The manufacturer provides a recommended shutdown procedure. Among components that may need attention are the compressor, compressor motor, control center, purge unit, oil return system, cooler, condenser, starter, and water pumps.

Several precautions are in order after the STOP button has been pressed and operation ceases. Power must be disconnected from the unit before any maintenance is performed. Occupational Safety and Health Administration lockout/tagout regulations must be followed. Proper safety equipment—safety shoes, hard hats, safety glasses, gloves, etc., depending on the situation—must be worn when the compressor is opened to the atmosphere. Ventilation must be adequate. And safety precautions appropriate to the refrigerant being used must be followed.

Shutdown requires that disconnect switches for compressor motor and oil pump starters be opened. The oil heater circuit breaker should be turned off. Suction, discharge, liquid injection, and economizer service valves, if applicable, and oil cooler water supply valve should be closed and marked “CLOSED.” For startup, any system water drained away or shut off must be restored. Service valves must be opened, and disconnect switches reconnected. Finally, procedures on the pre-start check list provided by the chiller manufacturer must be performed. Then the unit can be started safely.

3. KEEP IN CONTROL OF THE CONTROLS

It is important to make sure that the chiller control center and starter are operating properly, particularly on chillers installed before the advent of microcomputer control centers and advanced solid-state starters.

Starter maintenance involves making sure that electrical overload settings are correct and that the chiller will shut off promptly if amperage exceeds safe limits. The starter’s interior should be inspected for cleanliness. Dust and dirt should be removed.

Because proper starter disengagement is imperative for safe chiller operation, all starter wire connections and electromechanical linkages should be checked for loose contacts or obstructions. Contacts should be checked for pitting and replaced where necessary.

On the chiller control center, all safety switches should be tested and calibrated to minimize risk of major chiller failure. Pressure switches can be checked with a hand pump.

Electronic controls for motor current limit, overload, power fault interruption, and prerotation vane control (on centrifugal machines) should be tested according to the manufacturer’s instructions. Indicator lights and gauge accuracy also can be assured by testing.

4. PERFORM OIL SAMPLING AND ANALYSIS

Regular analysis of oil and oil filter can reveal increasing amounts of tin, indicating Babbitt metal bearing wear or bearing corrosion. High copper levels indicate evaporator or condenser tubing corrosion, or oil pump bearing wear. Finally, oil sample and filter analysis can reveal the presence of destructive acids or the degradation of the oil itself.

Because of the critical nature of these findings, oil should be analyzed by a laboratory familiar with the testing of chiller fluids; results should be interpreted by trained HVAC professionals.
Oil analysis provides clear evidence of chiller condition. Most HVAC manufacturers recommend that an oil sample be analyzed annually and that the filter be inspected and replaced at the same time. This task should be done during a period of low cooling demand when maintenance personnel can conveniently make necessary repairs.

5. KEEP REFRIGERANT CLEAN, CHARGED

In R-11 centrifugal chillers, moisture and air can infiltrate the refrigerant and start a destructive chemical reaction.

Steel condenser and evaporator shells become subject to corrosion. In itself, corrosion shortens the chiller’s useful life. But rust particles also gravitate to the bottom of the evaporator shell where they mix with oil to become sludge. Sludge-covered tubes in turn reduce heat-transfer efficiency, raising the chiller’s energy consumption.

There are several methods of reducing rust in refrigerant. The least expensive and most effective is installation of a refrigerant cleanup kit. This kit contains a large-capacity filter/dryer that is retrofitted to the refrigerant system. It draws a mixture of refrigerant, sludge, and oil from the evaporator, continuously removing impurities. Clean, “dry” refrigerant is then returned to the system. More complicated methods of cleaning the refrigerant system often require complete chiller shutdown.

Like the quality of refrigerant, quantity also affects a chiller’s heat-transfer capacity. Low or high levels increase head pressure and energy consumption. A sight glass in the evaporator shell is often used to monitor refrigerant levels. If it appears that the proper charge is not being maintained, charge the system according to manufacturer’s instructions.

6. ELIMINATE CONDENSER TUBE SCALE

Scale buildup in condenser tubes ultimately hinders the heat-transfer process, resulting in dramatically higher energy consumption.

The chiller’s condenser is designed to transfer heat efficiently from the refrigerant to the condenser water at a given pressure. Excess head pressure caused by scale makes the compressor work harder, using more electricity to produce the required cooling. If scale buildup is severe enough, the compressor may not be able to meet demand at all.

Most chillers operate with only a few degrees separating the temperatures of the refrigerant and water leaving the condenser. As this difference grows, energy consumption increases. The amount of energy wasted depends on the number of hours the chiller operates, its size, local energy rates, and so on.

If scale buildup is a problem, mechanical brush cleaning of the tubes is highly recommended. Once the tubes are clean, they can be maintained by chemical treatment and periodic bleed-off of the condenser water.

7. MAINTAIN CONDENSER WATER FLOW RATE

Maintaining the proper rate of water flow in the condenser indirectly affects operating costs. A reduced water flow rate increases head and energy consumption. For instance, a 20 percent reduction in flow rate increases full-load energy consumption 3 percent.

Eliminating scale buildup in the condenser tubes is the first step toward maintaining proper water flow. Other common causes of reduced flow are partially closed valves, clogged nozzles in the cooling tower, dirty water strainers, and air in the water piping. The flow rate often can be adjusted with the discharge valve on the condenser pump. If this does not work, determine and correct the cause of the reduced flow.
8. ELIMINATE EXCESS AIR

When an R-11 centrifugal chiller uses more energy than it should, the problem is usually air in the condenser.

Air must be purged because it increases head, forcing the compressor to work harder to maintain the required cooling.

The daily operating log helps solve this problem. First, determine the refrigerant pressure in the condenser from the operating log. Then consult the refrigerant’s temperature/pressure table and convert the pressure to temperature. Refer to the chiller operating log to determine the condenser liquid refrigerant temperature. Finally, subtract the actual refrigerant temperature from that found in the conversion table. If the difference is more than 2°F, the condenser contains air that increases power consumption.

Chillers have automatic purge units to correct this situation. If air continues to be a problem, the purge unit may not be functioning properly or the system may have an air leak larger than the purge unit can handle. In either case, the source of the leak should be determined and corrected. The purge unit also should be checked for proper operation.

9. MAINTAIN MOTOR EFFICIENCY

The largest energy consumer in a chiller system is the compressor motor. To operate efficiently, it must be kept clean and cool. The motor probably is not being cooled properly if the operating log shows an increase in current draw without an increase in voltage.

During a seasonal shutdown, moisture and dirt may collect in compressor motor windings, which must be cleaned out. A megohmmeter can be used to evaluate the integrity of the windings, as well as the power leads from starter to motor. All leads and terminal lugs, wire connections, and the bolts that hold the motor in place should be tight, and the bearings should be lubricated.

On hermetic motors, check for restricted refrigerant flow or a clogged refrigerant filter. On open motors, check for inadequate ventilation or air circulation, obstructed air intake or exhaust openings, and clogged intake filters. For both types of motors, check for dirty oil and loose electrical connections.

10. TEST HEAT-EXCHANGER TUBES

Tube failure in a chiller’s heat exchanger is a costly problem. When a tube leaks, water and refrigerant mix, forming hydrochloric and hydrofluoric acids. These acids destroy metal components, resulting in extensive damage.

Fortunately, eddy-current tube testing is a simple, cost-effective way to detect impending tube failure. Tests can be performed in a day or two and typically cost less than $2000. If any corrective action is needed, faulty tubes can be plugged or replaced.

The testing procedure works this way: A special electronic probe induces a small electrical current through a tube. Deviations from normal tube structure cause a change in the flow of current, which is picked up on an oscilloscope or chart recorder.

A trained operator interprets the data to identify problems. The most common heat-exchanger tube problems are internal pitting, freeze damage, support wear, zipper cracks, and corrosion.

FAILURE OF THE MAINTENANCE PROGRAM

Chiller preventive maintenance routines should be performed on a schedule, usually monthly. This allows a good service mechanic to spot and correct minor maintenance problems before they become major. And experience can teach him to anticipate common maintenance needs.
But even the best service mechanic cannot detect a developing problem that has not shown obvious symptoms. Monthly maintenance inspections give only a "snapshot" of chiller condition. For a more complete picture, electronic technology can be used to provide an effective method of predictive maintenance.

Electronic “guardian” systems can automatically monitor key operating parameters around the clock and send appropriate reports and alarms. This type of system greatly extends the maintenance professional's ability to predict maintenance needs and react to problems promptly. If a skilled service firm is under contract and also linked to the electronic system, remote service technicians can coach on-site maintenance personnel to correct the problem. Or they can dispatch someone to the scene.

Whether you use electronically enhanced service programs, outside service firms, in-house maintenance staff, or a combination, regular maintenance is still the key to maximum screw and centrifugal chiller performance.

- Safety cut-out points
- Operating control points
- Indicator lights
- Gauge accuracy
- Control panel electrical connections
- Check water flow
- Check flow switch operation
- Inspect front and back end sheets for corrosion
- Check water flow
- Check flow switch operation
- Check refrigerant levels
- Check dashpots setting
- Check overload settings
- Clean interior and filter
- Check wire connections for tightness
- Check contacts
- Check operation of starter
- Change oil