

Determining Contaminants of Concern When Implementing ASHRAE Standard 62.1 Indoor Air Quality Procedure

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SUMMARY

The Indoor Air Quality (IAQ) Procedure of ASHRAE Standard 62.1-2007 allows designers to reduce energy consumption by incorporating contaminant reduction measures, such as air cleaning, which in turn should reduce the required outdoor ventilation rates of a building. One key requirement of the IAQ Procedure is to define appropriate contaminants of concern (CoC). IAQ Professionals have proposed methods of choosing these CoC for the IAQ Procedure ranging from research of building material emissions to performing chemical air sampling in a building. However, a list of typical CoC to consider is still unclear.

This paper presents a summary of contaminants from published IAQ Procedure applications and research ranking common indoor air volatile organic compounds (VOCs) based on odor, sensory irritation, and noncancer chronic toxicity. Three publications referenced successful application of the IAQ Procedure with information pertaining to CoC. Comparing these applications to the reviewed VOC ranking research provided insight into developing a base CoC set for IAQ Procedure applications.

INTRODUCTION

Energy usage and associated environmental impacts of electric energy production are receiving much attention today. Engineers scour their designs for opportunities to reduce short-term and long-term carbon footprints while providing an acceptable indoor environment. ASHRAE Standard 62.1-2007 provides two ventilation strategies to meet these goals: the Ventilation Rate Procedure and the Indoor Air Quality (IAQ) Procedure. The Ventilation Rate Procedure provides prescriptive amounts of outdoor air depending on the space types within a building. The IAQ Procedure is a contaminant based design method, which allows designers to reduce energy consumption by incorporating contaminant reduction measures, such as air cleaning. Using the IAQ Procedure should allow a reduction in the required outdoor ventilation rates and associated energy requirements.

One key requirement of the IAQ Procedure is to define appropriate contaminants of concern (CoC). Engineers and architects must define the CoC for specific applications since ASHRAE 62.1-2007 does not define potential CoCs. Due to their importance and the possibility of improper contaminant choice, design professionals have posed the question "How do designers choose the CoC?" (Stanke, 2007).

IAQ Professionals have proposed methods of choosing these CoC for the IAQ Procedure ranging from research of building material emissions to performing chemical air sampling in a building (ASHRAE, 2007). Authors and presenters have also referenced successful applications of the IAQ Procedure using specific contaminants (Johnson, 2006; Lamping, 2008). However, the minimum numbers of CoC an engineer should consider is unclear. This

paper approaches this topic by comparing contaminants referenced in published IAQ Procedure applications to research ranking common indoor air volatile organic compounds (VOCs) found in building studies.

CONTAMINANTS FROM PUBLISHED APPLICATIONS AND BUILDING STUDIES

The authors reviewed three publications referencing successful application of the IAQ Procedure using air cleaning and citing contaminants considered in the design. The first application (Publication 1) was applied to an office building (Stanley, 2002). Building specifics including floor area and number of occupants were omitted and the application success was based on contaminant simulation results showing concentrations less than target concentration limits. The second application (Publication 2) was applied to a school auditorium (Johnson, 2006). The auditorium had a maximum design occupancy of 1,000 people and a total supply airflow of 30,600 m³/hr (18,000 ft³/min). The facility manager performed air sampling and kept a log of complaints as an indicator of occupant satisfaction to measure the success of the IAQ Procedure application. The third application (Publication 3) was applied to a high school (Lamping, 2008). The high school had a design occupancy of 448 people, a total supply airflow of 41,600 m³/hr (24,500 ft³/min), and a floor area of 1,440 m² (15,500 ft²). The facility manager performed air sampling and kept an IAQ complaint log as an indicator of occupant satisfaction to measure the success of the IAQ Procedure application. Table 1 displays the contaminants referenced in these three applications.

Hodgson and Levin (2003) presented a methodology to classify the relative importance of individual indoor VOCs with respect to odor, sensory irritation, and noncancer chronic toxicity. They evaluated VOC studies from residences and office buildings (including the U.S. Environmental Protection Agency's Building Assessment and Survey Evaluation [BASE]) taken between 1990 and 2003 by applying a hazard quotient methodology to the identified VOCs. The authors found "only a small number of the more than 100 reported VOCs were shown to exceed levels that might be of concern with respect to the comfort and health endpoints considered." This contaminant list is also shown in Table 1 under Building Data Review.

DISCUSSION

The IAQ Procedure applications referenced a total of four VOCs plus a TVOC measure. The Building Data Review identified more than 100 individual VOCs in offices and residences, of which the researchers ranked those in Table 1 as most likely to impact occupants through the hazard quotient method. The only VOC common to all the reviewed studies and publications was formaldehyde. Additionally, the TVOC of Publications 1 and 3 includes many of the VOCs from the Building Data Review. While there are significant differences in building usages and consequential selection criteria in determining the CoC it may be prudent to consider indoor chemicals that have been identified as typical and ranked with a ranking methodology similar to Hodgson and Levin's work as a beginning list of CoC representing VOCs in indoor air. Probable choices are the 14 compounds shown under the Building Data Review column of Table 1. Additionally, TVOC values are a well accepted overall indicator of VOC levels and a useful unofficial CoC to consider.

Table 1 – Identified Contaminants from Applications of the IAQ Procedure and from a Review of Building Study Data

IAQ Procedure Applications			Building Data Review ^d (office building)
Publication 1 ^a (Office Building)	Publication 2 ^b (School Auditorium)	Publication 3 ^c (High School)	
<i>VOCs</i> acetone formaldehyde methyl alcohol TVOC	<i>VOCs</i> none	<i>VOCs</i> acetone formaldehyde methyl alcohol phenol TVOC	<i>VOCs</i> 1,4 dichlorobenzene 3-methylbutanal acetaldehyde acetic acid benzene formaldehyde heptanal hexanal hexanoic acid naphthalene nonanal octanal propionaldehyde tetrachloroethene
<i>Other</i> none	<i>Other</i> carbon dioxide	<i>Other</i> carbon monoxide	
<i>Inorganics</i> nitrogen dioxide ozone sulfur dioxide	<i>Inorganics</i> ammonia	<i>Inorganics</i> ammonia hydrogen sulfide nitrogen dioxide ozone sulfur dioxide	

^a Publication 1 grouped the contaminants into three types, those from outdoor air (nitrogen dioxide, ozone, sulfur dioxide), occupants (acetone, methyl alcohol), and building materials (formaldehyde, TVOC).

^b Publication 2 considered other contaminants, but only specifically stated and measured the two listed.

^c Publication 3 grouped the contaminants into three types, those from outdoor air (carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide), occupants (acetone, ammonia, hydrogen sulfide, methyl alcohol, phenol), and building materials (formaldehyde, TVOC).

^d The list includes those VOCs whose hazard quotients (95 percentile maximum value divided by the respective threshold value) were greater than 0.1. It also includes contaminants whose hazard quotients were greater than 0.1 in residences, but were not considered or not monitored in the office building and therefore cannot be ruled out. These compounds were (3-methylbutanal, acetaldehyde, acetic acid, formaldehyde, heptanal, hexanoic acid, octanal, propionaldehyde).

The Building Study Review study did not consider inorganic and other compounds. The sources of the listed inorganic and other compounds were mainly outdoor air. Further evaluation of inorganic and other compounds may be needed. For outdoor air, the EPA has already delineated a criteria pollutant list in the National Ambient Air Quality Standards, which serves as the most likely starting point for outdoor sourced CoC – lead, PM_{2.5}, PM₁₀, carbon monoxide, nitrogen dioxide, ozone, and sulfur dioxide (EPA, 2009).

CONCLUSIONS

The IAQ Procedure of ASHRAE 62.1 has the potential to significantly impact the energy consumption of HVAC equipment through reductions in outdoor ventilation rates by controlling indoor contaminants using control methods such as air cleaning. In order for the IAQ Procedure of ASHRAE 62.1 to be widely used, there needs to be a base CoC set. This paper has provided a starting point for developing a base CoC set of indoor VOCs with the conclusion that indoor VOCs ranked as typical and likely to impact occupants with a ranking methodology similar to Hodgson and Levin’s work (2003) be considered as a basis. Further research is needed to establish a base CoC list for engineers using the IAQ Procedure of

ASHRAE 62.1. Continued refinements to such a list should be considered as building usages differ resulting in different indoor contaminants.

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