Engineering Bulletin
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Rev B

Piping Arrangements for
Heat Pump Water Heating

Contents

1. **INTRODUCTION**

1.1. Sanitary (Domestic) hot water can be effectively and efficiently heated using Colmac Heat Pump Water Heaters (HPWH). Because they use low grade (low temperature) heat as the energy source, Colmac Heat Pump Water Heaters can heat sanitary water and simultaneously cool air (or water) with as little as 1/10th the energy input of conventional boilers and chillers. Correctly piping the Colmac Heat Pump Water Heater to the building hot water system is critical to proper and successful operation. Incorrect piping and/or storage tank selection can result in inadequate hot water temperatures and/or heating capacity of the system - even though the heat pumps may be sized with more than enough heating capacity!

2. **WATER PIPING**

2.1. General: For proper heat pump operation it is important to plumb the water piping and storage tanks as indicated in the appropriate piping diagrams. Several common piping diagrams are included at the end of this section

2.1.1. All piping diagrams show nonvented pressurized systems. Vented nonpressurized systems are not recommended.

2.1.2. System piping should be plumbed and storage tanks installed in accordance with all local and national codes that apply.

2.1.3. A Pressure Temperature (P-T) type relief valve is required on all nonvented pressurized tanks, as shown in the piping diagrams.

2.2. Insulation: It is highly recommended that all hot water piping and storage tanks be insulated for energy efficiency.

2.2.1. Outdoor applications: Fiberglass with aluminum sheathing is preferred for piping and tanks (also sprayed foam for tanks).

2.2.2. Indoor applications: Fiberglass with paper sheathing is preferred for piping and tanks (also sprayed foam for tanks). Closed cell foam is acceptable for piping and tanks, where permitted.

2.3. Pipe Sizing: Colmac heat pump water heaters are equipped with internal hot water circulating pumps. These internal circulating pumps are capable of maintaining the minimum required water flowrate through the heat pump with external pressure drops up to 4.1 ft H_2O (12 kPa) for 50 Hz models and up to 7 ft H_2O (21 kPa) for 60 Hz models. Pressure drop through the hot water piping connecting the heat pump(s) to storage tanks must be carefully calculated and limited to these maximum values. If higher pressure drops are unavoidable then a pressure booster circulating pump must be installed in the hot water piping to compensate and maintain sufficient water flow through the heat pump(s).

2.4. Existing Water Storage Tanks: The use of existing resistance heat water tanks is permitted when the tank volume is suitable for the job application.

2.4.1. WARNING. The use of existing gas water heaters and boiler as storage tanks is not recommended due to high standby losses.

2.4.2. The use of existing water storage tanks is permitted only if measures are taken to remove all accumulated scale deposits in the tank prior to starting heat pump system.

2.4.3. WARNING. Using existing water tanks without proper cleaning can result in fouling of the internal heat pump water piping and may cause damage to the water circulating pump.

2.5. Booster Pump:

2.5.1. In piping systems where the heat pump is located far away from the storage tanks, it may be necessary to install a booster pump to maintain the minimum required flow rate. See the pump manufacturers design data for the required flow rate and pressure. Reference section 7.3 above.

2.6. Net Positive Suction Head (NPSH):

2.6.1. This term is defined as the water pressure required at the inlet of the pump to cause water to flow (and prevent cavitation). NPSH can be calculated as follows:

- NPSH = Barometric Pressure + Static Pressure on Suction - Friction losses in Suction Piping - Vapor Pressure of Water

2.6.2. Minimum NPSH required for the circulating pump to operate without cavitating is 9.5 psi (65 kPa).

2.6.3. Normally with non-vented pressurized hot water systems, NPSH is well above the 9.5 psi required by the circulating pump. NPSH becomes critical when the hot water system is vented and non-pressurized. For a vented system, it is important to locate the heat pump below the storage tank. This will: a) Keep the NPSH above the minimum required 9.5 psi, and b) prevent a loss of prime in the pump (the circulating pump is not self-priming).

3. **HEAT PUMP WATER HEATER PIPING**

3.1. General

3.1.1. For most sanitary water heating applications, hot water usage varies from hour to hour and follows a “load profile” over the course of the day. Normally in occupied buildings (hotels, apartments, hospitals, restaurants, etc), peaks in hot water usage occur in the morning hours and again in the evening.

3.1.2. Heating and storing hot water during off-peak periods allows the heat pump water heater size (and first cost) to be reduced.

3.1.3. Control of the heat pump water heat.er(s) is by a simple aquastat with the sensor located as shown in the drawings below. The sensor is located below the centerline of the cold tank.

3.1.4. Storage efficiency of the tanks is maximized when they are piped in series as shown in the diagrams below (See Colmac Document 930091-0053)

3.1.5. It is important to insure and confirm that there is an adequate source of heat for the heat pump year around, especially during winter months when air temperatures and air-conditioning loads are lowest. In the event that sufficient waste heat or air-conditioning loads are not available during winter months, backup or auxiliary water heating must be considered.

3.2. Colmac HPA Air-Source HPWH

3.2.1. Colmac HPA air-source heat pump water heaters can be used effectively when the building has a central hot water system but no central air-conditioning system, or limited access to the central air-conditioning system.

3.2.2. Piping connecting HPA heat pumps to storage tanks is as shown in the diagrams below. Only hot water piping is needed with air-source heat pump water heaters.

3.2.3. Strainers should be added to the water inlet to filter out sediment before it reaches the HPA.

3.3. Colmac HPW Water-Source HPWH

3.3.1. Colmac HPW water-source heat pump water heaters can be used effectively when the building has both central water heating and central air-conditioning.

3.3.2. Piping connecting HPW heat pumps to storage tanks is identical to HPA heat pumps and is as shown in the diagrams below.

3.3.3. Source water may be taken either from the condenser water loop or from the return chilled water line.

3.3.4. Energy efficiency and COP of the heat pump will be highest when condenser water is used as the heat source. However, care must be taken not to overcool the condenser water during periods of low air-conditioning loads. Overcooling the condenser water loop may result in problems with chiller operation (i.e. on startup).

3.3.5. Colmac HPW heat pump water heaters are provided with source water circulating pumps, so not external pumps are needed.

3.3.6. Source water piping consists of a simple tie-in to and from the chilled water return main, or to and from the condenser water supply main. In either case it is important to confirm that the flowrate in the source water main (return chilled water or condenser water) exceeds the flowrate circulated through the Colmac HPW unit.

3.3.7. Strainers should be added to the Potable and Source water inlets to filter out sediment before it reaches the HPW.

3.4. HPA/HPW Sequence of Operation

3.4.1. The HPA or HPW heat pumps are simply cycled on and off by an aquastat with its sensor mounted in the first of the storage tanks (the “cold tank”). The aquastat sensor should be located below the centerline of the cold tank as shown in the diagrams below.

3.4.2. When multiple HPA or HPW heat pumps are used with a common storage tank(s), a staged aquastat may be used to effectively vary the heating capacity of the system.

4. **RINGMAIN (RECIRCULATING LOOP) PIPING**

4.1. General

4.1.1. Colmac has developed the HRH Heat Recovery Ringmain Heater and the RH Ringmain Heater specifically to manage ringmain flow and heating to maintain 100% safe sanitary water temperature at set point at all times.

4.1.2. The Colmac HRH Heat Recovery Ringmain Heater is a heat pump water heater designed specifically to recover waste heat either from the building air conditioning system (returned chilled water or condenser water), or from a source of warm humid air, while reheating the sanitary water in the ringmain to maintain safe setpoint

temperature. The HRH15W water-source model incorporates both source water and sanitary hot water circulating pumps to simplify installation. The HRH15A air-source model produces cool dehumidified air which can be ducted directly to provide spot cooling.

4.1.3. The Colmac model RH15E Ringmain Heater uses self-regulating electric resistance elements to heat the ringmain loop water to maintain the sanitary water setpoint temperature while providing loop water circulation.

4.1.4. The sanitary hot water pump in both the HRH and RH units is designed to circulate the ringmain water and eliminates the need for a separate ringmain circulating pump.

4.1.5. The HRH and RH units are sized to provide enough make-up heating and sanitary hot water circulation for typical ringmain loops handling 6 to 10 floors, depending on loop configuration, water and ambient temperatures, and thickness of loop pipe insulation.

4.2. HRH Sequence of Operation

4.2.1. The HRH unit controls are self-contained, simple, and automatic. Whenever power is applied to the HRH unit, the hot water circulating pump is powered on and continuously circulates sanitary hot water through the ringmain.

4.2.2. Temperature of the ringmain return hot water entering the HRH is monitored by a temperature sensor mounted internally in the unit. Whenever this temperature falls below an adjustable setpoint temperature (minus differential), the unit compressor and source water circulating pump start and continue to operate until the ringmain return water temperature reaches setpoint, at which point the HRH compressor and source water circulating pump then cycle off. Safe sanitary water temperature in the ringmain is thus maintained at all times.

4.3. HRH Installation

4.3.1. The HRH15W water-source unit has been designed with small footprint dimensions to allow installation in mechanical spaces with limited floor space.

4.3.2. The most convenient location for the HRH15W water-source unit is in the mechanical space close to the building pipe well. This allows the unit to be easily piped to the source water piping (either the return chilled water riser or the condenser water riser). The unit is designed for installation against a wall or in a corner of the mechanical room with easy access to service the electrical and mechanical components.

4.3.3. The HRH15A air-source unit has been designed with low profile (vertical) dimensions to allow installation in overhead mechanical spaces and false ceilings to conserve floor space. The centrifugal fan allows the cooled air to be ducted to provide spot cooling or augmentation to the building air conditioning system.

4.4. RH Sequence of Operation

4.4.1. The model RH15E controls are self-contained, simple, and automatic. Whenever power is applied to the RH unit, the hot water circulating pump is powered on and continuously circulates sanitary hot water through the ringmain.

4.4.2. Temperature of the ringmain return hot water entering the RH unit is monitored by

a temperature sensor mounted internally in the unit. Whenever this temperature falls below an adjustable setpoint temperature (minus differential), the unit electric resistance heating elements cycle on and continue to operate until the ringmain return water temperature reaches setpoint, at which point the RH elements cycle off. Safe sanitary water temperature in the ringmain is thus maintained at all times.

4.5. RH Installation

4.5.1. The RH15E unit has been designed with small footprint dimensions to allow installation in mechanical spaces with limited floor space.

4.5.2. The most convenient location for the RH15E unit is in the mechanical space close to the building pipe well. This allows the unit to be easily piped to the ringmain piping. The unit is designed for installation against a wall or in a corner of the mechanical room with easy access to service the electrical and mechanical components.

5. **HOT WATER SUPPLY RISER PIPING**

5.1. General

5.1.1. In tall buildings with multiple ringmain loops (i.e. more than 8-10 stories) a hot water supply riser is needed to supply the multiple ringmains. Typically the highest ringmain is supplied by a booster pump to provide adequate water pressure to the fixtures on the top floor. Each of the lower ringmains is then supplied with hot water via the hot water supply riser pipe through a PRV (Pressure Reducing Valve) set to match the cold water pressure (also set through a PRV for the same floors supplied by the hot water ringmain).

5.1.2. NOTE: Colmac recommends that both cold water storage as well as sanitary hot equipment and storage be located at the top of each zone in the building. This is referred to as “top feed”. This arrangement insures that cold water and sanitary water pressures are easily and precisely balanced for each floor.

5.1.3. Just as each ringmain loop requires makeup heating to maintain safe water temperature, the hot water supply riser requires makeup heating and recirculating flow. Since the hot water supply riser is separated from the ringmain loops by PRVs it must be piped with its own Colmac HRH or RH unit and a return riser pipe. Recommended piping arrangement is shown below.

6. **PIPING DIAGRAMS**

6.1. Ringmain loop flow must be prevented from circulating directly through the hot water storage tanks used to store the hot water for the fixtures. Each ringmain loop as well as the hot water supply riser must be circulated and heated separately by its own Colmac HRH or RH unit (described above). This proprietary Colmac method of piping storage tank heat pumps and ringmain heating units separately results in a sanitary hot water system having the following operating characteristics and benefits:

- Lowest first cost,
- Lowest operating cost,
- Lowest life cycle cost,
- 100% health and safety for sanitary hot water,
- Optimized thermal management of hot water ringmains and supply risers,
- Optimized ratio of hot water storage volume to heat pump heating capacity,
- Smallest water heating carbon footprint (highest Carbon Reduction Coefficient – CRC).

Tanks in series with HRH water heating for recirculation loop line losses.

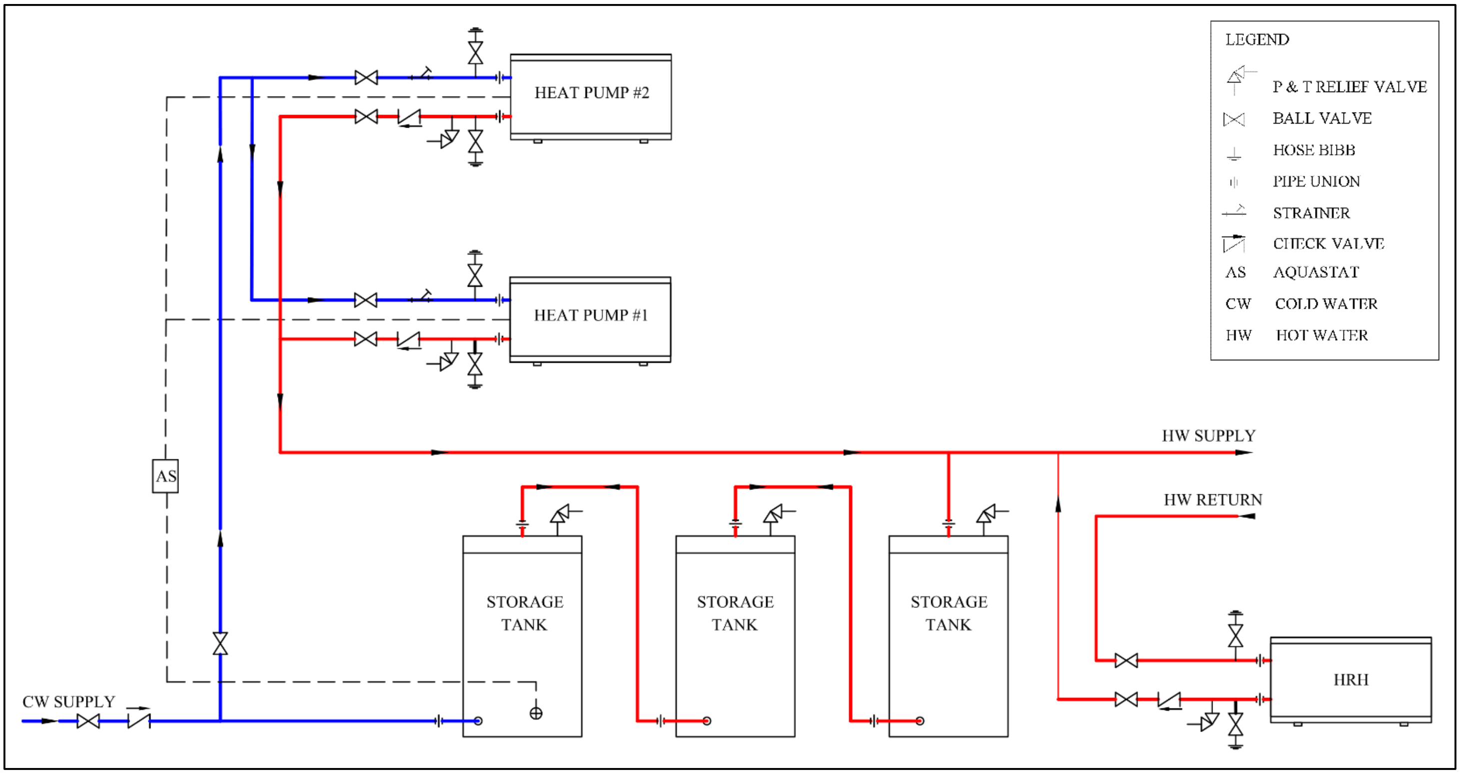

Figure 1

Tanks in series with electric resistance water heating for recirculation loop line losses.

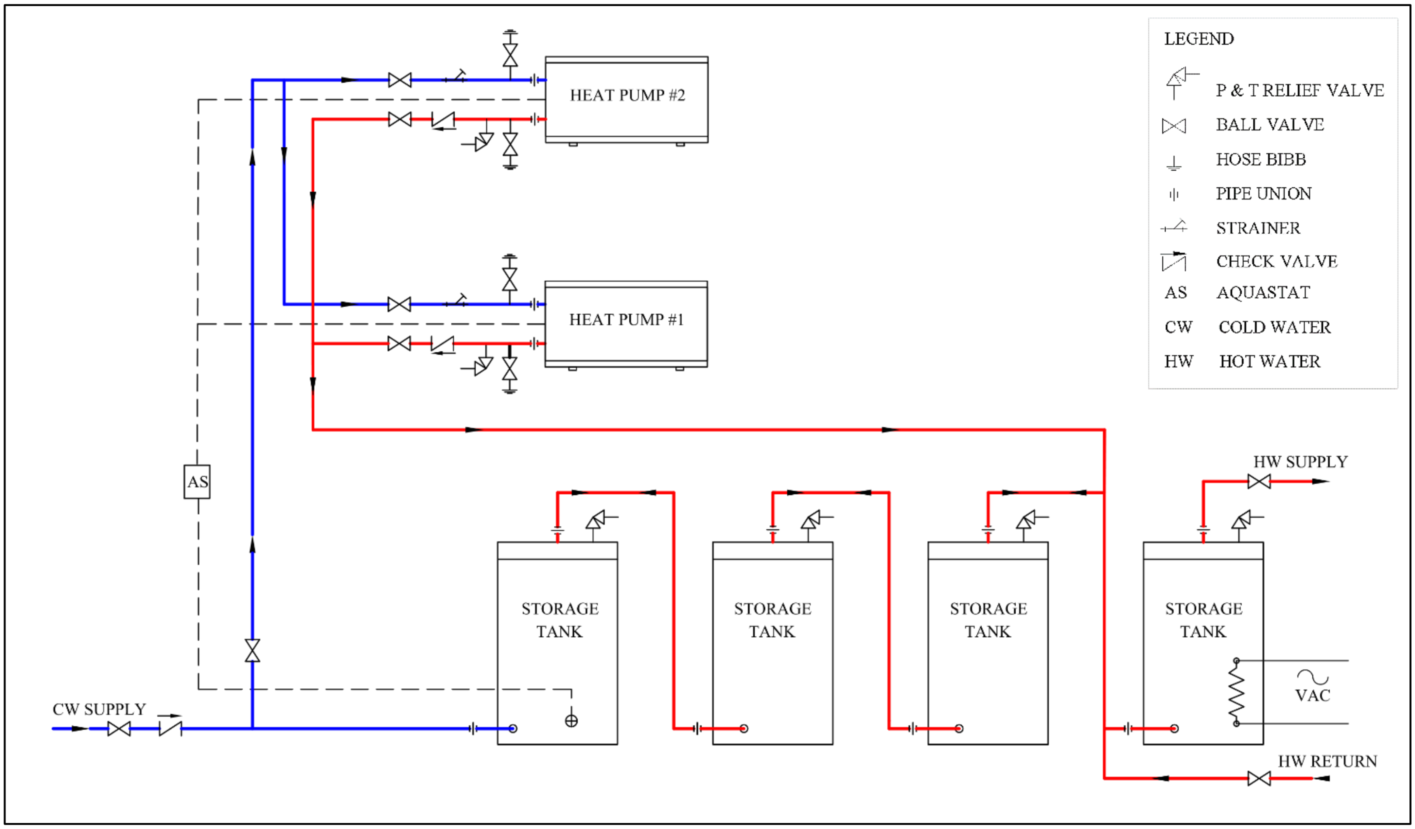

Figure 2

Storage tanks in series, dual aquastat, coldwater storage tank, heated building return

Aquastat setpoints
Start Setpoint: 80°F (Start call for heat at 80°F)
Stop Setpoint: 110°F (End call for heat at 110°F)

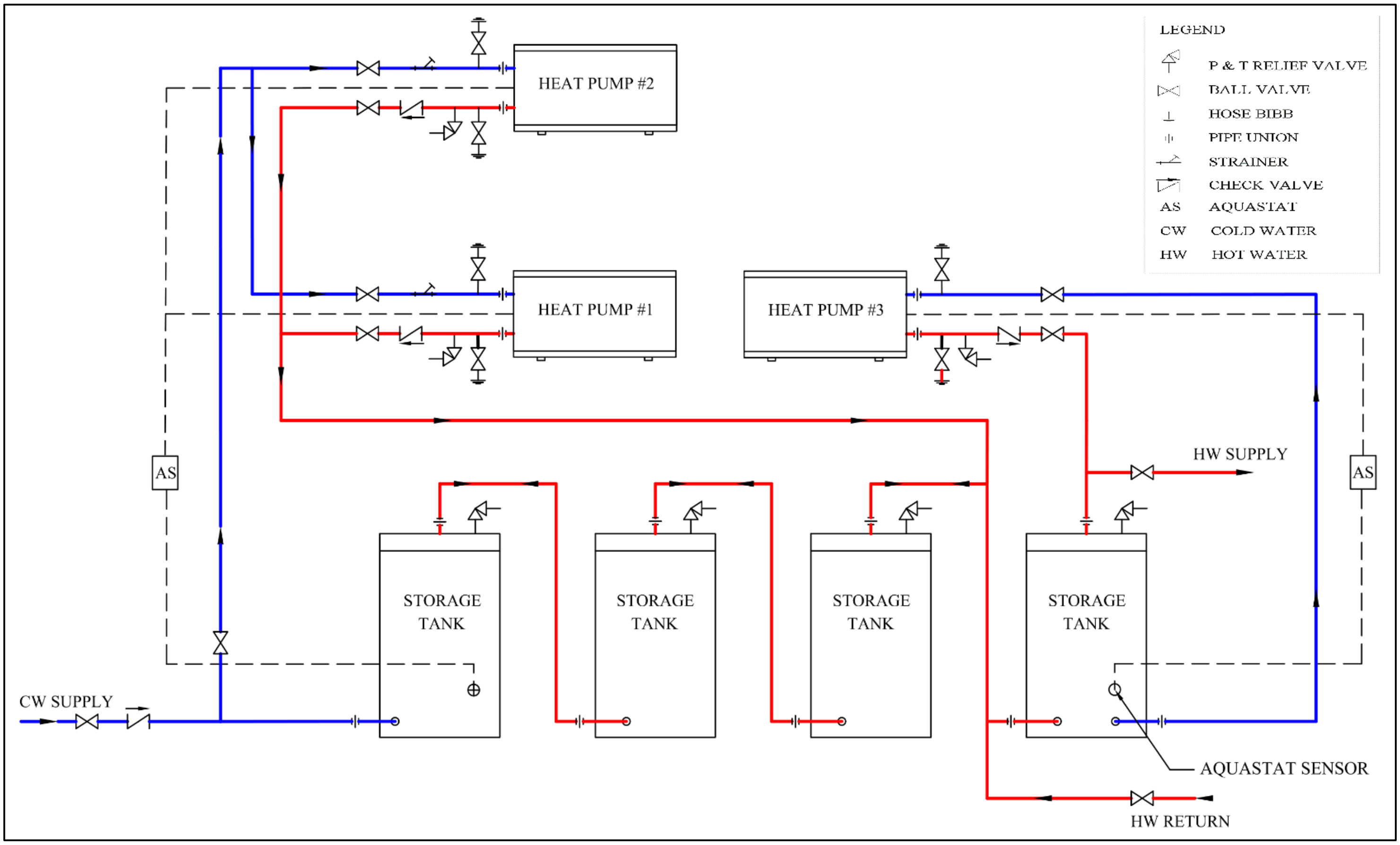

Figure 3

Storage tanks in series, dual aquastat, heated building return

Aquastat setpoints
Start Setpoint: 80°F (Start call for heat at 80°F)
Stop Setpoint: 110°F (End call for heat at 110°F)

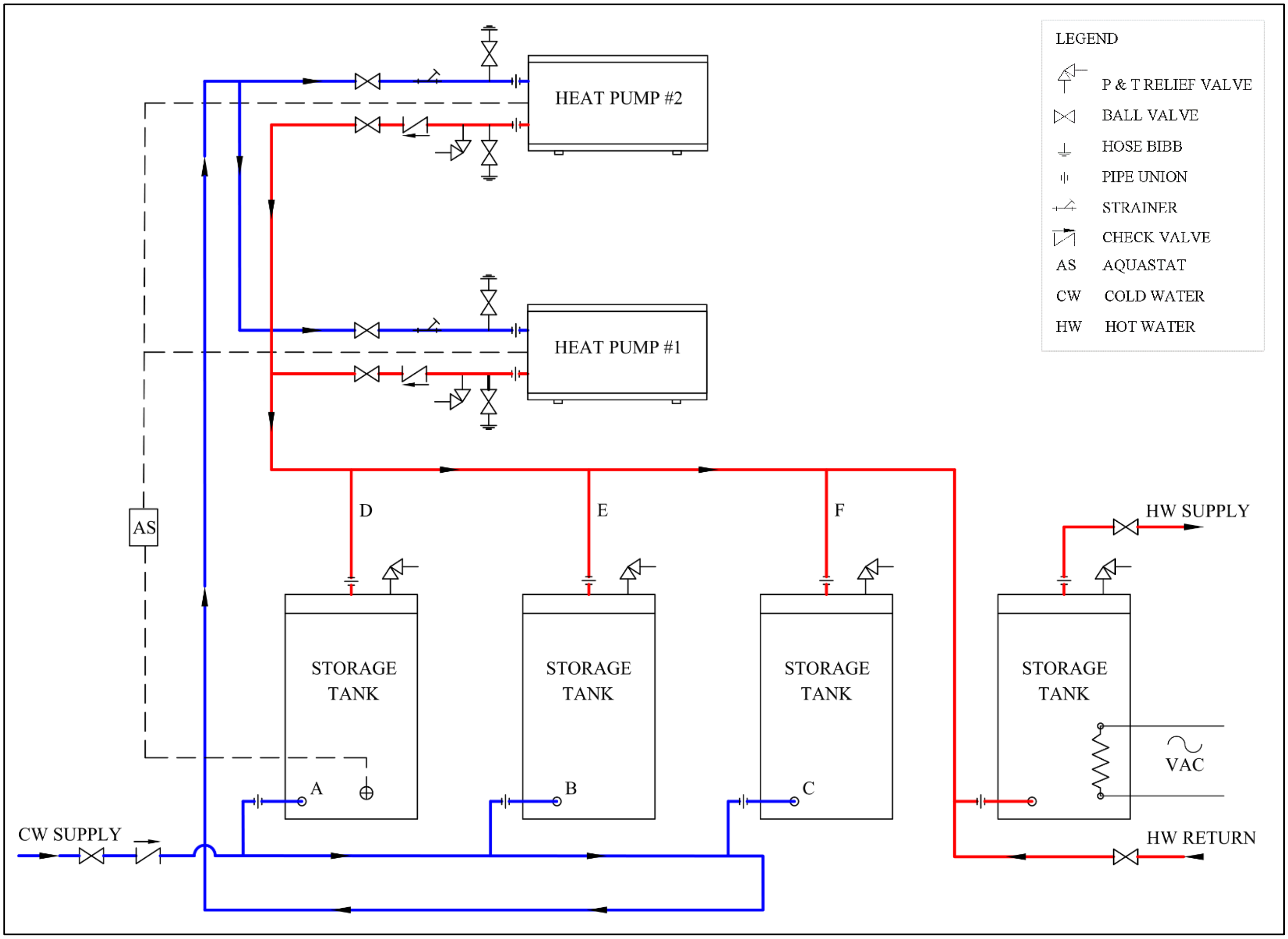

Figure 4

1.1. POOR

1.1.1.

Storage tanks in series, single aquastat, poor hot water return location

Aquastat setpoint and differential:
Setpoint: 110°F (End call for heat at 110°F)
Differential: 30°F (Start call for heat at 80°F)

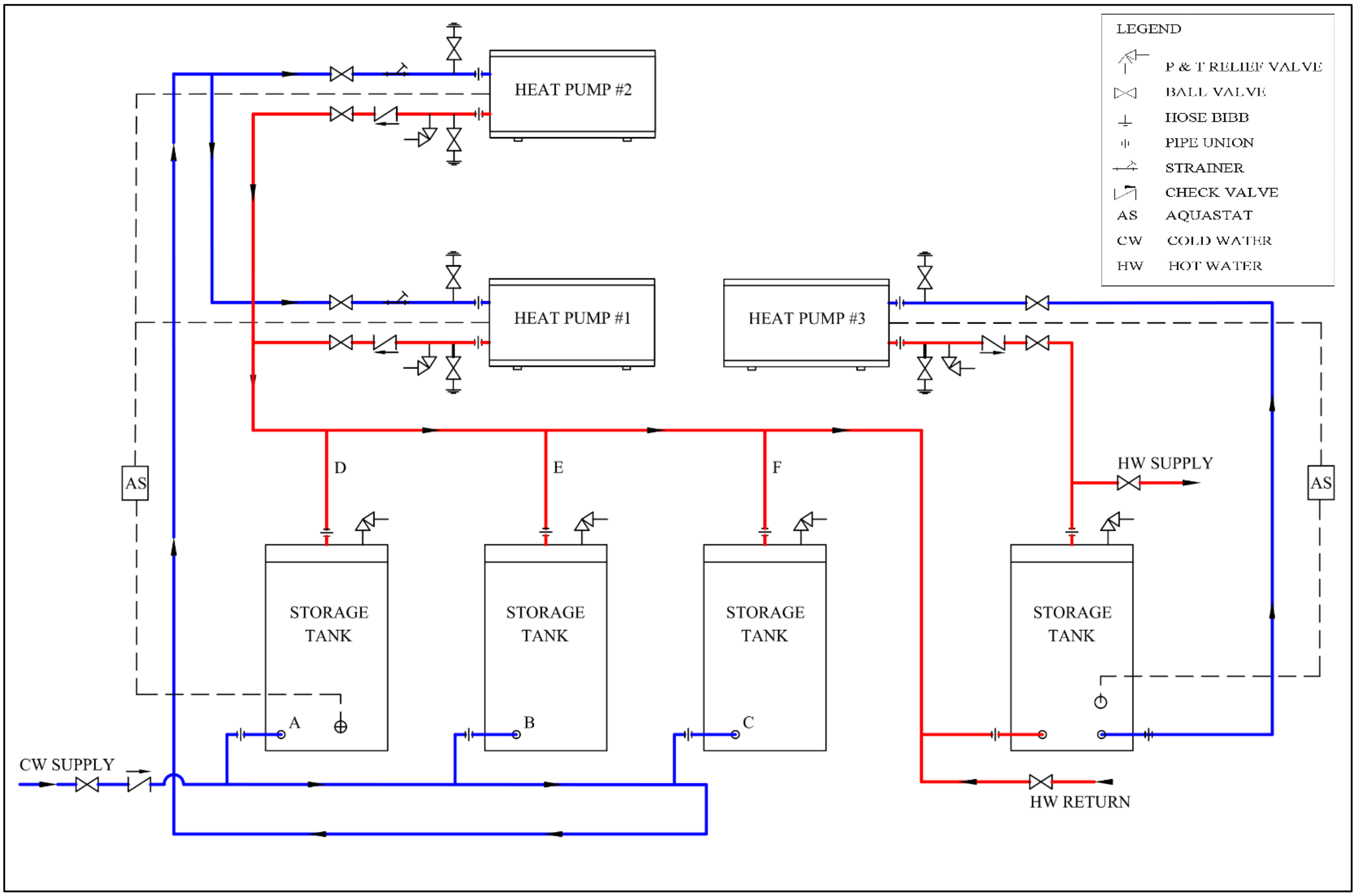

Figure 5

Storage tanks in series, poorly located single aquastat, bad setpoints, heated building return

Aquastat setpoint and differential:
Setpoint: 140°F (End call for heat at 140°F)
Differential: 5°F - 10°F (Start call for heat at 135°F - 130°F)

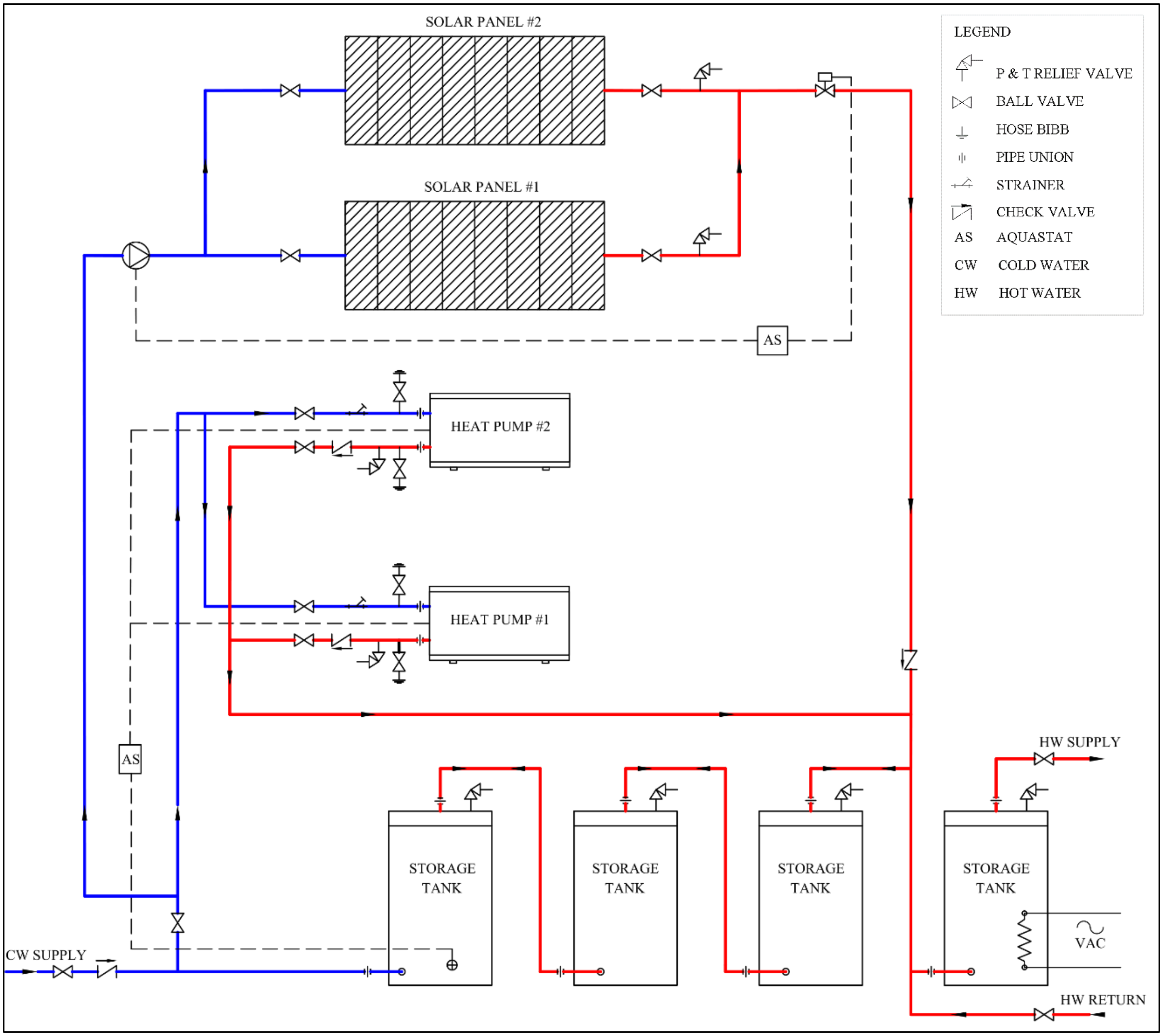

Figure 6

Storage tanks in parallel (reverse return), poorly located single aquastat with bad setpoints, heated building return

Aquastat setpoint and differential:
Setpoint: 140°F (End call for heat at 140°F)
Differential: 5°F - 10°F (Start call for heat at 135°F - 130°F)

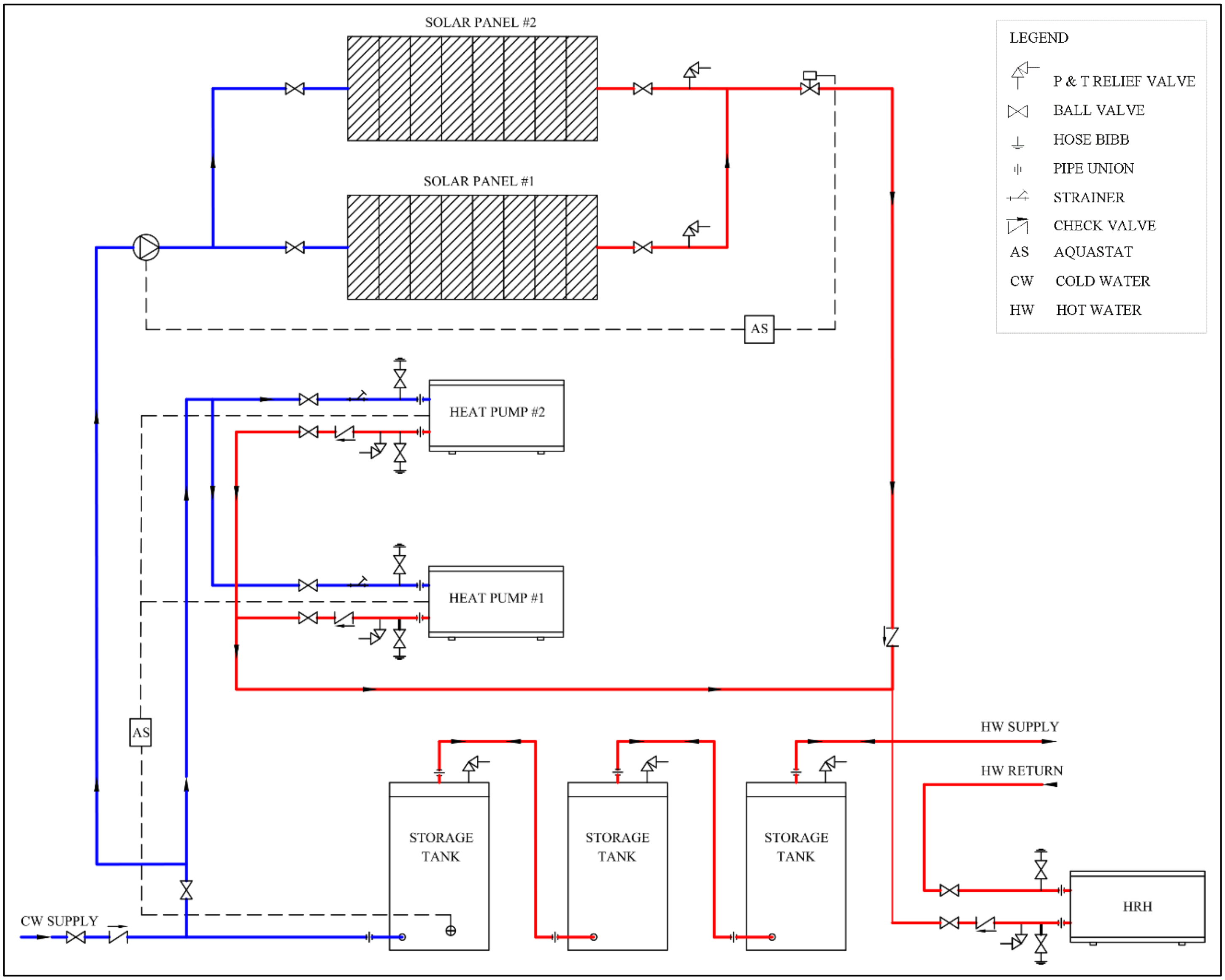

Figure 7

Multi-zone tall building with heat pump water heating for recirculation loop line losses.

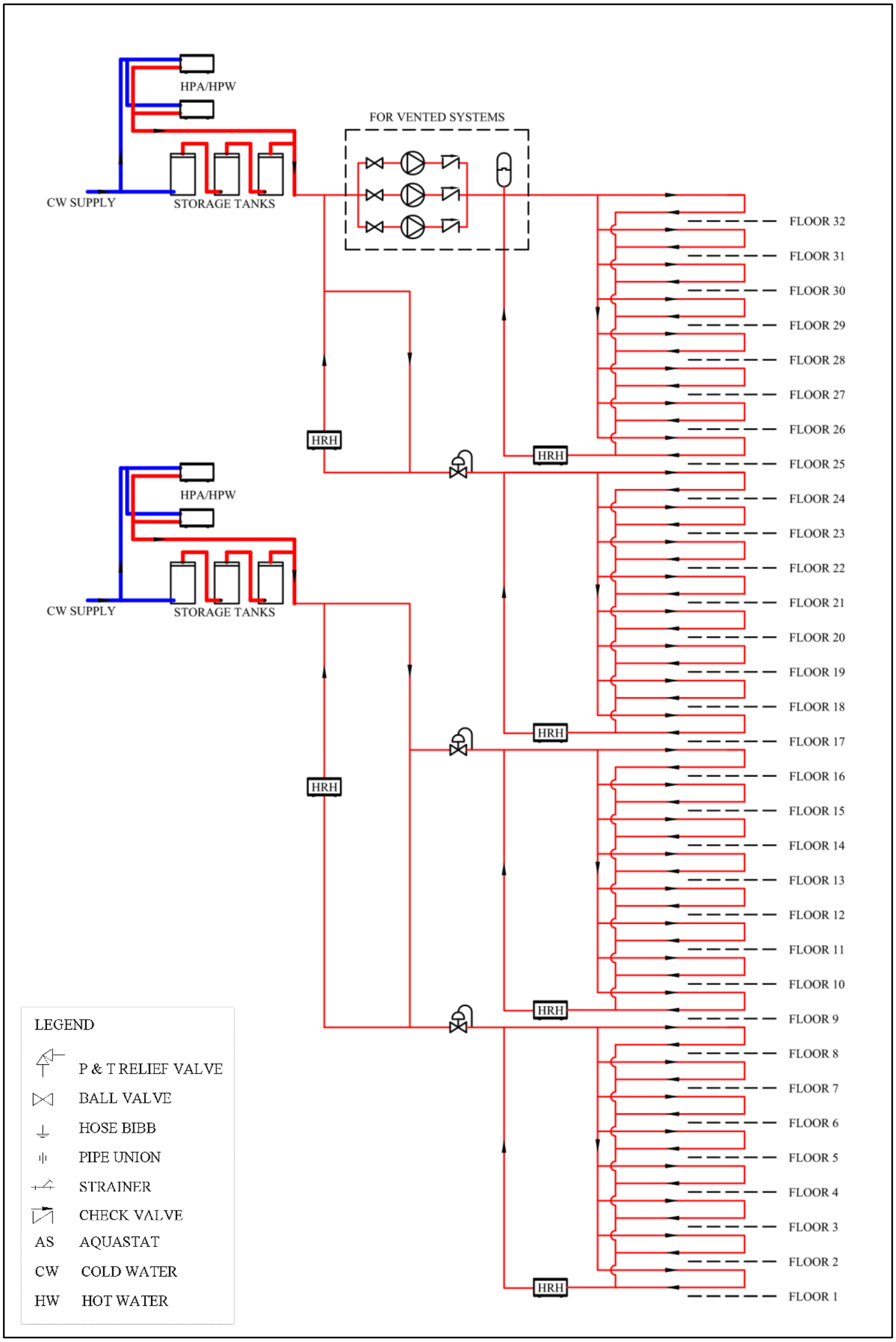

Figure 8

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