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Only clean hydronic systems give top performance

by Allan Jones

Specify cleaning before start up — it is not at all difficult specially if the system is kept clean of foreign materials during construction.

(PART 1)

Clean systems don't just happen—they are made that way. In this series of 3 articles a broad analysis of the problems that may arise will be included together with useful suggestions which, if given an ounce of attention, are worth a pound of cure.

Hydronic Systems are installed in a wide range of size and shape to suit the mechanical and heat carrying needs of the installation. Everyone comes in contact with them—they do a job of heating or cooling with liquids—usually water is used but very often brine, anti freeze or special fluids are circulated.

Foreign materials left in a Hydronic System often cause chronic problems such as excess venting, air binding and poor circulation, uncertain operation of mechanical accessories also equipment and system corrosion resulting in a dissatisfied customer.

Initial cleanliness is the main factor in all of these systems, while the nature of the fluid circulated and the type of circuit very often determine what other precautions are required to maintain cleanliness and prevent corrosion of piping and heat transfer units.

Briefly the following equation solves the contractor's problem:—Prevention of entry of foreign materials during construction + System cleaning before putting into operation + Prevention of Corrosion of Piping Circuits = Top Performance = Satisfied Customer.

Hot water heating a typical hydronic system

The most popular Hydronic System is the hot water heating system installed in homes, apartment buildings, plants, office buildings, etc. It is usually a closed system constructed of steel or copper piping, radiators, convectors, boiler or heat exchanger, circulating pumps and other accessories, all connected together to a cushion tank to allow for expansion and contraction of the heating fluid. A well designed system of this type with proper size of compression tank will allow the normal changes in temperature over the heating season to take place with no intake of air and with little or no loss of water. Little make-up water will be required, hence the entrance of impurities from this source will be of little concern.

Oxygen and CO_2 from the atmosphere have slight chance of entering excepting with initial fill water at start-up. However, foreign material left in the system at time of construction will break down and be a continuing source of air, gas, etc. causing circulation troubles and the basis of possible corrosion in the system.

As Hydronic Systems as a group are constructed of piping, fittings, heating or cooling units and other accessories often stored on the job for a time, it follows that all are potential collectors of foreign materials picked up during installation and also deposited from any hardness or chemicals carried by the fill water.

It is easy for Hydronic Systems to pick up many types of extraneous material which inadvertently find their way into the system during installation. Those commonly found are pipe dope, cutting oil, soldering flux, rust preventatives or slushing compounds, core sand, welding slag, bits of solder, sand, clay, cinders or other dirt from the building site.

A little more thought and care during construction can prevent later troubles due to corrosion, air binding or mechanical difficulties with pumps and accessories.

Wash out the system before putting in operation

Fortunately, every system is not plagued with serious obstructions from foreign material, however, the best insurance is:—**Wash out the System on completion.** Don't have your installation bugged by foreign material.

Make sure it is clean right at the start. It will assure the customer of good operation and save him money on operating cost by removing an important cause of sluggish heat transfer.

Source of fill water

Fill water used in Hydronic Systems has widely varying characteristics depending on its source. Great Lakes water, for example, is fairly uniform and of moderate hardness, while that from local wells very often has considerable hardness; Sulphur water usually contains excessive sulphides often in the form of hydrogen sulphide and is generally corrosive; Alkali waters of the prairies contain excessive amounts of chemicals that may be corrosive and very often cause deposits that hinder heat transfer and sometimes require early replacement of equipment.

In modern Hydronic Systems, rapid movement of the liquid is used to provide good heat transfer. Where systems are not washed out, foreign deposits such as iron oxide and scale tend to move from piping areas of relatively high velocity to areas of low velocity—such as boiler, storage tank, condensate tanks, sumps, heat exchanger heads, etc. where it is likely to be deposited becoming a nuisance and setting up corrosive conditions.

Water Treatment is indicated in some cases to protect the piping, etc. from corrosion and scaling, however, each type of system should be treated according to its needs and by experienced people. Excessive treatment often causes more harm than good, especially to such equipment as air vents, relief valves, heat exchangers, pumps, etc.

Types of hydronic systems

Hydronic Systems may be compared by knowing whether they are essentially closed or open to atmosphere, the extent and source of make-up water, the chemicals used, if any, the fluid velocity and temperature range. While condensate return systems, chilled drinking water systems and Domestic Hot Water Systems may not exactly come under the definition of Hydronic Systems, the problems are so similar· and allied to systems such as hot water heating and cooling, that we propose to include them in the present discussion.

The systems may be gouped as follows:—

(A) Closed Hot Water Heating or Chilled Water Cooling. Temperature not over 250°F.
(B) Open Hot Water Heating or Chilled Water Cooling.
(C) High Temperature Hot Water Heating.
(D) Evaporative Condenser or Cooling Tower Condenser Units.
(E) Brine Circuits.
(F) Chilled Drinking Water Systems.
(G) Domestic Hot Water Heating.
(H) Condensate Return Systems.

Today almost all of the above are equipped with one or more centrifugal pumps at some point in the recirculating system. Many of them operate on closed systems where it is desirable to maintain insignificant loss of fluid or cushion air. To accomplsh this, only mechanical seal pumps can be used. Such closed systems must be designed throughout so that normal operation will not cause air to enter or fluid to be taken in or expelled. Under these circumstances, closed systems most nearly approach the ideal in avoiding corrosion and the accumulation of scale.

Foreign material

We are convinced that any newly installed Hydronic System should be cleaned on completion. This is not at all difficult and is especially important in large systems where the movement of debris to the pump end can cause trouble. Where convertors or heat exchangers are used, dirt and debris tend to accumulate in low velocity areas on the convertor tubes setting up the start of later corrosion and reducing the effective heat transfer of the units. Where exchangers are used for snow melting, anti-freezes such as Ethylene Glycol sometimes hasten such deposit which may severely cut down the heat transfer capacity of the convertor.

The use of "stop-leak" compounds is not recommended in Hydronic Systems, unless absolutely necessary, as clogging of valves, air vents, erosion of the pump seal and possible chemical decomposition are likely to result if the chemical is left in the system. If it is really necessary to use "stop-leak" compounds, the system should be cleaned thoroughly, drained and refilled, immediately after their use.

(A) Closed—Hot Water Heating or Chilled Water Cooling Systems—Moderate Temperature Range

When foreign materials are allowed to remain in this type of system, chemical reactions are likely to take place in the fluid circulated. Such chemical change usually produces an acid condition, with an excessive amount of gas or air requiring extra venting. Water or liquid drained from such a system will often be muddy in appearance indicating the presence of impurities; on the other hand, the water may be clear but still contaminated. A quick test to see whether the system is alkaline or acid will give some indication of its condition. A system having excess air venting trouble due to chemical breakdown of foreign material will very often show a pH test of less than 7 and probably in the neighborhood of 4 or 5 (pH is an indication whether a solution is acid or alkaline).

e.g. A pH reading below 7 is acid and above 7 is alkaline.

A closed low temperature hot water heating or a chilled water cooling system connected to room heating or cooling units will generally operate best with a pH betwen 7 and 8.5. The pH can be easily checked using Hydrion paper available from a chemical supply house or through your local druggist. Chemical comparator may be used for more accurate determinations of pH but this equipment is quite expensive.

How to clean systems

Commercial boiling out powders are good for cleaning as they contain detergents that lower the surface tension and remove oil film, scale, etc. Instructions provided with the material should be carefully followed. The system must be flushed out when the cleaning process is completed, as these cleaners are generally detrimental to pumping equipment when left in the system indefinitely. Unless all vents are opened and the system given sufficient time to thoroughly drain a considerable quantity of cleaning solution may be held up in the system. If a check on pH of the system water after refilling and recirculating shows alkalinity over 8.5, the system should be drained again and refilled. A recent check on a large heating system where trouble was reported showed a pH of nearly 11 indicating a large part of the cleaning compound had been left in the system causing trouble with air vents and pump seals. Complete draining and refilling brought the pH back to 8 and the customer's troubles vanished.

Tri-sodium phosphate, sodium carbonate or sodium hydroxide (lye) are common materials for cleaning and they are readily available at paint and hardware stores. The preference is in the order named and should be used in the following proportions, using a solution of only one type in the system:—

1. Tri-sodium phosphate—one pound for each 50-gallon system.
2. Sodium Carbonate—one pound for each 30-gallons in system.
3. Sodium Hydroxide—one pound for each 50-gallons in system.

Fill, vent and circulate system with cleaning solution, allowing it to reach design or operating temperatures if possible. After circulating a few hours, the system should be drained completely and refilled with fresh water. Usually enough of the cleaner will adhere to the piping to give a slightly alkaline solution satisfactory for good operation.

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Different types of circuits require different care and treatment to keep service to a minimum and provide optimum performance

(PART 2)

Initial cleanliness is the main factor in all Hydronic Systems. Clean systems don't just happen; they are made that way. The simple procedure for cleaning a closed type hot water heating or cooling system, as outlined in Part 1, can with slight modification be applied to all Hydronic Systems. Discussion is now continued with respect to open Hot Water Heating Systems and other circuits classified as Hydronic. It is based on:

1. Prevention of Entry of foreign materials during construction.
2. System cleaning before putting into operation.
3. Prevention of corrosion of the piping circuits.

(B) Open Hot Water or Chilled Water Cooling

A heating or cooling or combination system that because of design or neglect requires excessive make-up or has substantial air intake to the system, or is fully open to atmosphere through an open expansion tank, must be regarded as an open system.

New or neglected systems of this type should be thoroughly cleaned as outlined in Part 1. Foreign material is troublesome, so let's get rid of it. Make-up water and entrance of air should be reduced to a bare minimum by correcting any outstanding faults of the system and converting wherever possible from open to closed type with adequate compression tank unless there is some good reason for continuing to operate as an open system.

When open hot water heating systems must be used in this manner, pH should be checked and if too low or too high flush out, clean with trisodium phosphate and refill with clean water making sure pH is between 7 and 8.5.

If pH is still not satisfactory, check method of flushing system and source of fill water. Where source of fill water is unsatisfactory, check with reliable water treatment concern.

(C) High Temperature Hot Water Heating

Hot Water Heating Systems using Temperatures of 250°F to 400°F are usually of closed type because of the need for high pressures as well as the exclusion of air and elimination of frequent make-up. Systems operating at 250° to 300° will generally have compression tanks while those of 300°F to 400°F will usually have expansion drums utilizing either steam or inert gas. All steel water cooled pumps are generally used for the 300°F to 400°F range and dissimilar metals in piping, valves and accessories should be avoided.

A clean system at the start is again of primary importance with careful attention to preventing leaks that require significant make-up water. In medium temperature systems, extensive water treatment is seldom required where there is continual re-use of the water.

The size of the system, operating temperature, amount of make-up, and the characteristics of the fill water available will indicate the precaution that should be taken with regard to system water treatment, also to possible make-up water treatment. Some of these systems are very large and in the high temperature range should be considered as central station systems with treatment and regular analysis of water.

(D) Evaporative Condenser or Cooling Tower Condenser Circuits

These two circuits are similar in nature both being open to atmosphere and water losses are continuous. The piping circuit, sump, spray equipment, pump and condenser tubing should be thoroughly cleaned before starting up and there after subjected to periodic cleaning. How often will be determined by the chemical nature of the water, the temperature, rating, flow conditions, arrangement of the circuit, water treatment and amount of continuous bleed-off or blow-down. In other words, when it is fouled arrange for cleaning and develop a cleaning schedule to suit conditions.

The type of cleaner used after fouling has occurred will depend on conditions and personal preference of how to handle the cleaner. Most cleaners for this purpose are essentially acid and should be handled with extra care for the protection of the equipment and the personnel. Consult with a reputable manufacturer of cleaning materials with a full understanding of the problem. A cleaner that comes in dry form is usually the safest to handle. Algae control will often be needed.

In this type of system, the water becomes heated at the condenser tubes and passing on from the pump through the spray nozzle it partially evaporates. Condenser tubes should be checked at regular intervals for fouling. The evaporated water is clear distilled water, but the drops falling down to the sump pick up foreign material from the air in addition to the extra concentration of chemical in the unevaporated droplets. The sump very quickly has a build up or concentration of chemical which must be taken care of by bleed-off and the addition of fresh water.

When cleaning this type of equipment, it is often helpful to use a recirculating pump with a flexible hose and nozzle to reach surface where scale readily builds up and is not washed off by normal operation.

Adequate and regular cleaning and the use of proper water treatment will increase the heat transfer rate of the condenser, decrease the amount of water used and make for longer equipment life.

(E) Brine Circuits

Refrigerating brines are usually made up from Sodium Chloride, Calcium Chloride or a mixture of calcium and magnesium chlorides. Foreign material should be kept from entering the piping and the circuits should be adequately cleaned and flushed out before filling with brine. Centrifugal Pumps used on these circuits should have bronze impellers for sodium chloride and steel or cast iron for calcium brines. Refrigeration people will recommend the proper materials, and precautions to be taken. Treatment for corrosion prevention is essential.

(F) Chilled Drinking Water Systems

Extra care should be used in the fabrication of piping, installation of chiller, recirculating pump, etc. to prevent the entrance of foreign materials from the job site. The system should be well flushed and if in doubt clean with non-toxic chemical or detergent followed by thorough flushing.

(G) Domestic Hot Water Heating Systems

All domestic or service water systems, just as in the case of chilled drinking water circuits, should be carefully installed preventing the entrance of foreign materials on the job. A thorough flushing should be used and if in doubt clean with non-toxic chemical.

The recirculating pump will generally be all bronze to keep corrosion to a minimum. The continual addition of fresh water from municipal water systems or pumped from local well or river will introduce fresh oxygen into the system, hence the usual use of galvanized or copper piping. Most waters contain some hardness but large lake waters are very often almost neutral in pH. Acid waters may be encountered in some localities where unusual amounts of CO_2 and H_2S (sulphur water) are present. An aeration system with the addition of chlorine may be used to get rid of the hydrogen sulphide.

Waters that have excessive Alkalinity may have to be handled as indicated by local customs to keep the system and pumping equipment in good condition. Regular flushing and inspection of pumps and heater equipment are necessary when local water conditions are unusual.

(H) Condensate Return Systems for Steam Boilers

Condensate return or boiler feed systems are usually partially closed but have several places where air, CO_2, rust and scale, etc. may enter. These spots are usually unavoidable due to the need for a hot well or condensate tank generally open to atmosphere to take care of flow surges. The alternating rise and fall of steam pressure in heating units leads to the addition of air to the system through vents and vacuum breakers. Any organic material in the make-up feed water or foreign materials left in the system on start up tend to break down chemically forming gases in the steam which will find their way into solution in the condensate. Carbon Dioxide CO_2 one of the most important gases causing corrosion in condensate systems is found in solution in the make-up water and is also formed by the heating of bicarbonates dissolved in the water.

It will be readily seen that keeping the condensate return circuits and the whole steam system as clean as possible during installation and washing out and flushing thoroughly will help reduce the corrosion tendencies largely due to oxygen and carbon dioxide generated in or entering the system. The size of the system, relative amount of make-up and its quality, operating temperature, etc., will determine the care that should be taken to prevent corrosion and deposition of scale.

Condensate return pumps may be either mechanical seal or packing gland type but generally they are selected to suit the conditions of the particular system. Regular attention to cleaning dirt pockets, trap strainers and adequate blow down of the system will show good return on maintenance of the system and pumping equipment.

Care of the steam boiler must be regarded as a separate subject in keeping with the size, type and operating pressure of the system. For this information, the boiler manufacturer should be consulted.

Hydronic systems — their care and maintenance

The advantages of using closed systems wherever feasible consistent with the type and operation of the system have been pointed out. The importance of initial cleanliness, the prevention of the entrance of foreign materials and general care of Hydronic Systems have been outlined sufficiently to give our readers food for thought.

Pumps are the most widely used piece of mechanical equipment in a hydronic system—their care deserves detailed attention

(PART 3)

To get the optimum performance from mechanical equipment on a hydronic system the complete circuit must be clean, free from foreign materials and, when indicated, the proper inhibitor or chemical treatment added to the liquid circulated. Pumps are dealt with in some detail as they are the most widely used piece of mechanical equipment applied to hydronic systems and their care is representative of most accessories used on these systems.

Pumps with mechanical seals

Pumps used on hydronic or water systems just described are generally single stage centrifugal with mechanical seal. Usually the rotating part of the seal is a carbon ring that is sealed on the shaft by a neoprene rubber sleeve. The carbon ring has a ground flat face which runs against an optically flat seat, very often ceramic, permanently mounted on the pump body at the shaft entrance. Where the seat is cemented in place, uniform support will be provided for the ceramic material to prevent strain that might result in breakage. A uniform cementing method also aids in preventing unusual thermal stresses that tend to be set up by pumping fluids of varying temperatures. A stainless steel spring usually holds the rotating carbon in place against the stationary seat.

Pumps of this design are almost regarded as stock units and can take care of 85% of systems discussed here. In exceptional circumstances of pressure, temperature and fluids handled, other materials besides ceramic may be used for the stationary seal seat—cast iron, niresist, stellite and others are available.

Pumps when equipped with mechanical seal use less hp and shaft leakage is reduced to a minimum. Any reduction of make-up means a reduction in corrosive materials entering the system.

Pumps with adjustable packing glands have their place in certain applications but do require more attention, extra leakage may be expected and more parts and time for replacement than mechanical seals.

Care of pump—Do not run dry

Mechanical seals in normal operation show no leakage. Actually a very small amount of the pumped liquid finds its way between the surfaces of the rotating and stationary seal faces and provides a cooling and lubricating action. The pumped liquid also cools the seal by flowing around and over the outside of the seal parts. Do not run dry. An electrical test run of say 5 to 10 minutes without fluid is almost sure to damage the seal causing premature failure within the early months of operation. A dry run of a packing gland pump will also start the shaft sleeve on the way to failure. If a test for direction of rotation must be made when wiring is connected, just touch the starter to see which way the motor turns, then leave a card "Not to be Started until System Filled."

Accessories for hydronic systems—select with care

In the design of hydronic systems and the selection of various accessories, a little forethought will pay off.

For example, the size of cushion tank used on closed heating systems is important if we are to prevent excessive pressure changes with accompanying loss of water and excessive make-up. Guess work has now been removed from the selection of cushion tanks and comprehensive data is available in various forms, see ASHRAE Guide and Data Book, for the selection of the proper size of cushion tank.

Today most people also agree that water gauge glasses should never be used on cushion or compression tanks, as they are a frequent source of trouble causing loss of cushion, water-logging, large swings in pressure and unnecessary need for make-up water carrying corrosive gases into the system. The frequent wetting and drying, and changes in temperature at the gauge glass, makes it impossible to keep them really tight.

Strainers are a must on condensate systems to protect traps, check valves, etc., but their value on hot water heating or chilled water circuits is very questionable where the system is properly designed, cleaned, filled and operates with no significant make-up. If strainers are used on such a system, consideration must be given to the pressure drop. On some hydronic systems, it is desirable to have magnetic pickup for collecting scale located at or in the strainer.

On larger systems the circuit should be arranged to prevent pressure dropping below atmospheric at any point where air vents, especially automatic hygroscopic or float types, are used when the pump is running. Automatic vents on the return line at considerable height above the pump suction may under some circumstances allow air to enter the system when the pump is running, causing circulation troubles and system corrosion. Be sure to check pressure under all operating circumstances at locations in question.

Hydronic systems have flexibility

Many different types and arrangement of piping circuits equipped with pumps, controls, heat exchangers, etc. are used to service a multitude of requirements for heating or cooling services. Water or other liquids used in these systems provide a wide flexibility in design by using high or low temperatures, and a narrow or wider temperature drop.

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