Thermal Stores and Ground Source Heat Pumps V1

Thermal stores and **heat banks** are becoming more common particularly with installations using renewables, they provide hot water at mains pressure, and can be used in applications where heat sources are combined, e.g. mixing solar or heat pumps with conventional boilers, and sometimes also for supplying underfloor heating systems alongside radiators.

The basic principle behind these systems are that a container of water is heated by the heat source (or sources) and mains pressure cold water passes through a heat exchanger where it is heated by the stored hot water and then supplies the taps etc. The thermal storage container itself is under low pressure, sometimes only a head of a few centimetres of water.

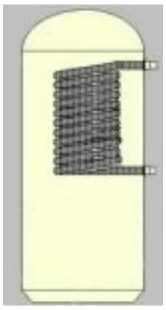
Fig 1 Classic Thermal Store

In a classic thermal store the heat exchanger is a coil of pipe (or a tank in tank system) with a large surface area within the cylinder itself. As cold water flows through the coil it is heated by the hot water surrounding it and as the surrounding hot water cools it, sinks by convection bringing hot water from elsewhere in the cylinder into contact with the coil.

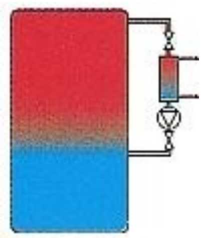
Fig 2 Heat Bank

In another type of system, sometimes referred to as a heat bank, the heat exchanger is external to the hot water cylinder. When DHW is required hot water is pumped through the heat exchanger and back into the cylinder. The pump is usually controlled by a switch in the DHW pipework which senses when water is flowing to the hot taps etc. In this type of design the heat exchanger is usually a type comprising several plates of stainless steel joined in a sort of multi-layer sandwich, known as a Plate Heat Exchanger (PHE).

Facts at a glance:

Thermal Stores—Will use a volume of stored hot water to produce DHW via a indirect coil or tank in tank system.

Heat Banks—Generally will use a volume of stored hot water to produce DHW via an external heat exchanger.

Stratification—Thermal stores and heat banks rely on temperature stratification to work effectively, this results in a high temperature at the top and a lower temperature in the bottom. Any turbulence can destroy this stratification resulting in a reduction of efficiency.

Heat Pumps—When producing hot water the higher the temperature the lower the efficiency of the heat pump, Heat pumps linked to thermal stores are not efficient, due to the higher temperature required by the thermal store to produce DHW.

Multi-energy source tanks—Care has to be taken with multiple energy sources on thermal stores to avoid disruption to the stratification, also if producing temperatures above the heat pump maximum, the heat pump will never operate.

Another difference between Thermal Stores and Heat Banks is in how efficiently they use the amount of hot water they contain to provide DHW. This concerns stratification and mixing of water in the store. The net effect is that a Heat Bank must have a higher capacity than a Thermal Store to provide the same quantity of DHW (if all other factors are equal).

Circulation of water in a thermal store is driven by convection currents caused by the cooling effect on the stored water of the cold water flowing through the heat exchanger. These convection currents are relatively gentle, and proportional to the amount of heat being drawn from the store. Thus the cooled water tends to fall gently to the bottom of the store leaving hotter water higher up, nearer the heat exchanger. As the store continues to supply heat to DHW the cooler layers of water extend further up the cylinder until at some point, when much of the heat exchanger is surrounded by cooler water, the temperature of DHW drops below 40°C after which the temperature of the DHW becomes unacceptably cold. At this point there will still be some hot water near the top of the cylinder, so the thermal store is not using the stored hot water with perfect efficiency.

In a heat bank water can be drawn from the very top of the cylinder to pass through the heat exchanger, so all the stored hot water should be available for heating DHW. Unfortunately most DHW heat banks use a simple fixed-speed central heating circulator switched by a flow switch in the DHW pipework. This has to provide sufficient flow through the heat exchanger to provide satisfactory DWH temperature at maximum DHW flow rate, so even when the demand is less the pump is still circulating water at its maximum rate. This causes unnecessary mixing in the cylinder, destroying stratification.

Using Thermal Stores or Heat Banks with Ground Source Heat Pumps

The efficiency of a ground source heat pump is highly dependant on the outlet temperature, the higher the outlet temperature the lower the efficiency. In fact a ground source heat pump generally has a maximum output temperature of 50-55°C. It cannot produce high temperatures as conventional boilers can. Due to this the temperature difference between the stored water (primary) and the required DHW temperature is small.

What this means for a thermal store or heat bank is that the energy that can be transferred from the heat pump to the DHW is limited, (in fact it will be even lower as the heat transfer is never 100% efficient). This results in the need for a very large amount of stored water to produce a small amount of DHW at a poor efficiency. As a higher flowrate will be required to produce this DHW a greater turbulence can be produced within the tank, which destroys the stratification and again leads to poor efficiency.

As thermal stores can accept more than just the heat pump as the energy source, e.g. Solar input, biomass, etc, the temperature can be raised by using other means, however additional inputs to the cylinder can again destroy the stratification. Also if the return temperature to the heat pump increases above 50°C, the heat pump will turn itself off, the other sources of heat will take all the load and the heat pump will never turn on again. While this is not a problem with solar, if an electrical immersion heater is used as the additional heat source then the running costs will be higher as will the carbon emissions.

Additionally with thermal stores the additional water pumps, complexity of design, size and installation all lead to higher capital and running costs. One advantage of a thermal store heat pump combination is that the thermal store can also act as a buffer vessel for the heat pump reducing the possibility of short cycling whilst providing full temperature control for all areas. However Kensa systems are designed so that a number of zones within the underfloor can be left open providing the required volume and flowrate for the heat pump to avoid short cycling without the need for a buffer vessel.