health estate journal

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JOURNAL OF THE INSTITUTE OF HEALTHCARE ENGINEERING AND ESTATE MANAGEMENT

Coastal protection from an air-handling perspective

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Coastal protection from an air-handling perspective

David Livingstone, a Chartered Engineer, and the managing director of DRLC, Consulting Engineers, discusses some of the key considerations for healthcare engineers to ensure that the performance of air-handling units in hospitals located in coastal areas is not compromised by corrosion created by the increased concentration of salt in the local atmosphere.

When you hear the phrase 'coastal protection', what images does it conjure up? Robust piles of large stones carefully constructed to protect the shoreline from eroding? Wooden groynes stretching out to sea to prevent the sand on the beach from disappearing?

The United Kingdom is made up of a number of islands. Coton in the Elms, a village and parish in Derbyshire, is 70 miles from the coast, which makes it the furthest place in the UK from coastal waters, and is equidistant from Fosdyke Wash in Lincolnshire, White Sands between Neston in Cheshire and Flint in Wales, and Westbury-in-Severn in Gloucestershire. The UK coastline as measured by the Ordnance Survey is about 11,073 miles long, and if the larger islands are added, the coastline as measured by the standard method at the Mean High Water Mark rises to about 19,491 miles. Thus inevitably many hospitals find themselves in close proximity to the sea, which has consequences for the fabric of the building and associated plant, due to the increased concentration of salt in the atmosphere

The Cornish coastline. There are potential risks to both the fabric and plant and equipment of hospitals located in close proximity to the sea, due to the increased concentration of salt in the atmosphere.

Mitigating the effect of sea air

However, what happens when sea air is drawn into the fabric of a hospital? Is this also capable of causing problems, and if so, how can we, as hospital engineers and designers, mitigate the effect? This article deals with the specific case of air-handling units ('AHUs') in hospitals which are deemed to be in coastal areas. Interestingly the design advice, Health Building Note 00-01: *General design guidance for healthcare buildings*, currently does not include any specific advice on design of healthcare premises which are near the sea.

The Cornish coastline

In my field, as an Authorising Engineer – Ventilation, there is guidance on the necessary protection of air-handling units sited within five miles from the sea or tidal rivers. This article will explain how the environment in coastal areas affects the integrity of AHU plant, which parts of an air-handling unit are mostly affected, how environmental conditions can accelerate the rusting process, what the appearance of rust means to the efficient and safe operation of the AHU, and some of the measures which can be taken to protect the plant.

Coastal corrosion of AHU plant

Coastal corrosion can affect any part of a hospital building. A well-publicised case involved the new Isle of Wight hospital, St Mary's, where, 18 months after the building was opened in 1992, the stainless steel cladding was beginning to show signs of corrosion, particularly at the junctions of the cladding, where trapped water was causing the metal sheets to corrode. The defects were investigated, and it was discovered that the salt-laden sea air which blows over the Isle of Wight was having a deleterious effect on the outside of the hospital.

Metal corrosion accounts for 40% of the premature failure of AHU plant and equipment. Heating, ventilation, and air-conditioning (HVAC) plant located in outdoor environments up to eight miles from the coast or tidal estuaries is constantly exposed to moist, salt-laden air. The combination of water, salt, and untreated metal surfaces, provides the ideal conditions for the formation of ferrous oxide – commonly known as rust.

Air-handling units draw in outside air to provide filtered interior air to hospital buildings. Therefore the quality of the outside air is vitally important to the ultimate quality of the interior air. In buildings which have been designed to have natural ventilation systems – cooling stacks and opening windows – there is no need to use ventilation plant. However, healthcare premises, where clinical procedures are carried out, by necessity have air-handling systems which are categorised as 'Specialised ventilation units', and their design and operation is specified in HTM03-01: *Specialised ventilation for healthcare premises – Part A*.

Many factors behind premature plant failure

Wind conditions, humidity, prevalence of foggy conditions, temperature, and proximity to the source of salt water, are all factors which may result in premature failure of plant and equipment. In the case

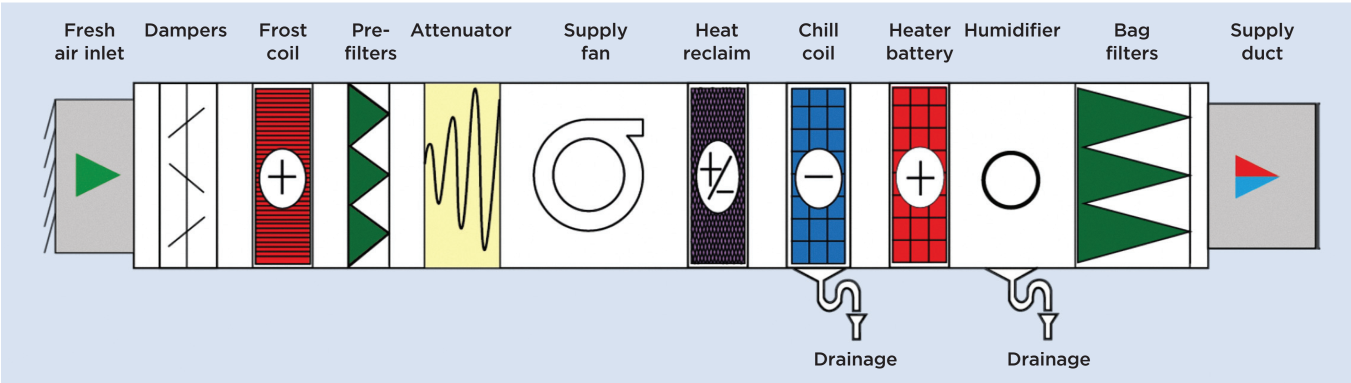

Figure 1: Diagram of a typical air-handling unit used in hospitals.

of air-handling units, the intake section must be sited to allow the intake of fresh air. This often means that the plant itself is sited outdoors. Even where the majority of the plant is housed inside a building, the intake itself must be open to the outside air. Figure 1 shows a schematic of a typical AHU used in NHS hospitals.

The corrosion associated with air laden with salt and water primarily affects the supply ductwork and the HVAC heat exchanger known as a 'Frost coil' or 'Fog coil' (see Fig. 1). The AHU itself draws in air from the atmosphere immediately outside the hospital. The air intakes of the AHU are often on the roof of buildings, or at a high level in a plant room through a louvre, with a vermin grille protecting the extract duct. A critical ventilation AHU contains a series of filters, typically four pre-filter panel filters and four F7 bag filters. The denomination of filters is associated with the size of particle that gets trapped in them. A G4 filter traps 80% of airborne particles larger than 10 microns in size, the dimension of flower pollen. The F7 bag filters are designed to remove smaller particles of contaminants from air which has already been through the pre-filter panel filters.

Exposure to salt-laden air

In a coastal area, where sea salt is in the air, pre-heating the incoming air by using the frost coil as a fogging coil to reduce the humidity will effectively remove the effects of the airborne salt in the first section of the AHU. However, this means that the salt-laden air has travelled through the air intake and vermin grille, through the attenuator, over the motorised damper, and past the fog coil, before it hits the first panel filter. Thus these parts of the AHU will inevitably be exposed to salt-laden air, and are liable to increased corrosion when located in a coastal area – particularly the ducting of the AHU, and the casing of the fog coil (see Fig 2).

Rust at the base of a frost/fog coil

This corrosion can be predicted in a coastal setting, and therefore the design of AHUs in coastal areas needs to take it into account. Measures that can be taken include ensuring that the vermin screen – which protects the fresh air inlet from ingress of outside objects, such as leaves, and also prevents the AHU from being invaded by small mammals and birds such as pigeons, is made of stainless steel. In addition, the fresh air intake ducting needs to have a rust prevention coating. Following the path of the salt-laden air, it also makes sense to provide the fog coil with a casing made of stainless steel. These are all measures which add cost to a project. I have seen a case where the coastal protection was 'value engineered' out of the hospital building project. Now, the air-handling plant at this particular coastal site is failing, due to excessive corrosion, after only 10 years, when ordinarily the type of AHU plant and ductwork installed in hospitals has a working life of over 30 years.

Environmental factors which influence rapid corrosion

The rate of corrosion of unprotected metal components sited in proximity to the coast is accelerated by a number of factors. Increases in humidity will have the effect of hastening the production of rust, as the water acts as an electrolyte in the chemical reaction between iron and water, which produces ferrous oxide. Chemical reactions are generally temperature-sensitive. Increases in temperature will cause a faster reaction rate. As the global temperature rises, due to global warming, this type of corrosion enhancement will become more important.

What is the problem with rust in an air-handling unit?

The air intake components of a typical AHU are not under tremendous physical forces, so it is reasonable to ask why it matters if these parts of the plant show a surface covering of rust? The rust may not penetrate the steel ductwork for many years, so why is it considered such a serious issue? The answer lies in the chemical structure of the rust itself. The oxygen contained in the ferrous oxide compound is known to feed certain bacterial species. These species of bacteria metabolically utilise solid iron oxides as a terminal electron acceptor, thereby reducing Fe (III) oxides (FeO_3) to Fe (II) (FEO_2) containing oxides. The bacteria capable of existing on a rusty surface include *Shewanella oneidensis*, *Geobacter sulfurreducens*, and *Geobacter metallireducens*.

As the main function of a hospital air-handling unit, and especially those

Figure 2: Rust at the base of a frost/fog coil.

supplying air to critical areas such as operating theatres and isolation rooms, is to supply very clean air, it is not desirable to have bacterial growth within the plant that is delivering the air.

Measures to protect AHU plant in costal locations

As previously mentioned, the intake section of the plant – fresh air inlet, supply duct, dampers, and frost coil – can be originally installed made of stainless steel. In the event that the original installation is formed from untreated steel, and has started to rapidly corrode, there are a number of things that can be done to stop the rust. Vulnerable areas of the AHU can be given a protective coating. Various types exist, including polyurethane coatings, epoxy resins, and fluoropolymers. Another alternative to is give the exposed metal parts an electro-coating, which will provide a corrosion-resistant layer on the surface of the plant. If the rust has progressed to the point where the supply duct is perforated, then there is no option but to replace the damaged section or the entire plant.

Conclusion

Any building situated in a coastal area – which is defined as anywhere within eight miles of the coast or a tidal river – is open to the risk of rapidly accelerating corrosion of the external unprotected metal components of AHU plant. The coastal conditions of humid, salt-laden air with mild temperature conditions provide an ideal environment for the chemical reaction between iron and oxygen, which produces rust. Rust within an air-handling unit can result in the growth of bacteria within the plant itself, which is less than ideal for a building service component primarily used to supply clean air, particularly to operating theatres, Critical Care Units, and isolation and treatment rooms.

Hospitals situated near the coast can design their air-handling units to include coastal protection design features – for example ensuring that components exposed to external salt-laden air are manufactured from stainless steel, and employing building energy management system control strategies to pre-heat the air using the frost /fog coil to reduce the humidity of the incoming air. If the plant has already started to show signs of accelerated rust, the affected areas can be treated with a variety of coatings, or, in very badly damaged plant, the replacement of coils, or even the AHU itself, may be the only practical solution. **hej**

David Livingstone

David Livingstone, an Authorising Engineer and corrosion professional, is a Chartered Engineer, and the managing director of DRLC, Consulting Engineers, which works mainly with NHS Trusts, supplying technical expertise and Authorising Engineers in the areas of Ventilation, Fire Safety, and Pressure Systems.

David Livingstone started his engineering career as an apprentice Marine Engineer in the Merchant Navy, working his way up to achieving qualifications as a Second Engineer, and obtaining his steam ticket. He worked on a variety of ocean-going ships, including container carriers and oil tankers. On coming shoreside, he got his first post in the NHS as an engineer in the Estates Department of the Northern General Hospital in Sheffield, one of the largest hospital sites in England. Seeking a variety of engineering experience, he moved from NHS estates maintenance to delivering engineering projects for Sheffield Hallam University, and then on to becoming head of Estates for another large NHS Trust – Nottingham University Trust, which at the time comprised the City Hospital and Queen's Medical Centre.

His NHS career culminated in a role as director of Estates and Facilities at the Princess Alexandra Hospital in Harlow, Essex. He launched DRLC in 2016, with a view to providing Authorising Engineering Services to healthcare providers.

The company has grown over the past three years, and now provides Authorising Engineers for Ventilation, Fire Safety, and Pressure Systems.

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Reducing Covid-19 transmission by Ventilation Systems

- ✔ Check ventilation ductwork from intake to pre-filter annually and clean if required
- ✔ Air Scrubbers play a part in clean air systems however ensure a maintenance policy is agreed and that they are on the Asset Register
- ✔ Wall mounted Air Conditioning Units are prone to throw the air across rooms. Restrict their use in Healthcare premises to the minimum
- ✔ HTM03-01 (2021) guidance is to inspect Critical Ventilation Quarterly and carry out Annual maintenance
- ✔ Treatment and waiting rooms with opening windows can use natural ventilation to dilute any airborne virus
- ✔ Ensure AHU filters are checked regularly and when they are changed check they are fitted correctly. A filter with an air gap will not deliver clean air.

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- ✔ AHU being newly installed or refurbished should be fitted with EC plug fans
- ✔ Large belt driven fans which use a lot of energy can be effectively replaced by fan walls
- ✔ Plan to upgrade old AHU units – the cost of replacement can be recouped by the energy savings from new plant
- ✔ Ensure filters are kept clean as this reduces the power required to drive the fans
- ✔ Inspect ventilation ducts and repair any leaks
- ✔ Switch off ventilation that is not required
- ✔ Ensure all new and refurbished plant has an energy recovery unit

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