Boiler life calculations

Trade & Pro

According to boiler manufacturer Vaillant, an average household can reasonably expect a domestic boiler to last 10-15 years although some continue much longer. This time span is conditional and may be considerably less if the boiler and system doesn't receive regular maintenance or for example, if the boiler is the wrong specification for the number of radiators.

There is one common denominator in wet heating systems which is they are susceptible to the effects of rust and corrosion over time. This is because the oxygen in the system water reacts with the metals creating ferric oxide which is the magnetic sludge that lines pipes and radiators more commonly known as magnetite.

Modern boilers condense and remove some of the free air, Automatic Air Vents (AAV) fitted into the pipework at high points also remove the free air but not the dissolved air and gasses.

Whether you have a combi or conventional model boiler the life expectancy is the same and even if they last longer these are less efficient than modern systems even if well maintained.

Over a four-year period, a domestic boiler system's efficiency will deteriorate by a given percentage. This is primarily influenced by:

1. Having the boiler regularly serviced

2. Flushing the system periodically

3. Cleaning magnetic filters if present

4. Prevention of lime scale accumulation in hard water areas

When Airgon is installed, we typically see an increase in performance of around 17% within a 48-hour period. Systems that are relatively clean show improvements of around 12%. Taking this as an average, we can suggest that a domestic system is typically running at 14.5% below optimum.

It is difficult to quantify how much additional wear this deterioration places on a given boiler as the accumulation of air in the radiators which form cold spots would not put as much wear on the boiler as magnetic sludge (magnetite) would. Magnetite is proven to increase stress on the pumps that ensures the water flows around the system, we must therefore assume an even division between them to come to a 'typical' or 'likely' figure.

Assuming that under these conditions a boiler has a maximum expected lifespan of 15 years, the removal of inefficiencies and additional wear placed upon motor components by installing an Airgon that wear is reduced and as a result the lifespan is extended beyond expected limits

If the cumulative effect is contributory to the eventual need for replacement, the reduction in cumulative effect, assuming 14.5% per annum would suggest an average boiler lifespan increase of 6.8 years. The calculations that lead to this estimation are based on the following assumptions:

Magnetite (Fe_3O_4) is formed when iron in the heating system reacts with oxygen and water. This reaction is known as oxidation and occurs under conditions, such as when the water is heated and oxygen is present.

The amount of magnetite formed in a heating system can be estimated based on

1.) the concentration of dissolved oxygen in the water,

2.) the temperature of the water, and the time of exposure.

The actual amount of magnetite formed may vary depending on the pH of the water, the presence of other minerals or chemicals, and the type of heating system.

The reaction for the formation of magnetite from iron and oxygen can be represented as follows:

$4Fe + 3O2 + 6H2O \rightarrow 4Fe3O4 + 12H+$

From this equation, we can see that four moles of Fe react with three moles of O_2 and six moles of H_2O to produce four moles of Fe3O4 and 12 moles of H+. The stoichiometric ratio of Fe to Fe3O4 is 1:1, which means that one mole of Fe can produce one mole of Fe3O4.

to calculate the amount of magnetite that can be formed in a heating system where there are around 125 litres of water, assuming water at pH 7 and a median temperature of 60°C, we need to know the concentration of dissolved oxygen in the water. Assuming that the water is saturated with oxygen at this temperature, the concentration of dissolved oxygen is approximately 9.1 mg/L.

The molecular weight of Fe3O4 is 231.53 g/mol.

Therefore, the maximum amount of magnetite that can be formed in 125 litres of water at pH 7 and a mean temperature of 60°C when the water is saturated with oxygen is approximately 0.284 grams.

If we further assume that as the water cools, oxygen continues to dissolve into solution, we can state that over a period of 12 months will produce approximately 180g to 200g of magnetite. This is considerable and will have a detrimental effect on the performance and life of the heating system if untreated.

A build up at these levels would potentially damage a boiler and / or radiators beyond repair in as little as 2 or 3 years, although the oxygen levels do not always reach full saturation on a daily basis and boiler life is generally expected to be 10 to 12 years, and longer if properly maintained.

Installing an Airgon into a heating system will stop corrosion and prevent the formation of magnetite, ensuring that wear and tear will only occur to the pump and other components at normal operational stresses. This dramatically increases their lifespan to levels commensurate with, or beyond their expected MTBF (Mean Time Between Failure). In the case of boiler components these would typically be:

1. **Boiler shell:** The boiler shell is typically made of steel and can last for 20 to 30 years or more, depending on the quality of the steel and the level of maintenance.
2. **Combustion chamber:** The combustion chamber is where the fuel is burned, and it is typically made of fireproof material such as refractory brick or castable refractory.

The expected lifespan of the combustion chamber can vary widely, depending on the type and quality of the material and the operating conditions. In general, a well-maintained combustion chamber can last 10 to 20 years or more.

3. **Heat exchanger:** The heat exchanger is where the heat from the combustion process is transferred to the water or air in the heating system. The expected lifespan of the heat exchanger can vary widely, depending on the material, design, and operating conditions. In general, a well-maintained heat exchanger can last 10 to 20 years or more.
4. **Burner:** The burner is the device that supplies fuel and air to the combustion chamber. The expected lifespan of the burner can vary widely, depending on the type and quality of the burner, the fuel used, and the level of maintenance. In general, a well-maintained burner can last 10 to 15 years or more.
5. **Controls and valves:** The controls and valves in a boiler system are responsible for regulating the flow of water, fuel, and air and controlling the temperature and pressure. The expected lifespan of these components can vary widely, depending on the type and quality of the components, the level of usage, and the level of maintenance. In general, a well-maintained control and valve system can last 10 to 15 years or more.

Whilst these are general guidelines, they provide an indication of expectations in a well maintained system. We can suggest that under the conditions present following the installation of Airgon, the MTBF levels can be achieved which suggests an extension to boiler component life of 5 to 10 years.

Based on these assumptions we can suggest that:

- There will be an average reduction in the cost of heating bills and carbon footprint of 14.5%
- That the cessation of decay in the system by preventing the formation of magnetite and maintaining radiator efficiency reduces annual wear on the system overall leading to;
- A potential boiler lifespan increase of over 6.5 years whilst also reducing annual It is therefore reasonable to say that installing Airgon into an aged centralised heating system may extend the life of that system by around 7 years.

Airgon Technologies is currently investigating this area with the help of TÜV SÜD National Engineering Laboratories. Results will be available in due course and posted on our website.