Maintenance: A Matter of Savings, Comfort and Legal Compliance

Performing regular maintenance checks for air conditioning systems is crucial to achieving optimal performance, yet it is not a standard practice in today's market. This article explores why taking a proactive stance on air conditioning maintenance is advantageous to attain higher performance and meet current legal regulations.

Keywords: maintenance, (energy) savings, comfort, legal compliance, monitoring, preventive, inefficiencies, EPBD, F-gas

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Regular maintenance service for air conditioners is not a requirement or market standard. In fact, most companies tend to use a more reactive method when servicing their air conditioner. For example, 33% of companies in the U.K. do not maintain their assets (Rexroth Bosch, 2016), which means they only seek maintenance services once an issue occurs.

At first, an end user may assume a reactive maintenance method is a smart choice because they believe if a system runs smoothly, there is no need to pay for regular service checks. However, the buyer will soon realise the price they pay for reactive maintenance services can add up, and over time, they may end up paying more to repair their installation than for a service expert under a regular maintenance contract (Sullivan, Pugh, Melendez & Hunt, 2004).

A study by Plant Engineering (2014) comparing the cost-effectiveness of maintenance methods supports this outlook. According to the study, only 30% of buyers who chose a reactive maintenance method listed their system as "cost-effective overall," in comparison to 50% who chose a regular maintenance method (Plant Engineering, 2014).

However, cost-effectiveness is not the only benefit of regular maintenance; there are also plenty of other opportunities to consider. In this article, we want to identify these opportunities by looking into the adverse effects of reactive maintenance and how regular maintenance not only improves an air conditioner's performance but can also help systems meet current regulations.

The drawbacks of reactive maintenance

Before looking at the advantages of regular maintenance, it is essential to understand how reactive maintenance can impact a system and reduce its performance over time. To illustrate this point, let's take a closer look at the various ways reactive maintenance lowers the energy efficiency of a product.

Refrigerant

Contaminants in refrigerant can build up if an air conditioner is left unchecked. These contaminants range from excess oil to the presence of moisture to non-condensable gas, and when present in specific amounts, these elements can reduce a unit's energy efficiency and performance (Jones & Harkins, 2005; Klemes, Smith & Kim, 2008; Sine, 2006). On another note, it is also necessary to check the quantity of refrigerant in an air conditioner to achieve on average 29% more energy savings (Knight et al., 2010).

Fouling

Fouling, or the build-up of material in an air conditioner, also significantly impacts an equipment's energy efficiency. According to the Department of Energy Climate Change & Energy Efficiency (n.d), a build-

up of 0,6 mm of fouling on condenser coils can cause 20% more energy consumption. This spike in energy consumption can also occur if microbes appear in tubes with sticky lime deposits which can reduce heat transfers by 15%, and the potential to decline 10% - 20% more if iron is present (Clark, 2005).

Wrong configuration

If a unit is setup incorrectly, there is a risk the system will not only consume more energy, but also miss energy-saving opportunities. For instance, a condenser fan can attain around 4% more energy savings (Knight et al., 2010), but only if a maintenance operator configures it correctly.

From these drawbacks we can conclude that the more inefficiencies present in an air conditioning system, the more likely it is a product will need to consume more energy to meet customer demands. Furthermore, the cost to fix these issues ad hoc with reactive maintenance will add up over time and become more expensive than investing in a regular maintenance plan. For example, dirty coils causing an increase in condensing temperature from 35 to 40°C can lead to an estimated €250 additional costs (in a 35 kW unit operating 2.000 hours per year) (AIRAH, 2013), but a maintenance operator can clean them for a fraction of that price.

Besides the impact on energy efficiency, reactive maintenance can cause system breakdowns, which are a loss of time and money for end users, but also discomfort.

- For customers, a system breakdown leads to exposure to extreme temperatures and can trigger avoidance behaviour (Bohl, 2012) with negative attraction and affective feelings towards strangers (Lam, 2001). It might cause customer dissatisfaction and impact the purchase intention.
- For employees, poor air quality inside office buildings can decrease productivity up to 9% (Wyon, 2004), while another study concludes creating comfortable temperatures in an office can save up to 2 euros per employee per hour (Witham, 2007).

Based on this research, we can see the costly drawbacks of choosing to service an air conditioner based on a reactive maintenance method. But let us go a step further to see just how a preventive maintenance method is a smart choice for end users.

The benefits of preventive maintenance

Preventive maintenance allows the customer to increase the energy efficiency of their unit and ensure continuous comfort. By establishing a fixed maintenance plan, product deterioration and potential breakdowns are avoidable because a maintenance operator can detect issues immediately and take the right steps to make sure a unit performs at optimal levels. Regular maintenance can also extend the lifetime of a product. For example, a chiller's lifespan can be increased by 50% (Firdaus, Prasetyo & Luciana, 2016). Furthermore, preventive maintenance can save between 12% - 18% on average on costs (Sullivan et al., 2004).

However, the main drawback to regular maintenance is that it does not protect the customer against catastrophic failures, and there is the chance that an operator does not detect all energy inefficiencies. To mitigate this disadvantage, it is worthwhile investing in a maintenance plan that also includes remote monitoring.

Rely on remote monitoring

Monitoring systems are a valuable investment for regular maintenance plans because they can pinpoint additional energy savings and detect abnormal installation behaviour. By tracking and measuring data, a remote monitoring system can take the right steps to prevent system breakdowns and deliver continuous comfort.

A study (i.e. iSERVcmb) supported by Europe Energy Intelligence finds that a combination of "measuring and logging" and inspections is the best way to avoid wasted energy and achieve long-term savings. Such was the case when the study found the McKenzie House of Cardiff University used 28% less energy when it adopted "measuring and logging" as part of its maintenance plan (European Commission, 2014).

It is clear there are many benefits when selecting a regular maintenance plan when it comes to energy performance and savings, but periodic checks for air conditioning systems are also essential to meet current legal regulations.

Legal compliance

In the European Union, preventive maintenance plans must include a mandatory F-gas check (EU NO 517/2014) and an inspection of your air conditioning system (Directive 2010/31/EU).

Since 2015 the F-gas check applies to all HVAC-R equipment containing fluorinated greenhouse gases (if >5 tons of equivalent CO_2). Depending on the F-gas charge, the installation must have a maintenance operator check the equipment a certain number of times a year (see **Table 1**), but the number of visits will be less if the equipment includes a leakage detection system.

In addition to the F-gas check, an air conditioning installation (if > 12 kW) also needs a regular inspection to meet the European Performance of Buildings Directive (EPBD). The number of visits, however, may be less frequent if remote monitoring and control systems are in use. According to the EPBD:

> "Member States shall lay down the necessary measures to establish a regular inspection of the accessible parts of air-conditioning systems of an effective rated output of more than 12 kW. The inspection shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building"
> (European Parliament & Council of European Union, 2010).

The EPBD allows countries to posit a different measure for inspection, but this option is not popular among member states because the majority already use the current inspection scheme. To ensure each inspection meets the requirements set by the EPBD, a CEN standard was made available (EN 16798-17:2017: Energy performance of buildings. Ventilation for buildings. guidelines for inspection of ventilation and air conditioning systems). It outlines the inspection methodology and requirements.

The current EPBD came into force in 2010. However, it was revised this year. The amendments were published in the Official Journal of the European Union on June 19, 2018 (EPBD 2018/844). The Member States have to incorporate this Directive into their legislative system within 20 months.

This revised EPBD (European Parliament, & Council of European Union, 2018) includes the following changes:

- Extending EPBD's scope to the accessible parts of combined air conditioning and ventilation systems
- Increasing the effective rated output from 12 kW to 70 kW
- Taking into consideration the capabilities of air conditioning or combined air conditioning & ventilation systems during inspection to maximize performance
- Requiring non-residential building owners to equip air conditioning and combined air conditioning & ventilation systems (greater than 290 kW) with automated control systems by 2025
- Exempting non-residential buildings from inspection if they fulfil the measure regarding automated control systems (similar inspection exemption for residential buildings)

Table 1. Frequency of visits depending on the F-gas charge measured in CO_2 tonnes equivalent.

Leak checks frequency	Tonnes of CO_2 equivalent	Refrigerant			
		R410A (kg)	R407C (kg)	R134a (kg)	R32 (kg)
12 months	5 ≤ t CO_2e < 50	2.4 – 24	2.8 – 28	3.5 – 35	7.4 – 74
6 months	50 ≤ t CO_2e < 500	24 – 240	28 – 280	35 – 350	74 – 740
3 months	t CO_2e ≥ 500	≥ 240	≥ 280	≥ 350	≥ 740

Conclusion

Operating under a reactive approach leads to various drawbacks that range from inefficient systems to long-term issues to discomfort for end users. In contrast, end users who choose preventive maintenance can guarantee the optimal condition of their equipment and further enhance their energy savings and comfort by combining it with remote monitoring. On top of these benefits this approach ensures the owners comply with the legal regulations regarding F-gas and EPBD Directive. ■

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