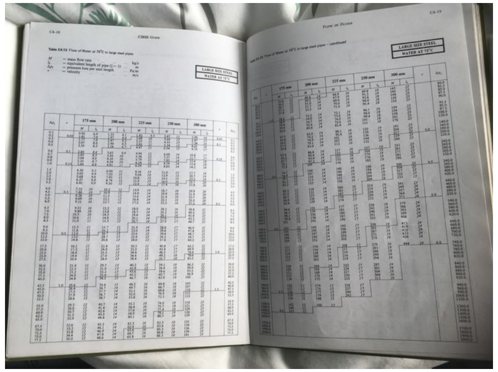
Fluid Engineering For Low Carbon Designs

$$H_F = \frac{4fLv^2}{2gd}$$



$$Q = m \, Cp \, \Delta T$$

(D’Arcy Equation/CIBSE Guide C Pipe Sizing)

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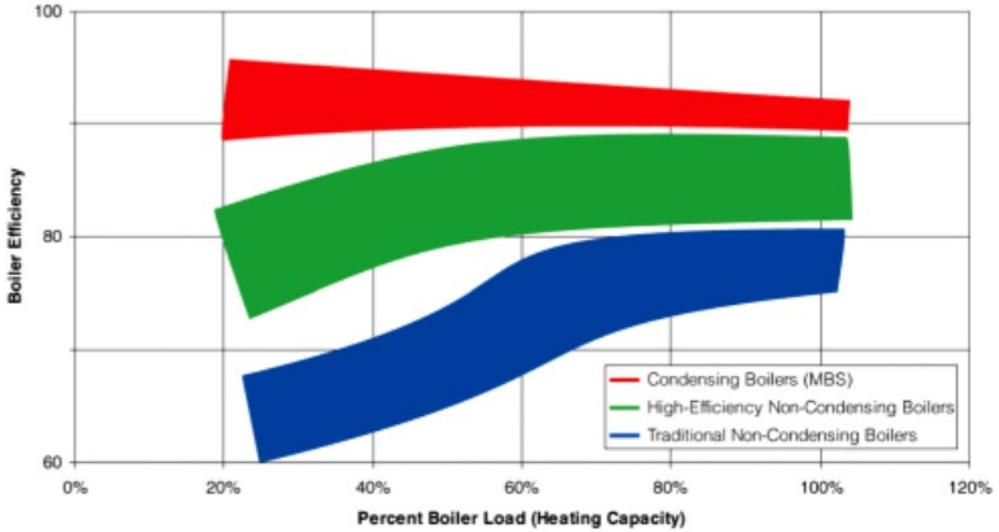
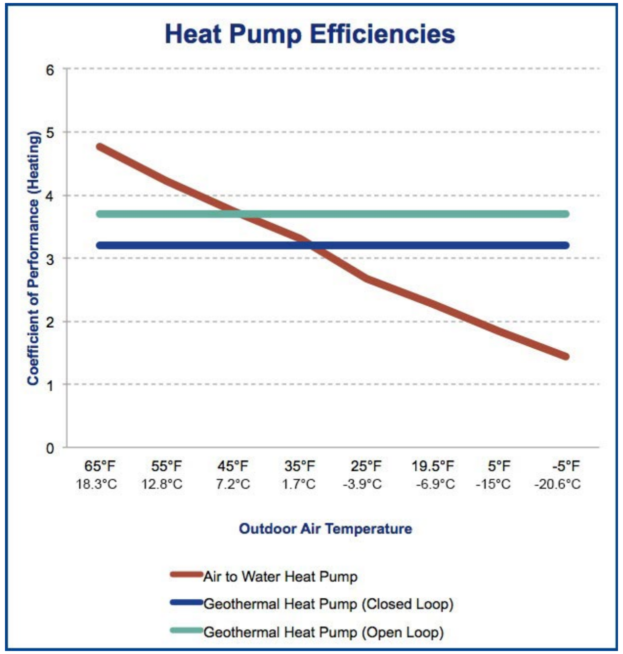
Traditional Heating Temperatures

LTHW was the most common system in use with a flow temperature of 82DegC and a return temperature of 71DegC (a differential of 11DegC).

This design has changed as we have incorporated condensing boilers and particularly heat pumps and other renewable energy sources requiring lower supply and return temperatures for improved efficiency.

"Heat pumps, air conditioners, and refrigerators utilize heat transfer from cold to hot. They are heat engines run backward"





Modern Flow Temperatures

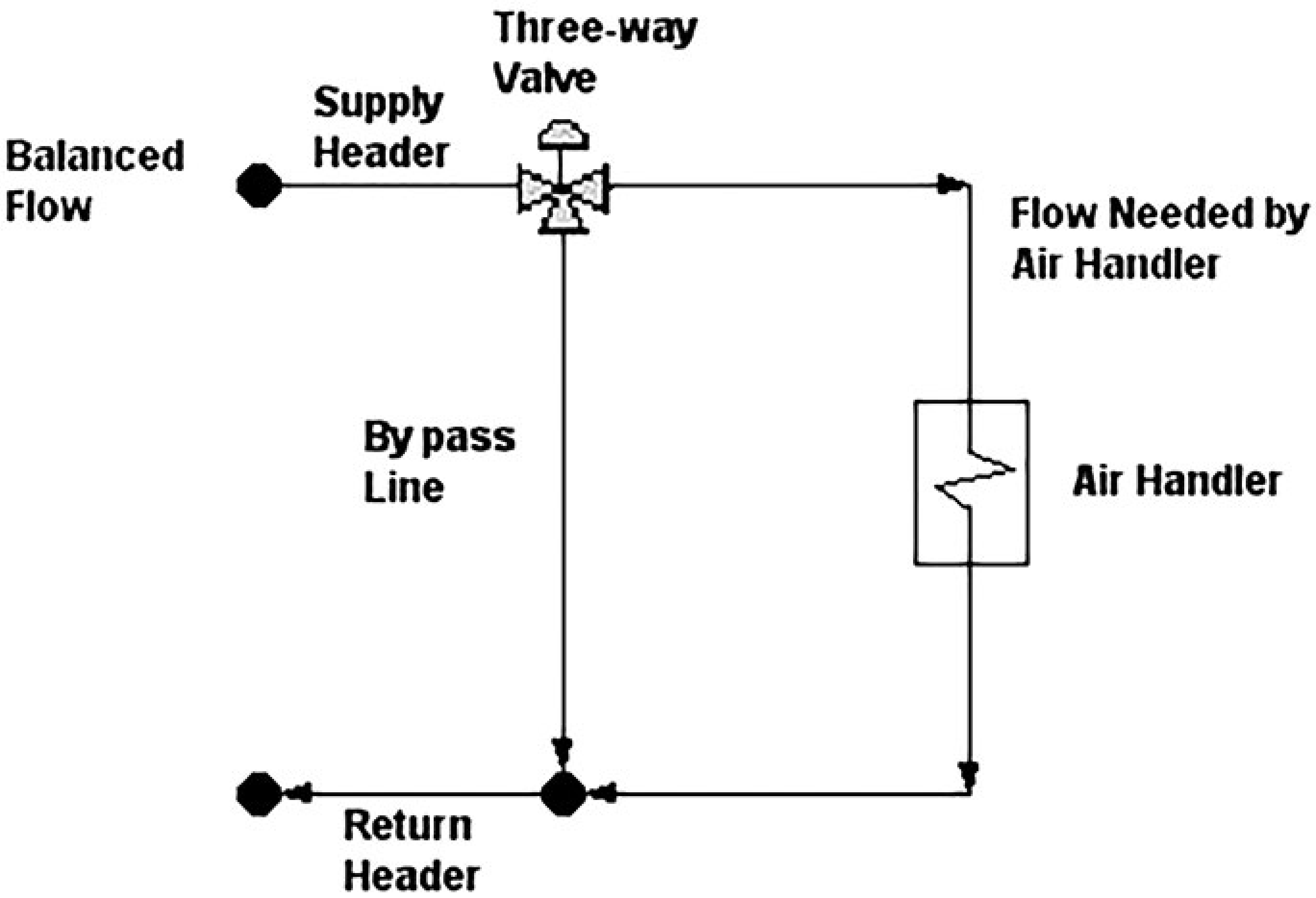
As we increase the temperature differential this gives a proportional reduction in water flow rates which in turn reduces pipe sizes and pump duties.

$$Q = m\,Cp\,\Delta T$$

A larger radiator has a greater surface area, which allows it to distribute heat more evenly and efficiently at a lower water temperature

Constant Fluid Delivery

Traditionally, the heating water would be pumped constant volume flow rate with a 3-port control valve diverting the flow back to the return so the emitter receives variable flow whilst the main circuit maintains constant flow. This results in increasing return temperatures and reducing differential temperature as the load decreases but with a constant pump cost.



Variable Fluid Delivery

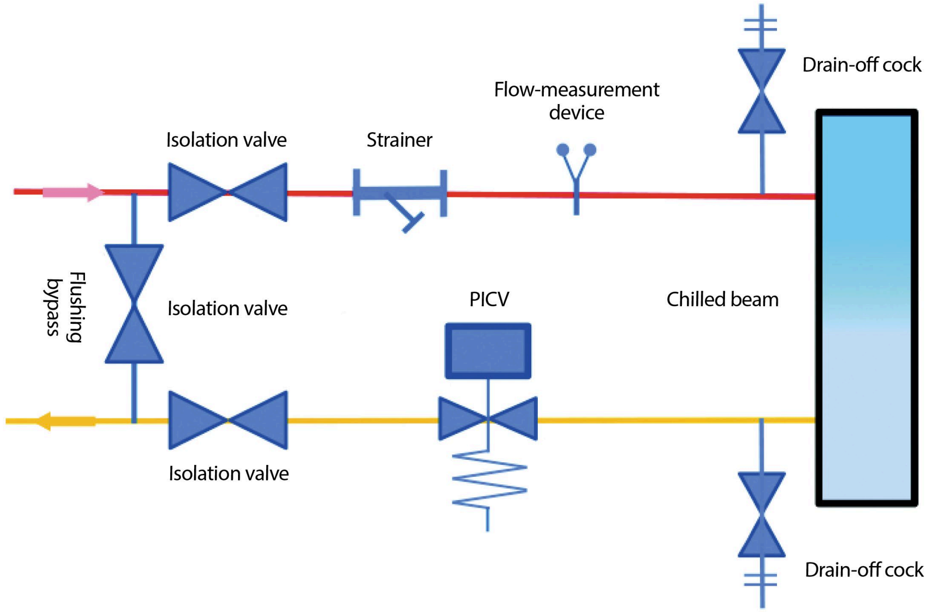
In contrast, variable flow systems incorporate a varying flow rate to meet demand use control valves to reduce flow as demand falls.

The pump senses the rise in differential pressure of the circuit as the control valves close and the pump speed reduces.

Hence, pump energy reduces according to the reciprocal of the flow rate reduction cubed.

So if we reduce flow rate by halve, the pump energy reduces by 12.5%.

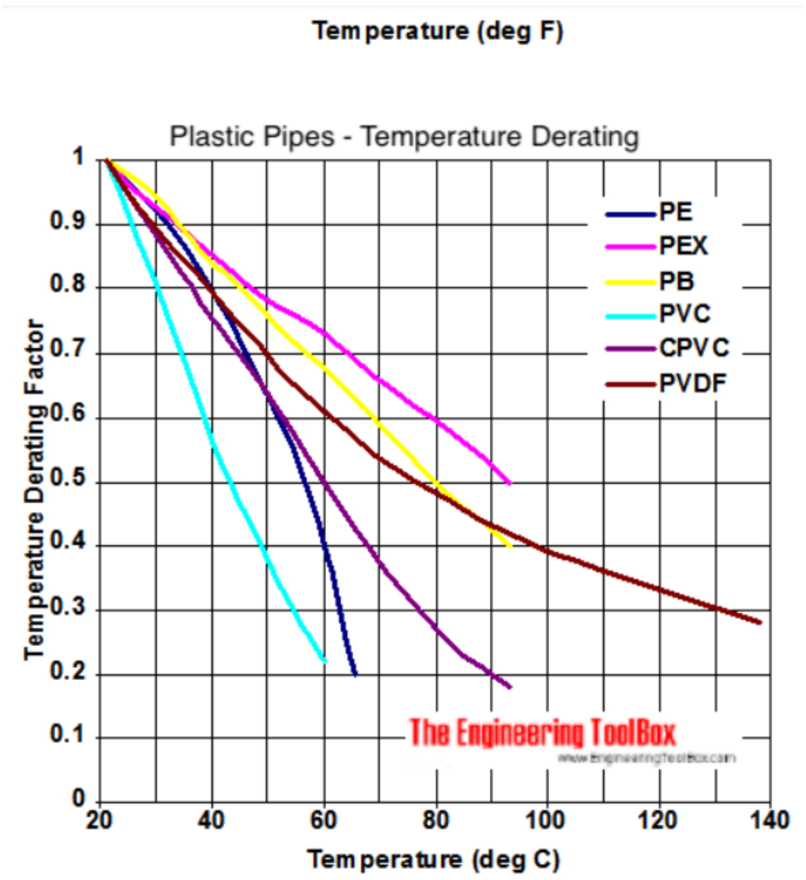
But, low flow and low temperature designs are not without issues.



Pipe Choices: Plastic

Thermoplastic materials loose strength to pressure and tension with increasing temperature. The table illustrates a guide to common thermoplastics and their derated strength with temperature. Manufacturing data should always be consulted on the fittings used due to friction losses as example below for PEX crimping:

PEX crimp fittings have a smaller inner diameter compared to the PEX tubing itself. The fitting is inserted inside the tubing, and this insertion reduces the overall available space for water to flow through. For instance, a 1/2-inch PEX crimp fitting may have an internal diameter closer to 3/8 inch, causing some level of restriction.
***Elbows and Tees**: Elbows and tees, commonly used in plumbing layouts, can further reduce the effective flow rate. The sharp angles and narrow bends slow down the flow of water compared to a straight pipe.*



Pipe Choices: Metal

Steel, galvanized, copper and stainless steel are common pipework materials.

Thin wall pipework is becoming increasingly common.

Press/crimped fittings have slightly increased pressure losses so check out manufacturers data

Pipe Choices: Mixed Metals

Lead, Steel and galvanized pipes were the most common pipework materials until copper and stainless entered the market

All these metal pipeworks are now available as thin wall versions so avoiding mixing metals and water quality is even more essential.

Select metals close to each other in the galvanic series

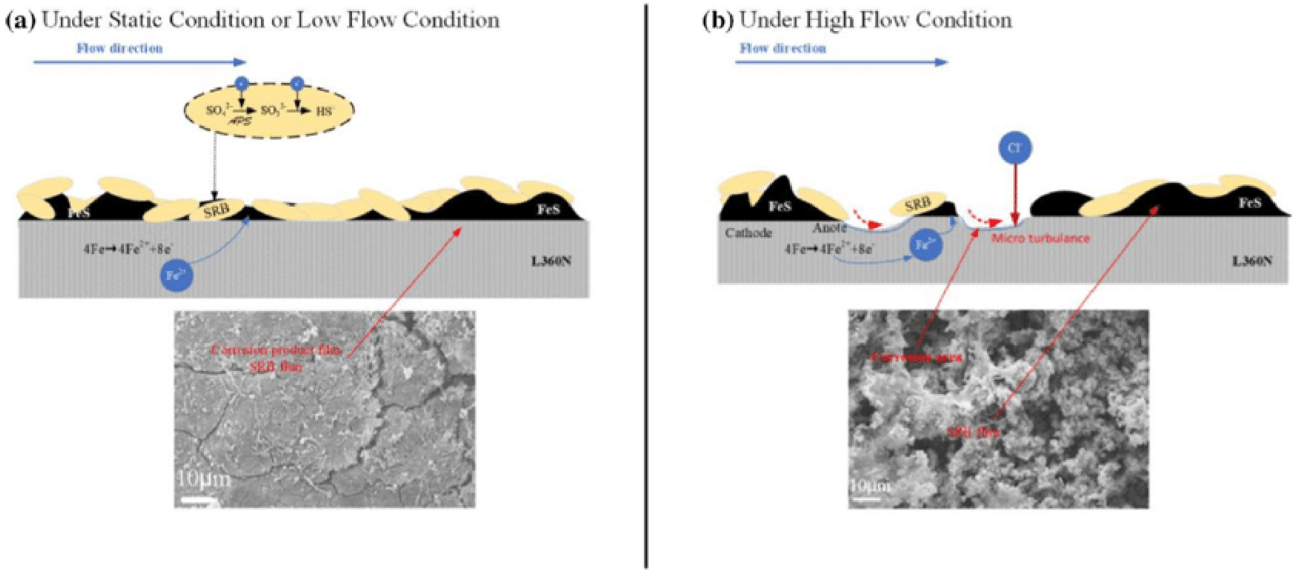
Break the electrical path at joints if using mixed metals and **exclude oxygen from the water**

The Pitfalls Of Low Carbon Delivery

Low carbon dioxide heat sources are naturally **encouraging lower circulating water temperatures and flow rates** which can impact ability to commission and maintain good water quality in closed pipework systems.

Reduced Flow Rates & Sluggish Water

Reduced flow rates can create large slow-moving pockets of water where it may be difficult to get water treatment chemicals into these areas and therefore biofilms and Sulphate Reducing Bacteria can cause steel pipework to corrode because these bacteria live in the absence of oxygen under biolfilms and areas of stagnation and they produce hydrogen sulphide which pits the pipework producing ferrous sulphide.



Commissioning Issues

Guides such as CIBSE suggest that ultra-low flow rates occur below 0.015 l/s. Whilst several manufacturers have developed PICVs to address the demand for ultra-low flow balancing and control commissioning has proven to be difficult .

In situations where individual terminal units have low design flow rates a single flow measurement and regulation device **could serve a group of terminal units.**

Alternatively, when commissioning an ultra-low flow system with flow rates below 0.015 l/s a practical approach is proposed to set the PICV at the design flow rate plus say 30% using the metering station reading

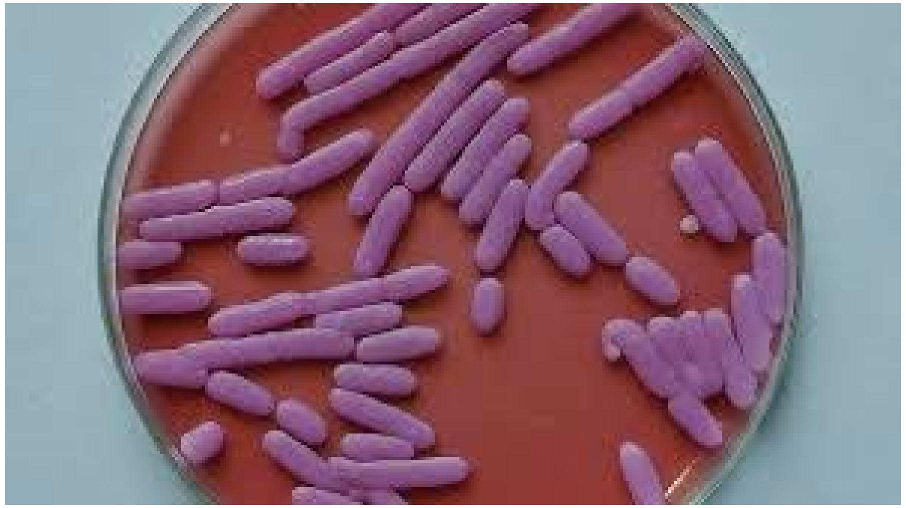
Setting	l/h	l/s	**Difference**	**Difference %**
1.0	17.3	0.0048		
1.1	19.7	0.0055	0.0007	13.9%
1.2	22.6	0.0063	0.0008	14.7%
1.3	26.1	0.0073	0.0010	15.5%
1.4	30.1	0.0084	0.0011	15.3%
1.5	34.7	0.0096	0.0013	15.3%
1.6	40	0.0111	0.0015	15.3%
1.7	45.9	0.0128	0.0016	14.8%
1.8	52.5	0.0146	0.0018	14.4%
1.9	59.7	0.0166	0.0020	13.7%
2.0	67.7	0.0188	0.0022	13.4%

Bacteria & Biofilms

For systems operating with this combination of low temperatures and low circulation rates, bacterial proliferation can become an ongoing problem because they multiply rapidly at temperatures between 20 to 45°C.

As flow rates reduced, the bacteria can settle and adhere to the pipe walls.

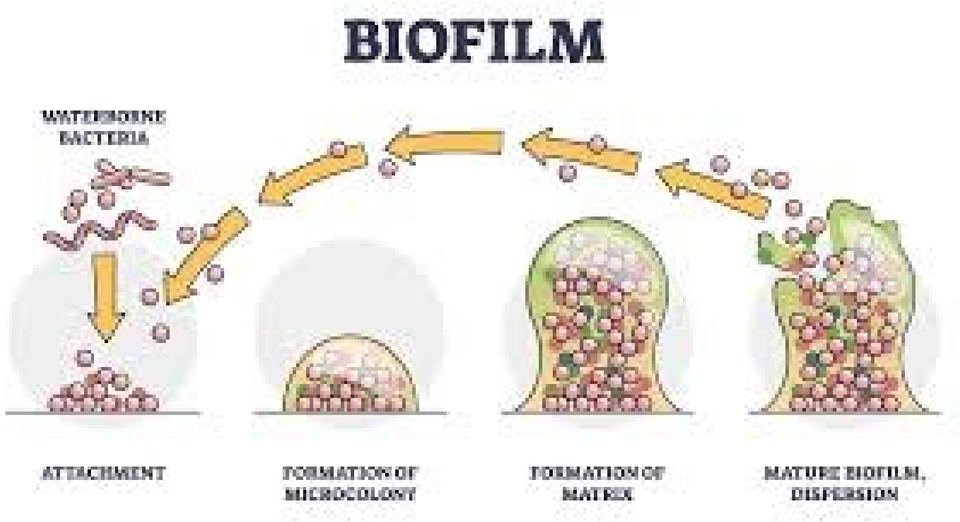
This is particularly relevant where **Pseudomonas spp. are present because these will multiply rapidly and produce a protective layer known as a biofilm.**

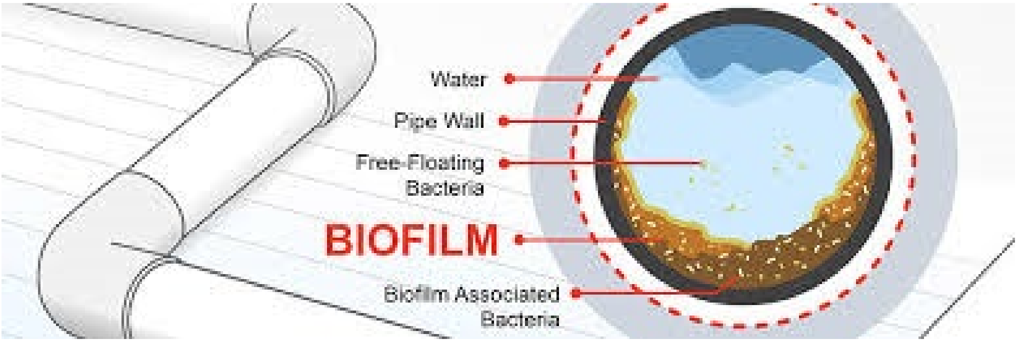


We have lost the sterilising effect

As well as causing a corrosion, a well-established biofilm can reduce flow and heat transfer.

Hence low carbon designs do not have the sterilising effect of high temperatures of traditional heating systems to help control bacteria levels.





Improved Water Monitoring

Hence, it becomes crucial that systems remain dosed with an appropriate corrosion inhibitor and receive regular microbial monitoring which may require a biocide control

For low carbon designs water monitoring will require **greater frequency than traditional systems due to the lower temperatures** which promote growth and the low water velocities which inhibit good chemical mixing.

It is certainly more cost effective to maintain microbial control rather than to try and clean up a system supporting an established corrosion issue or biological biofilm.

Corrosion is very expensive to put right!

Summary

- Heat & Flow Equations!
- Choice Of Pipe Materials & Frictional Resistance
- Water Flow Rate & Control
- Water Velocity
- Water Quality
- Management O&M