Hot Water Generation – Flooded Heat Exchangers

Steam heat transfer equipment emerges from the 20th century…
Space saving, GREEN design by Advanced Steam Technology

The Advanced Steam Technology XE Thermal unit is a new, patented form of vertical steam to water exchanger for building heat.

Two key factors have led to the growth of this style of heat exchanger for building heat. First, the new design is vertical, and much smaller than old-fashioned conventional steam heaters (convertors). Secondly, testing and research has enabled these units to eliminate flash steam, usable for LEED calculations and GREEN building certification, (not to mention saving energy and money).

Size is a frequent consideration. Floor space is at a premium in modern mechanical rooms. The difference in footprint between a 16 square foot vertical skid and trying to stack regular horizontal exchangers can be worth thousands of dollars.

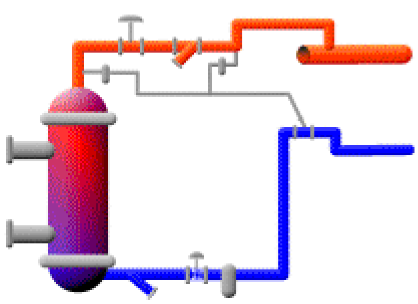

Fig. 1 Vertical steam piping layout

Retrofit applications are perfect for vertical units. Large, bulky exchangers that were installed over the last 40 to 50 years are at the end of their useful life. Many times the facility is built up around these failing units. The only way to get a new unit in would entail major demolition.

Vertical packages can be wheeled through a doorway. They can be piped up with the existing unit in place, causing minimal downtime. Sometimes the existing unit is encapsulated and left in place, or it can be drained and cut into pieces for removal.

Fig 2 Advanced Steam Technology XE Thermal Unit

Conventional piping components are utilized in every critical valve or pump. A facility can even specify pumps and valves for which they already stock parts.

Energy conservation is unparalleled. There is no unit on the market more energy efficient than a Advanced Steam Technology XE Thermal unit for steam to water heating. It squeezes every practical BTU out of the steam and condensate.

Normally when a system is energy efficient, it's not the **lowest cost to install**. The Advanced Steam Technology XE Thermal unit is different. It does not require a pressure reducing valve station, or a dedicated condensate pump. This can save up to 40% of the installed cost on a new job.

To explain how the dramatic energy conservation and cost savings are possible, let's start at the beginning, with water…

Steam fundamentals

When make-up water enters the boiler room or power plant, its first stop after treatment is the deaerator. Here it is sprayed over heated trays to drive out dissolved gases. The water is usually heated from 40F to 205F by adding sensible heat. It takes about 1 BTU to raise a pound (or pint) of water by 1F. These BTU's are supplied by steam in the trays.

Smaller package boilers might not utilize a deaerator, in which case, the boiler provides this same sensible heat demand.

Here is one place where the Advanced Steam Technology XE Thermal unit system makes a difference. Why is make-up water needed in the first place? Some losses are due to boiler blow-down and some to make up for leaks. The other loss is from "flash steam". That's the steam puffing out of vent pipes all around the condensate return system.

Fig 3 Flash steam puffing from vents

The steam boiler takes water from the deaerator, heats it to the boiling point by adding more sensible heat, and then adds latent heat to vaporize the water into steam. How much sensible and latent heat are needed? That depends on the steam pressure desired.

Pressure	Temperature	Sensible Heat	Latent Heat
0 psig	212 F	180 Btu	970 Btu
15 psig	250 F	218 Btu	945 Btu
60 psig	308 F	277 Btu	905 Btu
100 psig	338 F	308 Btu	880 Btu
150 psig	366 F	338 Btu	857 Btu
600 psig	486 F	472 Btu	732 Btu

Fig 4 Pressure compared to heat content in condensate

A sophisticated system for a university, food processor, or chemical plant will generate steam at 600 psig or higher, because steam is used to generate power before distribution. The steam is normally distributed at 100 or 150 psig. Some industrial plants (usually with turbine drives) will distribute steam up to 600 psig.

Systems are designed around higher pressure distribution because of the steam volume.

Pressure	Temperature	Volume
0 psig	212 F	27 ft3
15 psig	250 F	14 ft3
60 psig	308 F	6 ft3
100 psig	338 F	4 ft3
150 psig	366 F	3 ft3
600 psig	486 F	1 ft3

Fig 5 Steam pressure compared to volume

High pressure distribution is used to minimize pipe sizes, and reduce the drop in pressure experienced by flowing steam.

Intermediate pressure steam is normally 60 or 80 psig. It is used for sterilizers, autoclaves, wash mixers, and pumping stations. This steam is usually generated from distribution pressure by a pressure reducing station.

Low pressure steam is normally 10 to 15 psig. It is used for heating air and water. The water heating systems are either "service" or "domestic". Domestic water is for the hot side of sinks and showers. Service water is first heated by the steam, then it circulates through coils and baseboard to heat air. It's usually mixed with glycol to avoid freezing. **Between building heat and domestic, most facilities use at least 50% of their steam for heating water.**

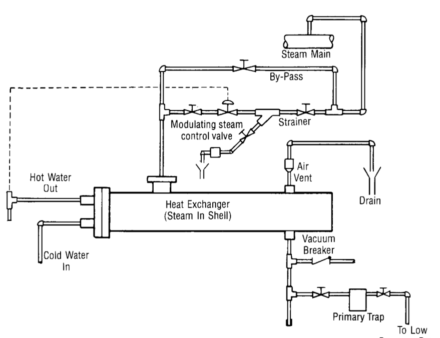

Fig 6 Typical building heat system with "conventional" control

Condensate system pressure is normally 0 psig. Industrial process dryers sometimes use intermediate 30 to 60 psig return systems, which then "cascade" down into a 0 psig system.

Conventional Heaters

When heating air or water, the conventional control method is to use a modulating valve on the steam inlet. Its job is to throttle the steam pressure feeding the heat exchanger. By raising and lowering the pressure, the steam temperature changes in response to the sensor which controls the valve. A person could even do it manually. Just watch a thermometer in the leaving fluid. If the temperature is too high, then start closing the inlet steam valve. If it's too low, open the valve.

This is called the "feedback" method. In a storage tank or service water application it works well from a temperature control standpoint. From the steam management side, it's complicated. Also, it does not work well for domestic water heating without a storage tank.

What's the problem with conventional "feedback" control? For one thing, its very nature is "after the fact". The modulating valve only reacts after it sees a variation in outlet temperature. If that leaving water is too hot, that's too bad; it's out into the system already.

The other problems can be summed up in one word… vacuum. The inlet modulating valve typically has 15 psig steam supplied to it. We often forget that this is really 30 psia steam. The modulating valve doesn't know that 14.7 psia is what we call 0 psig. It will throttle the steam pressure to whatever satisfies the temperature sensor. If it needs 200F steam to satisfy the sensor, it's no problem. It will throttle the pressure down into vacuum, and "presto!" there is 200F steam. (See following appendix VACUUM)

That's where the problems start. Because the condensate return system is at 14.7 psia, the heat exchanger can't drain. **Water hammer, valve hunting, and uneven control result.** The solution is simple, fortunately, but the design becomes much more complicated.

The solution is to install a vacuum breaker. It sucks air into the exchanger, breaking the vacuum. The system can then drain by gravity.

That solves the problem, but three factors make the system design complicated.

- ✓ There is now air in the heat exchanger
- ✓ The pressure is very low (0 psig) and condensate is still being created
- ✓ An overhead return line can't be used without a pump

Fig 7 Complicated steam and drainage piping

Between larger steam trap selection, air vent placement, and adding a condensate pump, the design gets **expensive**.

Lifting condensate to an overhead return is not recommended, so a condensate pump may be needed. Hot water can potentially work its way back into the supply, so thermal "U loops" are needed on the water side.

Advanced Steam Technology XE Thermal Vertical Design

This is a new twist on a proven design. Vertical exchangers were called "Calorifiers" years ago. They used the conventional control method with the inherent design problems.

Advanced Steam Technology XE Thermal Operation

The Advanced Steam Technology XE Thermal unit system uses a control valve on the condensate side for temperature control. This difference allows two advantages. First, high pressure steam can be used. A pressure reducing station is not needed, and steam piping is smaller and lighter. Second, the heater utilizes the latent and sensible heat of the steam.

Fig 8 Advanced Steam Technology XE Thermal Skids

At full load, a Advanced Steam Technology XE Thermal unit style is designed to discharge condensate at or even below 200F. Compared to a conventional or a blending heater at 250F, this saves 50 BTU's for every pound of steam consumed. Furthermore because the condensate is less than 212F, it will not create flash steam.

When flash steam is formed, it flows up through the vent on the condensate return station. It's lost in the atmosphere through the vent pipe. In the deaerator discussion above, remember that make-up must be added, treated, and heated when flash steam is lost.

The condensate pump station behaves better with the cooler condensate. Hot condensate cavitates as the pump pulls it into the volute. The pump will sound like it's full of gravel, and the internals will wear out quickly.

Fig 9 Worn impeller from condensate pump

In addition, the unbalanced impeller wobbles and causes the shaft seals to leak.

The Advanced Steam Technology XE Thermal unit eliminates the need for a dedicated condensate pump. The 200F condensate has high pressure behind it, so it does not need a pump. This piping is sized like a water line, so smaller and lighter pipe can again be used.

In order to deliver these benefits, the control valve on the condensate side is a vital component. Every precaution is taken to be sure it does not leak. The system is normally furnished with a temperature controlled steam regulator to prevent high water temperatures should the control valve leak. A steam trap is also provided to prevent a leaking control valve from discharging live steam.

In summary, the Advanced Steam Technology XE Thermal unit steam heater has many advantages:

- Lower installed cost than other fluid heaters
- Utilize steam that is wasted by other heaters (Save 20%of energy usage at 125 psig steam, save 5% of energy usage at 15 psig steam.
- Smaller footprint
- A dedicated condensate pump is not required
- No dedicated PRV station required
- No vacuum breaker required

• Control liquid leaving temperature at +- 3F

Figure 10 Hotel Domestic Heaters

You can use the Advanced Steam Technology XE Thermal units for:

• Domestic Hot Water
• Heating Water/Glycol for Building Heat
• Hot Oil or other Heat Transfer Fluids
• Wash Stations
• Emergency Showers