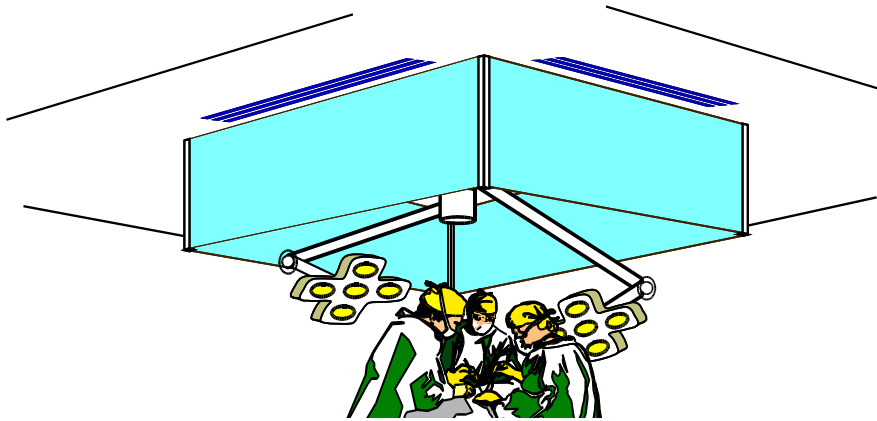


SVHSoc.

Specialised Ventilation for Healthcare
Society



Operating Theatres

Energy Control Strategies and
the Surgeon's Panel

Document SVHSoc.01-V1.2
12 April 2017

Operating Theatres - Energy Control Strategies and the Surgeon's Panel

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The Specialised Ventilation for Healthcare Society (SVHSoc.)

The Society was formed in November 2014 with the aim of bring together those who were practicing or wished to become Authorising Engineers (Ventilation) (AE(V)) or who have a more general interest in Ventilation in the Healthcare setting.

- The SVHSoc. meet several times a year at various locations around the UK.
- Full membership of the Society is open to registered AE(V)'s.
- The Society "Code of Conduct" is issued with all quotations for AE(V) services.
- The Society maintains a register containing details of practicing AE(V)s.
- A set of competencies have been drawn up for prospective AE(V)s.

- Associate membership is open to anyone interested in Ventilation for Healthcare.
- A significant portion of the Society meetings is given over to discussing and clarifying interpretation of HTM03-01 and other healthcare ventilation standards.

Looking ahead the SVHSoc. would expect to be involved in any update or rewrite of Healthcare ventilation standards.

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The following documents have been issued by SVHSoc. to help clarify Healthcare Ventilation requirements

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Operating Theatres

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Specialised Ventilation for Healthcare Society

SVHSoc.01-V1.2 Operating Theatres

Energy Control Strategies and the Surgeon's panel

(April 2017)

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Operating Theatres - Energy Control Strategies and the Surgeon's Panel

The Ventilation of Operating Theatres

Introduction

In ventilation terms there are two basic types of operating theatre:-

The Conventional Ventilated Theatre

This is supplied with conditioned air from an Air Handling Unit (AHU) and delivered to the operating room through ceiling terminals. These may be four way blow, circular or take the form of a number of perforated plates. In some older theatres air is supplied via side wall grilles or linear diffusers. In either case an air change rate of from 18 to 25 per hour will be provided while maintaining a positive pressure of between 18 to 25 Pascal with respect to the adjoining area.

Conventional ventilated theatres are used for general surgery, obs & gynae, etc. where the infection risk is considered low and its consequences manageable.

The Ultra Clean Ventilated (UCV) Theatre

This is supplied with conditioned air from an AHU and delivered to the operating room through a ceiling mounted canopy fitted with High Efficiency Particulate Air (HEPA) filters. This downward flow of air provides an essentially particle free zone within the canopy footprint. The air is re-circulated back through the canopy or via a sub AHU in a plant room. In some older theatres air is supplied via a wall mounted vertical canopy that provides a horizontal airflow. Primary air from the AHU provides 18 to 25 air changes per hour (ac/h) in the theatre, this combined with the re-circulated air may give an air change rate in the region of 300-400 ac/h locally under the footprint of the canopy. The pressure regime will be as for a conventionally ventilated theatre.

UCV ventilated theatres are primarily used for orthopaedic surgery. They may also be used for transplant procedures, bariatric patients, ophthalmic treatments and any other procedure where the risk of infection is particularly high and if it occurs, extremely difficult to treat. When not being used for these case types, the UCV canopy air supply can be reduced to not less than that supplied to a conventionally ventilated theatre and the theatre used for general surgery.

In both cases failing to provide adequate ventilation during an operation will significantly increase the risk of a surgical site infection. It is therefore essential that the operating team know that the ventilation is running correctly prior to commencing a surgical procedure.

Operating Theatres - Energy Control Strategies and the Surgeon's Panel

Operating Theatre Energy Control Strategies

Introduction

The supply air to an operating theatre has four main functions:-

- a) To dilute airborne contamination.
- b) To control air movement within the suite such that the transfer of airborne contaminants from less clean to cleaner areas is minimised.
- c) To control the temperature and, if necessary, the humidity of the space.
- d) To assist the removal of, and dilute, waste anaesthetic gasses.

The ventilation system for an operating theatre is designed to fulfil these functions when the theatre is in active use by supplying air sufficient to provide the desired air change rate while maintaining a positive pressure to the surrounding area. If the operating theatre is not in active use, there is no requirement to maintain these conditions so the ventilation can be reduced to a level that keeps the space at a suitable temperature. Switching the AHU to this lower operating output is termed "Set Back". If the operating suite is within the heated volume of the building then the ventilation can be switched "Off" when the theatre is not in use.

Operating theatre ventilation systems are expensive to run so switching the ventilation to "Set Back" or turning it "Off" entirely will save considerable amounts of energy, extend the life of the filters, reduce wear on the AHU and its control system and help to lower maintenance costs. Note that when switching an AHU to "Set Back" or "Off", the control valves of the main and trimmer batteries may need to be driven open or closed to suit and the unit "Run On" for a period to dissipate any residual energy.

It is important to recognise that the theatre ventilation system is primarily designed to cope with the particulate contamination generated inside the operating room by the occupants and their activity when the theatre is in use. If it is not in use then this specific particulate load does not exist.

If doubt exists as to the advisability of switching the theatre ventilation "Off" when not in use then a Light Scattering Airborne Particle Counter (LSAPC) can be used to determine whether particulate contamination is occurring and if so, how quickly the particles are removed once the ventilation is switched either to "Set Back" or "On". As a guide, in particulate contamination terms, a system that has been "Off" will typically only need to run at "Set Back" for 15 minutes in order to be ready for use. It may however take significantly longer to achieve a suitable temperature.

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Ventilation Energy Control

Operating theatre ventilation can be controlled in any of the following ways:-

- 1) Switch the AHU "On" and "Off" at fixed times using a time clock or BMS programme. The AHU needs to come on at least to "Set Back" early enough in the morning for the theatre to be up to temperature by the normal theatre start time.
- 2) As above but with an "Optimum start" control that uses the outside temperature to determine the start time. In the winter, the lower the outside temperature, the earlier the AHU starts. In summer, the higher the outside temperature above that desired, the earlier the AHU starts.
- 3) As above but link the AHU to a temperature sensor in the theatre. If out of hours the temperature inside the theatre drops to the dewpoint, typically 16°C in winter, or rises above 25°C in summer, the AHU will start and run at "Set Back".
- 4) Install movement sensors (e.g. Passive Infra Red [PIR] or similar) in the theatre with a "double knock" programme so that if movement is detected twice within 10 minutes the AHU will switch "On" to full speed. If no movement is detected for 30 minutes the AHU switches "Off". The double knock prevents the system switching on just because someone has popped in to get something when the theatre is not in use.
- 5) The above can be combined so that if there is no movement for 15 minutes the AHU switches to "Set back" during the working day and "Off" outside of normal hours.
- 6) Link the AHU to the theatre lighting. If the Theatre general lights are switched "On" the AHU switches on to "Set Back". If the main operating lamp is then switched "On" the AHU goes to "Full speed". If all the lights are out the AHU goes "Off".
N.B:- There are occasions when this approach is not suitable e.g. if the type of surgical procedure requires the lights to be "Off" during a part of the operation.
- 7) Any combination of the above or any other appropriate and applicable method.

Ultra Clean Ventilation (UCV) Systems – Additional Requirements

- 8) UCV canopies must be interlocked to their AHU so that they go to "Set Back" when the AHU is "Set Back" or switches "Off". When the AHU is at operational speed the UCV operational setting can be selected by the theatre staff at the surgeon's panel.

This is particularly important when a Conventional Theatre is retrofitted with a UCV canopy. The additional UCV control panel must be fully interlocked with the existing surgeon's panel and not left as a stand alone unit.

- 9) There is no aero-biological reason why the UCV canopy cannot be switched "Off" when the theatre is not in use, however most canopy manufactures recommend that they remain in "Set Back". This is to prevent dust blowing back into the theatre from the canopy return air filters when the AHU is running in "Set Back" with the UCV

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“Off”. This potential problem can be overcome by delaying the UCV shut down until after the AHU has shut down and restarting it before the AHU.

If the UCV canopy is fitted with anti-backflow dampers in the return air paths then this problem does not arise.

AHU's Serving Two Theatres

Current Department of Health (DH) guidance does not recommend that a single AHU serve two theatres however there are many examples in the field. There are also cases where a pair of theatres share a Preparation room and / or a Sluice / Utility room. In these cases the ventilation control should only switch the system to “Set Back” or “Off” when the entire facility is not in use.

In order to overcome the problem of shared ventilation, some systems are fitted with motorised dampers and constant volume boxes or even auxiliary fans so that if one theatre is not in use the AHU output can be reduced while still maintaining the desired air flow to the in use theatre. These systems are overcomplicated, difficult for the local Estates staff to fully comprehend once the installers have left site and troublesome to reset if they breakdown.

Out of Hours Use

An operating suite may need to be used outside of normal scheduled hours due to list overruns or an emergency case. There should be a means of overriding the programmed “Set Back” or “Off” signal.

PIR movement sensors (or similar devices) are the simplest way of achieving this. Alternatively an override or plant extension facility should be provided on the surgeon's panel. This is typically set to give an extra 1 hour run time.

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Operating Theatres - Energy Control Strategies and the Surgeon's Panel

The Surgeon's Panel

The prime function of the surgeon's panel is to provide information about the status of the ventilation within the theatre. This document has been produced because across the NHS there are a wide variety of panels, many of which, whether new or old, do not provide this function. As an example, in many theatres it is not obvious if the ventilation is running but there are bright lights on the surgeon's panel to indicate the theatre general lighting is on!

Traditionally surgeon's panels were hard wired with relays at the back and indicator lamps on the front. These panels can easily be upgraded with multi bulb LED indicators and digital temperature and humidity displays. It is useful to have a lamp test button.

Membrane panels were the first to display a mimic of the theatre air flow utilising coloured LEDs to indicate "Correct" air flow, "Set Back" flow and "No flow" or "Fault" conditions.

The latest models use video display or touch screen panels either as stand alone units or integrated into the Building Management System (BMS).

Whichever method is used to provide information to the surgical team the essential requirements will be the same. It should be remembered that surgeons regularly move from hospital to hospital. They need to have critical information presented in a way that is easily recognisable when they arrive in an operating theatre that is new to them.

The panel should be located as near as practicable to the centre of a wall at a convenient height for viewing such that it can be easily seen by the surgeon while standing at the operating table.

Clock and Timer

Every Theatre should have:-

- a) A clock with an analogue display to show the time of day.
- b) A timer with a digital display to show elapsed time in minutes and seconds. The timer should be capable of being started, stopped, restarted and reset to zero.

The clock and timer may be separate devices or incorporated in the surgeon's panel.

Medical Gas and Anaesthetic Gas Scavenge System (MG&AGSS) Panel(s)

It is good practice to keep the Medical gas and AGSS indicators and controls on a separate dedicated panel(s) rather than incorporating them in the surgeon's panel. The MG&AGSS panel(s) can then be installed in a position convenient to the anaesthetist and easily upgraded or replaced without having to revamp the surgeon's panel. The surgeon's panel should be linked to the MG&AGSS panel(s) by a monitored cable. A fault on the MG&AGSS panel(s) or connecting cable should trigger an area alarm on the surgeon's panel.

Alternatively the MG&AGSS panel(s) may be incorporated in the surgeon's panel.

Operating Theatres - Energy Control Strategies and the Surgeon's Panel

Conventionally Ventilated Operating Theatre Surgeon's Panel – Basic Requirements

The basic requirements for a surgeon's panel in a **Conventionally Ventilated Operating Theatre** are as follows:-

- 1) A readout sufficiently large (Minimum display 25mm) to be clearly visible from the operating table that shows the temperature of the air in the theatre.
- 2) A means of adjusting the theatre air temperature within the range of 15 – 25°C.
Note1: Theatre air temperature sensor must be actively ventilated either in a "sample" duct in the surgeon's panel or a low level extract duct in the theatre.
Note 2: A temperature range of 17 to 27°C may be more appropriate for some types of theatres e.g. maternity.
- 3) A readout sufficiently large (Minimum display 25mm) to be clearly visible from the operating table that shows the relative humidity of the air in the theatre.
Note: Humidity sensor must be actively ventilated (See temperature sensors above).
- 4) A red indicator that will illuminate when the supply AHU fails or is switched "Off" or is in "Set Back" mode or has a "Low air flow" (See definition below). The indicator should be labelled "**Ventilation not operational**". An audible alarm should sound for 15 seconds when the indicator first illuminates and repeat at 1 minute intervals until cancelled.
*Note that in this state **the theatre must not be used**. If the indicator illuminates during a surgical procedure then the operating staff will have to decide whether to complete the procedure or move the patient to another theatre.*
- 5) A green indicator that will illuminate when the supply AHU is operating at full operational speed. The indicator should be labelled "**Ventilation operational**".
Note that in this state the theatre may be used for Surgery.

Conventionally Ventilated Operating Theatre - Indicator logic table

AHU	Indicator	Comment
Switched Off	Red	Ventilation not operating at a suitable level to commence surgical procedures
Fault		
Low air flow		
On (Set back)		
On (Full speed)	Green	Full standard operating conditions

NB:- "Low flow" is defined as:- A supply AHU delivering less than 75% of its original design flow rate, **or** is delivering an air flow that will result in less than 18 ac/h in the Operating Theatre.

- 6) A means of overriding the ventilation time control unless a movement detector is fitted.

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- 7) The foregoing elements should be located towards the top of the panel. Other indicators e.g. Laser warning and Theatre in Use switches, etc. should be towards the bottom of the panel and in general should be smaller and less prominent.
- 8) To avoid confusion the panel should contain the minimum of lights, switches and information displays. The surgical team just need to know that the theatre is in a condition that means that it is safe for them to operate; A big Green indicator! Or it's not, a big Red indicator!

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Ultra Clean Ventilated (UCV) Operating Theatre Surgeon's Panel – Basic Requirements

The basic requirements for a surgeon's panel in a **UCV Operating Theatre** are as follows:-

- 1) A readout sufficiently large (Minimum display 25mm) to be clearly visible from the operating table that shows the temperature of the return air in the UCV canopy.
- 2) A means of adjusting the theatre air temperature within the range of 15 – 25°C.
Note: Significant alterations to the supply air temperature to a UCV canopy will change the air flow pattern under the canopy which may take a considerable time to return to a stable pattern. To overcome this it may be appropriate to limit the rate of change of the temperature control.
- 3) A readout sufficiently large (Minimum display 25mm) to be clearly visible from the operating table that shows the relative humidity of the return air in the UCV canopy.
- 4) A switch to "Set Back" the UCV canopy fans when the theatre is used for General surgery. This will reduce the air supplied through the UCV canopy to a volume that equates to not less than 20 air changes per hour of the operating room gross volume whilst still leaving the supply AHU operating at full speed. The switch should be labelled "UCV Theatre Mode" / "Conventional Theatre Mode".
- 5) A red indicator that will illuminate when the supply AHU is switched "Off", fails, or has a low air flow (See definition below) or is in "Set Back" or the UCV canopy is switched "Off" or fails. The indicator should be labelled "**Ventilation not operational**". An audible alarm should sound for 15 seconds when the indicator first illuminates and should repeat at 1 minute intervals until cancelled.
*Note that in this state **the theatre must not be used**. If the indicator illuminates during a surgical procedure then the operating staff will have to decide whether to complete the procedure or move the patient to another theatre.*
- 6) An amber indicator that will illuminate when the UCV canopy is at "Set back" and the supply AHU is running at "Full speed". The indicator should be labelled "**Conventional Theatre Mode**".
Note in this state the theatre may be used for general surgery but not orthopaedic or other procedures requiring ultra clean ventilation.

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- 7) A green indicator that will illuminate when both the supply AHU and UCV canopy are at full operational speed. The indicator should be labelled “**UCV Theatre Mode**”.
Note that in this state the theatre may be used for orthopaedic or other procedures requiring ultra clean ventilation.
- 8) A blue indicator that will illuminate when the UCV canopy air flow, as detected by a differential pressure sensor, falls below 80% of the design flow rate. The indicator should be labelled “**Change HEPA Filters**”.
*Note that in this state the theatre may continue to be used but the UCV canopy HEPA filters **must** be replaced and the UCV canopy re-commissioned as soon as practicable.*

UCV Theatre - Indicator logic table

AHU	UVC Canopy	Indicator	Comment
Off, Fault or Low flow	Off or Fault	Red	Ventilation not operating at a suitable level to commence surgical procedures
Off, Fault or Low flow	On (Set back)		
Off, Fault or Low flow	On (Full speed)		
On (Set back)	Off or Fault		
On (Full speed)	Off or Fault		
On (Set back)	On (Set back)		
On (Full speed)	On (Set back)	Amber	Ventilation provided to at least conventional theatre standard
On (Full speed)	On (Full speed)	Green	Full UCV standard conditions
-	-	Blue	HEPA filter resistance reducing air flow to 80% of design. <i>Change filters as soon as practicable</i>

NB:- “Low flow” is defined as:- A supply AHU delivering less than 75% of its original design flow rate, **or** is delivering an air flow that will result in less than 18 ac/h of primary air in the Operating Theatre.

- 9) A means of overriding the ventilation time control unless a movement detector is fitted.
- 10) The foregoing elements should be located towards the top of the panel. Other indicators e.g. Laser warning and theatre in use switches, etc. should be towards the bottom of the panel and in general should be smaller and less prominent.
- 11) To avoid confusion the panel should contain the minimum of lights, switches and information displays. The surgical team just need to know that the theatre is in a condition that means that it is safe for them to operate; a big Green indicator! Or it's not, a big Red indicator! Or that they must exercise caution as to the type of operation undertaken, a big Amber indicator!

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Operating Theatres - Energy Control Strategies and the Surgeon's Panel

Membrane Mimic Panel

This takes the form of a flat surface panel with a mimic of the theatre and its airflow printed on the front. Touch points on the membrane activate micro switches at the back of the panel to turn items on or off.

Airflow in the theatre is shown by coloured LED lights in the form of arrows within the mimic. Green lit arrows for normal air flow, Amber for "Set back", Red for no airflow and flashing Red if there is a fault with the UCV's recirculation fans. The panel for a conventionally ventilated theatre is similar.

These panels are clear, simple and because they have a flat plastic surface, easy to wipe clean.

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Video Display screen and Touch Screen Surgeon's panels

Many companies offer a video display screen or touch screen version of the surgeon's panel.

Video display screens eliminate the need for coloured indicators by displaying a mimic of the theatre and its ventilation condition. Parameters such as air flow, temperature, humidity, system run, set back, stop and faults are displayed directly on the screen and adjustments can be made by buttons on or to the side of the screen.

Touch screens incorporate the ability to interact and adjust parameters directly with the mimic on the screen.

In both cases there is usually a range of screen displays that can be accessed. These **may** include in no particular order:-

- A mimic of the ventilation air flows in the theatre
- A medical gas status screen
- A power supply status screen
- An AGSS status screen
- A temperature and humidity trend logging screen
- A system information screen
- Main and satellite operating lights control screen
- Etc.,etc.

While these systems have a wider choice of options than the traditional hard wired surgeon's panel it should be recognised that they are "single point failure" devices. If you lose the screen you lose all of the information. There is also the issue of how long the screen and software driving the panel will be supported given that the life of a theatre between major refurbishments can be 25 years.

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Reported Issues with VDU / Touch Screen Panels

Video display and Touch screen panels have many advantages but can suffer from presenting too much information and too many options for the user. The following list is not exhaustive but identifies **typical problems** that have been reported by theatre users:-

- The systems often have several ways of accessing a particular screen which can make the interface overcrowded and confusing for the user.
- The screen contrast and viewing angle can be poor making it difficult to see the information displayed unless directly in front of the screen.
- More problematic is that there are sometimes two "Ventilation" screen shots, one for the AHU and the other for the theatre, but both show views of a theatre! This is very confusing for the user and if the wrong one is selected may lead to the belief that the ventilation is satisfactory in the theatre when it is not.
- A similar problem occurs when the screen shows a green sector labelled "Ventilation Normal" (meaning that the AHU is running) at the same time showing Red arrows on the theatre mimic (meaning that the UCV is not operating). While the distinction may be obvious to a ventilation engineer it is far from clear for the surgeon.
- The "Mimic" of the theatre may not reflect the actual way that the theatre is ventilated. e.g. a) The screen shows a theatre with four ceiling diffusers but the theatre is fitted with a perforated plenum diffuser. b) The screen shows an UCV canopy with side screens but the theatre is fitted with a screenless UCV canopy.
- The display stays on the last screen selected rather than reverting to a "Home" screen. e.g. The display stays on the AGSS status screen which is useful for the anaesthetist to know but does not help the surgeon decide whether it is safe to operate!
- The temperature "Set Point" is displayed continuously and in a larger and more prominent position than the actual "Measured" temperature. So which one would theatre staff assume is relevant to them?
- The trend logging screen uses the same 0 to 100 side scale for temperature and humidity. This is too large a scale for accurate interpretation, a side scale from 0 to 40 °C would be more appropriate for temperature and 20 to 80% for humidity.

It is important to remember that the surgeon's panel is there to present clear unambiguous information to the surgical team. They are experts in their field but are not ventilation or control engineers!

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Additional Requirements for Video Display and Touch Screen Panels

The overall requirements for these panels will be the same as for the conventionally ventilated and ultra clean ventilated (UCV) operating theatre panels as detailed above. In addition the following general rules should be observed when specifying video display and touch screen panels.

- 1) The "Mimic" should depict the theatre and its ventilation terminals as it really is.
- 2) The AHU should have its own "Mimic" screen that shows a schematic of the AHU and not use a generic "Theatre" mimic.
- 3) The "Home" screen should be the "Ventilation in the Theatre" screen as this is something that cannot otherwise be known. We are back to the surgeon needing absolute clarity that the ventilation is working before deciding to commence an operation.
- 4) If the user selects any screen the display should revert back to the "Home" screen after 1 minute if there is no interaction from the user.
- 5) The temperature "Set Point" should only display while adjustments are being made, the display should then revert to the actual "Measured" theatre temperature.
- 6) The coloured indicators may take the form of a static or moving display together with appropriate legends to clearly define the operational state of the ventilation system as described above.
N.B. It is not appropriate to indicate that the air flow is "Off" or has "Failed" by moving red arrows as this has been known to confuse theatre staff. It should be indicated by a broad red band across the middle of the "Home" screen bearing the legend "Ventilation not operational".
- 7) If any system develops a fault or fails, then the display should go to the screen for that system, flash the screen red and sound an audible alarm for 15 seconds. Once the user has acknowledged the alarm on the panel the display should revert to the "Home" screen. The fault should then be displayed within the "Home" screen so that it is not forgotten.
- 8) It should be possible to download PDF documents to the information screen so that the design, commissioning, initial validation and annual verification reports are available to view in the Theatre.
- 9) There is a move to integrate the VDU / Touch Screen panels into the BMS so that adjustments to the control parameters can be made and the system performance monitored remotely. While this development has advantages it is important that the basic monitoring functions are retained within the surgeon's panel. It is essential that in the event of a BMS or its connecting link outage, the surgeon's panel continues to display the critical parameters listed above.

The main points to bear in mind are simplicity, dependability and clarity for the user.

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Endnote

The foregoing represents a "Consulting Engineers" view on Theatre ventilation energy control strategies and Surgeon's panels with input from Colin Gaffney, a practicing "Validation Engineer". They are based on many years experience of trying to get Theatre ventilation systems to work and surgeon's panels to display information in a way that is understandable to their non engineering users!

Any comments that will aid clarity on these topics for specifiers and users will be very welcome and should be addressed to:-

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Operating Theatres - Energy Control Strategies and the Surgeon's Panel

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