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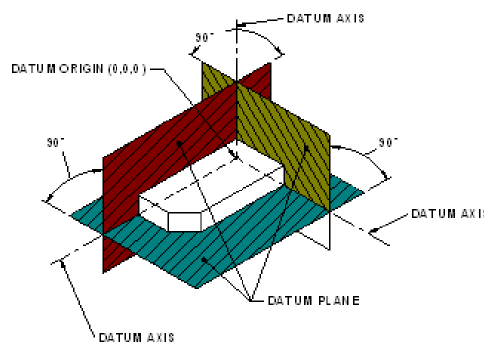

An Introduction to Treatment of Closed Industrial Water Systems

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1. INTRODUCTION. The term “closed water system” refers to a water system that is used to provide heating, cooling, or both for industrial processes or facilities. The system is sealed (closed), sometimes under pressure, and is not open to the atmosphere. No evaporation takes place and, with good operation, water is lost only minimally from the system. In general, water treatment for closed systems is much easier than for open systems. Makeup water is needed only to replace seal leakage and other incidental leakage. Because of the small makeup water requirements of these systems, they require little chemical treatment, which can be added intermittently as needed. Once properly treated, the system water does not form scale and has little or no corrosion potential. Two main types of closed water systems are used at many installations: hot water closed heating systems and chilled water closed cooling systems.

1.1 HOT WATER HEATING SYSTEMS. Hot water heating systems are designed to produce hot water, and although they are often referred to as hot water boilers, they are actually hot water heaters rather than boilers. For new construction, hot water heating systems are preferred over steam systems. Hot water heating systems, also known as hydronic heating systems, recirculate water to distribute heat in facilities. They operate at three temperature ranges:

- High-temperature water systems (pressurized systems with water temperatures higher than 177 °C [350 °F]) – no steam, only very hot water.
- Medium-temperature water systems (pressurized systems with water temperatures from 121 to 177 °C (250 to 350 °F]) – no steam, only quite hot water.
- Low-temperature water systems (water temperatures lower than 121 °C [250 °F])– no steam, only hot water.

1.1.1 HOT WATER BOILERS. Hot water boilers can be either direct-fired (heated by combustion of gas, oil, or coal) or unfired (heat supplied by steam from a steam boiler, heated by hot water from a higher-temperature hot water system, or heated by a solar energy system). For many applications, hot water boilers are preferred over steam boilers because there are essentially no makeup water requirements and chemical treatment programs are less complex and easier to maintain. They require less manpower for operation, less maintenance, and have fewer water-related problems than steam boiler systems. Figure 1 shows a hot water boiler.

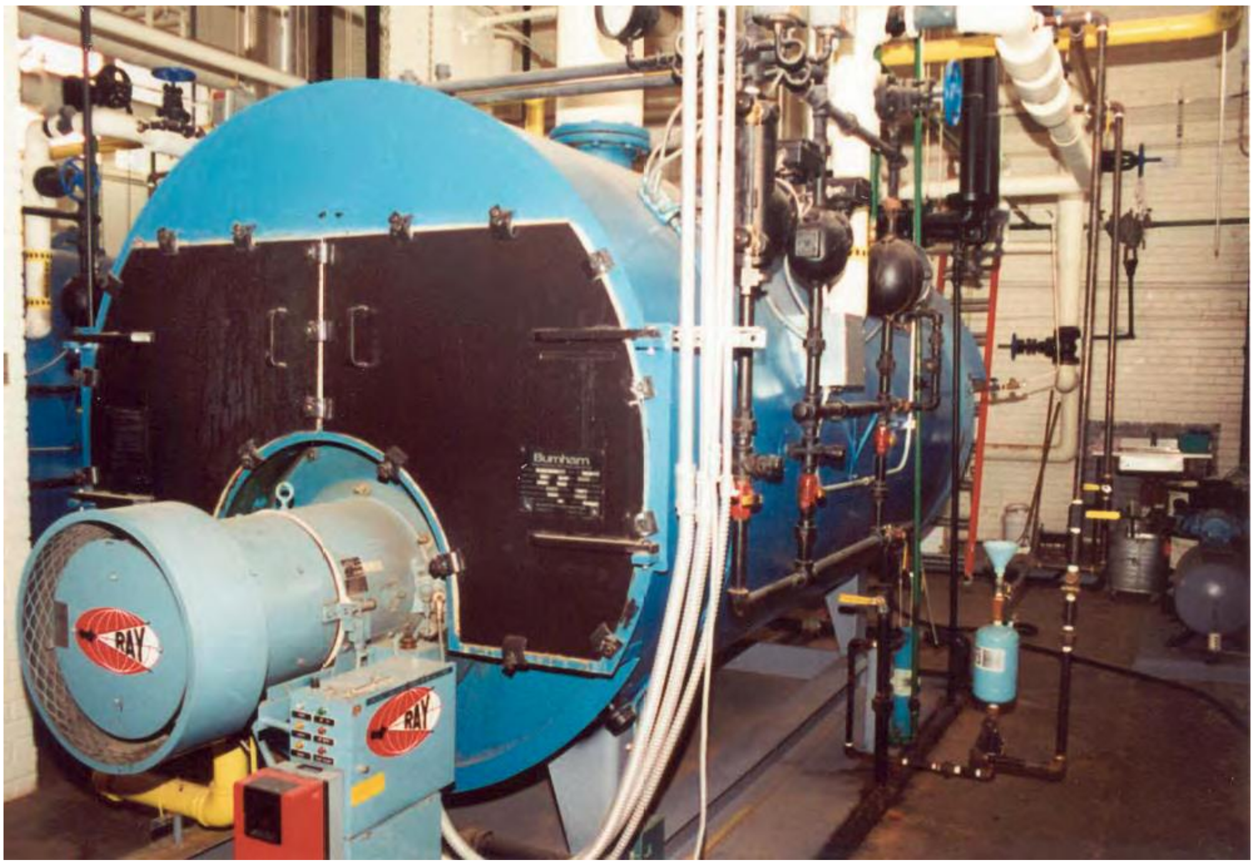

Figure 1

Hot Water Boiler

1.1.2 DESCRIPTION OF HOT WATER SYSTEMS. A typical hot water (hydronic) heating system is similar in composition to the closed cooling water system shown in Figure 2, except that a fired or non-fired heat exchanger is used rather than a chiller. Hot water boilers (fired and unfired) differ from steam boilers described in Chapter 3 because hot water boilers:

- Provide heated water but do not generate steam.
- Do not have deaerating heaters. (These are not required because there is essentially no makeup water requirement and thus very little air enters the system.)
- Require recirculating pumps to distribute the heated water to the processing equipment.
- Require expansion tanks that contain a cushion of steam or nitrogen.
- Do not contain a condensate return because there is no steam generated, but there is a return system.
- Are fabricated with mild steel components, but also may contain copper heat exchanger tubes, particularly in unfired systems.
- Do not require blowdown.

1.2 CLOSED CHILLED WATER SYSTEMS, BRINE SYSTEMS, AND GLYCOL SYSTEMS. Closed chilled water systems, brine systems, and glycol systems supply cold or chilled water for cooling processes and air conditioning. They are water systems designed for minimal loss of water. These systems contain mild steel piping, copper heat exchangers and, in some systems, aluminum piping, stainless steel piping, cold rolled steel piping, and potentially other metals.

1.2.1 CLOSED CHILLED WATER SYSTEMS. Closed chilled water systems circulate water that is cooled by refrigeration equipment. Water temperature ranges typically vary between 4 to 13 °C (40 to 55 °F). A typical chilled water system is depicted in Figure 2. Chilled water systems can have large storage capacity (3785 cubic meters [1,000,000 gallons] or higher). Chillers are shown in Figure 3.

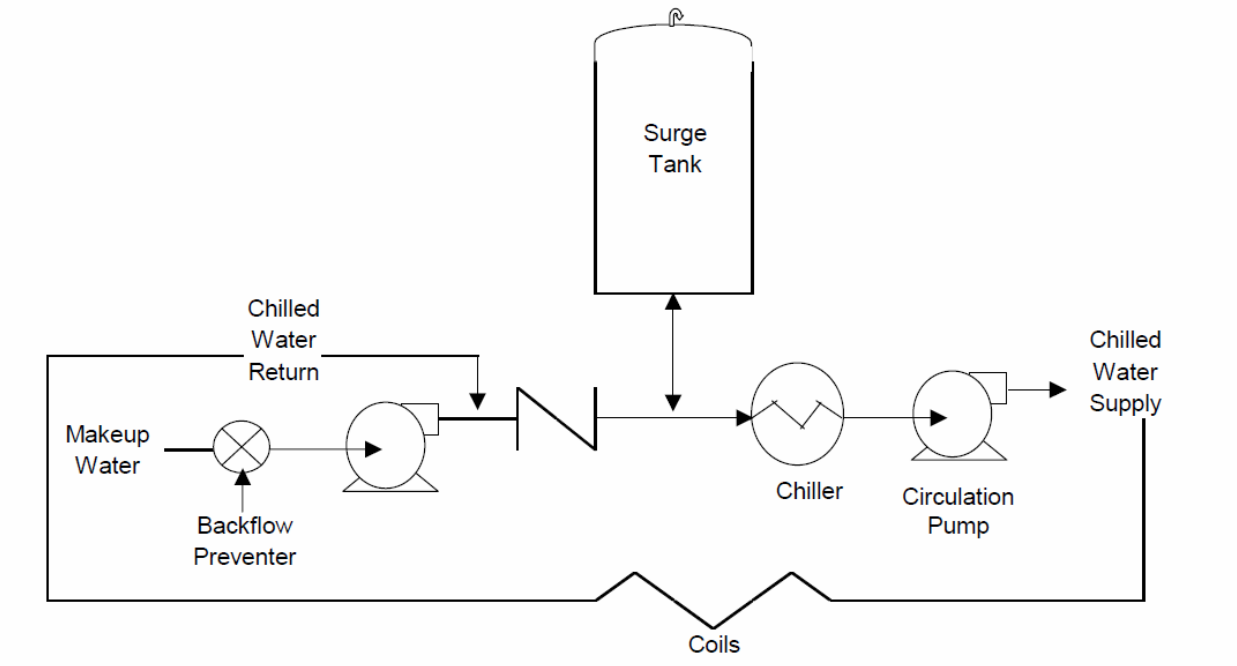

Figure 2

Typical Closed Chilled Water System Schematic

Figure 3

Chillers

1.2.2 CLOSED BRINE SYSTEMS. Closed brine systems are chilled water systems in which calcium chloride, sodium chloride, or a mixture of sodium chloride and calcium chloride has been added to the water to lower its freezing point sufficiently to maintain it as a liquid (ice-free) at temperatures of -1 to 10 °C (30 to 50 °F). Brine systems have been largely replaced by glycol systems.

1.2.3 CLOSED GLYCOL SYSTEMS. Closed glycol systems are chilled water systems that contain a mixture of water and glycol (ethylene or propylene) that will not freeze at the system operating temperature of -7 to 2 °C (20 to 35 °F).

1.3 COMBINED HOT AND CHILLED WATER SYSTEMS. Some closed systems serve the dual purpose of producing circulating hot water during the cold season and chilled water during the hot season.

1.4 DIESEL ENGINE JACKET COOLING SYSTEMS. Diesel engine cooling systems are considered closed systems, even when surge tanks are open to the atmosphere. The heat transfer from the circulating water is usually accomplished using a heat exchanger, not by evaporation. These systems have low water losses. Several of the metals used in these systems require good corrosion control. The three basic types of diesel engine cooling systems are described below.

1.4.1 AIR-COOLED DIESEL COOLING SYSTEMS. Air-cooled diesel cooling systems are used on most small engines as well as some large engines. The jacket water is circulated through an air-cooled radiator. Antifreeze must be used in these systems when radiators are exposed to low-temperature atmospheric air or when the water temperature exceeds the boiling point (100 °C [212 °F]).

1.4.2 WATER-COOLED DIESEL ENGINE COOLING SYSTEMS. Water-cooled diesel engine cooling systems are used mainly on large engines. The jacket cooling water passes through a heat exchanger, rather than a radiator, where a separate cooling water loop removes the heat from the jacket cooling water. These systems commonly use antifreeze.

1.4.3 VAPOR-PHASE DIESEL ENGINE COOLING SYSTEMS. Vapor-phase diesel engine cooling systems, also called ebullient systems, use water that is heated to a temperature at the boiling point or above the boiling point for pressurized systems. Steam is formed from the cooling water as it removes heat from the system. The steam produced in this way can be recovered and used for space heating. This type of system requires significant amounts of makeup water and chemical treatment.

2. WATER TREATMENT FOR CLOSED SYSTEMS. Water treatment programs for both closed hot water and closed chilled water systems are developed primarily to control corrosion, although the programs may also control deposition of microbiological organisms. If needed, scale deposition can be prevented by external treatment (i.e., ion exchange softening) or can be controlled with inhibitors as described in Chapter 4. Corrosion must be completely controlled by water treatment programs. If corrosion occurs, corrosion products will eventually plug the system, resulting in decreased operational efficiency and the need for cleaning. Microbiological growth is not a concern in hot water systems, but can occur in chilled water systems and should be controlled (see paragraph 2.3).

2.1 MAKEUP WATER REQUIREMENTS. Makeup water requirements for closed systems are very small unless there are leaks in the system (see paragraph 2.4). Closed systems should not be drained or purged unless there is evidence that indicates the need to remove dirty water or sludge. For proper operation, makeup water in high-temperature and medium-temperature water systems is deaerated (de-oxygenated) using both mechanical and chemical methods and is also softened. Oxygen can be removed from low-temperature water systems either chemically or mechanically to prevent oxygen-induced corrosion. Chilled water systems can require partial softening if the makeup water exceeds 250 ppm total hardness (as CaCO). The makeup water requirements are monitored carefully in systems of all types (see Table 1). If there is an increase in the quantity of makeup water required, the leak should be found and repaired quickly. After the repair, water treatment chemicals should be replenished immediately.

System Type	Requirement
High-temperature hot water	Softened and deaerated
Medium-temperature hot water	Softened and deaerated
Low-temperature hot water	Less than 100 ppm total hardness as $CaCO_3$
Chilled, br	
Diesel en	CO_3 ater is

2.2 CORROS rams are

used in close

- Sulfite
- Nitrite

Molybdate-a

-
- Nitrite
- Polysi

The choice o arily on the water tempe f the treatment pr ograms are listed in Tabl biological control monit