Keeping it Fresh

POOR QUALITY AIR – CAUSES AND CURES

When we think about HVAC failure the terms of reference are usually temperature. However, although that is a vital component and contributes to high quality air it's not the only aspect. The writers of this article show that interior temperature should be much higher than many realise and if shiveringly low it may indicate a failure. Here Larry Beard, owner of the Beard Marine Group – who has worked with the marine air-conditioning industry for the past 33 years – and Patrick O'Donnell, who is a Certified Indoor Environmental (CIEC) and forensic investigator of indoor air quality in buildings for the past 35 years and a consultant on vessels, bring their combined 68 years of HVAC expertise to bear by explaining the ins and outs – literally in some areas – of keeping the air fresh and clean as well as cool.

When the indoor environment aboard our vessel is comfortable and relatively odour free we may not give much thought about the indoor air quality. However, when individuals sense malodours, feel uncomfortable, or experience health related symptoms such as headaches, fatigue, nausea and allergy symptoms while aboard the vessel and then notice that symptoms improve when they leave the vessel, this could be an indicator of poor indoor air quality (IAQ).

Many years ago we considered the heating ventilation air-conditioning system (HVAC) to be operating satisfactorily as long as it produced warm or cool air when needed. However, like everything else, things change and in the last few decades researchers have found a number of concerns with the indoor air quality and its impact on human health. Ironically the same mechanical systems that we rely on to provide an acceptable IAQ comfortable environment may be in fact causing problems.

To make matters more complex, vessels – unlike many modern buildings – are subject to significant changes in the outdoor environment and these dynamic conditions can adversely affect the IAQ. For instance, a vessel operating in a cold environment experiences significantly different conditions than when it is in hot and humid conditions such as the tropics.

Indoor Air Quality

We expect our HVAC systems to maintain acceptable indoor thermal comfort and IAQ conditions regardless of whether it's cold and dry or hot and humid outdoors. But we need to understand some of the HVAC's limitations depending upon the environment in which we're operating. In addition, in order to properly maintain acceptable indoor air quality we need to understand that we have to provide a certain amount of outdoor air ventilation to control/mitigate contaminants (that is odours, CO_2, particulates, volatile organic compounds, microbiological agents). If the HVAC system is not properly introducing enough outside air to dilute these indoor contaminants, it would not be unusual to hear complaints of discomfort from occupants as a result of poor IAQ. Common problems associated with poor indoor air quality are often associated with the operation and maintenance of the HVAC system. These problems include (but are not limited to) poor air temperature and relative humidity control, poor outdoor air ventilation and failure to maintain appropriate relative pressure differences within the vessel.

Image 1: Dirty ductwork can introduce mould, dust and other irritants into the indoor air.

Image 2: This cooling coil is clogged with debris and mould. This is caused from poor air filtration and a lack of proper service.

Image 3: A technician is performing air balancing to correct indoor air quality problems.

Image 4: Condensation on ductwork. This causes mould growth and in the long term the duct will fail due to rusting.

Cold Climate Conditions

In cold climates (and most airplanes) it is not unusual for us to find that the relative humidity is so low that occupants complain of eye irritation, irritation of the mucous membranes and drying of the skin. Very low relative humidity can also cause problems: furniture wood shrinkage, static build-up in electronic equipment and damage to certain artwork like canvas paintings. To make matters worse, when it gets cold outside the vessel tends to be sealed up pretty well (that is port holes, hatches and doors closed). With a tight environment (without sufficient outdoor air ventilation) the indoor air can get stale. Stale air along with those infected with colds and viruses can increase the number of infectious agents in the air, resulting in further individuals becoming sick.

Hot and Humid Climates

Tropical environments generally offer some comfortable outdoor temperatures and good cruising. However, heat and humidity present their own challenges to the vessel. Ideally, you should be looking to maintain indoor temperatures in the range of 72°F (22°C) to 78°F (25°C). When we see low temperatures (relative to those values) indoors it suggests that there may be a problem with the moisture-removal capability of the HVAC system. For example, shutting down one stage (or more) of a chilled-water system (one or more compressors off) may result in a less than optimum chilled-water temperature at the fan coils, resulting in poor relative humidity control indoors. Ideally, the leaving water temperature at the chiller should be at least 45°F (7°C). When chilled water temperatures rise to 48° (9°C) and above the ability of the cooling coils to dehumidify the cabin is reduced or eliminated.

In summary, monitoring indoor air temperature and relative humidity is a worthwhile endeavour to address these parameters effect on indoor air quality. The industry accepted maximum relative humidity should be no more than 65% and the minimum is around 30%. If conditions do not fall within these ranges, or if you are seeing condensation forming on the inside of the windows or the interior of the hull then an evaluation of the HVAC system is warranted to determine if humidification and/or dehumidification is required.

Musty and Mouldy Odours

Besides making the indoor environment uncomfortable, elevated relative humidity conditions can result in mould growth and

Image 5: This section of duct has insulation missing – as a result condensation and mould growth are forming.

Image 6: This condensate line is dripping and should be insulated.

Image 7: This is what a clean cooling coil looks like.

Image 8: An example of proper insulation on chilled water lines.

increase the likelihood of other allergens such as dust mites, which thrive in environments maintained at relative humidity levels at 65% and greater indoors. If the HVAC systems are unable to maintain the proper relative humidity levels, it is not unusual to immediately sense musty type odours upon boarding a vessel. Although mould is ubiquitous in our environment and to some extent is expected indoors, we should not have any visible mould growth indoors and appropriate measures/precautions are necessary to prevent its growth indoors. A number of health problems have been attributed to the inhalation or exposure to mould spores. Individuals with allergies or asthma may experience symptoms in relatively short periods of time and even individuals that may not be allergic to mould could become sensitised over a period of time/exposure.

Cooling Coils and Ductwork

The cooling coils inside the fancoil units in particular are a prime location for mould growth to occur. Cooling coils are designed to maintain surface temperatures between 45°F (7°C) and 55°F (12.8°C). This results in condensation on them as moisture is removed from the air passing over the coil. They are also prone to impact from debris as a result of low efficiency filtration and/or filter bypass. Therefore, these coils should be inspected on a regular basis for signs of visible debris, as debris along with moisture can serve as a food source for mould growth. Ductwork too can also become a breeding ground for mould and should be properly inspected on a regular basis.

Unsealed return plenums are fairly common on vessels. The problem with this type of system is we may be drawing air and from any number of undesirable sources (for example bilge, engine room, unconditioned areas, etc.) resulting in odours and/or undesired contaminants indoors.

Air filters should be properly installed in a manner that prevents air bypass and should be inspected and replaced, or cleaned on a regular basis. How clean the environment is and how efficient the air filter is will determine the frequency for replacement or cleaning. We suggest monthly intervals for the average vessel (more frequently for dirtier environments and obviously less frequent for clean ones).

Compromised Insulation

Chilled water lines and air ducts need to be properly insulated to prevent condensation, another source of mould growth. Regularly inspect insulation to see if it is degraded and look for signs of moisture or condensation. These are indicators that insulation repairs are warranted.

Outside Air Ventilation

Inspecting the HVAC system(s) and reviewing mechanical plans to confirm that provisions are made for outdoor air ventilation is a good first step. If you do not see ducting for outdoor air you may not be getting sufficient outside air ventilation. However, it should be noted that the retrofit is not as straightforward as just adding a duct from outdoors into the vessel. Proper engineering data should be utilised to determine if the existing HVAC equipment is capable of handling the added moisture load or heating/cooling load.

The introduction of uncontrolled/unconditioned outdoor air without proper engineering data and controls (that is a dehumidifier) can run the risk of elevated humidity and subsequent mould growth indoors. Thus, we recommend that you consult with a qualified marine air-conditioning contractor to achieve the best possible results and reasonable expectations. Also, check from where the outside air is being brought into the vessel. In particular you want to avoid cross contamination from diesel exhaust or other sources of known contaminants.

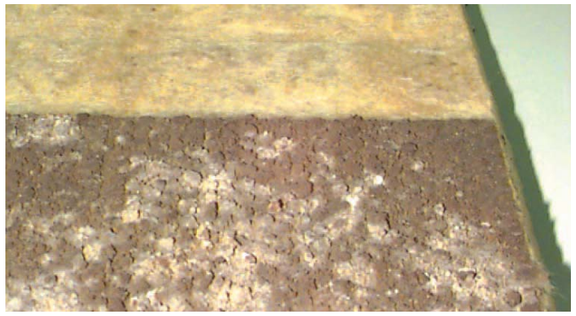

Image 9: Significant mould growth on insulation indicates an underlying problem.

Image 10: A chiller with four stages (four compressors) of cooling. If properly adjusted, the control system will automatically activate the compressors only when needed to maintain the proper water temperature.

ISSUES & OPINIONS – AIR CONDITIONING

While health symptoms can be caused by a number of things not necessarily related to the indoor environment, it is still prudent to address concerns of poor indoor air quality in a timely manner before conditions become more serious.

Pressurisation

Maintaining acceptable indoor air quality also requires appropriate relative pressurisation. The idea here is that we want the airflow movement from clean to less clean areas. This can be assessed via the use of a thin piece of tissue paper to get a feel for where the airflow is moving. For example, we don't want the engine room to be at a relative higher pressure with respect to the occupied areas. If you are noticing airflow is going in an undesired direction (less clean to clean), then the HVAC system should be evaluated to determine what efforts are required to achieve the appropriate pressure relationship.

Keep it Healthy and Comfortable

Let's keep in mind that most people spend their majority of their time indoors. Maintaining acceptable indoor air quality helps promote a productive environment for crew and guests. Proper maintenance and understanding of the HVAC system can help mitigate a number of indoor-air-quality problems. While health symptoms can be caused by a number of things not necessarily related to the indoor environment, it is still prudent to address concerns of poor indoor air quality in a timely manner before conditions become more serious.

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