TadpoleEnergy

Tadpole Deaerator Preventing inefficiencies in wet heating systems and reducing energy and CO_2.

Reduced energy bills.

Reduced annual maintenance costs and call outs.

Works with all kinds of wet heating systems.

Will prolong the life of the heating system.

No more bleeding radiators.

End of line rads come back to life.

Simple retrofit.

Fit & forget technology.

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![TadpoleEnergy]

Tadpole - Preventing inefficiency and reducing energy and CO_2.

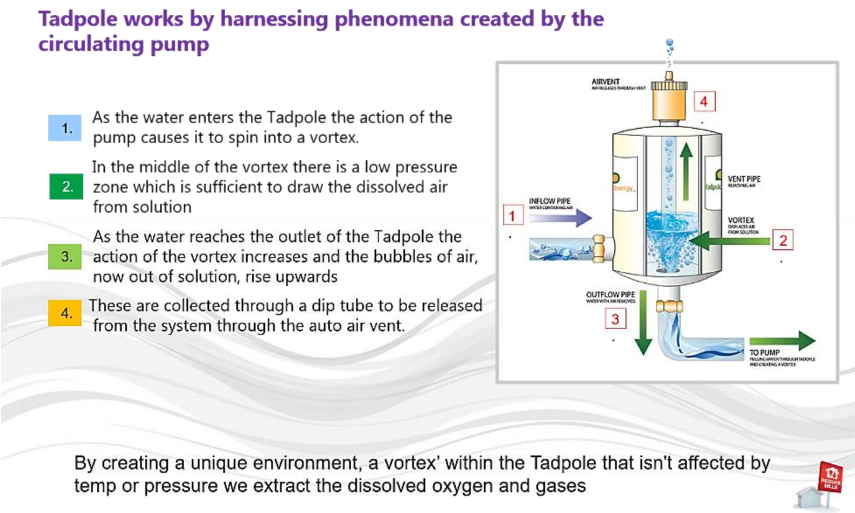
The cost of energy has always been important to any organisation especially in the sectors where these businesses are obligated to provide a stable, comfortable, internal temperature and continuous hot water which cannot be compromised.

As more businesses are required to reduce their carbon footprint, the amount of energy used also becomes an area of scrutiny and consideration. Carbon reporting has cost attached to it so anything that improves efficiency and reduces consumption by more than 5% should automatically be considered.

Tadpole helps businesses reduce costs and carbon emissions by ensuring that heating systems operate at their optimum level of efficiency and preventing deterioration from taking place. Optimising the system can have a substantial impact, reducing the cost of heating and carbon emissions by between 10% and 20% per year.

1. What is Tadpole and how does it work?

Tadpole is a highly efficient deaeration unit that removes dissolved (entrained) gasses from the water in a closed heating system. Tadpole creates an environment within a chamber that extracts the dissolved gasses using a vortex, pushing the air and gases upwards where it is released by an automatic air vent.



This deaeration process has a significant effect on improving system performance and reducing energy usage, which in turn reduces carbon footprint and the cost of heating.

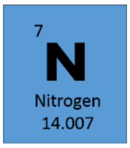
Removing the DO and entrained gasses leaves the system water inert (below 0.5ppm) this halts corrosion and by removing the Nitrogen barrier allows more heat transfer for less fuel. By installing Tadpole into a qualifying system there is a measurable difference in system performance.

2. Henrys Law. C=kP

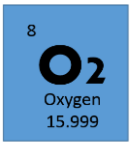
Temperature and pressure have a direct and predictable relationship to the amount of entrained gas in water. This was discovered in the late 19th century by William Henry and is referred to as Henry's Law or Henry's constant.

What Henry realised is that at room temperature under normal atmospheric pressure, around 24Kg of air is dissolved in every 1000 Litres of water, or around 2.4% by volume.

As the temperature of the water rises these gasses are released and at around 80° Celsius, which is a typically the temperature the water reaches as it travels through pipework and into radiators in wet heating system, around 4/5 of the entrained air is forced out of the water. This is an issue because in a closed heating system it is unable to escape with problematic results:



Nitrogen (approx. 78% of the air) creates a thermal barrier by collecting in heat exchangers/radiators which means more energy is required to overcome the barrier to heat a given environment. This causes 'cold spots' in radiators so they don't heat completely or operate efficiently.



Oxygen (approx. 21% of the air) combines with iron and the water in the system to cause corrosion. This results in a Ferric Oxide sludge called magnetite which increases the stress on the pumps and heating mechanisms reducing component life, whilst increasing the need for unplanned maintenance calls, and shortening the life of the system by destroying the physical components.

3. Removal of the thermal barrier.

Within a closed wet heating system, the entrained gasses that are released as water temperature increases, have no means of escape, and so collect in the nearest available chamber, usually a radiator. This can only be overcome by running the boiler for longer to reach the temperature set by the thermostat.

Air is continually being introduced into the system water from a range of instances including but not limited to

- Heating and cooling,
- Pin holes
- Leaking seals and valves
- Topping up system water

Air is also generated as the water is circulated making this effect inevitable.

Tadpole provides the escape route for these gasses which prevents air pockets and cold spots occurring. Radiators continually operate at maximum efficiency and don't need 'bleeding' as there is no air build up in the system to cause the problem. Nitrogen that lines the heat exchangers and radiators is removed.

4. Investigation of bubble behaviours in wet central heating systems

Ali Shefik [1, a] and Yunting Ge[1] [1] Brunel University, Department of Mechanical Engineering, UB8 3PH,

A study published by Brunel University, Department of Mechanical Engineering, sets out in considerable detail the behaviour of gasses in a closed wet heating system, determining predictable qualities based not only on pressure and temperature but on liquid viscosity and the introduction of impurities and additional gasses.

By understanding gas behaviour, in particular the reabsorption rates back into a liquid medium during periods where the boiler is not used, we can determine how effective the application of a Tadpole will be in terms of the amount of impurity addressed and if / how long it will take to achieve an optimum level.

One of the more significant aspects of the study details the absorption rates of these gasses back into the liquid from which they came. This is significant for Tadpole as it illustrates the ongoing efficiency of the apparatus.

Tadpole essentially provides a low pressure chamber where gasses released under temperature and pressure would 'choose' to collect. As they do the pressure increases within the chamber causing release via a one-way valve to exit the system thereby reducing the volume of gas present within the closed environment overall.

This means that there is now less gas within the heating system to be reabsorbed when the water temperature cools, so there is less gas present to cause corrosion and create a thermal barrier and reduce the efficiency of the system.

Gasses (air) are continually being reintroduced into the system which over time continue to collect in radiators and pipework unless the system is 'flushed' and 'bled' periodically. By means of the action thus described, Tadpole removes the need for manual intervention to maintain efficiency by preventing the opportunity for thermal barriers and cold spots to arise.

The magnetite residue produced by corrosion due to the presence of oxygen in the heating water is prevented by removing the oxygen, thereby improving pump life, heating element life, and heating system efficiency.

5. No need for magnetic filters or additives.

Magnetic filters are used to help combat corrosion in a wet heating system. The filter uses magnets to attract particles of magnetite which helps reduce the build-up of sludge in the system.

Magnetite, Fe_3O_4, also known as iron (ll, lll) oxide or ferrous-ferric oxide, is a magnetic naturally occurring mineral.

Magnetic Filters simply remove the product of corrosion but don’t stop it from occurring, they also require regular maintenance which includes removing, disposing of and cleaning the devices.

Magnetic filter manufacturers recommend using additives with their Filters. MagnaClean, recommends additives as part of ADEY's Best Practice System they recommend using MC1+ Inhibitor after installation to protect against further system corrosion.

Additives can remove some Oxygen but not to an inert level, most additives typically reduce the DO level to around 20ppm but additives that contain Oxygen scavengers like hydrazine and sodium sulphite can effectively reduce both DO and oxides to maintain water quality.

However, using multifunctional treatments requires a considered regime, combining alkali, phosphate and polymers for all round protection requires effort. Whilst there are advantages to using sulphite It is difficult to get the right chemical level (over or under dose very easily) Chemical adds to boiler water Total Dissolved Solids (TDS) increasing blowdown requirements

Multifunctional treatments can also accelerate deterioration and the breakdown of boiler components if correct temperatures or pressures are not maintained.

6. Toxicity and impact on the environment

Most additives used in heating system water are classified as toxic - cause skin and eye irritation. Ingestion may cause irritation of the gastrointestinal tract and disposal requires consideration although it is usually drained off into soakaways or nearby land drains when changing the system water. This is also not eco-friendly. Because Tadpole stops the production of magnetite there is no longer a requirement to collect it or dispose of it.

7. Maintaining and managing dosing

Central heating inhibitor has to be changed regularly usually once a year or so. It will break down over time, meaning minerals and rust build up once more. This requires regulating the system's inhibitor intake ensuring it runs steadily and consistently. (dosing) and you should always replace the inhibitor every time your system is drained.

- In our experience, most Dosing pots fitted to commercial systems are not used
- In 4 years of visiting plant rooms to survey and install, our engineers have reported not one was operational
- It would seem that maintenance either runs out of additive or simply forgets to use it. This also applies to sites managed by FM companies
- Magnetic filters are occasionally found in situ but usually don't work or haven't been emptied and even when they are working don't remove the problem

Cost of equipment and refreshing chemicals plus the annual maintenance time and service charges should be considered.

With Tadpole installed there is:

- NO requirement for Additives or Magnetic filters.

The water remains inert – so there is NO product of corrosion because there is NO air or dissolved gasses in the system water.

8. Why are aged systems usually inefficient?

Inefficient energy use in heating systems is often due to maintenance work not being undertaken until there is a system failure or breakdown.

Without a Tadpole installed, systems need to be regularly flushed to ensure removal of any magnetite deposits and trapped air so that the system returns to a state of high efficiency. This is expensive and therefore rarely happens.

Flushing a commercial system typically costs around [1.)] £1200 into multiple thousands and so the installation of Tadpole considerably reduces the cost of preventative maintenance, replacement radiators and boiler parts.

All aged heating systems are in different states of inefficiency, the contribution seen by installing a Tadpole can vary but we expect between a 15-20 percent differences.

As systems are used, the benefits of the Tadpole become increasingly pronounced over time. Typically, the difference between systems where dissolved gasses are removed reduces energy consumption by around 17% as the energy requirement to bring an environment to a given temperature is reduced, and 'boiler run-ons' are cut reducing energy wastage further.

1.) typical cost for flushing is £25 per radiator. 70 bed care home x 1.5 radiators per room £2,625.

9. Carbon Reduction

If you are reducing consumption you are saving Carbon, It is possible to calculate the carbon savings provided by a Tadpole in a domestic environment as follows:

Assumptions

- 1 Metric ton of CO2= 5346.715 kW/h gas burned
- Boutique Hotel (20 bedrooms) with restaurant typical usage 860,000 kW/h per year of which approx. 50% is heating system use
- Tadpole installation and usage reduces prior energy consumption by 17%

Based on the above the expected CO2 reduction can be calculated:

17% of 430,000kW/h = 73,100 kW/h, equating to approx. 13.67MT CO2 (16,670kg) per annum.

10. Tralee Institute of Technology reports

Tralee IT (now renamed MTU) is an Irish University and Accredited Test House with a long standing commitment to renewable energy and has a level 7 and 8 renewable energy management course.

In 2016 The commercial Tadpole was tested on a primary school with 300 pupils. The school operated a 4 zone oil fired De Dietrich GT 339 330Kw sealed heating system, considered at that time to be state of the art.

The dissolved oxygen was initially measured at 2.7ppm and the average value achieved during the test was 1.46ppm. When the Tadpole was switched into the system the D.O. went from 3.8 to 0.7 ppm in 25 minutes and maintained an average value of just under 0.5 ppm for the remainder of the test.

The results were conclusive and mirrored the earlier tests on the Domestic Tadpole carried out in June 2010.

Over the three weeks when the Tadpole was installed the average fuel consumption was 17.87 L/hr. This was at an average outside temperature for Tralee of 6.8°C.

The report identified that with the Tadpole removed the system was less efficient. The average oil consumption during the three-week period was 20.41 L/hr. This was with a warmer outside average temperature of 8.2 ° C, 1.4 ° C warmer than when the system was tested with the unit installed. The savings in this case were calculated at 22.76 % in favour of the Tadpole installed in the system. Again, referring to domestic tests carried out in June 2010 similar efficiencies (23.71%) were achieved when degree days were taken into consideration to calculate energy savings. The full test reports are available upon request.

11. Measuring results (degree day methodology)

Heating energy consumption depends in part on external (weather-related) temperatures.

Therefore, we use heating degree days which are a measure of how much (in degrees), and for how long (in days), the outside air temperature was below 15.5°C to analyse the energy consumption pre and post tadpole installation.

1	2	3	4	5	6
Month	Degree days (hWh)	Actual consumption (kWh)	Predicted consumption (kWh)	Difference (kWh)	CSUM
	From published or self-calculated values	From meter readings	Slope x Column 2 + intercept	Column 3 minus Column 4	Cumulative sum of figures from Column 5

The base temperature of 15.5°C is used because at this temperature most UK buildings do not need supplementary heating.

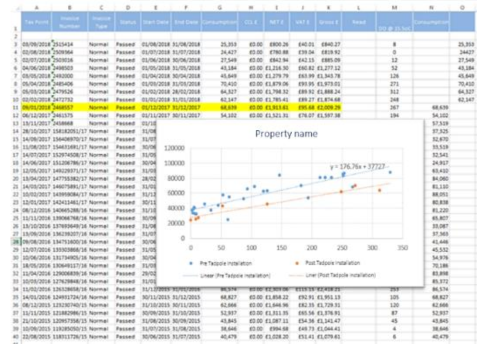
By using Degree-day analysis, we factor in the outside temperature. Degree days are not specific to the building being monitored only the postcode, but it is the best and only way of measuring before and after without the precise temperature data of an external and internal temperature logger. Therefore, using weather compensation improves the accuracy of the measurement if we are to make a baseline and measure historical consumption against new.

The other consideration is the energy data month on month by year is never constant because no measured day is exactly the same. However, where consistent supply exists it is possible to create normalisation and a baseline. For example, in Private Care home and NHS sites there is a requirement for a consistent space temperature and constant DHW because of these factors there is usually parity on monthly and annualised consumption. Private Care home and hospitals, offices and most commercial environments have similar heating demands year on year, this is outlined in the next paragraph.

12. Methodology

Step 1 - Collection and processing of energy and degree day data.

We plot the monthly gas consumption (kWh) against monthly degree days over a 2-3 years' period before each Tadpole device was installed.



Step 2 - Obtaining a pre-installation performance line.

The graph of space-heating energy consumption against degree days shows a relationship between the two. We then generate a performance (trend) line and its equation which is an expression of how much energy the building can be expected to use for a given number of degree days.

Step 3 - Calculating post installation cumulative savings against the pre-installation performance line equation.

13. Measuring Improvement in System Performance

There are many ways to measure the impact a device has on boiler and heating system performance. Most require installing sub-meters on the heating fuel (Gas) supply. Monitoring the flow and return, installing thermostats in rooms and on radiators and factoring external weather compensation.

These types of tests require stringent clinical parameters, Energy Management Software and remote monitoring using specific data collection and data-logging equipment to get the level of accuracy required by, for example BRE.

To satisfy the requirement of the public sector or to achieve a SAP rating these types of tests will cost around £8 ,000 to £50,000 for a comprehensive report. However, the difficulty with these tests is there is no one size fits all scenario with aged heating systems because they are all specific to the building they heat. Importantly, we are not improving boiler performance we need to measure Tadpole performance. The impact that Tadpole has on heating fuel consumption and CO2 in a given system varies because each system is unique.

Systems degenerate at different rates and over different periods of time. As a result, Tadpole's effect is determined by the level of inefficiency being corrected. The net result is similar, the boiler uses less fuel, and the heat transfer is improved at less cost.

As an example let's consider that a 4 -5-year-old boiler system can have reductions in efficiency due to Nitrogen of between 15% -30%, this translates directly into an additional energy requirement to heat a given environment. By removing the nitrogen Tadpole effectively reduces the cost of heating by that percentage as efficiency is restored. The important element is that this can be measured.

14. Will Tadpole work on a New System?

Yes, but it won't be a quick win. We are not saying that Tadpole improves the performance of every wet heating system because if a system is new, it will already be optimised and therefore cannot be improved. Conversely, there is still benefit in installing a Tadpole in a new system. There is the immediate benefit of removing Nitrogen from the heat exchanger/radiators and improving heat transmission and by maintaining optimum levels extend the life of the system.   However, these benefits are difficult to quantify as every system would deteriorate at different rates.

There haven't been any long term studies completed on new systems because it would be necessary to measure two identical systems in the same environment over an extended period, (4-5 years) one with Tadpole installed and one without, but there is little doubt there would be a significant difference if one system was fitted with Tadpole and one wasn't.

Tadpole doesn't directly reduce the amount of energy a boiler uses but as boilers age and systems degrade, they become inefficient.   Air, dissolved gasses, especially Nitrogen builds up in the pipes and radiators causing decay and air pockets. Ferric oxide becomes Magnetite sludge which settles in the lower parts of the system and creates blockages

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So, Tadpole doesn't make a system more efficient it makes a system efficient by correcting the percentage of inefficiency that exists in that system. Tadpole doesn't improve the efficiency of the boiler it improves the percentage of heat that can be delivered into a specific environment

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