Designing systems for applications that use hot water in Full On/Full Off mode, or where solenoid type fixtures are used, requires a different approach than typical diversified domestic type applications. Diversified applications consist of fixtures such as showers, tubs, lavatories, sinks, etc., that draw varying loads, with one or more peak times occurring in a 24 hour period. These fixtures are typically turned on and off manually by hand. Full On/Full Off and Solenoid Type applications consist of fixtures that draw constant volume of water over a given amount of time, and then the load instantly drops off to zero. These fixtures are switched on/off electronically instead of manually. This instant transition from full load to zero load does not allow enough time for the water heater controls to react, regardless of how advance the temperature control system it has. Residual heat inside the heat exchanger will not be able to dissipate fast enough and as a result, the water heater's over-temperature limit (electrical/mechanical) could get energized, and the temperature control in subsequent cycles can become sluggish. In addition, when flow is instantly stopped, built up water pressure in the heat exchanger may cause the relief valve to open. This can be prevented with the use of water hammer arrestors which will absorb the pressure spike instead of reverberating throughout the heating system.

When designing systems for the full on/full off applications, it is recommended to use the following guidelines. The primary means of preventing the nuisance over-temperature conditions for these applications is making sure that water is always flowing through the water heater (that is, by using recirculation loop) – even after the load drops to zero. In larger capacities (greater than 60 gpm), storage tank is also required to provide additional volume that will further help dissipate residual heat.

Application #1
Capacity of EACH water heater is less than or equal to 60 gpm

STORAGE TANK:
  Minimum required storage tank volume = None
  Note: *Same as domestic heating applications, over-sizing a water heater for full on/full off applications can impact temperature control. If the heater(s) is/are oversized for a full on/full of application, it is recommended to add a storage tank – see Application # 2 for storage tank sizing.*

BUILDING RECIRCULATION:
Table 1

Water Heater Model	Minimum Building Recirculation for EACH Water Heater
SW1A+, SW1B+, B+II WaterWizard, WW3E+	25% of heater capacity
SWDW24, WWDW24	25% of heater capacity
SWDW45, WWDW45	25% of heater capacity
SWDW68, WWDW68	25% of heater capacity

Example:

A Full On/Full Off application has two (2) SWDW45 water heaters, EACH has a capacity of 40 gpm.

STORAGE TANK:

Each heater has a capacity of less than 60 gpm, therefore, no storage tank is required.

BUILDING RECIRCULATION:

25% of 40 gpm is 40 x 0.25 = 10 gpm.
The total recirculation required is 10 gpm x 2 = 20 gpm.

Application #2
Capacity of EACH water heater is greater than 60 gpm

STORAGE TANK:

- Minimum required storage tank volume = 200 gallons
- If water heater is sized to cover portion of the required amount of water throughout the duration of the load, and the storage tank is sized to cover the rest of the water volume (that is, storage tank volume is not only present to dissipate residual heat, but it will also cover some of the load requirements):

1) Calculate the portion of required water volume that will be covered by the tank using the following formula:
   [Total Load (gal/min) x Duration of Load (min)] – [Water Heater capacity (gpm) x Duration of Load] = Portion of water that will be covered by the tank volume (gal)

2) If calculated volume from step 1 is less than or equal to 200 gallons, then use 200 gallons as the usable storage tank volume. Total storage tank volume is the usable storage tank volume divided by the storage tank efficiency.

   If calculated volume from step 1 is greater than 200 gallons, then use that calculated volume as the usable storage tank volume. Total storage tank volume is the usable storage tank volume divided by the storage tank efficiency.

WATER HEATER/STORAGE TANK PUMP; BUILDING RECIRCULATION:

A) If the storage tank is piped as a stratified storage tank — see Figure 1

- The pump between the water heater and the storage tank is sized equal to the water heater capacity.
- There is a possibility that when the load drops to zero, the pump between the water heater and the storage tank may also turn off (that is, the tank aquastat is satisfied), therefore, in order to ensure there is always water flow through the water heater, building recirculation is still required — see Table 1.

B) If the storage tank is piped as an accumulator storage tank — see Figure 2

- The pump between the water heater and the storage tank is sized so it is able to completely circulate the contents of the storage tank through the heater within the period at which there is zero load. This will ensure the tank is completely replenished with hot water for the next load.
Pump capacity between the water heater and the storage tank = Storage tank total volume ÷ amount of time at which there is zero load.
- Required building recirculation — see Table 1.

Note: Make sure that the water heater and accumulator tank water connections are sized to handle the combined flow rates of the water heater capacity, heater/tank pump capacity, and building recirculation capacity. Ensure water velocities are maintained below 7 feet/sec. Below are maximum continuous water flow rate allowed through AERCO water heaters:

Table 2

Water Heater Model	Maximum Continuous Water Flow Rate Allowed
SW1A+	55 gpm per heater
SW1B+, B+II WaterWizard, WW3E+ with standard 3" NPT connections	125 gpm per heater
SW1B+, B+II WaterWizard, WW3E+ with 4" Flanged connections	200 gpm per heater
SW1B+, B+II WaterWizard, WW3E+ with 6" Flanged connections	450 gpm per heater
SWDW24 (Models with 3" inlet)	125 gpm per heater
SWDW24 (Models with 2" inlet)	40 gpm per heater
WWDW24	40 gpm per heater
SWDW45, WWDW45, SWDW68, WWDW68	125 gpm per heater

Example:
A Full On/Full Off application has a load of 120 gpm that lasts for 20 minutes at a time, with a downtime of 10 minutes between each load. One B+II WaterWizard is sized to handle 2/3 of the load (2/3 x 120 gpm = 80 gpm) and the rest will be provided by a tank that has an efficiency of 80%.

STORAGE TANK VOLUME:
Portion of required water volume that will be covered by the tank is:
[120 gal/min x 20 min] – [80 gpm x 20 min] = 800 gal
Since this is greater than 200 gallons, the required usable storage volume is 800 gallons. The total storage volume is 800 gal / 0.80 = 1000 gallons.

WATER HEATER/STORAGE TANK PUMP; BUILDING RECIRCULATION:

If the storage tank is piped as a stratified storage tank
  – The pump between the water heater and the storage tank is sized equal to the water heater capacity = 80 gpm.
  – The minimum building recirculation for a B+II WaterWizard = 25% of heater capacity = 80 gpm x 0.25 = 20 gpm.

If the storage tank is piped as an accumulator storage tank
  – The pump capacity between the water heater and the storage tank = 1000 gal / 10 min = 100 gpm
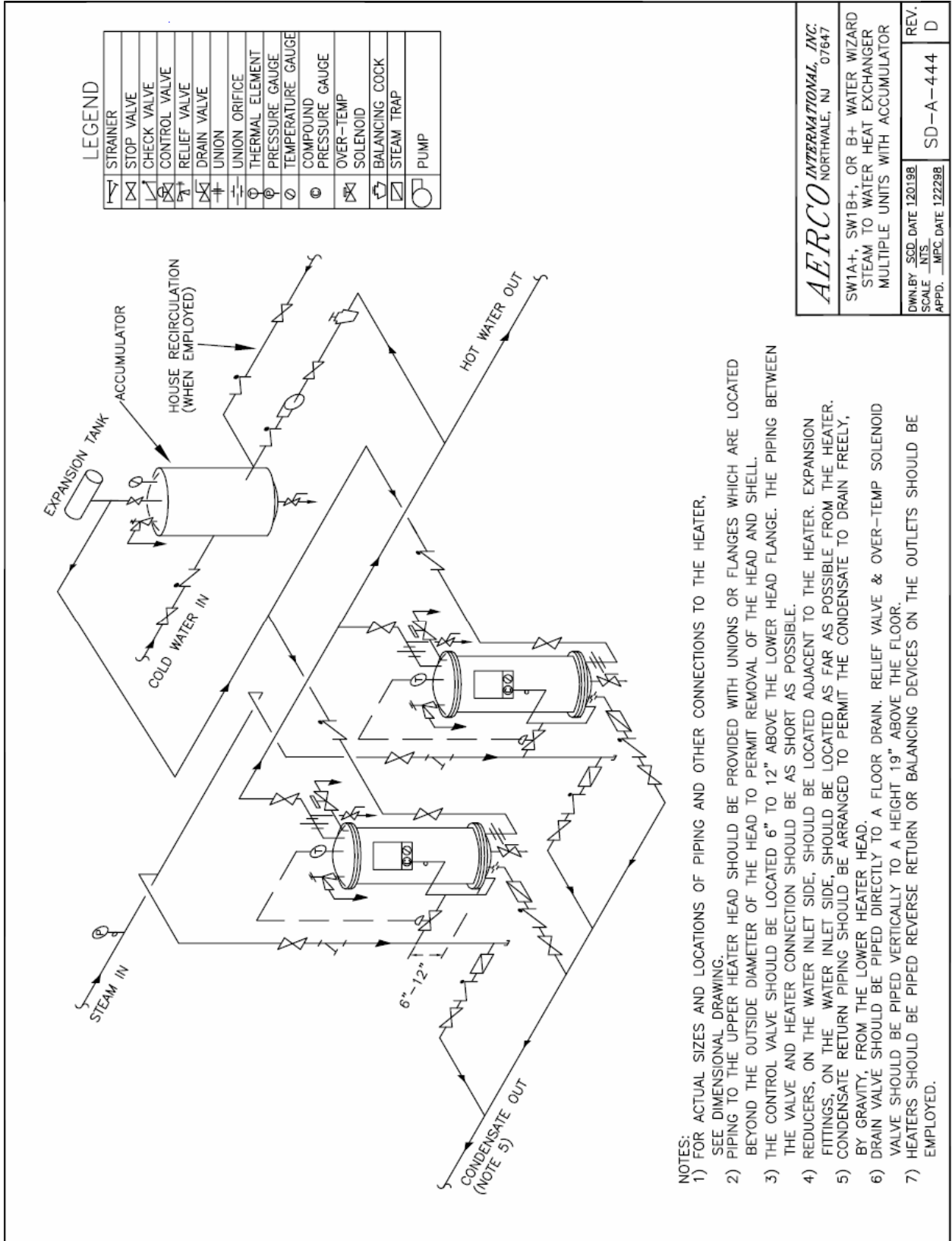 – The minimum building recirculation for a B+II WaterWizard = 25% of heater capacity = 80 gpm x 0.25 = 20 gpm.
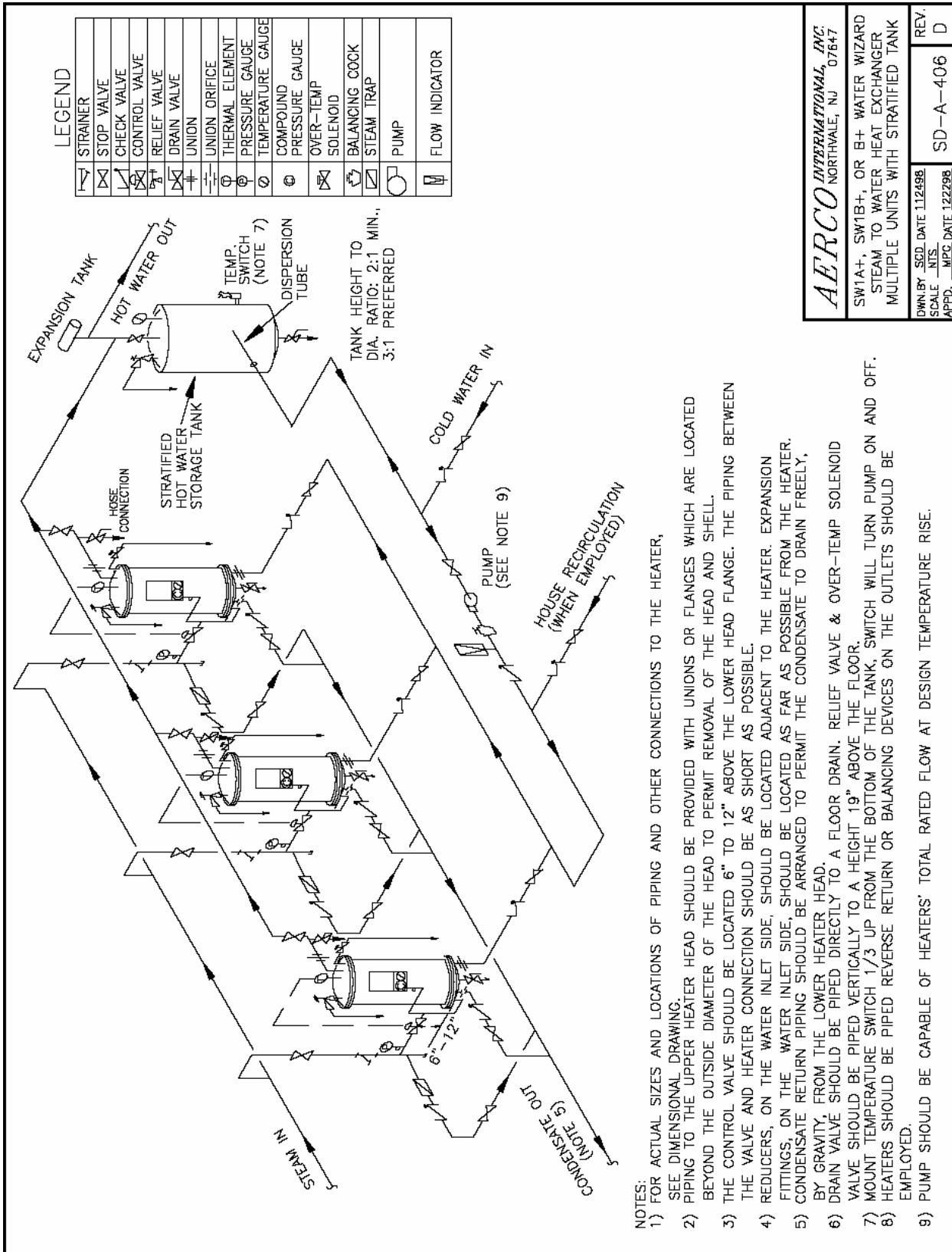
Figure 1 – Stratified Storage Tank Piping Schematic

Figure 2 – Accumulator Storage Tank Piping Schematic