Tankless Water Heaters and the "Cold Water Sandwich Effect"

The term "cold water sandwich effect" is a term that is used to describe the introduction of cold water into the hot water supply line during frequent on/off operation of an instantaneous water heater. The cold water sandwich effect, when present, appears as a momentary drop in hot water temperature as it is discharged from a hot water supply outlet (i.e. shower, tub, or faucet). This phenomenon is present in the operation of all instantaneous, tankless style, water heaters, but is minimized with the high tech design of Rinnai water heaters.

The cold water sandwich effect is inherent in all tankless water heaters and is a direct result of the operating principles used to provide an efficient, cost effective, and safe method of providing hot water to energy conscious consumers. The development of a high efficiency, cost effective, hot water heating source required a departure from the common "tank" type storage water heater. Tank type water heaters heat a stored volume of water slowly over a long period time (approximately 1 hour) and then maintain this stored water at a high temperature until used. The efficiency losses, or standby losses, associated with keeping this stored volume of water at a high temperature over an extended period of time result in operating costs in excess of 1.5 times the cost actually required to heat the water that is used by the consumer. For the consumer to realize these cost savings tankless water heaters have been developed which eliminate the standby losses associated with a large volume of stored water. The net result for the Rinnai water heaters is operating cost savings of up to $300 per year in residential applications. It is the elimination of stored water from hot water systems that has resulted in the cold water sandwich effect.

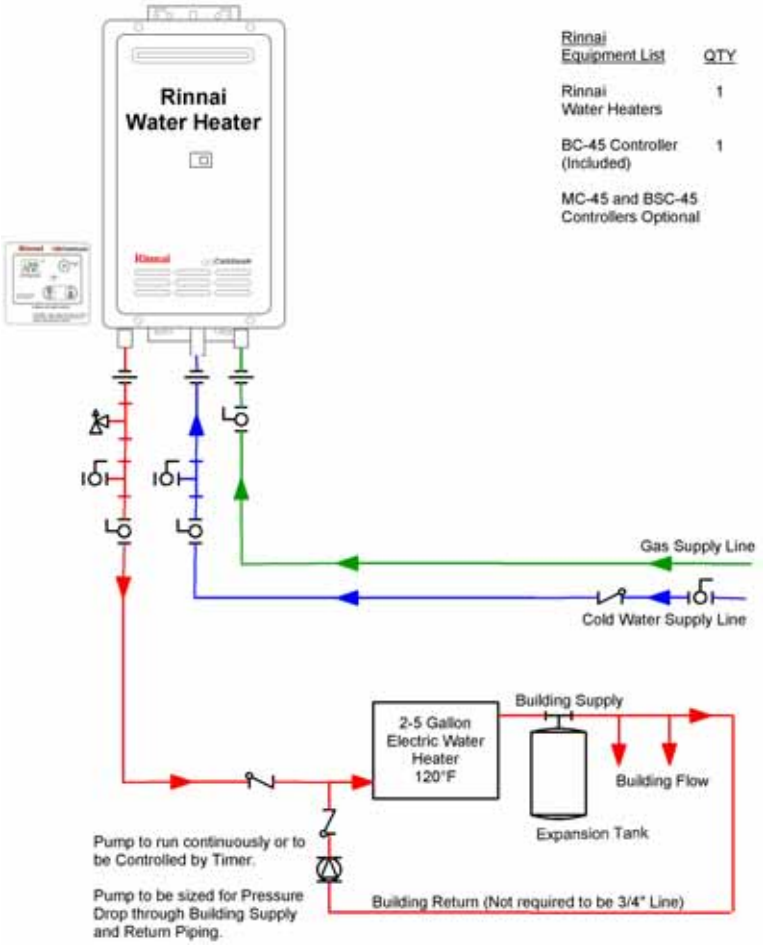
For a better understanding of why a cold water sandwich effect exists with tankless water heaters, the operating principles and safety mechanisms involved in their operation must be understood. The basic operation of all tankless water heaters is as follows: 1) A water flow sensor senses water flow through the heater. 2) Burner ignition is initiated resulting in the production of hot water. 3) Water flow and temperature is monitored and used to adjust the flow of gas to the burner, so that the outlet setpoint temperature is maintained. 4) When water flow ceases, the water heater shuts off. To maintain a safe ignition sequence, steps 1 and 2 typically take up to 10 seconds. During this ignition sequence, a small amount of cold water flows through the water heater. When hot water usage is stopped briefly and then started up again, this ignition sequence is repeated, and the small amount of cold water that passes through the water heater forms a "cold water sandwich".

The technology built into the Rinnai water heaters is designed to minimize the cold water sandwich effect. Rinnai water heaters are microprocessor controlled and when water flow through them ceases, they remain in a "ready to fire state" for approximately 1 minute. If water flow through a Rinnai water heater begins within the first minute following water flow stoppage, the water heater will fire back up within 1 to 2 seconds. This minimizes the cold water sandwich effect that would otherwise be

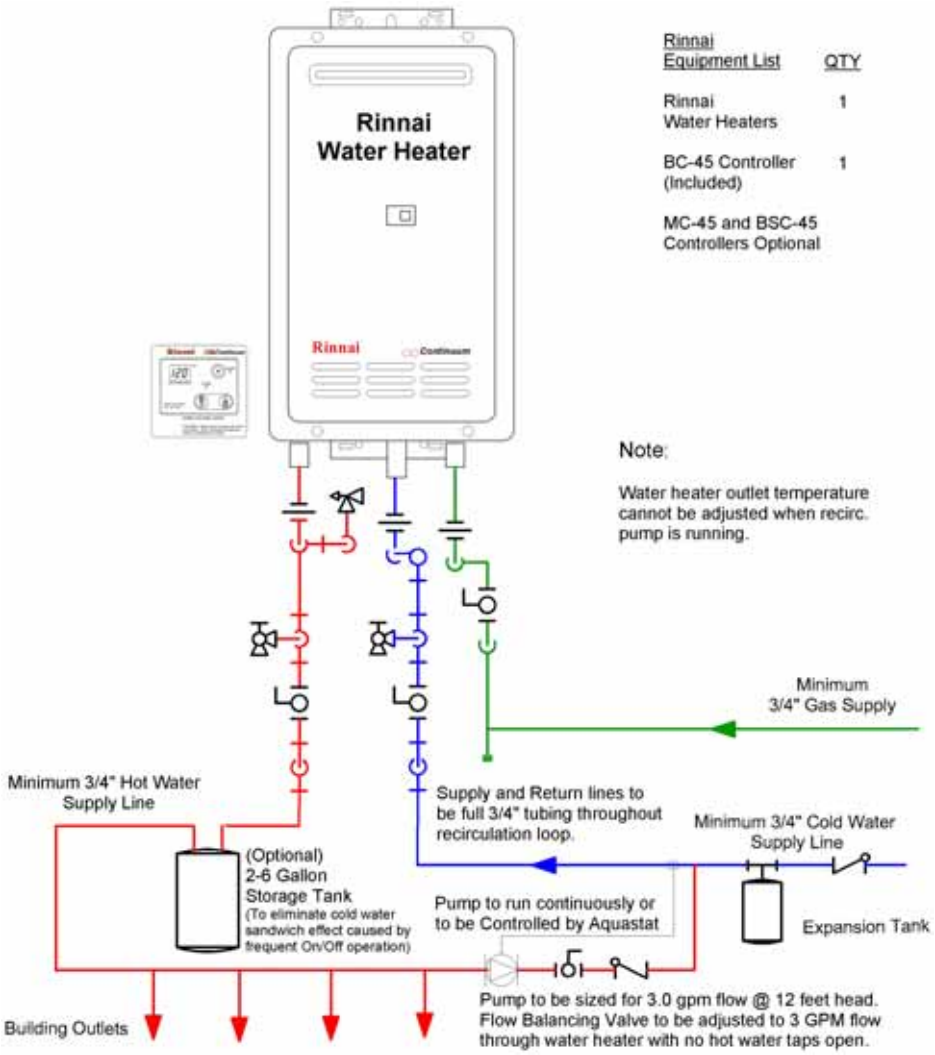
experienced with a low tech tankless water heater. It should be noted that the cold water sandwich effect cannot be removed completely from tankless style water heaters. The safety standards developed to insure the safe operation of water heaters require a delay in the ignition sequence of all gas water heaters.

While the cold water sandwich effect cannot be completely eliminated from standard plumbing systems, it can be eliminated from plumbing systems that have a supply and return hot water circulating system. Rinnai has developed 2 methods to eliminate the cold water sandwich effect in residential hot water circulating systems.

The first (and preferred) method to remove the cold water sandwich from circulating systems utilizes a small electric tank water heater (powered up) that is used with a dual purpose (see figure below). The small water heater acts as a mixing tank to eliminate the cold water sandwich effect from the Rinnai water heater and it uses its electric heating element to offset the heat losses from the hot water circulating system. With this piping system, the circulating pump does not have to be sized to overcome the pressure drop through the Rinnai water heater. As such, this system works best in retrofit applications utilizing existing pumps and piping. This system should always be used in systems using 1/2" diameter hot water supply or return lines. It should be noted that like method 1, this system does not negatively impact the efficiency of the hot water circulating system, as the heat loss of the insulated storage water heater is much less than the heat loss associated with the circulating loop piping.



The second method to remove the cold water sandwich from circulating systems utilizes a small 2 to 6 gallon storage tank installed on the hot water outlet of the Rinnai water heater (see the figure below). This tank acts as a mixing tank to blend the cold water sandwich with hot water and eliminating its effect at fixtures. This type of system can only be used if the hot water supply and return lines are a full ¾" diameter pipe size. It should be noted that the installation of this small storage tank does not negatively impact the efficiency of these circulating systems, as the heat loss of the well insulated storage tank is much less than the heat loss associated with the circulating loop piping.



When considering the efficiency of all of these hot water system designs along with the efficiencies of systems utilizing storage type water heaters, the most efficient is the tankless water heater with no circulating system. The second most efficient is the tankless water heater with hot water circulation utilizing a small water heater (method 1 above). The third most efficient is the tankless water heater with hot water circulation utilizing a small storage tank (method 2 above). The fourth most efficient system is a tank water heater with no hot water circulation. And the least efficient system is a tank water heater with a hot water circulation system. (Note: In all systems utilizing circulation loops, all supply and return lines must be well insulated!)