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Template for Abstract to UKIEG Conference 2021; Indoor Environmental Quality for Healthy Buildings: the indoor/outdoor interface

Why do people still die from unintentional carbon monoxide poisoning? An overview of coroners' findings

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ABSTRACT (Times New Roman Bold 12 pt, UPPERCASE, style: Heading 1)

Background:
Analysis of narrative reports from coroners may increase knowledge as to prevention of carbon monoxide (CO)-related fatalities. The aim of this work is to delineate the circumstances under which unintentional CO-related deaths occurred in the study population to inform prevention initiatives.

Methods
Coroners narrative reports on fatal unintentional non-fire related CO poisoning, England and Wales, 1998-2018 (includes workplace deaths) were collated by the Office for National Statistics (ONS). We designed search terms related to CO exposure to be applied to ONS summaries of coroners' narrative reports, and obtained information regarding the circumstances of the death. We grouped findings by dwelling-related, appliance-related, and behaviour-related factors to summarise the circumstances under which deaths occurred.

Results
There were 751 deaths (74% male). Annual numbers of deaths decreased over the study period (1998: 54 deaths, 2018: 17 deaths). Most (68%) deaths occurred in autumn/winter. Almost half (45%) of deaths occurred in people's homes. The source of CO was incomplete combustion of domestic gas in 23 % of deaths, followed by petrol/diesel (15%) and solid/multifuel fuel (13%). In 40 % of cases that involved domestic gas, the appliance involved was a central heating boiler. Most deaths in vehicles (89%) and garages (93%) were of males. A quarter of all deaths (90% male) occurred in boats, tents, garages, workshops, and outhouses, places that may not be fitted with CO alarms.

Conclusion

Coroners' narrative reports provide information to aid prevention strategies. There is a need to not only maintain domestic appliances and to fit and maintain CO alarms in dwellings, but also to raise awareness of the hazards that may be posed by CO when working in an enclosed space such as a garage, vehicle, or garden shed. Fitting CO alarms and ensuring adequate ventilation in such areas may help further reduce unintentional CO-related deaths.

Current word count: 299

Prepare an informative summary of fewer than 300 words.

As with an abstract, the summary should provide information on the purpose of the study, methods or procedures, results, discussion, and concluding remarks or interpretation of the results. If feasible, it should also indicate the meaning or importance of the work.

Submission Instructions

Please email your abstract (300 words) using this template to monica.mateogarcia@bcu.ac.uk with the subject title 'UKIEG 2021' specifying if you are applying for an oral or poster slot. The call for abstracts will remain open until 26th March 2021.

Demonstrating the ASHRAE 62.1 IAQ procedure – Total Air Quality

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Abstract

This talk aims to demonstrate the benefits of utilizing the ASHRAE 62.1 Indoor Air Quality procedure to select the appropriate outdoor ventilation rates.

In combination with air cleaning technology, the IAQ procedure gives engineers an alternative method for selecting outdoor air flow rates.

Examples of the 62.1 calculations will be shown along with site testing on air quality where the IAQ procedure was used.

Keywords IAQ TVOC VENTILATION EFFICIENCY ENERGY

1.0 Introduction

ASHRAE defines acceptable Indoor Air Quality as "Air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction"

CO2 is not dangerous until levels exceed 30,000ppm, and yet it is regarded as the primary indoor air contaminant by many in the HVAC industry because it is not widely understood that CO2 is primarily a proxy for acceptable indoor air quality.

2.0 Main content

Trying to save energy by demand controlling ventilation rates purely on CO2 concentration is not an appropriate solution for much of the built environment.

Providing good IAQ by ventilating buildings with large quantities of outdoor air results in significant energy being used. In addition, the quality of outdoor air is decreasing to the point where it can seldom be called "fresh".

during the 1979 oil crisis, ASHRAE developed the 62.1 standard. The standard defines two methods for determining the outdoor air rate required in order to provide acceptable indoor air quality.
Option one is the ventilation rate procedure (VRP), the second option is using air cleaning systems and the IAQ procedure.
The ventilation rate procedure simply calculates the amount of outdoor air required to dilute the contaminants to acceptable levels.

The IAQ procedure allows engineers to model the concentration of indoor pollutants once the air is cleaned by an air purification technology.
If the calculations show that the level of contaminants of concern are lower when using the IAQ procedure than when modelled with the VRP, then the lower outdoor air flow rates from the IAQ procedure may be used.

Selection of lower outdoor air flow rates at design stage will reduce plant size and the reduction in heating, cooling and dehumidification will result in significant energy savings.

If air cleaning is utilized as an alternative to outdoor during peak temperature spikes, it may be possible to design a free running building when using the IAQ procedure, compared to having to utilize mechanical cooling when using the VRP.

2.1 Case Study Tables and Figures

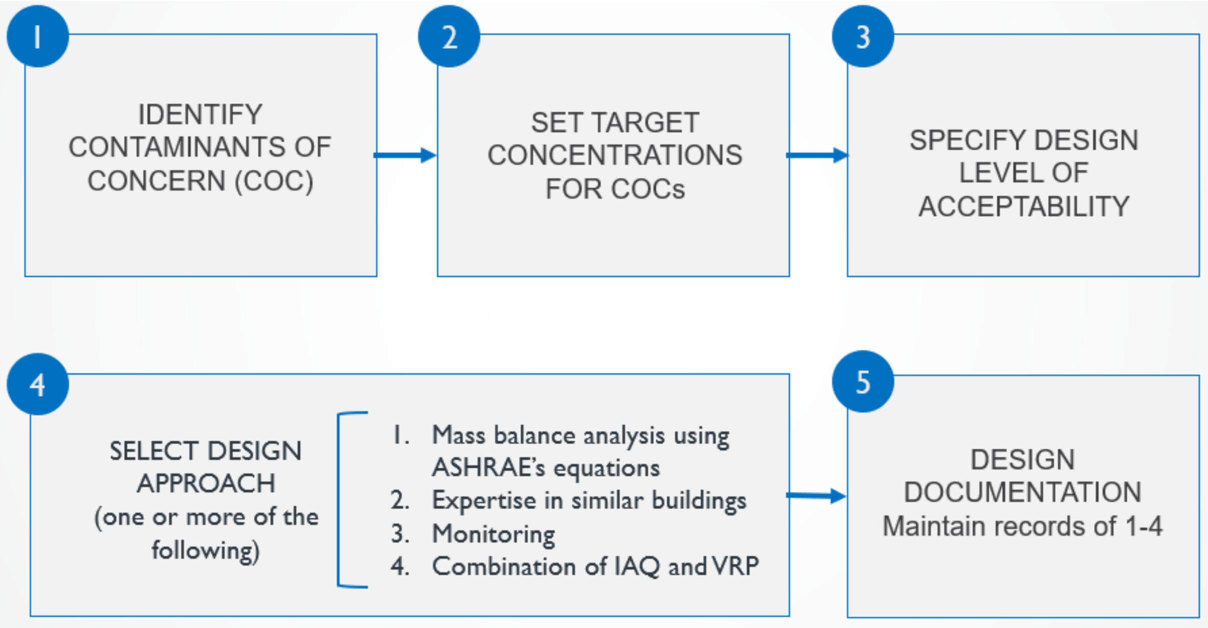

Figure 1 – How to design an IAQ project

Contaminant	Generation Rate per Person (ug/hr)
Ammonia	15,600
Carbon Monoxide	10,000
Hydrogen Sulfide	15
Methane	1710
Propane	1.3

Table 1 – Emission rates per person from ASHRAE

Contaminant	Concentration (ppm)
Ammonia	1.103
Carbon Monoxide	0.361
Hydrogen Sulfide	0.0005
Methane	0.098
Propane	0.00003

Table 2 – Typical contaminant concentrations in a classroom using VRP

Filter Location	Flow	Outdoor Airflow	Required Outdoor Airflow	Space Contaminant Concentration
None	VAV	100%	$V_o = \frac{N}{E_v F_r (C_s - C_o)}$	$C_s = C_o + \frac{N}{E_v F_r V_o}$
A	Constant	Constant	$V_o = \frac{N - E_v R V_r E_f C_s}{E_v (C_s - C_o)}$	$C_s = \frac{N + E_v V_o C_o}{E_v (V_o + R V_r E_f)}$
A	VAV	Constant	$V_o = \frac{N - E_v F_r R V_r E_f C_s}{E_v (C_s - C_o)}$	$C_s = \frac{N + E_v V_o C_o}{E_v (V_o + F_r R V_r E_f)}$
A	VAV	Proportional*	$V_o = \frac{N - E_v F_r R V_r E_f C_s}{E_v F_r (C_s - C_o)}$	$C_s = \frac{N + E_v F_r V_o C_o}{F_r E_v (V_o + R V_r E_f)}$
B	Constant	Constant	$V_o = \frac{N - E_v R V_r E_f C_s}{E_v [C_s - (1 - E_f) C_o]}$	$C_s = \frac{N + E_v V_o (1 - E_f) C_o}{E_v (V_o + R V_r E_f)}$
B	VAV	100%	$V_o = \frac{N}{e F_r [C_s - (1 - E_f) C_o]}$	$C_s = \frac{N + e F_r V_o (1 - E_f) C_o}{e F_r V_o}$
B	VAV	Constant	$V_o = \frac{N - E_v F_r R V_r E_f C_s}{E_v [C_s - (1 - E_f) C_o]}$	$C_s = \frac{N + E_v V_o (1 - E_f) C_o}{E_v (V_o + F_r R V_r E_f)}$
B	VAV	Proportional	$V_o = \frac{N - E_v F_r R V_r E_f C_s}{E_v F_r [C_s - (1 - E_f)(C_o)]}$	$C_s = \frac{N + E_v F_r V_o (1 - E_f) C_o}{E_v F_r (V_o + R V_r E_f)}$

Project Information

Project Name	ABC School	Number of People	25	Plasma Air Model	101 D
Classroom No.	123	Emmission Rate/Person (L/min)	0.00037	Ionization Setting	3
Area (Sq. Ft.)	1000	Ionization Efficiency (E_f)	0.680	Space Contaminant	Ammonia
Ceiling Ht (Ft)	9.25				
Volume (Ft^3)	9,250				

Calculation of Space Contaminant Using Ventilation Rate OA

Outside Airflow Rate per Person 14.8 CFM

Classroom Airflows	CFM	L/min
Supply Air	1080	30586
Outside Air	370	10478
Return Air	710	20107

For constant supply air and constant outside air, use:

$$Cs = \frac{N + Ev\ Vo\ Co(1 - Ef)}{Ev\ (Vo + R\ Vr\ Ef)}$$

Where:

Factor	Description	Value	Units
N	Contaminant Generation Rate	0.00925	L/min
Ev	System Ventilation Efficiency	0.8	
Vo	Outdoor Air Flow Rate	10478	L/min
Ef	Filter Efficiency	0.000	
Co	Contaminant Concentration, OA	0	ppm
R	Recirculation Flow Factor =Vr/(Vo+Vr)	0.66	
Vr	Return Air Flow Rate	20107	L/min
Cs	Contaminant Concentration, space	1.103	ppm

Calculation of Space Contaminant Using IAQ Procedure OA

Specified Outside Airflow Rate per Person 7.4 CFM

Classroom Airflows	CFM	L/min
Total Supply Air	1080	30586
Outside Air	185	5239
Return Air Flow Rate	895	25346

For constant supply air and constant outside air, use:

$$Cs = \frac{N + Ev\ Vo\ Co(1 - Ef)}{Ev\ (Vo + R\ Vr\ Ef)}$$

Where:

Factor	Description	Value	Units
N	Contaminant Generation Rate	0.00925	L/min
Ev	System Ventilation Efficiency	0.9	
Vo	Outdoor Air Flow Rate	5239	L/min
Ef	Filter Efficiency	0.680	
Co	Contaminant Concentration, OA	0	ppm
R	Recirculation Flow Factor =Vr/(Vo+Vr)	0.83	
Vr	Return Air Flow Rate	25346	L/min
Cs	Contaminant Concentration, space	0.526	ppm

Figure 2 – Software calculation comparing VRP and IAQ procedures.

3.0 Testing

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Lab  Parameter        Volume   Amount      LOQ        Concentration  Analysis

-001 1 (ROOM 237)  Samp Date: 10/02/08    Silica Gel Tube Trtd with Sulfuric
Acid
  -     NH3 Front              < 2.5 ug    2.5 ug
10/08/08
  -     NH3 Rear               ND          2.5 ug
10/08/08
  -     NH3 Total      19.4 L  < 2.5 ug    2.5 ug      < 0.185 ppm
10/08/08

-002 1 (ROOM 227)  Samp Date: 10/02/08    Silica Gel Tube Trtd with Sulfuric
Acid
  -     NH3 Front              < 2.5 ug    2.5 ug
10/08/08
  -     NH3 Rear               ND          2.5 ug
10/08/08
  -     NH3 Total      19.8 L  < 2.5 ug    2.5 ug      < 0.181 ppm
10/08/08

-003 3 (ROOM 218)  Samp Date: 10/02/08    Silica Gel Tube Trtd with Sulfuric
Acid
  -     NH3 Front              < 2.5 ug    2.5 ug
10/08/08
  -     NH3 Rear               ND          2.5 ug
10/08/08
  -     NH3 Total      18.5 L  < 2.5 ug    2.5 ug      < 0.194 ppm
10/08/08

-004 4 BLANK  Samp Date: 10/02/08    Silica Gel Tube Trtd with Sulfuric Acid
  -     NH3 Front              < 2.5 ug    2.5 ug
```

4.0 Types of Air cleaning technology.

Bi-Polar Ionisation

Carbon Filters

Catalyst filters

Re-generative adsorbent filters

Post-retrofit monitoring of indoor environmental conditions in a low-rise block of flats

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ABSTRACT

This paper presents an empirical investigation of the post-retrofit indoor environmental conditions in a 1950s low-rise block of six flats in the UK, in comparison to pre-retrofit conditions. The fabric-first energy retrofit consisted of full wrap-around external insulation of the building fabric, triple-glazed windows and mechanical ventilation with heat recovery (MVHR) systems installed in each flat. Post-retrofit air permeability level was measured as 0.918 $m^3/h/m^2$@50Pa against pre-retrofit level of 4.7 $m^3/h/m^2$@50Pa.

Indoor temperature, relative humidity (RH) and CO_2 levels were continuously monitored at five minute intervals using HOBO U100 and TinyTag TGE-0011 devices for nine months prior to retrofit and for four months after retrofit (October 2020 – January 2021). Indoor air quality (PMs, formaldehyde and VOCs) was monitored in two flats using Airthinx IAQ monitors.

Post-retrofit mean indoor temperatures were found to be higher at 20.7 °C (September-December 2020) against 19.8 °C pre-retrofit (September-December 2019). The temperatures were more stable (inter quartile range was 1.8°C as compared to 2.8 °C pre-retrofit) and did not stretch to the lows and highs that were experienced pre-retrofit. After installation of MVHR systems, mean RH reduced from 60% (pre-retrofit) to 45% (post-retrofit), while CO_s concentration reduced to 680 ppm (September-December 2020), as compared to 1038 ppm (September-December 2019).

Post-retrofit monitoring of IAQ indicated reduction in TVOCs levels, but occasional spikes in PMs and formaldehyde. From October 2020 to January 2021, formaldehyde averaged 0.009 mg/m^3 with spikes up to 1.340 mg/m^3 though it was within ‘good’ levels for 95% of monitored hours. Particulate matter (PM10, PM2.5) averaged 14.2ug/m^3 with spikes up to 423.7 ug/m^3, staying within ‘good’ levels for 86% of monitored hours. However ethanol (EtOH) levels were much higher and only within ‘good’ levels for 53% of monitored hours. The study reinforces the need to monitor exposures to indoor pollutants to understand the IAQ effects of advanced energy retrofits.

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Understanding how home development processes influence Indoor Air Quality and overheating in UK homes

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ABSTRACT

As global warming and climate change continue to manifest by changing weather patterns, the effects of environmental air pollution (not only outdoors but also indoors) raise interest and attention on the need to improve the quality of air inside homes. The current pandemic has caused people to spend more time indoors than ever before. The quality of air in homes is seen to play a significant role, and more importantly, understanding how to achieve Indoor air quality (IAQ) has perhaps never been so crucial. Here in the UK, in homes with poor IAQ, occupants may be exposed to various organic, inorganic and biological pollutants, which have been thoroughly investigated in the literature. However, attention has not been given to the housing providers' role in creating healthy indoor environments. There is a need to better understand the way their businesses operate and what influences their decision-making processes in relation to indoor air quality and overheating. It is also important to understand the business models of housing developers and their supply chains in the UK to better understand the constraints they experience and opportunities they can explore in the competitive and highly legislative industry they operate in. Furthermore, understanding this will be key to developing mass market, scalable and cost-effective strategies that will adapt our indoor environments to a changing climate. Therefore, this paper will explore the whole business and decision-making processes of housing developers through interviews, from the specification of procurement and design to the implementation of construction, handover, operation, and maintenance.

Using easy-to-deploy devices to monitor the performance of a portfolio of homes

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ABSTRACT

Passiv UK have deployed Connected Airtwits devices to monitor a portfolio of homes, with devices self-installed by the occupants. The AirWits device is a carbon dioxide (CO2), temperature, and humidity sensing device for real and accurate air quality monitoring, that communicates using the Sigfox national radio network. Passiv UK have explored how AirWits data can be analysed to assess the performance of homes and identify potential concerns.

Our approach is to analyse the monitoring data and provide a layer of intelligent interpretation. The output is presented as a dashboard which indicates which homes in the portfolio are rated best and worst,as well as potential concerns at each home. Individually homes can then be explored at a more detailed level, providing insight on key metrics and the ability to explore the device data directly.

This submission covers initial scoping work which has been performed by Passiv UK for a prototype dashboard to present AirWits analysis results. The following warnings are currently considered for each device: over-heating , under-heating, poor heating control, high humidity, low humidity, indoor drying of clothes, risk of damp, high CO2, high overnight CO2, over occupation, and frequently opening windows.

We gratefully acknowledge the help of Innovate UK, STBA, and Vivid Homes with this work.

Submission Instructions

Please email your abstract (300 words) using this template to monica.mateogarcia@bcu.ac.uk with the subject title 'UKIEG 2021' specifying if you are applying for an oral or poster slot. The call for abstracts will remain open until 20th April 2021.

Carbon dioxide indoors - a pollution indicator or a pollutant? A health-based perspective.

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ABSTRACT

With modern populations spending approximately 90% of their time indoors, and with carbon dioxide (CO_2) concentrations inside being able to accumulate to much greater concentrations than outdoors, it is important to identify the health effects associated with low-level CO_2 exposures in indoor environments. Although other reviews have summarised the effects of CO_2 exposures on health, none have considered the individual study designs of investigations and factored that into the level of confidence with which CO_2 and health effects can be associated, nor commented on how the reported health effects of exposure correspond to existing guideline concentrations. This investigation aimed to (a) evaluate the reported health effects and physiological responses associated with exposure to less than 5000 parts per million (ppm) of CO_2 and (b) to assess the CO_2 guideline and limit concentrations in the context of (a). Of the 51 human investigations assessed, many did not account for confounding factors, the prior health of participants or cross-over effects. Although there is some evidence linking CO_2 exposures with health outcomes, such as reductions in cognitive performance or sick building syndrome (SBS) symptoms, much of the evidence is conflicting. Therefore, given the shortcomings in study designs and conflicting results, it is difficult to say with confidence whether low-level CO_2 exposures indoors can be linked to health outcomes. To improve the epidemiological value of future investigations linking CO_2 with health, studies should aim to control or measure confounding variables, collect comprehensive accounts of participants prior health and avoid cross-over effects. Although it is difficult to link CO_2 itself with health effects at exposures less than 5000 ppm, the existing guideline concentrations, which suggest <1500 ppm as acceptable for the general population, appear consistent with the current research.

Aerosols from Cooking at the Indoor/Outdoor Interface

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ABSTRACT (291 of 300 words max)

Indoor Air Quality (IAQ) is a key component of indoor environmental quality, whose importance has been brought to the forefront of public interest during the pandemic. Aerosols of all types are an important contributor to IAQ owing to their well-established influence on human health.

As a result of their diverse sources, ranging from infiltration, cooking, chemistry and resuspension, there remain uncertainties in the influence of different human behaviours on relative contributions of aerosols from different sources in the home. Aerosols from cooking are known to influence IAQ in homes, as well as being detected as a large source at an urban scale. However, the variability of aerosols at the indoor/outdoor interface related to human behaviour remains uncertain at a household or neighbourhood level.

In this study, we make use of the new DOMESTIC facility for studying air quality in the built environment at The University of Chester, to study the influence that cooking has on aerosol at the indoor/outdoor interface. We make use of the novel MODULAIR^{TM}-PM sensor systems to probe real-time, size resolved aerosols simultaneously indoors and outdoors during typical household activities. These findings provide new insights into the effect of domestic cooking on indoor and outdoor air quality, under a range of typical ventilation scenarios.

As we move to new ways of living and working, spending more time working from our homes, we are increasingly exposed to the pollutants generated in our homes, and especially, in our kitchens. These exposures perpetuate existing inequalities, with those living in smaller, poorly ventilated dwellings, or open plan living, being exposed to pollutants at a higher intensity. Looking beyond the COVID-19 pandemic, understanding household sources of aerosols, and mitigation strategies for their reduction will be important for healthy building design for the future.