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MTS hydraulic power units (HPUs) are equipped with heat exchangers that are designed to remove 100% of the HPUs heat load.

Heat exchangers usually provide a long service life with little required maintenance because they have very few or no moving parts. Often, however, the heat exchanger is a neglected component of the HPU until it fails. A heat exchanger failure can result in a costly and time-consuming cleanup, especially when your cooling water supply is mixed with hydraulic fluid. Proper maintenance is therefore essential to maintaining a long life for your heat exchanger. The information that is provided below will help you get the longest possible service from your heat exchanger.

What is a heat exchanger?

A heat exchanger is a mechanical device that is used to transfer heat from one medium to another. The amount of heat transferred is directly proportional to the temperature difference between the hydraulic fluid and the cooling medium. MTS uses two types of heat exchangers: hydraulic fluid-to-water or hydraulic fluid-to-air.

Hydraulic fluid-to-water heat exchangers are used in an HPU when an ample cooling water supply is available. Hydraulic fluid-to-water heat exchangers, also referred to as oil coolers, use heat transfer to cool the hot hydraulic fluid in the HPU by passing it over or through a conductor that separates the hydraulic fluid from the cooling water.

The two most common designs are the plate design, and the shell and tube design.

Plate design

In the plate design, the hot hydraulic fluid passes between a series of copper-coated, corrugated stainless steel plates. The herring bone design of the corrugations in the plates increases the turbulence in the fluid to maximize the transfer of heat. Cooling water passes between alternating plates to effect the heat transfer.

Shell and tube design

In this design, the hot hydraulic fluid circulates through the shell and over the outside surface of a bundle of tubes. Baffles direct the hydraulic fluid through the shell side of the unit at right angles to the tube bundle. Cooling water passes through the inside of the tubes and the heat is exchanged from the hot hydraulic fluid to the cool water. Heat is removed from the water by passing it through a cooling tower or an evaporation pond.

Shell and tube hydraulic fluid-to-water heat exchangers are available in many design variations. The straight tube design with a fixed tube bundle is used by MTS. These units are available with various baffle arrangements to create single or multiple pass heat exchangers. Multiple pass designs use less water and can be used more efficiently and at less cost when colder circulating water is available. The tubes are accessible from either end for cleaning.

Hydraulic fluid-to-air

Hydraulic fluid-to-air heat exchangers, also referred to as air coolers, are similar to the cooling system in an automobile. Hydraulic fluid-to-air heat exchangers are used in locations that do not have a sufficient water supply for cooling. Hydraulic fluid passes through a radiator while air is blown over the tubes and cooling fins to remove the heat.
What are the major components of my heat exchanger?

**Hydraulic fluid-to-water**

**Plate design**
The plate design hydraulic fluid-to-water heat exchanger has no moving parts. It consists of a series of corrugated stainless steel plates brazed together. The direction of the herring bone design of the plates alternates to provide maximum turbulence and therefore maximum cooling efficiency. The plates are brazed together to provide strength and a compact package.

![Cutaway View of a Plate Design Hydraulic Fluid-to-Water Heat Exchanger](image)

**Shell and tube design**
A shell and tube design hydraulic fluid-to-water heat exchanger has no moving parts. It is composed of an outer shell, tubes, tube sheets, baffles (or fins), hubs and bonnets:

![Cutaway View of a Shell and Tube Design Hydraulic Fluid-to-Water Heat Exchanger](image)
• Shell—the shell is a seamless, nonferrous tube, usually made of brass. Both ends are welded into the hubs. The shell encloses the baffles or fins very closely to prevent any bypassing and ineffective flow areas.

• Tubes—straight, seamless, nonferrous tubes are usually made from copper, a copper-nickel alloy or stainless steel.

• Tube sheets—brass tube sheets hold the cooling tubes in place. Tube sheets are bonded to the inside of the hubs.

• Baffles or fins—brass baffles or fins provide a contact area for dissipating heat. The hot hydraulic fluid flows around the baffles (fins), while the cooling water flows through the tubes.

• Hubs—forged brass hubs are used to connect the shell with the end bonnets. Vents and drains are located on the underside of the hubs.

• Bonnets—cast iron bonnets provide an unrestricted connection for cooling water flow. Renewable zinc anodes may be attached in the bonnet to prevent electrolytic damage.

**Hydraulic fluid-to-air**

A hydraulic fluid-to-air heat exchanger is composed of a motor and fan, tubes, fins and a cabinet.

![Cutaway View of a Hydraulic Fluid-to-Air Heat Exchanger](image)
What ambient conditions are required?

**Operating temperatures**

Water-cooled heat exchangers used in HPUs, operate at a minimum ambient temperature of 4°C (40°F) and a maximum ambient temperature of 40°C (104°F).

Air-cooled heat exchangers operate effectively up to an ambient temperature of 37°C (98°F).

A nameplate specifying operating pressures and temperatures is attached to each heat exchanger by the manufacturer. The *MTS Hydraulic Power Supply Product Manual* provided with your test system contains specific information on the fluid temperatures and cooling water requirements for your HPU.

The *Air-Cooler to SilentFlo® HPU Integration Product Information manual* provides system integration requirements for MTS Air-Coolers used with MTS Series 505 SilentFlo™ Hydraulic Power Units.

**Environment**

Heat exchangers should not be located in a corrosive atmosphere, as rapid deterioration of the brass casing, cooling element, fan and motor (hydraulic fluid-to-air units only) may take place, resulting in a shortened operating life and unnecessary replacement costs.

**Water quality**

Water chemistry for hydraulic fluid-to-water heat exchangers, is critical for a successful heat exchange system. Generally speaking, municipal drinking water that is pollution free, bacteriologically safe, and has a neutral pH is perfectly acceptable for hydraulic fluid-to-water heat exchangers.

Cooling tower water and natural water sources, such as wells, rivers, or ponds, must be free of pollutants and treated to reduce contaminants to the same levels as municipal drinking water.

Softened or distilled water may not be suitable as a cooling liquid because although most of the minerals have been removed there is a higher than desirable level of carbon dioxide and oxygen present in the water. High levels of carbon dioxide and oxygen will act to decrease the protective layer of minerals that form on the surface of the tube, and increase the formation of copper oxide.

If the source of cooling water is a cooling tower, the presence of contaminants that are corrosive to metals will vary over time. Contaminants must be controlled to the levels listed in the following table. Ideally, the pH level should be maintained in the 6.5–8.0 range for most applications. Chlorine should be used to limit the growth of microbiological organisms that are generated by protein decay. You must be careful not to use excessive amounts of chlorine. The chloride concentration in the cooling water must be kept to less than 5 ppm.

The following table lists the acceptable levels of common compounds allowed in the cooling water supply:
Cooling towers located in an industrialized area should be a closed-loop design to provide protection against airborne contaminants.

Different types of contaminants in the cooling water supply may react in combination to create corrosion rates a hundred times higher than would be seen by either contaminant acting alone. Cooling towers, unless regularly treated and controlled, are the systems that have had the most problems with corroded heat exchangers.

Local industrial water treatment specialists can provide information on your water conditions and solutions to contaminant problems.
What is the life expectancy of my heat exchanger?

All heat exchangers have a finite life and must be considered an expendable component, subject to failure at some point in time. Properly used and maintained, your heat exchanger could last up to 20 years.

What causes heat exchanger failure?

Heat exchangers usually provide a long service life with little maintenance other than a routine inspection and cleaning. Fouling and corrosion are the main causes of degraded performance or failure. A very expensive failure occurs when a leak develops, allowing the cooling water to mix with the hydraulic fluid, contaminating both the hydraulic system and the cooling water system.

Other heat exchanger failures can be caused by silting, scaling or other forms of obstructing the cooling water passageways. These types of failures are not as disastrous as corrosion failures, but can occur over time.

Fouling

Fouling is the accretion of deposits that decrease the thermal transfer of a surface and increase the system's flow resistance. The result is that due to reduced heat transfer coefficients, the cooling water volumetric flow rate has to increase to keep the system at the same temperature.

Corrosion

Corrosion is the degradation of a metal due to chemical reactions with the environment.

Shell and tube hydraulic fluid-to-water heat exchangers are usually constructed with copper or copper alloy tubes. Copper and its alloys are normally resistive to corrosion, but the corrosion rate will vary depending on the concentration of one or more corrosive elements present in the hot hydraulic fluid or cooling water. A normal corrosion rate is 5–25 µm per year. This implies an operating life of 20 years for your heat exchanger. Higher than expected corrosion rates will drastically reduce this operating life.

Over a period of time, this slow dissolving of the metal will result in component failure:

• Corrosion products may settle in the heat exchanger tubing, causing the fluid flow to be blocked.

• Corrosion can eventually cause leaks between the water and hydraulic fluid supplies.
  – Water contamination in the hydraulic fluid can seriously shorten the life of the hydraulic components of your HPU and test system.
  – Hydraulic fluid in the water can result in a costly cleanup supervised by your local environmental protection agency.

Which type of contamination occurs is dependent on the extent of the corrosion and the pressure in the hydraulic fluid and water supplies. Since fluid tends to flow from a high pressure area to one of low pressure, the lower pressure fluid will become contaminated. Eventually, however, both the water and the supplies may be contaminated as more leakage occurs.
Contaminated water supply
The most likely cause of corrosion failure in heat exchangers is their use with cooling towers. These towers use fan propelled ambient air to evaporate a portion of the cooling water and thus cool the remaining water. This action transfers whatever air pollution exists into the cooling water. Also, since the towers are open to the environment, they are prone to collecting animal and vegetable matter which is damaging to heat exchangers.

How can I prevent heat exchanger failure?
There are four types of heat exchanger failures that can occur: mechanical, chemically induced corrosion, a combination of mechanical and chemically induced corrosion, and fouling due to the accumulation of scale, solids, and algae.

Mechanical failure
Mechanical failures may take one of the following forms: metal erosion, water hammer, vibration fatigue, thermal fatigue, or freeze-up.

- **Metal Erosion**: Excessive fluid velocity through the heat exchanger can cause damaging erosion as the metal elements wear away. Any existing corrosion is accelerated as erosion removes protective films from the metal, exposing fresh metal to further attack.

  Most metal erosion problems occur in the chambers and at the entrances to the heat exchange. The entrance areas experience severe metal loss when high-velocity fluid from a nozzle is divided into much smaller streams upon entering the heat exchanger. This stream dividing results in extreme turbulence with very high localized velocities.

  The maximum recommended velocity in the chambers and at the entrance nozzle is dependent on the chamber material, fluid handled, and temperature. Materials such as stainless steel and copper-nickel can withstand velocities of 10-11 ft/s (3.0-3.4 m/s). Copper is normally limited to 7.5 feet per second (2.3 m/s). The water flow velocity in copper should be kept less than 7.5 ft/s when it contains suspended solids or is softened.

- **Water Hammer**: Damaging pressure surges or shock waves can result from an interruption in the flow of cooling water. To reduce your risk of water hammer, the cooling water flow should always be started before heat is applied to the exchanger.

  Fluid flow control valves that open or close suddenly also produce water hammer. Modulating control valves are preferable to on-off types.

- **Vibration Fatigue**: Excessive vibration from equipment or transients in the fluid flow (pulsating) can cause failures in the form of a fatigue stress crack or erosion at the welded joints. Heat exchangers should be isolated from excessive vibration.

- **Thermal Fatigue**: Fatigue resulting from accumulated stresses associated with repeated thermal cycling can also cause failures. In thermal fatigue, the temperature differences cause flexing, which produces a stress that acts additively until the tensile strength of the material is exceeded and it cracks. The crack usually runs radially and many times results in a total break.

  A thermostatic or spring loaded by-pass relief valve installed ahead of the heat exchanger will hasten warm-up and relieve the system of excessive pressures, as well as control the hydraulic fluid temperature in certain installations.
• **Freeze-Up**: These failures can occur in a water cooled heat exchanger in which the temperature drops below the freezing point of the cooling water. Freeze-up results from failure to provide thermal protection, a malfunction of the thermal protection control system, or protective heater device, improper drainage of the unit for winter shutdown or an inadequate concentration of antifreeze solutions.

Chemically induced corrosion failures result from the complex chemical interaction between the materials of the heat exchanger and the fluids circulated through it. There are several types of chemically induced corrosion failures: general corrosion, pitting, stress corrosion, dezincification, galvanic corrosion, and crevice corrosion.

• **General corrosion**: This type of corrosion is characterized by a slow, uniform attack over the chamber material, with little or no evidence that corrosion is taking place.

    In copper, low cooling water pH (less than 7) combined with carbon dioxide or oxygen produces corrosion. A blue or bluish-green color on the material are indicative of carbon dioxide attack inside the chamber. Various chemicals, such as acids, also produce this type of metal loss.

    You can reduce general corrosion and maximize the life of your heat exchanger by selecting a material with adequate corrosion resistance for the operating environment and by using the proper treatment chemicals to clean and protect the components of your heat exchanger.

• **Pitting**: Localized pitting is frequently encountered in metals. It is caused by the electrochemical potential set up by differences in the concentration of oxygen within and outside the pit, and is frequently referred to as a concentration cell. The oxygen-starved pit acts as an anode and the unattacked metal surface as a cathode. A small number of pits may be present; however, any one can cause a heat exchanger failure.

    Pitting corrosion is most likely to occur during shut-down periods when there is no fluid flow and the environment is most suitable for the buildup of concentration cells. Imperfections such as scratches, dirt or scale deposits, surface defects, breaks in protective scale layers, breaks in metal surface films and grain boundary conditions increase the susceptibility of the metal to pitting corrosion.

• **Stress corrosion**: This form of corrosion attacks the grain boundaries (changes in the crystalline structure of the metal) in stressed areas. Heat exchangers usually have residual stresses that are the result of drawing or forming the materials during manufacturing.

    Failures from stress corrosion take the form of fine cracks, which follow the lines of stress and material grain boundaries. All naturally occurring waters contain the chloride ion, which is potentially present in any compound formulated with chlorine. The frequency of chloride stress corrosion rises with an increase in temperature and chloride ion concentration. Keeping chamber wall temperatures below 125°F (52°C) prevents stress corrosion cracking problems with chloride ion concentrations up to 50 ppm.

    The substance that causes stress corrosion cracking on copper or copper alloy is ammonia. Very small concentration (1 ppm or less) can create a problem. Copper-nickel alloys have good resistance to stress corrosion cracking and should be used in applications where low concentrations of ammonia are expected.
• **Dezincification**: This problem occurs in copper-zinc alloys containing less than 85 percent copper when they are in contact with water having a high oxygen and carbon dioxide content, or in a stagnant solution. The effect tends to accelerate as temperature increases or pH decreased below 7.

Dezincification creates a porous surface in which the zinc is chemically removed from the alloy. The remaining copper has a sponge-like appearance. Dezincification is prevented by using a brass with lower zinc content or a brass containing tin or arsenic to inhibit the chemical action, or by controlling the environment causing the problem.

• **Galvanic (electrical current) corrosion**: This type of corrosion occurs when dissimilar metals are joined in the presence of an electrolyte, such as acidic water. Galvanic corrosion usually produces a higher rate of reaction on the less noble (chemically inert) metal.

• **Crevice corrosion**: This type of corrosion originates in and around hidden and secluded areas, such as between baffles and tubes, or under loose scale or dirt. A localized cell develops and the resulting corrosion appears as a metal loss with local pits, often giving the impression that erosion is taking place. This condition is in contrast to a vibration failure in which the metal is sharply cut and there are no pits. Relatively stagnant conditions must exist for crevice corrosion to occur.

Crevice corrosion can often be controlled by making sure that fluid flow velocities are adequate to prevent stagnation or the accumulation of solids.

**Mechanical failure with chemically induced corrosion**

Heat exchanger failure is often not from a single cause, but a combination of more than one condition. Quite often, a mechanical problem combined with a corrosion problem produces a quicker failure than either of them alone. There are two common types of combination mechanical and corrosion failures: erosion-corrosion and corrosion-fatigue.

• **Erosion-corrosion**: any corrosion is greatly accelerated if the protective films are worn away by excessive velocity, suspended solids, or mechanical vibration. Erosion-corrosion is usually found in the entrance area of chambers, below the inlet nozzles, at the point of contact of two surfaces such as where baffles and tubes meet.

• **Corrosion-fatigue**: in this dual failure mode, stresses associated with fatigue are the result of externally applied mechanical loads, such as vibrations from machinery, expansion or contraction because of temperature cycles, or light water hammer. In most environments where only corrosion occurs, corrosion products and films block or retard further attack. However, in corrosion-fatigue, cyclic stresses rupture the protected areas and make them permeable; this action subjects open areas to accelerated corrosion.
Fouling due to accumulation of scale, solids, and algae

Various compounds and marine growths present in cooling water will deposit a film or coating on heat transfer surfaces. The film acts as an insulator, restricting heat flow and protecting corrosive compounds. As a result of this insulating effect, temperatures go up and corrosion increases.

- **Scale** is the result of dissolved minerals precipitating out of heat transfer fluids. The solubility of these minerals is affected by changes in temperature within the heat exchanger and chemical reactions between compounds found in the cooling water. MTS has designed your HPU to have an optimum fluid velocity based on the heat exchanger material and the heat transfer needs of your system. This fluid velocity is normally sufficient to keep the rate of precipitation low. If your fluid velocity decreases due to fouling or clogging of the tubes, the rate of precipitation will increase. Regular cleaning of the tubes and inlet filters will keep the fluid velocity high enough to inhibit scaling.

- **Suspended solids** are usually found in the form of sand, iron, silt, or other visible particles in one or both of the heat transfer fluids. If fluid velocities are not high enough to keep them in suspension, particles settle out and build up on the chamber walls. Suspended solids are very abrasive to chambers and other heat exchanger parts. The proper use of filters and screens for the cooling water and hydraulic fluid will reduce the presence of abrasive particles in the fluid and protect your heat exchanger from erosion damage.

- **Algae** and other marine growths are a serious problem if they get in the heat exchanger. In many cases, the environment in the heat exchanger is conducive to rapid proliferation of algae and other marine growths, which restrict cooling water flow and impede heat transfer. A chemical algicide, such as chlorine, is effective in controlling algae and other marine growths; high fluid velocities also discourage them from proliferating.

### How do I know when I have a heat exchanger failure?

The first indication of a hydraulic fluid-to-water heat exchanger failure is a milky or cloudy coloration of the hydraulic fluid, indicating a water content greater than 0.2–0.3% by weight. Hydraulic fluid in the water discharge is also a sign of heat exchanger failure. A corrosion failure starts as a small pin hole, which produces a very low flow of water into the hydraulic fluid. Checking the hydraulic fluid color on a daily basis will reduce the amount of water contamination and the severity of the damage.
**How can I improve the life of my heat exchanger?**

Routine inspections and maintenance enable you to slow the degradation effects in heat exchangers. The effects will always be present, however, and will sooner or later result in the necessity of replacing the degraded components.

**Choose the right material for your water conditions**

Although you cannot prevent corrosion from ever occurring in your heat exchanger, the corrosion rate can be reduced by selecting the appropriate materials for your heat exchanger. MTS can assist its customers in selecting the proper material for heat exchangers (copper, copper-nickel alloy or stainless steel) based on an analysis of the water supply.

**Plate design heat exchangers**

The plate design heat exchanges use stainless steel plate because it generally resists most of the cause of corrosion making it suitable for use with most sources of fresh water: city water, pond water or cooling towers. The city water should have a chloride content of <5 ppm. Pond water should be filtered or screened and cooling towers must be properly maintained to prevent fouling. The cooling water can have a pH of 7 to 8.5

MTS does not recommend using stainless steel plates if your cooling water is saltwater or sea water.

**Tube and shell design heat exchangers**

The standard material used in heat exchanger tubes is 99.9% pure soft copper. Copper-nickel (CuNi), an alloy of copper that has 10% nickel, offers a higher resistance to corrosion caused by many common pollutants. A 90-10 copper alloy tube has a corrosion rate that is typically one-half to one-third that of pure copper, and adds 20–25% to the cost of the heat exchanger. This alloy is a good solution to the problem of mildly corrosive water, such as ground water supplies. But it is not a solution to severe corrosion problems that may occur when cooling towers are used.

Another measure that can be taken to enhance heat exchanger life is to add zinc anodes to the heat exchanger bonnet. Most copper-nickel heat exchangers can be furnished with zinc anodes. These anodes screw into a threaded opening added to the bonnet, and protect the tube sheet and bonnet metal against dezincification corrosion. The zinc anodes will corrode before the copper alloy tubes in most cases. Zinc protection from the zinc anodes will decrease with time because of metal loss, so the zinc anodes should be inspected regularly and replaced as required.

MTS recommends that if your cooling water supply is saltwater or sea water, heat exchangers with 90-10 copper-nickel tubes and tube sheets, bronze bonnets and zinc anodes should be used to reduce the corrosion rate.

**Keep your water supply clean**

Contaminants in the cooling water supply can partially or completely block the heat exchanger chambers. Blocked chambers will decrease the efficiency of the heat exchanger and may result in damaging erosion or corrosion. Dirt or small objects, such as organic material may coat the chambers and lead to corrosion.

You can prevent sediment buildup in the chambers by installing a filter or strainer in the cooling water inlet to prevent large particles from entering the chambers. MTS recommends that water strainers be installed ahead of the heat exchanger if the source of cooling water contains large amounts of particles or sediment.

*Note* Because most corrosives are dissolved solids, strainers usually provide only minimal corrosion protection. A strainer will be useful in preventing corrosion damage only in those instances where a suspended solid is corrosive.
Monitor the cooling water flow rate

The easiest way to prevent fouling is by assuring that there is a sufficient flow of cooling water in all of the chambers. This will maintain a “self-cleaning” effect in the chambers, which also helps them retain their heat transfer characteristics. If you notice a decrease in the efficiency of your heat exchanger, inspect the filter or strainer and the chambers for signs of fouling.

When there is a possibility of cooling water surge pressures above the design pressure of the heat exchanger, a pressure relief or regulating valve should be installed to protect the exchanger from bursting pressures.

Protect your heat exchanger during shipping or storage

To prevent corrosion during shipment and short-term storage, MTS flushes the chambers with Dow Chemical's Dowfrost HD antifreeze (propylene glycol) after testing the HPU and preparing it for shipment. Dowfrost HD is a heat transfer fluid designed to be used in closed loop HVAC systems. It has excellent anti-corrosion properties and is low in toxicity. The HD signifies that this Dowfrost is designed to work with the different metals in heat exchangers. MTS warns against using flushing solutions of ethylene glycol, which can be very corrosive under certain conditions.

If your heat exchanger is to be shut down or stored for a period of time (weeks or months) MTS recommends that you drain the heat exchanger and flush it with a corrosion-preventive fluid to prevent corrosion. Keep the heat exchanger ports sealed to prevent the entry of dirt or other foreign matter. The heat exchanger should always be drained when the ambient temperature is less than 32°F (0°C) to prevent freezing of the cooling fluid and damage to the components.

What regular heat exchanger maintenance is required?

To maintain the life of your heat exchanger, you must service it periodically. The frequency in which you clean your heat exchanger internally and externally, depends on the nature of its operating environment and how rapidly it will foul.

Before you use the heat exchanger for the first time

Upon receipt of your HPU, MTS recommends that you inspect the heat exchanger thoroughly, making sure that no dirt or foreign matter entered the unit during shipment. Check the bolts on the heat exchanger and tighten them if necessary. The heat exchanger should be mounted solidly in place.

For all types of heat exchangers

Regular inspection of your heat exchanger will help you identify any decrease in the efficiency of your heat exchanger. In addition to regular inspections, MTS recommends that you follow these guidelines:

- Keep a log of data to monitor changes in temperature and pressure. Collecting and comparing performance data at regular intervals will help you identify any loss of efficiency and determine the proper interval required between cleanings.

  A loss of efficiency can usually be traced to an accumulation of water scale. MTS has designed your HPU to provide a fluid velocity of 0.6–1.8 m/s (2–6 ft/s) through the heat exchanger. This flow rate is normally sufficient to keep a heat exchanger relatively clean.

- Inspect the hydraulic fluid and cooling water often for signs of contamination. Hydraulic fluid that has water in it will appear cloudy.
• Be careful using sealant tape on pipe threads, which lessens the degree of resistance between mating parts, and results in a greater chance for cracking the heat exchanger castings. Do not over-tighten pipe connections when re-mounting the heat exchanger after you have disassembled it for maintenance.

• When you are ordering replacement parts, mention the model and serial number of the heat exchanger, the model of the HPU and the original MTS job number.

**WARNING**

**Commercial solvents may cause irritation to eyes and skin.**

Always wear protective clothing, eye protection, and if required a respirator. Follow the manufacturer's safety instructions when using chemicals.

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**For hydraulic fluid-to-water heat exchangers only**

**Stainless steel plate heat exchangers**

Depending on fouling conditions, MTS recommends inspecting your heat exchanger every 500–2000 operating hours. If you notice a decrease in the efficiency of your heat exchanger, it should be cleaned.

1. Clean all filters and screens.

2. Begin with an external inspection of the heat exchanger. Visually inspect for:
   - Corrosion
   - Signs of a previous repair
   - Leakage

3. A marked decrease in pressure and/or reduction in performance usually indicates cleaning is necessary. The following are suggested methods of cleaning either side of the heat exchanger.
   - Back flush the heat exchanger with a high pressure stream of hot water to remove loose deposits
   - Circulate hot wash oil or light distillate to remove sludge or similar soft deposits.
   - To remove more stubborn deposits, try a commercial cleaning compound such as “Oakite” or “Dowell”. Follow the manufacturers instructions for using the cleaning compound.

**Important** It is recommended that you contact a representative of the manufacturer of the cleaning compound to determine the correct cleaning compound for your type of scaling problem and its compatibility with the metals and alloys used in the heat exchanger.

4. If the heat exchanger is excessively fouled and cannot be cleaned using the commercial cleaning methods, then replacement of the heat exchanger is recommended.
1. Clean all filters and screens.

2. Begin with an external inspection of the heat exchanger. Visually inspect for:
   - Dents or bulges in the shell
   - Extruded or damaged gaskets
   - Corrosion
   - Damaged flanges on the bonnets and hub or tube sheets
   - Stress marks in the shell
   - Signs of a previous repair
   - Leakage

3. After you have completed the external inspection, continue with an internal inspection of the heat exchanger:
   A. Completely drain and inspect the tubing and internal parts to determine the extent of cleaning necessary. If severe fouling or corrosion of the tubes and/or bonnets of the tube and shell heat exchanger is found, then disassembly of the heat exchanger may be necessary.
   B. If disassembly of the heat exchanger is required, discard the old gaskets and replace them with new ones. Visually inspect for the following:
      - Damage to the tube ends due to corrosion or erosion
      - Wearing of the zinc anodes (copper-nickel tubing units)
      - Damage to the nozzle threads on the tube and shell side
      - Erosion of the tubes under the shell side nozzle

      Signs of any of the above conditions may indicate high flow rate with particle entrainment in the fluid, or the presence of a corrosive environment. Depending on the degree of degradation of the unit, it may need replacement.
   C. Inspect all zinc anodes and replace them if a marked corrosion is visible. If they are coated with scale, remove the scale.
   D. Unscrew and remove the bonnets, carefully inspect the tubes for corrosion, erosion and any foreign materials and clean as required.

   **Note**  
   Protect the baffle plates and tubes from damage. Bent baffle plates will cause in the hydraulic fluid to bypass the tube surface, resulting in a decrease in heat transfer rate.

   Be careful when you remove or handle the tube bundle of a removable tube bundle exchanger.
Mechanical cleaning

Complete the following steps if your internal inspection of the shell and tube heat exchanger indicates that you need to remove any sediment or light scale from the tubes:

1. Remove residues from the inside of the tubes with a rotary brush. Use a soft nylon brush to prevent scratches in the metal surfaces since any scratches will accelerate corrosion.

2. Flush the tubes with clean water to remove dirt and scale loosened during the brushing.

3. Pressurize the shell side to verify the integrity of the tubes and all joints before reassembling the heat exchanger.

4. Clean the bonnets as required, and reattach them to the heat exchanger. New gaskets are required whenever you re-assemble the heat exchanger. Use of oiled gaskets is acceptable.

5. Pressure test the tube side.

Chemical cleaning

Internal chemical cleaning of the tubes is required to remove calcium deposits that build up in and around the tubes over time. Clean and flush the internal tubes regularly.

1. Clean the internal water passage by flushing with a 15% solution of inhibited muriatic acid (hydrochloric acid) in water. The length of time required for flushing is dependent on the amount of scale built up in the tubing. For 1 mm scale, flush the tubes for about 30 minutes. The system must be open to vent gases as they become free.

2. Drain completely, then flush the tubes thoroughly with clean water.

3. Repeat the flushing with a neutralizing agent, such as a 5% sodium carbonate solution, and drain completely. Flush with clean water.

4. Repeat the process in the opposite flow direction.

5. Remove any fluid residue with a commercial solvent.

For hydraulic fluid-to-air heat exchangers only

Depending on fouling conditions, MTS recommends inspecting your heat exchanger every 500–2000 operating hours. If you notice a decrease in the efficiency of your heat exchanger, it should be cleaned.

1. Clean all filters and screens.

2. Inspect the unit regularly for loose bolts and connections, rust, corrosion and dirty or clogged heat transfer surfaces.

3. Remove dirt and dust from the heat transfer surface by brushing the fins and tubes and blowing loose dirt off with an air hose or by turning on the fan. If the surface is greasy, remove the motor and spray or brush the fins and tubes with a mild alkaline solution or a nonflammable degreasing fluid. Follow the degreasing with a hot water rinse and dry thoroughly. A steam hose may also be used effectively.

4. Remove any dirt and grease from the casing, fan and motor. Sand and repaint rusty or corroded surfaces.
5. Keep the motor outside surface of direct drive heat exchangers free of dirt and grease so the motor will cool properly. Make sure the cooling air over the motor is not obstructed. Pre lubricated ball bearing motors require no lubrication for extended periods of time. Follow the lubrication instructions attached to the motor and provided by the motor manufacturer.

6. The combination fan hub and sheave assembly on external drive heat exchangers is pre lubricated at the factory prior to shipment. Lubricate the assembly after every 1000 hours of operation following the manufacturer's instructions.

How do I remove corrosion?

MTS recommends you use Dowfrost HD, an industrially inhibited propylene glycol fluid to remove corrosion from the tubes and protect them from future corrosive attack.

1. Clean new or lightly corroded existing systems with a 1–2% solution of trisodium phosphate in water prior to the installation of the Dowfrost HD.

2. Extensively corroded systems should be cleaned by an industrial cleaning company and all necessary replacements and repairs should be made before the heat exchanger is used again.

How do I remove water from the hydraulic fluid after a heat exchanger failure?

Once a heat exchanger failure occurs, remove the damaged unit from service and assess the amount of water in the hydraulic fluid. If the contamination is severe (the water content is greater than 2.0% by weight), the sensible approach may be to drain and discard the hydraulic fluid in the distribution system. If discarding the contaminated fluid is not desirable of feasible, the hydraulic fluid can be left standing and a large portion of the water will separate out. This water can then be siphoned from the bottom of the reservoir. Water absorbing filter elements can be used in the HPU to remove most of the water from the hydraulic fluid.

The hydraulic distribution system also requires attention after a heat exchanger failure. Water will tend to settle in low points in the system. These points should be drained and the fluid discarded. If contamination is not severe (water content is less than 1.0% by weight), it may be advisable to simply flush the system with the “dry” fluid from the HPU, and continue dry filtering the water.

How do I know when to replace my heat exchanger?

Watch for changes and trends in your regular analysis of the hydraulic fluid (for example, the copper counts in the hydraulic fluid may rise with each analysis). A slow trend is nothing to worry about, but a sudden change in the fluid analysis may indicate that your heat exchanger will fail soon.
Acceptable Ranges for Copper

<table>
<thead>
<tr>
<th>Copper Concentration</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–50 (ppm)</td>
<td>Normal amounts</td>
</tr>
<tr>
<td>&gt;50 (ppm)</td>
<td>Watch for additional trends in the hydraulic fluid analysis</td>
</tr>
<tr>
<td>Sharp rise</td>
<td>There is a problem which requires immediate action</td>
</tr>
</tbody>
</table>

Look for the presence of hydraulic fluid in the cooling water, or water in the hydraulic fluid. MTS has water-in-fluid and fluid-in-water sensors available to aid in the early detection of contamination of your cooling water or hydraulic fluid. Contact MTS for more information.

Replace the heat exchanger at the first signs of a problem. If you wait for a catastrophic failure, you will contaminate the entire cooling water supply, ground water or hydraulic system and face expensive cleanup costs and the loss of valuable time that could be devoted to testing. If the ground water becomes contaminated, your company may face severe penalties and cleanup costs for environmental damage. If you have several pumps on the same hydraulic supply line, you risk damaging them and incurring the added expense of repairing several heat exchangers and hydraulic power units.
### Troubleshooting

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Corrective Action</th>
</tr>
</thead>
</table>
| HPU won’t cool (hydraulic fluid-to-water models) | • Verify the proper water connections:  
|                                              |   IN→IN                                                                                                                                         |
|                                              |   OUT→OUT                                                                                                                                      |
|                                              | • Verify that the water temperature vs. flow rate is correct for your model of HPU (refer to the *MTS Hydraulic Power Supply Product Manual* that came with your system). |
|                                              | • Verify that the operation of the water saver valve is correct. Adjust it if necessary (refer to the instructions in the *MTS Hydraulic Power Supply Product Manual* that came with your system). |
| Heat exchanger is plugged                    | • Perform a mechanical cleaning                                                                                                                  |
|                                              | • Perform a chemical cleaning as needed                                                                                                           |
|                                              | • Install a filter in the cooling water inlet line to prevent the buildup of sediment                                                          |
|                                              | • Ensure that you are using clean cooling water                                                                                                  |
| Heat exchanger leaks externally              | • Inspect the heat exchanger for signs of corrosion                                                                                              |
|                                              | • Repair the leak                                                                                                                                |
|                                              | • If the leak occurs at a fitting, it may be loose. Remove the fitting, inspect it and repair or replace it as necessary. Re-install the fitting, being careful not to over tighten it. |
| Heat exchanger leaks internally              | • Disassemble the heat exchanger                                                                                                                 |
|                                              | • Conduct a pressure test to determine the location of the leak                                                                               |
|                                              | • Repair the leak if possible, or replace the heat exchanger                                                                                 |