CHEMICAL TREATMENT
OF
HOT WATER HEATING SYSTEM WATERS

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1.0 INTRODUCTION

In light of the upcoming, if not already present, heating season, this paper is intended to be a general review of hot water heating system characteristics and chemical treatment.

2.0 DESCRIPTION OF TYPICAL HOT WATER HEATING SYSTEMS

Hot water heating systems are closed water recirculating systems basically consisting of an apparatus for heating a recirculating fluid, a recirculating pump, and a heat exchanger designed to heat another medium

The key word here is "closed", the importance of which will become obvious later. In the meantime, a closed system, by convention, is one in which the make-up water generally is limited to an average of 0.1 - 0.5% of the system capacity per day.

Specifically, there are two major types of low temperature hot water heating systems in use within the AGS network, both of which are schematically indicated in Figures 1 and 2 overleaf.

The major difference between each system type lies in the manner in which the closed system is heated. In the conventional type, a hot water boiler is used to provide heat to the circulating system. The second type involves the use of a convertor (i.e. heat exchanger) to indirectly heat the closed hot water system, the heat to the convertor being supplied in most cases by steam from a steam boiler.

Fig. 1: CONVENTIONAL HOT WATER HEATING SYSTEM

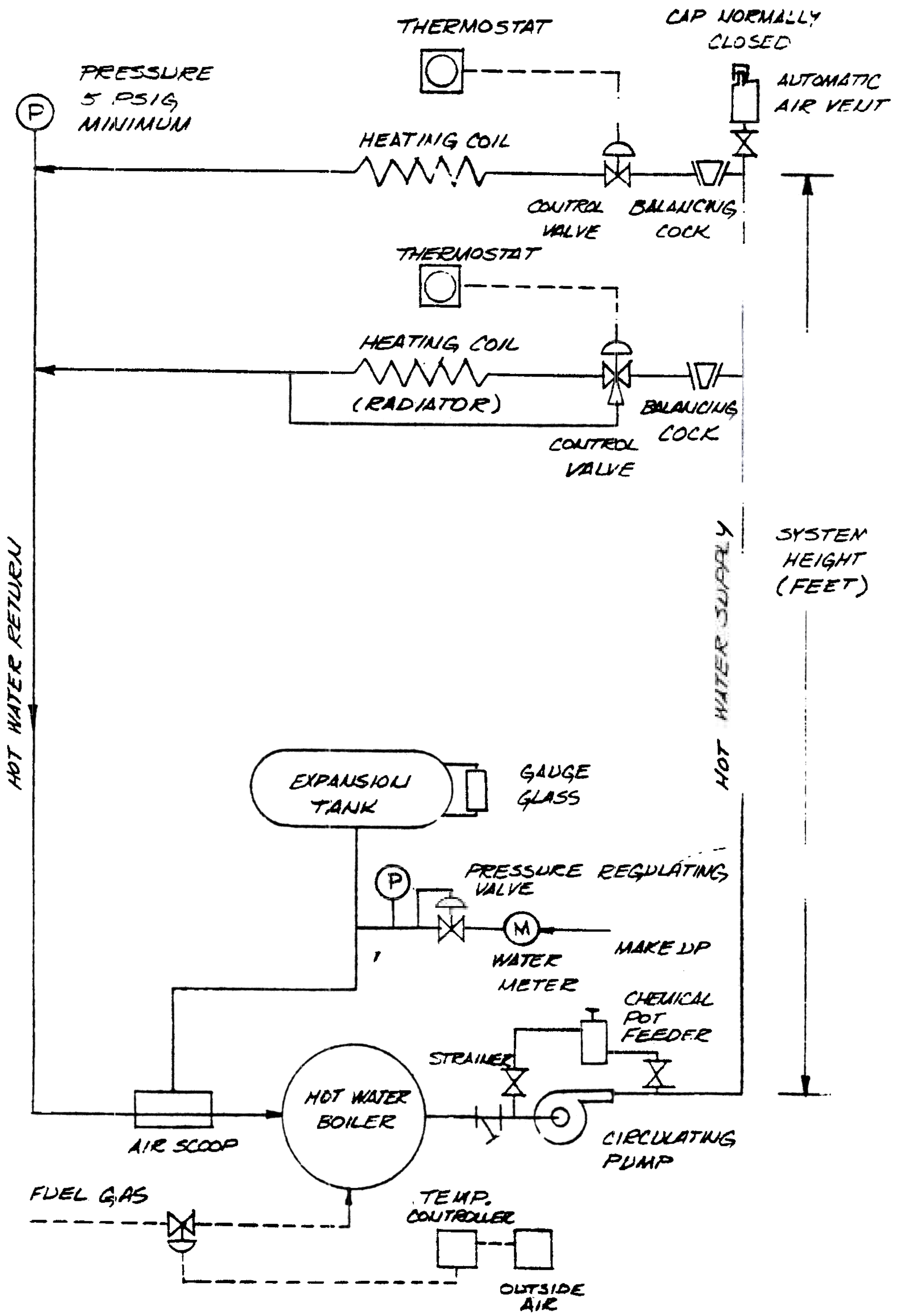
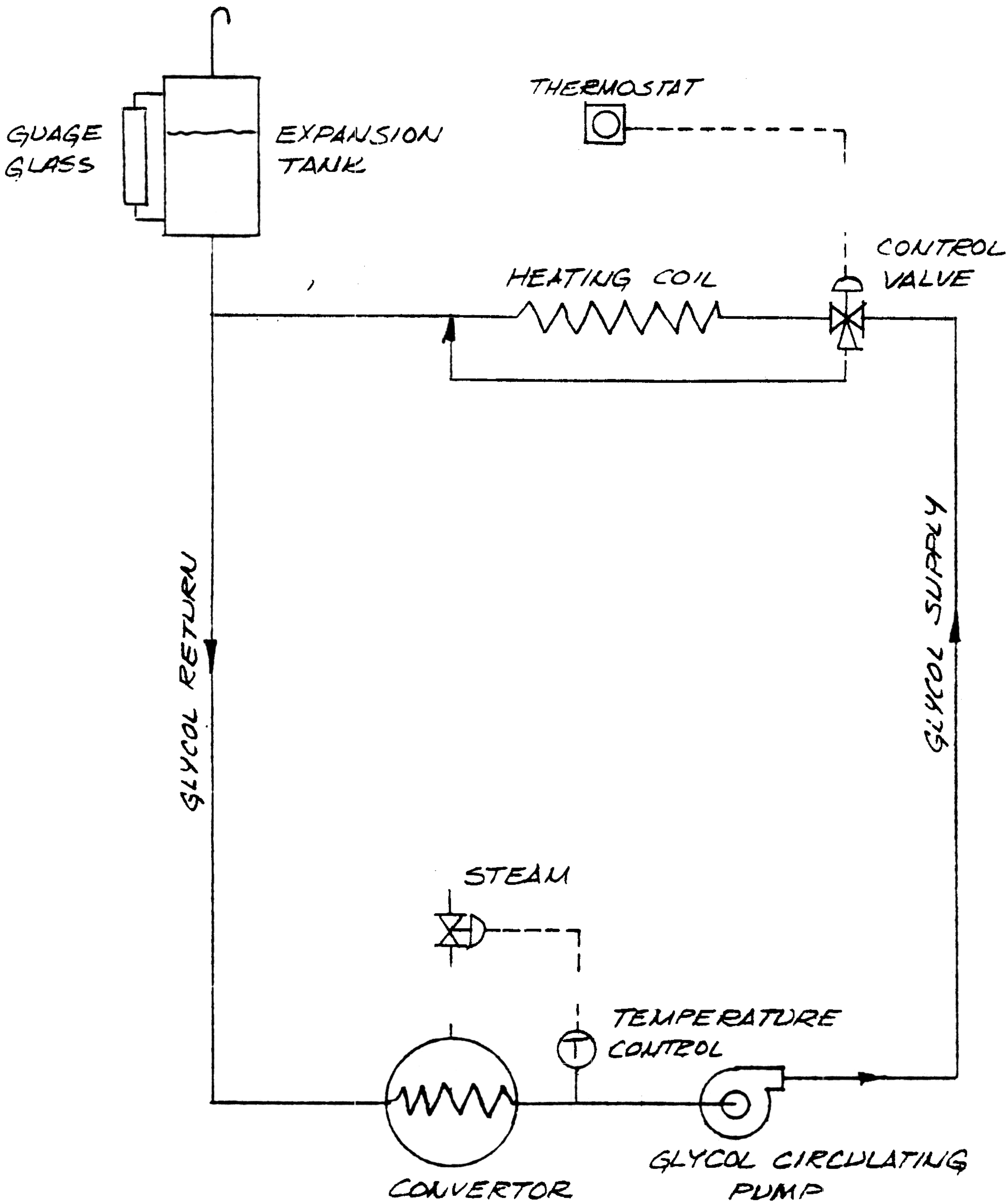


Fig. 2: HOT WATER HEATING SYSTEM WITH CONVERTOR



Aside from the source of heat, both types of systems consist of heated water which is circulated through a radiator system by circulating pumps, the volume difference between the hot supply and cold return water to the heating source being taken up by an expansion vessel

Recirculating water velocities generally tend to be in the 3 - 5 feet per second range and the temperature change in the recirculating fluid will generally average 10 - 15°F for the average system.

Table 1 below indicates the variety of metals which may be found in a single closed hot water system.

Table 1 Metals Used In Closed Hot Water Systems

Group A	Group B	Group C	Group D
Iron	Copper	Aluminum	Stainless Steel
Steel	Admiralty Brass		Nickel
Cast Iron	Red Brass		
	Muntz Metal		
	Naval Brass		
	Cupronickel		
	Aluminum Brass		
	Bronze		
	Aluminum Bronze		

3.0 CHEMICAL TREATMENTS

3.1 General

The objectives of water treatment in general are as follows

1) Prevention of hard scale deposits or soft sludge type deposits which would, if present, impair the rate of heat transfer;

2) Prevention of general corrosion and of pitting.

Theoretically, closed recirculating water systems should not require corrosion inhibitors or scale conditioners since any oxygen, carbon dioxide, or temporary hardness introduced with the initial fill of water should soon be depleted by their attack/precipitation on the system metals, after which time neither corrosion nor scaling should occur. However, such systems may lose enough water and admit enough air to justify the cost of protective chemical treatment. In any event, the make-up water rate should be metered and logged on a routine basis.

3.2 Zeolite Softeners

If the make-up rate is large enough, major quantities of scale will be deposited on the metal surfaces during service of a hot water system, thus impairing heat transfer and possibly resulting in line plugging. Under these circumstances, the hardness should be removed from the make-up water by passing it through a zeolite softening unit. some users soften the make-up irrespective of the make-up rate.

Since zeolite softening of most domestic waters in Alberta would revert their otherwise slightly scaling to slightly corrosive tendency to a very corrosive tendency under service conditions, the initial fill of a hot water system should be with domestic water and only the make-up water zeolite softened.

The logic of this application is that during the heating season the soft water make-up gradually redissolves the scale laid down by the initial fill with domestic water. By the end of the heating season, the softened make-up will have displaced the initial fill and the system now full of softened water can be drained and prepared for the next heating season. However, in order to provide a safety margin a corrosion inhibitor is maintained in the system.

3.3 Oxygen Scavenger

As a minimum treatment, an oxygen scavenger should be added to hot water systems since air in-leakage, the the principal factor in the establishment of a corrosion cell, can not be metered and reduced as can the make-up water.

An oxygen scavenger does not establish a corrosion inhibitor film, rather it reacts chemically with dissolved oxygen, thus removing it as a corroding agent. Therfore, a constant residual level of concentration must be maintained and the system tightened if this residual can not be maintained.

The most frequently used oxygen scavenging chemicals are hydrazine and sodium sulfite. However, since hydrazine reacts with oxygen very slowly at temperatures below 350°F, it is not used in low temperature hot water systems.

Therefore, sodium sulfite at a residual concentration of 30 - 60 ppm as Na_2SO_3 is used in the AGS systems. In order to increase its reaction rate with oxygen at lower temperatures, a catalyst, namely cobaltous chloride, is mixed with the sulfite at a rate of 20 mls per pound of sulfite added. However, in order to avoid deactivating the cobalt catalyst, catalyzed sulfite must be fed prior to the introduction of phosphates. Otherwise the cobalt will be precipitated and will not function as a catalyst.

Since the addition of sulfite to any water will increase the dissolved solids level and add to the sulfate concentration, care should be taken that the solubility product of calcium sulfate is not surpassed, particularly if the system is filled with hard domestic water and has had a history of air in-leakage with subsequent high sulfite usage. As a rule of thumb, the sum of calcium and sulfate concentration, both expressed as $CaCO_3$, must be kept below 1500 ppm in order to avoid the precipitation of calcium sulfate.

3.4 D.M. Treatment

D.M., a tannin manufactured by Houseman & Thompson Ltd., D.M. House, New Castle, England, is a dark brown almost black liquid extract from several plant types.

It prevents scale from adhering together and from building up on heating surfaces by keeping it in suspension until it is released by blowdown. It also absorbs dissolved oxygen.

D.M. is a good treatment for remote systems which are largely unattended. However, because of its colour, D.M. treatment should be discouraged where there is a possibility of system leaks

3.5 Chromate Treatment

Treatment with chromate salts of sodium in closed recirculating systems at pH levels of 7.0 - 9.5 provides extremely low corrosion rates

The treatment level varies from system to system, but it is within the range of 200 - 1500 ppm CrO_4 depending on the results of corrosion coupon tests. At chromate levels below 200 ppm, the inhibiting film will develop inconsistencies and all attack will be concentrated at individual points causing severe pitting

The corrosion inhibiting characteristics of chromate are not influnced by the concentration of dissolved oxygen in the recirculating water Therefore, when using chromates, it is not necessary to take any steps to eliminate oxygen or carbon dioxide in the make-up or system water

However, there are three disadvantages of chromate treatment which limit its use in closed hot water systems. Firstly, its yellow-orange colour would quickly locate system leaks, but would also result in unsightly staining of floors, etc. Secondly, the environmental restrictions on the release of chromate to sanitary systems or natural water courses would prevent system drainage for annual inspections. Thirdly, the reactivity of chromates with glycol and the subsequent loss of their corrosion inhibitor qualities means that other inhibitors must be used in glycol systems.

3.6 Boron-Nitrite Treatment

Nitrite based inhibitors, at treatment levels of 750 - 7500 ppm and buffered with borate, offer corrosion inhibition equal to that of chromate treatment, yet possess advantages which make them superior in certain applications.

In addition to being able to eliminate essentially all corrosion in the system, irrespective of the concentration of oxygen or most dissolved gases, boron-nitrite ingibitors are compatible with glycol.

Unlike chromate inhibitors, nitrite solutions are colourless and are not subject to the same disposal restrictions to sewage systems.

3.7 Phosphate Treatment

Two types of phosphates, namely polyphosphates and orthophosphates, are used in the chemical treatment of closed recirculating systems at concentrations of 20 - 40 ppm.

Polyphosphates, the most common one of which is sodium hexa-meta phosphate, are cathodic corrosion inhibitors. However, its solutions are acidic and can cause corrosion of feeding equipment unless sufficient caustic is added to the feeding tank in order to obtain a P alkalinity reading. Similarly, because of its reaction with natural OH alkalinity to form tri-sodium phosphate, caustic should be added with the hexa-meta phosphate in amounts sufficient to maintain an OH alkalinity of greater than 50 ppm.

When analyzing for polyphosphate, samples must first be boiled, cooled, and then analyzed. This converts the polyphosphate to orthophosphate, thus making it measurable with the standard comparator test kits. The polyphosphate concentration is the difference between tests on the boiled and unboiled samples

Ortho phosphates, the most common one of which is tri-sodium phosphate, are anodic corrosion inhibitors as well as scale inhibitors. As a corrosion inhibitor, it forms an adsorbed precipitate of iron phosphate at the anodic sites; as a scale inhibitor, it precipitates hardness as a non-adherent sludge. Since tri-sodium phosphate also hydrolyzes to form caustic and disodium phosphate, caustic addition is not required with this treatment

3.8 Glycol Treatment

Glycol is added to closed hot water heating systems when there is a possibility that freezing may occur (i.e. in outside heating coils)

Since commercial glycols contain inhibitors, no additional chemical treatment is required provided that the glycol concentration is greater than 25%. Otherwise additional inhibitor and alkalinity must be added. Most systems contain 50% glycol which gives freezing protection to -34°F. By comparison, a 25% glycol solution will give freezing protection to only 7°F

Dilution of the glycol concentrate should be with soft water Otherwise, precipitation of the hardness will result. Also, dilution will increase the normal 1 year shelf life of concentrated glycol.

Since uninhibited glycol has a pH of approximately 5, a drop in system pH approaching this level indicates that the inhibitor has decomposed, thus necessitating system drainage and refilling with inhibited glycol.