

## WATER TREATMENT

### OPEN AND CLOSED HEAT EXCHANGER SYSTEMS

#### 1. GENERAL

1.01 This section outlines some conditions to be considered in planning equipment and water piping for water treatment of heat exchanger systems. Included in such systems are hot water heating systems, water chiller systems and water-cooled condensing systems used in air conditioning installations.

1.02 The control of corrosion, scale, algae, fungi, and sludge is essential to obtain maximum life and performance of the equipment used in these systems. The water to be used in a system should be analyzed by a reliable water testing laboratory or water treatment company to determine the need for a water treatment program. In addition, consideration should be given to the nature and extent of air-borne pollution to which an evaporative condenser or cooling tower may be exposed. The location of equipment of this nature should be guided by the location of building chimney, the type of fuel used and the prevailing wind direction.

1.03 The Engineering Department through the Building Engineer should:

- (a) Make the decision after consultation with the Plant Department whether treatment is to be provided.
- (b) Reach an agreement with the Plant Department on the method of treatment to be used.
- (c) Provide the equipment required as part of the mechanical equipment of the building.
- (d) Provide the initial supply of chemicals.
- (e) Check for satisfactory installation and operation before turnover to the Plant Department.
- (f) See that adequate operating instructions are provided for Plant Department use.

1.04 The Plant Department through its Superintendent of Buildings has the responsibility of administering the water treatment program.

#### 2. REFERENCES

2.01 The following BSPs contain information on related subjects:

- H34.280 Evaporative Condensers
- H34.281 Cooling Towers
- H51.370 Fundamental Principles of Water Conditioning
- H51.371 Water Treatment — Air Conditioning Systems (to be issued)

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#### 3. DEFINITIONS

3.01 *Corrosion* is destruction of a metal by chemical or electrochemical reaction with its environment.

3.02 *Scale* is a deposit formed from solution directly in place upon a confining surface. In general, hard water tends to form scale, especially when subjected to successive heating and cooling. In most cases, scale is the insoluble carbonates of calcium and magnesium.

3.03 *Sludge* is a water-formed sedimentary deposit. It usually does not cohere sufficiently to retain its physical shape when mechanical means are used to remove it from the surface upon which it deposits. Sludge is not always

found at the place where it is formed. It may at times be hard and adherent and baked to the surface on which it has deposited.

**3.04 *Algae and fungi*** are types of plant life which may grow in circulating systems. They tend to form slime on the surfaces of the system.

**3.05** The *pH-value* is a term used to describe the degree to which a water is acid or alkaline. Neutral water has a pH of 7. The pH-values range from 0 to 14, those less than 7 being acidic and those above 7 being alkaline. However, the pH-value is a logarithmic function, not a straight line function. Thus a pH of 4 indicates a solution ten times more acidic than one having a pH of 5, and 100 times more acidic than one having a pH of 6. A pH of 9 would indicate a solution ten times more alkaline than one having a pH of 8.

**3.06 *Once Through System*** — The condenser water passes through a heat exchanger absorbing heat and increasing in temperature before being discharged to waste.

**3.07 *Closed Recirculating System*** — The water circulates through a heat exchanger where it absorbs heat, rises in temperature, then circulates through another heat exchanger where its temperature is lowered.

**3.08 *Open Circulating System — Cooling Towers*** — The condenser water passes through a heat exchanger absorbing heat and increasing in temperature. The water then flows to water cooling equipment such as atmospheric (natural draft) towers or mechanical draft towers. As water passes through the tower, a portion of it evaporates thereby cooling the remainder. Loss of water through evaporation tends to concentrate the salts, since the salts do not evaporate. In addition, a small amount of water is lost through drift. Automatically fed make-up water replaces that lost for these reasons.

**3.09 *Open Circulating System — Evaporative Condenser*** — The water, recirculated from a sump, is sprayed over hot refrigerant piping where it absorbs heat and increases in temperature before returning to the sump. As this water is again sprayed over the piping, it is cooled by evaporation, aided by an induced air

movement. Water losses occur in evaporative condensers for the same reasons as in cooling towers.

#### 4. ECONOMIC CONSIDERATIONS

**4.01** Chemical feeding and control devices, as well as the chemicals used in a program, are expensive. The cost of such devices and the chemicals may influence the design of the condenser water system for smaller installations. Closed systems usually require less costly feeding devices and fewer chemicals than the open systems.

**4.02** Where serious water problems occur, consideration should be given to the use of air-cooled condensers. Not only is this consideration recommended for small systems, but also for large ones, particularly where there are serious water problems. Air-cooled condensers have been used satisfactorily for systems as large as 200 tons. They have two disadvantages — the amount of power required to handle the necessary air volumes and the fact that their capacity is at its lowest on the hottest days. The choice between installation of a water treatment system and the use of air-cooled condensers should be governed by the result of a cost comparison, with due consideration for the fact that personnel must be available to administer a water treatment system.

#### 5. SPECIFYING THE WATER TREATMENT PROGRAM

**5.01** The following items are considered as essential in any water treatment program specified by a water treatment company:

- (a) A written report of the water analysis, which should include the determinations, usually in parts per million, of calcium, magnesium, silica, iron, bicarbonate, sulfate, chloride, total hardness as calcium carbonate, total solids, and pH.
- (b) The chemical names of the water treatment compounds recommended for use.
- (c) The concentration of chemical and pH to be maintained in the water.
- (d) That chemicals recommended and the apparatus used to feed these chemicals comply with municipal and state health codes.

(e) That chemicals recommended will have no detrimental effect on nonmetallic materials such as rubber, plastic, etc, often used in water systems.

(f) That chemicals recommended will not cause delignification of wooden parts sometimes used in cooling towers.

(g) The amount of continuous bleed-off, water run to waste, from open circulating water systems required to limit scale formations.

**6. SUMMARY OF WATER TREATMENT CONTROLS**

6.01 Table 1 is a summary of water treatment controls for various types of heat exchanger water systems. This table is condensed from "Carrier Document 2D-7." It may be necessary to use one or several of the treatments listed depending on what a water analysis shows to be the most economical. Certain of the listed items may prove to be too costly in some cases.

**7. CHEMICAL FEEDING**

7.01 The preferred way to add chemicals to large open recirculating systems is by means of an electric driven, positive displacement mechanical feeder. This type feeder should be connected so as to operate only when the recirculating water pump is running. Such a feeder should be considered for systems larger than 100 tons. Other factors may make it desirable to use this type pump on systems smaller than 100 tons. For example, where it is desirable to locate the chemical treatment equipment in a basement equipment room for easy access by maintenance personnel, this type of pump may be used advantageously.

7.02 Bypass feeders can be used for adding chemicals to closed systems. In this case the chemicals are added manually and in one shot. Bypass feeders usually are not used on open systems due to the lack of good control. Fig. 1 shows one type of bypass feeder.

**TABLE I**  
**Summary of Water Treatment Controls**

WATER PROBLEM	SYSTEM		
	CLOSED RECIRCULATING	ONCE THROUGH	OPEN RECIRCULATING
Scale Control	No Control Required	1. Pretreatment a. Sequestering Agent b. pH Adjustment	1. Bleed-off 2. Pretreatment a. Sequestering Agent b. pH Adjustment c. Ion Exchange
Corrosion Control	1. Deaeration 2. Corrosion Inhibitors	1. Corrosion Inhibitors 2. pH Control	1. pH Control 2. Corrosion Inhibitors
Algae Control	No Control Required	No Control Usually Required	1. Manual Cleaning 2. Chemical Algacides

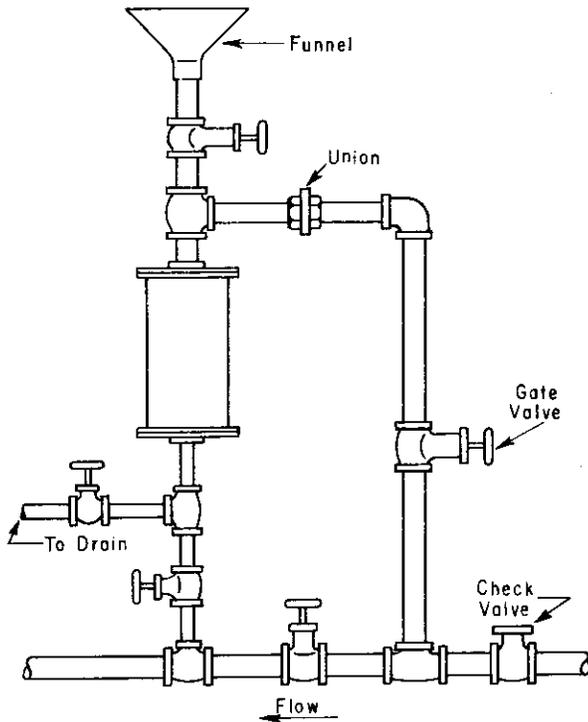


Fig. 1 - Bypass Feeder

7.03 On small open-type systems where the cooling tower or evaporative condenser is accessible, the chemicals may be fed by gravity to the sump from a tank mounted above the sump. Because a continuous drip of the chemical solution would be too small for proper adjustment, a timer and solenoid valve may be used to allow chemicals to be fed for two minutes or so during each hour of tower operation. The chemicals must be in solution in the tank in order to be fed into the system. The rate of flow of the solution will depend on the amount of water used as the solvent. Since the solution will flow for only two minutes each hour, the flow will be great enough to be regulated satisfactorily by means of a globe valve. Fig. 2 shows this arrangement. A second solenoid valve regulates bleed-off. If the tank can not be elevated above the sump of the tower, then a small pump may be installed as shown in Fig. 3 to feed the chemical solution into the system. This pump would not be as expensive as the type mentioned in Paragraph 7.01.

7.04 Fig. 4 shows one type of feeder which can be purchased commercially. This type unit can be used singly or in groups. It is to be placed in the bottom of the cooling tower or evaporative condenser and arranged so that the top cup is always full of water when the circulating pump is running. The proper rate of flow is obtained by using the proper size of orifice. The chemical is replaced by removing the empty can and placing a new can of chemical in its place.

7.05 There are certain devices on the market today which claim to control scaling and corrosion by electric current or magnetism. These are not recommended. They should not be confused with those devices which are based on scientific principles, such as the magnesium rod placed in hot water storage tanks for the control of rust.

7.06 The most accurate way to add acid for pH control to assist in scale control is to use an electric driven, positive displacement mechanical feeder controlled by an electronic pH controller. However, this equipment is quite expensive and its use should be limited only to the extremely large systems requiring the addition of acid. Intermittent dosages by manual feeding or excess concentrations from the use of inexpensive feeders can be harmful to the system.

7.07 Hot water heating systems as a general rule do not need chemical treatment. These systems tend to have a small amount of scale formed in the piping and this helps protect it against possible corrosion. Chilled water systems should have some provisions made for treatment against corrosion. There is a tendency for all the dissolved oxygen in the water to unite with the metal in the pipe over a period of time. In this case, it would probably be more economical to provide a chemical feeder than a deaerator. It should be remembered that for a closed system the best policy is to prevent as little change of water as possible. For this reason, unnecessary leaks should be detected as early as possible and eliminated.

## 8. PIPING

8.01 In open-type circulating systems it is necessary to allow a small percentage of the water to discharge to a drain in order to pre-

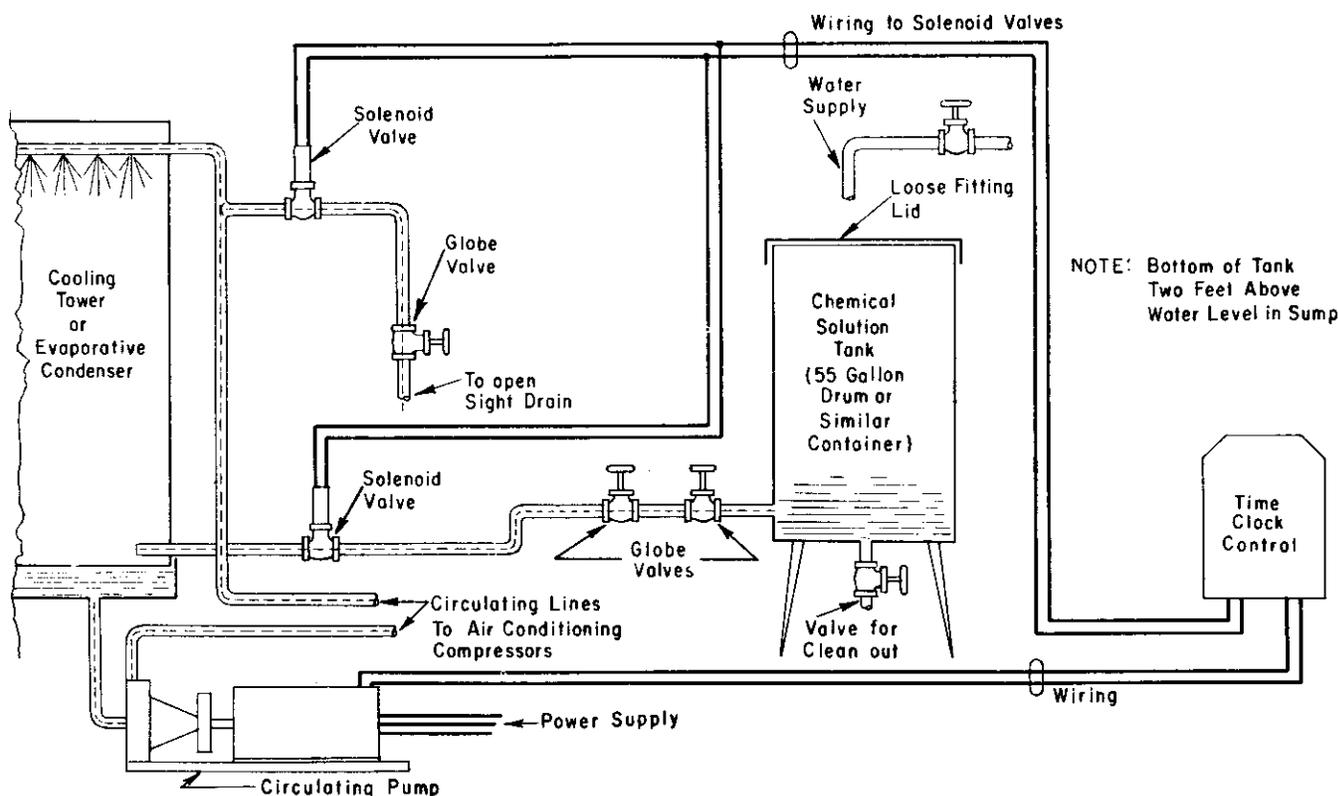


Fig. 2 - Timer - Solenoid Valve Gravity Chemical Feed System

vent the build-up of minerals in the water. This is known as bleed-off. For easy control on small systems this can be done by installing a funnel or pan with a rectangular sliding cover and with a line running to a drain. This pan should be installed in the path of the spray. The amount of bleed-off can then be regulated by opening or closing the cover. A means of diverting the bleed-off water into a separate container should be provided so that the amount of bleed-off can be measured. In general, where bleed-off is to be continuous, facilities sized to bleed-off one per cent of the water circulated should be provided. The actual bleed-off can then be regulated as required. There may be cases where the chemical content of the water or the temperature drop through the water-cooling device may require a larger bleed-off than one per cent. A bleed-off line taken directly off the circulating

pipe is not recommended where the bleed-off is less than  $\frac{1}{2}$  gallon per minute because of the likelihood that the valve regulating the amount of bleed-off will become clogged. In these cases, and in other cases where an intermittent bleed-off is desirable, the solenoid valve and timer arrangement, mentioned in Paragraph 7.03, is recommended. This must be sized as required by the frequency of solenoid operation and volume of bleed-off necessary.

**8.02** When a positive displacement pump is used to add water treatment chemicals in solution to a cooling tower, the pump discharge line should be connected to the condenser water line to the tower. The connection should be made at a point in the condenser water line after the water has passed through the condenser water pump and the condenser.

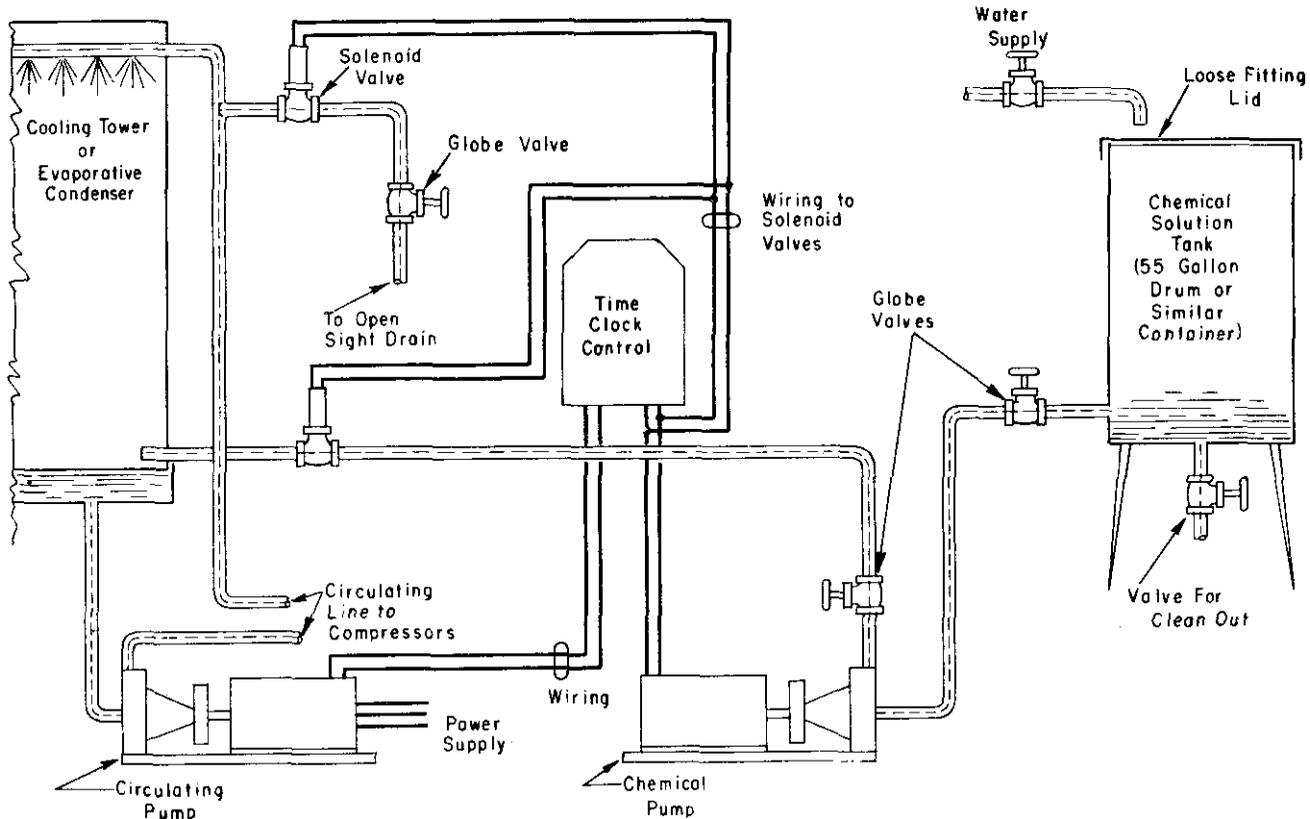


Fig. 3 - Timer - Solenoid Valve Pumped Chemical Feed System

8.03 Fig. 5 shows a commercially manufactured device for regulating the amount of bleed-off. This type device is located in the bottom of the cooling tower or evaporative condenser. Water should overflow the top cup whenever the circulating pump is running. The orifice can then be changed to give the desired rate of bleed-off. This method would be used where the bleed-off rate is less than  $\frac{1}{2}$  gallon per minute. Depending upon the condition of the water, this would be used for systems of about 70 tons or less.

8.04 On open-type systems provide an air gap between the system and the water supply. Closed systems which have the water supply connected directly to them should be treated with chemicals in such concentration that the resulting solution is not poisonous. The use of chemi-

cals in poisonous concentrations in boiler water or chilled water systems may require the use of expensive make-up water controls to prevent the possibility of the treated water from backing up into the potable water supply.

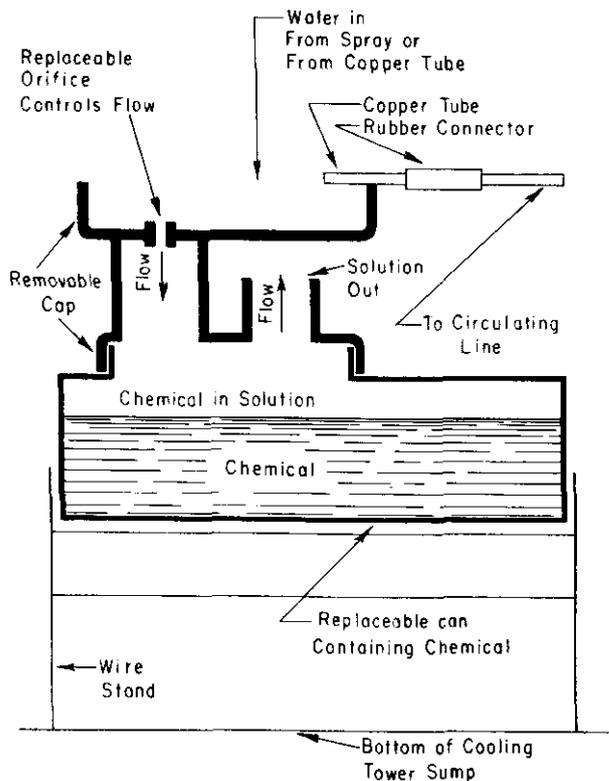
8.05 A fouling factor is usually applied in designing equipment. This fouling factor is the allowance made for a small amount of deposits on the piping and equipment which slows down the rate of heat transfer. Table 2 is taken from "Carrier Document 2D-7" and lists suggested fouling factors for industrial equipment operated 24 hours a day and cleaned every 6 to 12 months. This table should be used only as a guide to help select the correct fouling factor. Equipment manufacturers usually give a fouling factor when listing the performance data of their equipment.

Lower water temperatures are less conducive to scaling.

(c) Select shell and tube condensers with removable water boxes to facilitate inspection and scale removal from the coils by mechanical means. Avoid the use of heat exchangers which pass the water through the shell rather than through the coils, since this type is usually difficult to descale and clean.

(d) When evaporative condensers are used, design so the condenser fan is cycled, not the spray pump. Continuous operation of the sprays will eliminate successive wetting and drying of the coils and decrease scale deposit.

**9.03 Equipment to Minimize Corrosion** — Aluminum is susceptible to corrosion and is effectively protected by chemical water treatment only if the treated water washes all of the aluminum surfaces. Avoid the use of aluminum tube coils when recirculated water is pumped through the coils. Aluminum cooling towers will require a protective coating of paint to prevent the pitting type of corrosion.



**Fig. 4 - Cross Section of a Simple Manufactured Feeder**

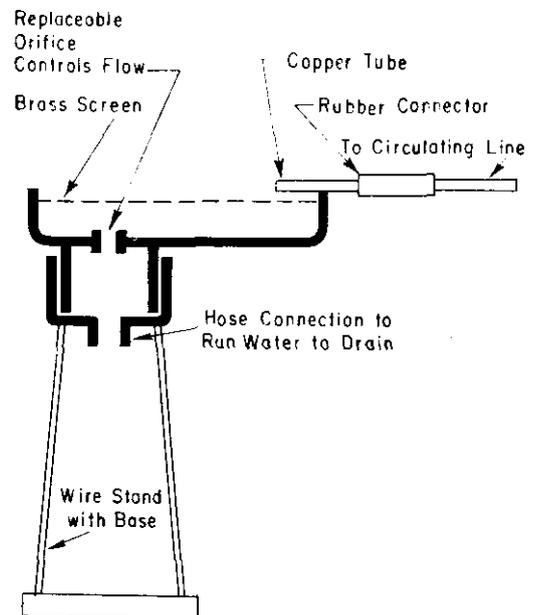
**9. EQUIPMENT SELECTION AND DESIGN**

**9.01** When designing condenser water systems select equipment and a design criteria which will minimize or be less susceptible to the damaging effects due to failure or lack of water treatment. Included in the following paragraphs are suggestions for the selection of some of these items of equipment.

**9.02 Equipment to Minimize Scaling**

(a) Avoid the use of finned coils for evaporative condensers. It is difficult to remove the scale between the closely spaced fins. Acid cleaning damages the fins.

(b) Select slightly oversized condensing coils in hard water areas to permit operation at lower condensing and water temperatures.



**Fig. 5 - Cross Section of a Simple Manufactured Bleed-off Regulator**



(f) Provide a plugged tee in the condenser water lines to package units at the units. This will make chemical (acid) cleaning of the condensers easier if it becomes necessary.

#### 10. SUMMARY

**10.01** The need for a water treatment program should be determined by an analysis of the water made by a competent laboratory or water treatment company. When the need is established, recommendations for the treatment program should be obtained from one or more competent water treatment companies. Such recommendations should include the result to be attained, the name and quantity of each chemical to be used and the method of adding them.

**10.02** When all parties concerned with the design and operation of the system have knowledge of the potential water problems during the planning stages of a job, adequate chemical feeding devices for treatment can be built into the system when it is installed.

**10.03** The problem of controlling corrosion, scale, and biological deposits can be reduced through the proper selection of equipment used in the condenser water system.

**10.04** Local ordinances should be investigated to see if chemical treatment is restricted or whether any restrictions might govern the installation of chemical feeders.