CONCLUDE

Informed Decision Making

Insanity or what?

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Why we have a duty of care to challenge conventional solutions for ventilation system design that prevent cost savings and contribute to higher carbon emissions.

For decades the basis of ventilation systems design in UK hospitals has been based in the principles of Constant Air Volume (CAV), displacement ventilation where stale and contaminated air is expunged and replaced by fresh air. The volumes of air that are replaced within any given space are determined by what in effect are 'rules of thumb' – formulaic principles (*"if this, then do that"* kind of principle). Whilst these are inexact, they have served the industry well...until now.

Designing ventilation systems using these 'rules of thumb' is equivalent to opening a door with a sledge hammer when a key would suffice.
By continuing to adopt this practice in preference for alternative methods, hospitals are hemorrhaging energy –and so incur far higher energy costs than necessary. In these straitened times it is at best judged irresponsible to continue using the same formulaic principles with their inevitable costs to the environment.

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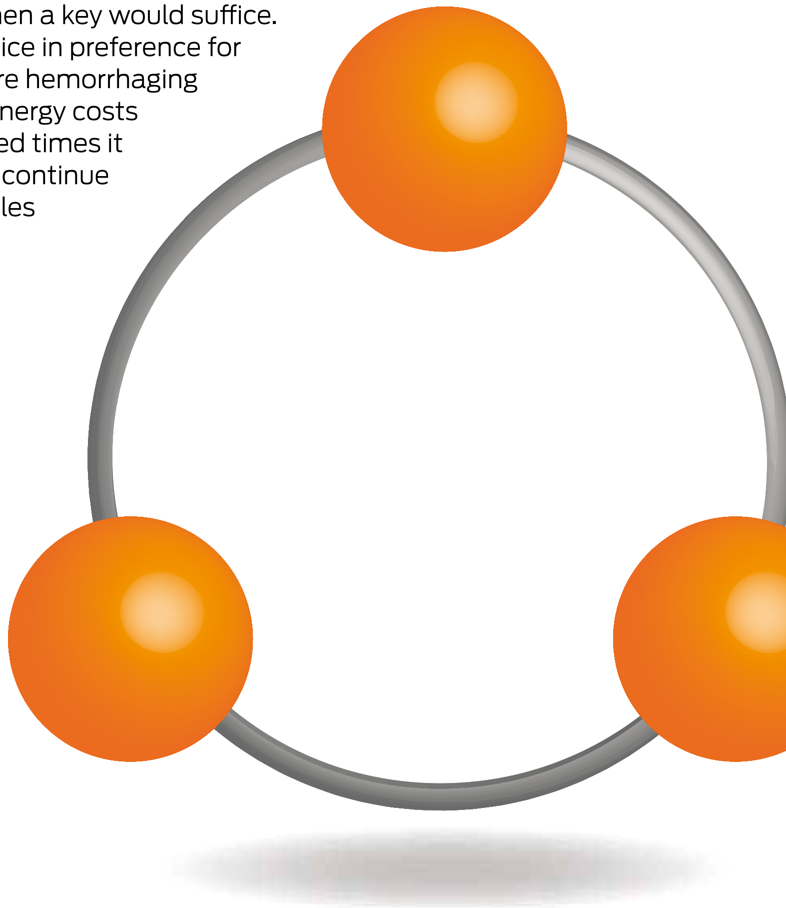

So what is the scale of this impact? In buildings using a CAV system, it will amount to about 40% of the overall electrical consumption. One could argue with the exact figures, but this is the order of magnitude. Many also acknowledge that apart from being incredibly energy inefficient, these systems are often grossly over-sized. In a report published by BSRIA a decade ago, the evidence points to an over sizing issue on a scale that cannot be simply dismissed. The BSRIA report studied 50 buildings, and of those, in 100% of them the ventilation system was over-sized, and in 88% of them the cooling systems were over-sized. The over-sizing of plant has two huge consequences. Firstly, hospitals are spending (CAPEX) excessively on surplus plant and secondly running costs (OPEX) are inflated as the plant never attains peak operating efficiency and so consumes considerably more energy than is expected. Additional studies in the United States identified that in every building studied, plant never reached peak load design parameters and in nearly all instances it was working at less than 50% of its design capacity.

The NHS Sustainability Development Unit states that in real terms energy consumption of the NHS Estate needs to be reduced by approximately 80% of the consumption in the 1990's. This is clearly a very significant challenge. To achieve this, a fundamental change is required to the way that facilities are both designed and operated. Our argument is that a major part of our effort should be focused on the design and specification of ventilation systems.

So what is preventing our engineers from developing new approaches that would both achieve the outcomes that protect human health and provide acceptable environmental conditions within our hospitals? Sadly, we think that it is a combination of fear and ignorance. Fear of being held accountable for embarking on alternative design strategies that do not follow convention (seeking security from formulaic principles written into standards) – which might not deliver – "No one ever got fired for buying IBM". This is combined with an ignorance of alternative, proven ventilation strategies and ignorance of the latest scientific research that demonstrates that these formulaic principles have no foundation in science and have equal or greater potential to compromise patient health.

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It is too easy to listen to the negative comments:

"Are you going to guarantee patient health and expose yourself to potential professional negligence claims by promoting an unproven alternative?"

"How are you going to overcome the contractual specifications that specifically state that you will design to these formulaic principles?"

"How are you going to argue with the Infection Prevention Control Team when they slap HTM-03 on the table and say – you WILL work with this!"

To be frank: It is now time that the ignorance of those that specify the standards and those that implement them are tackled. I believe that all parties in the debate have a 'duty of care' to research and understand the alternatives and how they can be best applied to future facility design.

We have discussed this issue at some length with the Department of Health, and they point out that their documents (Health Technical Memoranda and Health Building Notes) are intended as ***"guidance only"***. They are not specifications, but reflections of known good practice for the *"whole spectrum of facilities that comprise the NHS Estate"*. Yet, I am often informed that procurement departments rigorously apply them as specifications. This is clearly unacceptable and a case of "policing by individuals who do not understand the need".

I suspect that all too many design professionals are also ignorant of the alternatives to formulaic – 'one size fits all' types of ventilation design. Dogged procurement practices that pursue 'lowest cost by any means' as opposed to seeking 'optimal life cycle value' are short sighted and simply result in design professionals with little margin to invest in research. Without an evidence base backed up by data, they have to rely on anecdotal evidence, which is hardly a basis for reasoned argument.

So what of the alternatives? What does the research tell us?

Firstly it informs us that there is no scientific evidence (yet) that supports the assertion that a formulaic design, founded in air-change rates, beyond a certain limit, has any material effect on the spread of infection. An extensive literature review by the York Health Economics Consortium earlier this year pointed out that it was not possible to discern the effectiveness of ventilation systems because other factors may be influencing the results. Furthermore, other research has drawn attention to the huge variations in ventilation standards across Europe, and yet infection rates are not substantially better in those countries where higher ventilation standards predominate. To emphasise this point, work carried out at Brighton & Sussex University Hospital NHS Trust a few years ago found that infection rates fell uniformly across the estate when a common infection control policy was implemented, indicating the ventilation systems had little impact on the results, particularly given the substantial variety of ventilation systems present across the campus.

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Secondly it informs us that the efficacy of air-change rates falls away substantially as air-change rates are increased beyond about two air-changes per hour. Professor Clive Beggs identified this issue in his paper exploring the relationship between ventilation and spread of air borne infection.

The research also identified that our understanding could be improved through more research. However, we are now developing a much better understanding as to how airborne infection is spread. Recent research carried out at the Hong Kong Polytechnic University has studied the factors that affect the air-borne spread of infection in connection with the SARS virus. The results challenge conventional understanding in so far as displacement ventilation is concerned.

Professor Niu at Hong Kong Polytechnic University has patented a personal air ventilation system. The theory is that extraction of contaminated air near to source must be much more efficient than attempting to achieve this through a room ventilation system. In the US, there are commercially available air-dosing systems, which claim to eradicate all known air-borne pathogens. In these latter two examples, the benefits become apparent: Firstly that centralised air-handing plant could be used for maintaining indoor air quality and secondly 'point of source' systems could be used for specific needs – not unlike dedicated laminar airflow systems in operating theatres.

Whilst infection prevention control is of uppermost importance, so too is the need for ventilation systems to be capable of responding to specific needs. As single bedrooms become common-place, there is an argument to suggest that such rooms will inevitably have to serve a much wider range of needs – from fracture patients to those with potentially infectious diseases. For example, it has also been suggested that more procedures should be carried out at the bedside rather than in the operating theatre. These examples point to substantial diversity of use. Is it realistic to serve such spaces with a 'one-size fits all' strategy? This would clearly be inefficient and certainly not help to engineer a low carbon environment. An alternative strategy is required.

Developing a new approach to hospital ventilation.

The concept of 'Demand Control Ventilation' (DCV) has been understood for some years and over the same period our understanding of how to measure indoor air quality (IAQ) has also considerably improved. In these systems the air-flow rate is matched the actual demand of the space being served. The benefits of DCV are also well documented; efficiency, significant energy reduction and low carbon emissions are common gains. Figures such as 40% savings in operational costs have been identified. Given all these relevant advantages it raises the question as to why have these systems have not already been more widely deployed within UK Hospitals?

The answer lies in part in their greater complexity so far as the sensor and control technologies are concerned. It has only been in recent years that the sensors can now monitor a wider range of IAQ measures. For example, significant advances have been made in terms of sensing for volatile toxins.

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We would also contend that the discipline is not widely understood in the engineering profession. We suspect that the reluctance of the engineering profession to embrace DCV and other strategies is as much to do with lack of investment in research than any other reason. However, both CIBSE and ASHRAE have been promoting DCV in recent years, and establishing it as part of their Continuing Professional Development (CPD) Programmes.

In their 2010 report, *Engineering a Low Carbon Environment*, The Royal Academy of Engineers, lamented that the loss of understanding of building science is major issue for the profession. Rob Manning in his CIBSE Presidential address a few years ago repeated this concern. DCV challenges an engineers understanding of building science and this also points the finger towards university engineering institutions to embrace this need.

The need for better data

However, even when the science is understood, there has always been the challenge of accurate data on which to base the systems design. This is as true for CAV systems as it is for DCV systems. The most significant omission in design briefs concerns the lack of understanding of how the facility is to be used and the impact of this use on occupancy. It is in this area where assumptions concerning occupancy lead to the greatest uncertainty concerning the design of ventilation systems. The BSRIA report mentioned earlier confirmed this. The Conclude Consultancy's work in Occupancy Analytics, a new science that we have developed, has clearly demonstrated that engineers can over-estimate occupancy in hospitals by as much as 35%. Occupancy Analytics forecasts the diversity of use and assesses the probability of occupancy based on different variables.

The right sizing of ventilation systems is as much of a concern with DCV as it is with CAV systems. We would argue that it is even more important to understand the issues of occupancy in a DCV system, both in design and operation. This is why we believe that Occupancy Analytics is critically important for optimised ventilation design.

Moving forwards

If the NHS Estate is to achieve its aspirations for an 80% reduction in carbon emission in real-terms then we need to think very hard as to how we will engineer our facilities to achieve low carbon outcomes. Technology can influence this, but the engineering profession has an even greater part to play. It must seek to challenge the status-quo. Clients too, must challenge their professional teams to push the boundaries of ventilation design.

The engineering profession must embrace building science and learn to design systems that are cost, energy and carbon efficient for the long term. DCV systems are only one solution in an arsenal of potential answers waiting for our considered appraisal. We need the profession and the educators of the profession to lead the industry to new solutions, rather than repeating the same old formulaic solutions without question.

"Insanity: doing the same thing over and over again and expecting different outcome." *Albert Einstein (attributed)*