Microbubbles Air Dirt Separation in Heating and Chilled Water Systems

Air, or more specifically the oxygen content in the air, that has entered a piped water system during installation or operation, corrodes the steel surfaces in Heating and Chilled water systems, which creates the black sludge known as magnetite. The magnetite collects in comparatively still areas, wears out pump seals, blocks up heat exchangers and fouls valve seats. Entrained air affects the pump's ability to efficiently circulate the water, so increasing the power required to drive the pump. This CPD Presentation is designed to outline the methods for deaeration and dirt separation and illustrate the benefits of installing Stainless Steel air and dirt separators to your new or existing systems.

Air in Systems

Air will be present in piped water systems both as a result of incomplete purging after the system is filled but also due to the release of dissolved air. The amount of air dissolved in the water depends on the temperature and pressure that may be determined and explained using Henry's Law. Henry's Law is that at a particular temperature the amount of gas that will dissolve in a liquid is proportional to the partial pressure of that gas over the liquid – the potential solubility of air in water is shown in Figure 1

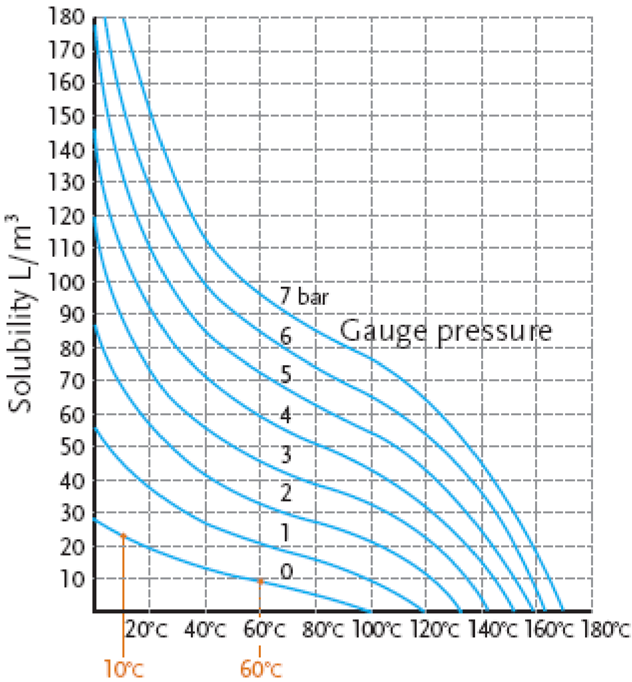

Figure 1: The solubility of air in water

For example, a heating system open to atmospheric pressure (i.e. 0 bar gauge) that is initially full of water at 10°C potentially has about 22 liters air dissolved for every cubic meter of water (22 L/m3). When the low temperature system is heated to 60°C the volume of dissolved air falls to about 10 L/m3 – this released air (12 L/m3) circulates around the system to create the air pockets at high points such as tops of radiators. considering the effect of pressure, for example at a system temperature of 60°C, for every reduction of 1 bar pressure (equivalent to a pipe rise of 10 meters in a building) there is potentially about 11 L air released for every cubic meter of water.

Problems that can occur in systems that are not free from air and microbubbles

Air and microbubbles in a heating or chilled water system cause problems from the commissioning stage; some of the problems are

- Unreliable pressure readings
- Reduced heat transfer from heat exchangers
- Increased production of sludge and magnetite
- Cavitation from pump impellors

By fitting an air removal device the heating or chilled water system will be protected from the possibility

Air and Microbubble removal

Air is typically present in piped water systems as a result of the incorrect bleeding of the system after filling, In addition no matter at what pressure the system is operating, air will leak into the system through ‘microleaks’, seals, glands and by diffusion through the pipe walls. Air will increase system noise and pressure drops, and also increase pumping costs or reduce the pump capacity due to cavitation. Components will be damaged such as the ‘pitting corrosion’ of pump impellors from microbubbles and drawing of valve seats.

Following a correct design process, and using a combination of manual and automatic air vents the bulk of air can be removed from a piped water system. However, when water is being pumped around the system microbubbles cannot be readily removed by our automatic air vent, as the momentum of the water/air passing under the automatic air vent connecting tee does not allow the air to rise into the air vent. When the circuit is not operating air can gravitate in the still water to the top of the system – this is why automatic air vents are normally located at the top of risers.

The Coalescence of Microbubbles In heating & chilled water systems

The explanation for this is simple; the unique concentrator inside the Deaerator allows no direct passage of water straight through the unit. Due to the multitude of fine wires, it is impossible for the flow water to pass directly through. Therefore, all microbubbles eventually come into contact with the filter and the coalescence process takes place.

In the event of increasing head of water the microbubbles do decrease in size. Nevertheless just because the microbubbles are getting smaller this does not mean the microbubbles cannot be removed in this range of water. The explanation is because the microbubbles collide together to make one larger bubble then rise to be vented. However, above 60 meters the efficiency of the unit is reduced.

The principle above is the same for chilled water systems except the 40 meter head of water applies.

Our Separators have been tested & they can remove microbubbles down to 20 microns (0.02mm) in size at six bars with a water temperature of 10 degrees centigrade.

Air separators are normally cheap and rely on relatively low centrifugal forces. They can separate out the larger air bubbles circulating around the system, but will not be able to remove microbubbles because the environment in the vessel remains turbulent, not still.

The Deaerator

The simplest and most common deaerators should be installed close to the point where the bubbles are formed. This is normally the system's hottest point (in a heating system this would be the flow header). As the water cools it will absorb air that then returns back to the boiler, in solution. The absorbed air is then released as the boiler reheats the water and then the following deaerator removes a proportion of the released air until eventually all the air pockets have been automatically removed by the Coalescence process. The water is deaerated to an extremely deep level to the extent that at no point in the circulating system can air be released. The absence of air means oxygen corrosion is also minimized to the point it does not exist.

A Stainless steel deaerator reduces the oxidation which is caused by the rough internal surfaces of mild steel; stainless steel is a far more superior material than mild steel.

The deaerator should always be installed at the hottest point in the system (on a boiler flow or a chiller return for the deaerator to operate properly it must also be located where the static pressure is lower – preferably on the suction side of pumps.

Temperature differential deaeration requires no input from operatives (except for the initial manual venting procedure), and is fully automatic.

Case study:
Reduction of pump power through deaeration – London UK

An existing heating system was designed to supply 103m3/hour (28.6 L/s). However when in operation large fluctuations in flow rate were observed, although, the pump was maintained at a constant speed. The system was monitored both before and after the fitting of a deaeration system. The effect of the deaeration may be clearly seen on the outline pump/system curves shown in Figure 7. Deaerating the system effectively reduced the system resistance so moving the operating point from one to two, employing a smaller impellor and reduced pump head. This reduced the power input to the pump by 31% compared to the original system without a deaerator.

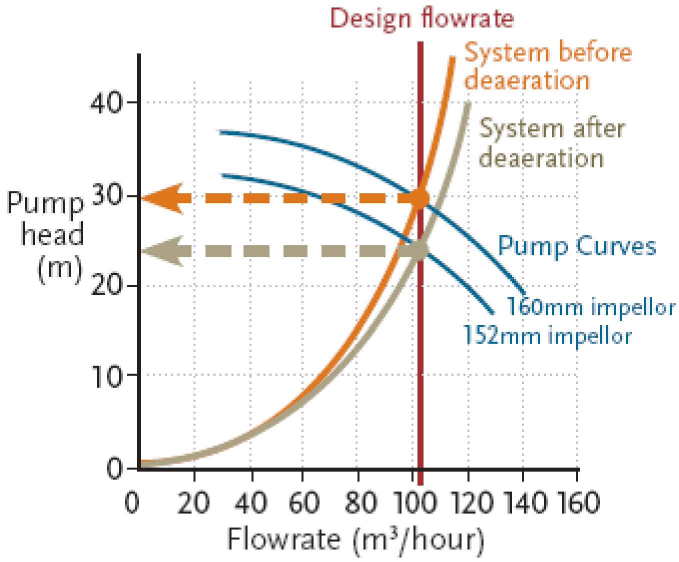

Figure 7: Case study two – pump power reduction through deaeration

The result of air and microbubbles in a heating system

Dirt, sludge and magnetite removal

Dirt, magnetite & Sludge is formed over time in the heating and cooling systems. Dirt & magnetite will circulate a piped water system while they are in use, this can block heat exchangers – particularly more modern low water content heat exchangers; heat emitters and under floor heating pipes become partially blocked and the heat output is reduced.

A common way of reducing particles in piped water systems is to incorporate a filter or a strainer. There is always a compromise when using strainers – large mesh sizes allow larger particles to pass through, while a finer mesh will collect a large volume of particles rapidly, potentially leading to obstruction of the waterway. To prevent problems, and ensure that system performance does not suffer, strainers are provided with apertures that allow all the by-products of corrosion to pass through or they would block the filter. Specialised magnetic dirt separators remove particles down to 0.5µm (compared to strainers that typically only remove down to 1,600µm).

Inline Magnetic Dirt Separator

Manufacturer & BSRIA tests have shown that, during the normal commissioning period, the separator will remove approximately 96% of all circulating material, which can then be ‘blown down’ through the valve at the base of the separator.

In operation a dirt separator would normally be blown down at building handover and quarterly thereafter. Maintenance is typically then no more than five minutes in a year.

Dirt separators can remove any dirt particle, not just magnetic dirt, provided that the particle is heavier than water. As with the deaerator, dirt separators require a still water zone to remove all dirt particles that are heavier than water. Fitting dirt separators into existing systems has reportedly shown impressive reductions in solid matter. One particular independent test saw the dirt content reduced from 620 g/m3 (sized 5 to 10µm) to less than 1 g/m3 of all particulates larger than 0.45µm following the installation of a dirt separator, over a seven-week period.

Case study:
Example of reduced maintenance through dirt and air removal – Sheffield UK

This was undertaken in a department Store built in the 1990s using two-pipe heating systems. An investigation was undertaken comparing the use of air and dirt separators in three similar buildings – one fitted with a combined air and dirt separator; one with a dirt separator; and one with standard strainers

Graph showing cost reduction in % rather than nothing installed.

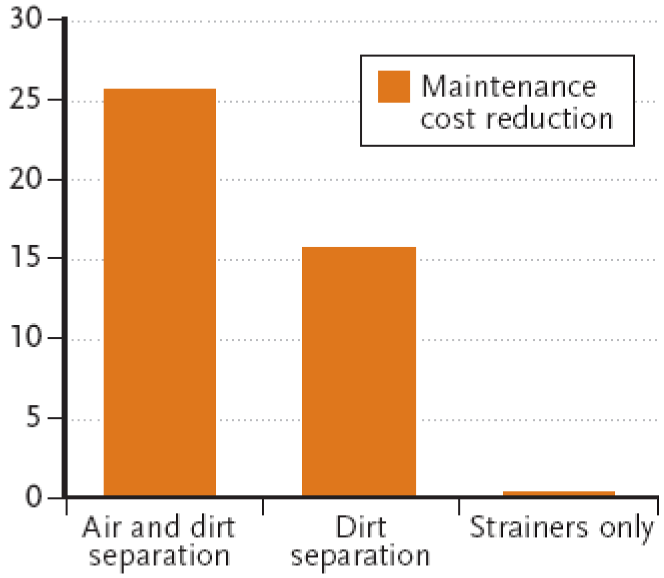

Figure 6: Case study one – impact of deaerators and dirt separators on maintenance costs

The cost of maintenance in the three buildings was recorded and the normalised values are shown in Figure 6. The system with the combined dirt and air separator required far less maintenance to ensure effective operation of the systems by reducing the dissolved air as well reducing the amount of ‘dirt’ in the system by 27 per cent compared to the previous year. By comparison, the system that used dirt separators reduced maintenance by 17 per cent.

Combined deaeration and dirt separation

A combined deaerator and dirt separator reduces the cost and space requirements compared to separate devices.

Conclusion

By achieving an air and dirt-free system components will have an extended life and increased performance. By applying modern deaerator and dirt separator technology this can be achieved to a higher level without the need to clean strainers and without repetitive maintenance requirements. Temperature differential deaerators need little or almost no maintenance, and dirt separators typically require blowing down for the first two to three months – then just a quarterly blow down lasting around 5-10 seconds. Thereafter, pressure differential deaerators require annual maintenance and solenoid valve diaphragm replacement. Hence where on equipment will be reduced, and maintenance costs on heat exchangers, pump seal replacement and radiators will be lower, with consequent improvements in effectiveness and reduced operating costs.

References

Air separation

Fabricated products website for air separation and coalescence:-

http://www.fabricatedproducts.co.uk/air-separators.asp

Dirt separation

Fabricated products website for dirt separation:-

http://www.fabricatedproducts.co.uk/dirt-separators.asp