process HEATING

Heat Exchangers

10 Tips to Help Optimize Your Tank Heating and Hot Water Supply System

It is important to carefully review requirements to make the most of the direct steam-injection water heater.

September 1, 2020

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There is a need for hot water in virtually all food, chemical and industrial process plants. From clean in place (CIP) hot water and sanitizing to paper mill whitewater heating applications, hot water plays a critical role in process sanitation and performance. The amount of hot water required can vary significantly as process demands change. In addition, different processes can require a range of ideal temperatures at which they operate. Changes in supply and usage as well as seasonal effects on the process all can contribute to the variance in demand for hot water.

Variable process needs, multiple hot water users and high turndown from normal to peak hot water use make a direct steam heater well suited to support these applications. But, it is important to carefully review the requirements to make the most of the direct steam-injection water heater.

Steam-injection heating is a direct-contact method of heating where steam is directly injected into the fluid. This article will discuss important considerations to help size your steam-injection heater and optimize your hot water tank storage system. The following tips and recommendations can help ensure successful hot water system design.

1. Specify the Purpose of the Hot Water Tank

Before purchase, communicate to your steam-injection heater supplier the purpose of the hot water tank. Will the tank be filled, heated and maintained at target temperature for future use? Will the tank be manually filled, or will the tank level be controlled automatically? Will the steam-injection heater and tank act as a surge tank system in a very active hot water system (figure 1)? When used as a surge tank in an active water system, multiple users (hose stations, CIP spray nozzles, washdown areas, etc.) place variable demands on the hot water system. The answers to each of these questions can affect system sizing.

FIGURE 1. *An active hot water system with multiple users such as hose stations, CIP spray nozzles and washdown areas can put variable demands on the hot water system. This can affect the sizing of the system.*

2. Look at Peak Capacity vs. Normal Usage

Does hot water demand ramp up significantly at times? For example, many food plants have heavy hot water usage at the end of a shift due to hot water sanitizing and cleaning requirements. This peak demand needs to be compared to normal water usage to determine the appropriate sizing of both the hot water tank and the steam-injection heater.

For example, consider a food plant with two operating conditions (table 1). Both scenarios have significantly different heat load requirements. This leads to a high turndown in steam-load requirements during the daytime's normal hot water use and the high demand cleaning cycle at end of shift.

Applications such as this example demonstrate why it is important to clearly communicate the complete range of fluid-heating requirements and not just the "worst case" requirements. Failing to provide a complete picture can lead to oversized equipment. Sizing of the hot water tank and steam-injection heater need to be considered together. A properly sized hot water surge tank can maintain an adequate supply of hot water for normal daytime use and still ensures all plant hot water sanitation and cleaning needs are supplied at peak demand periods.

Table 1

Normal vs. Peak Load Comparison			
	Units	Daytime Normal Use	End of Shift Cleaning
Water Flow	gal/min	100	600
Temperature	°F	120	140
Average Steam Load	lb/hr	4,800	25,000

3. Design for Reliable Hot Water Temperature Control

Many applications only require “hot” water without specific temperature requirements. Others such as CIP hot water supply, plant hot water sanitation, chemical or detergent activation have very specific requirements. Assessing the actual water-flow rates without oversizing improves temperature control through the entire range of steam-injection heater operation.

Keep in mind system-induced effects. For instance, temperature control loops are inherently sluggish due to the delay in temperature probe response. A large tank can greatly increase this lag because it can take a long time to completely disperse the hot water throughout the tank. A sound approach in these conditions is to have temperature control monitoring on both the heater and the tank. This keeps the steam-injection heater from overshooting the target temperature, which can lead to steam flashing.

In addition, design the mixing characteristics of the tank to improve temperature uniformity. Is there a mixer in the tank? Are the water inlets and discharges located in a way that promotes mixing? Is the inline heater on a recirculation loop to improve mixing? What is the tank rate of turnover? Faster turnover generally leads to a better temperature response.

FIGURE 2. *Injecting steam directly into the hot water tank with a tank jet sparger can be a simple and economical approach.*

4. Select the Appropriate Steam-injection Heating Device for Specific Process Needs

Injecting steam directly into the hot water tank with a tank jet sparger (figure 2) can be a simple and economical approach. Tanks generally are atmospheric, so low pressure steam can be used. There are limitations to the sparger that you should consider, however. They may affect your process hot water heating needs.

Heating an unpressurized tank above 150°F (66°C) can be difficult due to localized hot spots in the tank near the sparger.

Hot water tank recovery after draw down can be slow and may affect the availability of hot water. Using an external inline steam-injection heater (figure 3), which can have up to 8:1 turndown on flow and 100 percent turndown on steam, often provides better performance in heating a hot water storage tank. Faster system startup and quicker recovery time during high use periods also can be achieved because the steam-injection heater can be located on a tank re-circulation loop. Also, an inline steam-injection heater can be added at point of process use to boost temperature at those locations.

Table 2

Impact of Startup Time on Heat Load Requirements			
Tank Size	gal	5,000	5,000
Starting Temperature	°F	50	50
Target Temperature	°F	140	140
Heatup Time	minutes	30	60
Steam Required	lb/hr	7,000	3,500

5. Examine the Stability of the Steam and Water Utilities

How does utility availability affect the process? Will peak usage times exceed the capacity of your boiler steam supply? Does steam pressure vary throughout the day? Does water supply temperature or pressure vary? If pressure, temperature or supply changes are rapid or severe, it might be necessary to install regulators or other means to stabilize the conditions.

FIGURE 3. *Hot water tank recovery after drawdown can be slow and may affect the availability of hot water. Using an external inline steam-injection heater may provide better performance.*

6. Integrate Safety Procedures in the Hot Water Process

Can excessive temperature present safety issues to personnel or adversely affect the process? If the water is used for washdown, control monitoring in the hot water system or tank can prevent injury to personnel or system damage. Setting high temperature alarms in the control system can help minimize risk of overheating the water or for steam flashing (heating above the boiling point) to prevent injury.

Avoid rapid swings in flow rate. Temperature control loops tend to respond slowly. Fast drops in water flow can lead to surges in temperature, which can cause inline boiling and steam hammer.

7. Size Hot Water Surge and Storage Tanks Appropriately

Important questions to ask include: What is total demand of all users at peak use? How much surge capacity is required? Can the required capacity vary during the day, month or year?

Keep in mind that oversizing the hot water storage tank can lead to slower startups, slow recovery in peak-demand periods and excessive energy use. A properly sized steam-injection heater with high turndown can ensure the tank temperature is maintained and improve the responsiveness of the system to the process needs.

8. Look at the Process for Seasonality Issues

Does the heating load vary during the year? If so, there are several effects from seasonality that should be considered when specifying heating equipment. Incoming feed water often is colder during the winter months, which can affect heating demand for a part of the year.

Ambient heat losses in open tanks, colder pipes (uninsulated pipes), and hot water tanks located outside all can add to higher heat loads. For the opposite reasons, during the summer months, the heat load can drop significantly.

9. Determine the Required Level of User Interaction and Control for the Process

Are systems typically operated manually, or will they be automated? Is the hot water heating system part of a plant-wide control system, or is local point-of-use control required? It is often desirable to tie temperature setpoints, flow rates, tank refill level point and operating sequences together to optimize the speed and response of the plant's hot water system. Plan your system accordingly and consider ease of use for operators.

10. Size the Startup Capacity Properly and Avoid Too Much Excess

Be realistic on your startup needs because they can have a significant effect on operating success. Often, the steady-state load for heating throughout the day is significantly lower than the startup load.

- Avoid overestimating cold startup needs. This can lead to oversizing equipment where normal heater operating conditions are on the low end of control range where sensitivity is high, which can affect stable temperature control (table 2).
- Consider whether multiple re-circulations of the water system can be performed to reduce the initial temperature rise on each pass. Can time of startup be extended?

Tank heating and hot water systems can be complex. Taking the time to accurately assess operating conditions leads to a better performing and more reliable hot water system. Incorporating the above recommendations in the planning process should allow you to develop a solid plan for designing and optimizing your hot water tank and steam-injection heating system.

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Direct Steam Injection Heating

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