

## COMPARISON OF THREE IAQ CALCULATION METHODS

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### ABSTRACT

Calculating contaminant concentrations in or the required ventilation for a space has been a difficult and confusing part in the application of the IAQ Procedure of ANSI/ASHRAE Standard 62.1-2004; Ventilation for Acceptable Indoor Air Quality. Appendix D of ASHRAE Standard 62 presents one method for performing these calculations, but it is limited to the steady-state analysis of a single zone. More recently, two software tools have been developed by the United States National Institute of Standards and Technology (NIST) to facilitate these calculations and to include transient effects. One is the Indoor Air Quality Design Tool (IAQDT) that was developed to aid in contaminant-based design of ventilation systems, such as when using the IAQ Procedure. The IAQDT differs from Appendix D in that it does not assume steady state conditions to exist. The other is CONTAM, a multizone airflow and indoor air quality and ventilation analysis computer program designed to help predict airflows and contaminant concentrations in multizone building systems.

This paper reports on the application of all three methods to a single zone, showing how the results obtained by each method may be similar, with exceptions occurring when transient effects are important. The paper also evaluates difficulties that arise from applying a single zone mass balance model to a multiple zone system. Application and appropriateness of each method for modeling indoor air quality and when using the IAQ Procedure will be discussed.

### KEYWORDS

Design, Modeling, Indoor Air Quality, ASHRAE Standard 62, Indoor Air Quality Procedure

### INTRODUCTION

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 62.1-2004 "Ventilation for Acceptable Indoor Air Quality," (ASHRAE 2004) provides formulas in Appendix D for calculating the space contaminant concentrations of a zone for application with the standard's Indoor Air Quality (IAQ) Procedure. These equations are based on a single-zone mass balance under steady state conditions. They have been used for many years to calculate contaminant concentrations in a zone and compare them to guideline levels.

The U.S. National Institute of Standards and Technology (NIST) has developed two software tools

that can be used to aid in contaminant-based design of building ventilation systems based on concentration targets and emission information using mass balance calculations. Corresponding ventilation rates can be calculated for each contaminant of concern.

One is the Indoor Air Quality Design Tool (IAQDT) that can be used to calculate transient concentrations of contaminants based on the HVAC system configuration and operation (Walton 2003). It differs from the mass balance model in Appendix D of Standard 62.1 in that it does not assume steady conditions to exist.

The other modeling tool developed by NIST is a multizone indoor air quality and ventilation analysis computer program called CONTAM (Anon.). It is designed to help one determine airflows, contaminant concentrations and personal exposure.

A comparison of a sample office space using these three approaches will be performed. This comparison is intended to highlight similarities and differences in the resulting contaminant concentrations in the space, possible reasons for the differences between each model, and the appropriateness of each model for use in office building scenarios.

### **ASHRAE Standard 62.1 Mathematical Model**

The formulas provided in Appendix D of Standard 62.1 take into account (among other things) the amount of outdoor air, contaminant generation rate(s), outdoor contaminant concentrations, filter locations and efficiencies, ventilation effectiveness, supply air circulation rate and the fraction recirculated. The schematic of a representative system is shown in Figure 1.

The variables in this model are defined as follows:

$V_o$  = volumetric flow of outdoor air, from ambient into air handling system (AHS);

$V_r$  = volumetric flow of return air, from the zone to the AHS and ambient air;

$V_s$  = volumetric flow of supply air, from the AHS;

$R$  = recirculation flow factor;

$F_r$  = flow reduction factor, used with variable air volume (VAV) systems;

$C_o$  = contaminant concentration in the outdoor air;

$C_s$  = contaminant concentration in the occupied zone;

$E_f$  = filter efficiency for contaminant;

$E_v$  = ventilation effectiveness;

$N$  = contaminant generation rate in the zone;

$\mathbf{A}, \mathbf{B}$  = filter locations in the recirculation air and the supply (mixed) air, respectively.

This model is intended to model one zone at a time. In the simplest form, the user would use constant contaminant generation rates and filter removal efficiencies, and the mechanical system properties to determine the total concentration in the space or the amount of outside air or recirculation air needed. For the purposes here, the concentration of the contaminant in the space will be calculated and compared to a guideline level. An example of those formulas (Eq. 1) is shown below for the setup modeled in this work.

- Filter Location: "B"
- HVAC flow type: constant
- Outdoor air flow type: constant
- Space contaminant concentration ( $C_s$ ):

$$C_s = \frac{N + E_v V_o (1 - E_f) C_o}{E_v (V_o + R V_r E_f)} \quad (1)$$

### Indoor Air Quality Design Tool (IAQDT)

The mathematical model behind the IAQDT is based on mass balances of a single-zone system. This system (or zone) over which the balances are written is shown in Figure 2. It takes into account the amount of outside air, recirculation, total supply air and infiltration to the space as well as the amount of exhaust, return air and exfiltration from the space. Air cleaning technologies applied in the HVAC system or in the space can be modeled if efficiencies and flows are determined.

The zone model allows for the following airflows:

- $\dot{m}_i$  = infiltration flow – direct from ambient into the zone,
- $\dot{m}_e$  = exfiltration flow – from the zone to ambient,  
= exhaust flow – from the zone to ambient,
- $\dot{m}_c^x$  = air cleaner flow – within the zone through a filter,
- $\dot{m}_r$  = return flow – from the zone to the air handling system,
- $\dot{m}_s$  = supply flow – from the air handling system to the zone,
- $\dot{m}_u$  = spill flow – from the air handling system to ambient,
- $\dot{m}_t$  = recirculation flow – from the return to the supply side of the air handling system,
- $\dot{m}_v$  = ventilation flow – from ambient to the supply side of the air handling system,  
-or- if there is no air handling system, from ambient directly to the zone.

In addition to the mass flows described above, the following variables are used for each contaminant of concern:

$c_o$  = contaminant concentration in the outdoor air, kg/kg;

$c_s$  = contaminant concentration in the mixed supply air, kg/kg;

$c_z$  = contaminant concentration in the zone and return air; kg/kg;

$\eta_v$  = filter efficiency for the ventilation air stream;

$\eta_r$  = filter efficiency for the recirculation air stream;

$\eta_s$  = filter efficiency for the supply air stream;

$\eta_c$  = filter efficiency for the air cleaner;

$G$  = contaminant generation rate in the zone;

$R$  = contaminant removal (sink) coefficient in the zone.

For each contaminant we calculate the concentration in the fully mixed zone and the supply flow by simultaneously solving Eq. 2 and 3. These are based on a mass balance for the contaminant concentration on the supply flow over system #1 and a mass balance for the rate of change of contaminant concentrations in the zone over system #2. These equations are solved throughout a day from midnight (00:00) to midnight (24:00) until steady state is reached, i.e. the contaminant concentration at the end of the day equals the contaminant concentration at the beginning of the day. These calculated concentrations throughout the day are saved and compared to limit concentrations for further reporting.

$$\dot{m}_s c_s = \dot{m}_v (1 - \eta_v) c_o + \dot{m}_t (1 - \eta_t) c_z \quad (2)$$

$$\left( \frac{\rho_z V_z}{\Delta t} + \dot{m}_c \eta_c + \dot{m}_r + \dot{m}_e + \dot{m}_i + \sum R \right) c_{z,t} - \dot{m}_s (1 - \eta_s) c_{z,t-\Delta t} = \frac{\rho_z V_z}{\Delta t} c_{z,t-\Delta t} + \dot{m}_i c_o + \sum G \quad (3)$$

### CONTAM Version 2.4

CONTAM (or CONTAMW) is a multizone indoor air quality and ventilation analysis computer program also developed by NIST and is designed to help predict the following items.

1. Airflows: infiltration, exfiltration, and room-to-room airflows in building systems driven by mechanical means, wind pressures acting on the exterior of the building, and buoyancy effects induced by the indoor and outdoor air temperature difference.
2. Contaminant Concentrations: the dispersal of airborne contaminants transported by these airflows; transformed by a variety of processes including chemical and radio-chemical transformation, adsorption and desorption to building materials, filtration, and deposition to building surfaces, etc.; and generated by a variety of source mechanisms.

3. Personal exposure: the predictions of exposure of occupants to airborne contaminants for eventual risk assessment.

CONTAM can be useful in a variety of applications. Its ability to calculate building airflows is useful to assess the adequacy of ventilation rates in a building, to determine the variation in ventilation rates over time and the distribution of ventilation air within a building, and to estimate the impact of envelope air tightening efforts on infiltration rates. The prediction of contaminant concentrations can be used to determine the indoor air quality performance of a building before it is constructed and occupied, to investigate the impacts of various design decisions related to ventilation system design and building material selection, and to assess the indoor air quality performance of an existing building. Predicted contaminant concentrations can also be used to estimate personal exposure based on occupancy patterns in the building being studied. Exposure estimates can be compared for different assumptions of ventilation rates and source strengths.

CONTAM enables the user to model multiple zone systems with both transient (CONTAM<sub>T</sub>) and steady state (CONTAM<sub>SS</sub>) modes as opposed to the single zone models presented in Appendix D and the IAQDT.

## METHODS

For this purposes of this comparison, CONTAM was used to model the space as a single zone to show the relative performance of this calculation tool versus the other two models. A separate example is also provided modeling a multiple zone system. This enables the user to see the effects of recirculating air from other spaces and the different results of differences in supply air amounts, occupancies, etc. among the zones. Finally, one zone from the multiple zone system was modeled using the single zone model, only considering its occupants, its supply air, and its amount of ventilation air.

The sample zone parameters used for comparison of these three models are listed in Table 1. These parameters were entered into the Standard 62.1 formulas as well as the IAQDT and CONTAM software, which used these schedules to determine the contaminant generation rates and ventilation periods as well. The Standard 62.1 formulas were used with constant, always on contaminant generation and ventilation rates to find the steady state properties. The contaminant concentrations and generation rates used for all three models are shown in Tables 2 and 3.

A filter efficiency of 25% ( $E_f = 0.25$ ) was used for all contaminants except ammonia and carbon monoxide, against which, according to the manufacturer's literature, the filter had no effectiveness ( $E_f = 0$ ).

## RESULTS

Results from each model are shown in Table 4.

### **Standard 62.1 versus the IAQDT**

The differences between the resulting indoor air concentrations using the Standard 62.1 model and the IAQDT were greatest for ammonia and carbon monoxide which are not controlled by the air cleaning system. Figure 3 provides an example showing concentration versus time data for ammonia and sulfur dioxide as derived by the IAQDT.

Since the ammonia is not being removed by the air cleaning system and has an internal source (building occupants), it is able to build up during the day. Thus, the concentration increases as it approaches the Standard 62.1 concentration until the internal source is "turned off" at 6 p.m.

Therefore, the concentration determined by the Standard 62.1 formulas for ammonia is higher than the IAQDT concentration because the Standard 62.1 formulas calculate steady state conditions based on what can be assumed the worst case; constant occupancy and minimum airflows.

Sulfur dioxide is not assumed to have an internal source and it is removed by the air cleaning system. The indoor concentration levels off fairly rapidly and begins to drop back down towards the unoccupied minimum.

### **Standard 62.1 versus CONTAM**

The differences between the resulting indoor air concentrations for the Standard 62.1 model and CONTAM<sub>T</sub> were greatest for formaldehyde and VOCs due to these contaminants building up while the outside air was off. When the outside air was turning on at 0600 hrs, the concentrations were close to their maximum values.

### **Steady-state versus transient state models**

Standard 62.1 calculations and CONTAM<sub>SS</sub> are based on steady state conditions and the resulting space concentrations are the best that could be achieved if there was constant airflow, continuous contaminant generation, and the air cleaning system continually removing the contaminants. This should provide the lowest values of all the models.

The IAQDT and the CONTAM<sub>T</sub> models calculate contaminant concentrations in a transient state. The resulting space concentrations are calculated over time using the information provided about all airflows, contaminant generation rates, etc. and their corresponding schedules. For both transient models, the concentrations near the end of the occupied period were very close to the steady state values shown in Table 4. The IAQDT incorporated a contaminant sink for all contaminants internal to the building resulting in the concentration for all contaminants, including

ones not removed by the air cleaning system, to decay over time. CONTAM was used without any sinks besides the air cleaning system, so the resulting space concentrations were higher than those from the IAQDT and did not decrease for the contaminants not removed by the air cleaning system (i.e., ammonia, carbon monoxide). The following figures illustrate these types of differences between these two transient models

Ammonia (Figure 4) is not removed by the air cleaner and CONTAM does not have a sink for any contaminants besides the air cleaner. The occupants leave and the outside air turns off at 1800 hrs. The source is removed, but since there is no outside air to dilute the ammonia, the concentration stays the same.

The IAQDT does have a sink for ammonia. The occupants leave, the outside air turns off, and the sink slowly decreases the concentration.

Formaldehyde and TVOC (Figures 5 and 6) are removed by the air cleaner and CONTAM has no sinks besides the air cleaner. When the outside air turns off, the contaminant concentrations increase because of less dilution. When the outside air turns back on dilution causes the concentrations to decrease.

IAQDT did have sinks for contaminants in addition to the air cleaner. Therefore, when the outside air turned off, the sink helped decrease the contaminant concentrations. When the outside air turned back on, the presence of these contaminants in the outside air raised the internal concentration.

Carbon monoxide (Figure 7) goes through a similar pattern as ammonia except that for CONTAM the outside air assumed to be the only source for this contaminant and there were no sinks. When the outside air turns off, the concentration stays the same.

For the IAQDT, there is an internal sink for every contaminant. The outside air is turned off and the internal sink slowly decreases the contaminant concentrations.

The curves for the contaminants modeled from outdoor air without internal sources and which were removed by the air cleaning system were fairly similar. Their space concentrations decreased during the non-ventilated hours (6 PM to 6 AM) and then increased toward a steady state value during the occupied hours. Figure 8 shows an example of this.

### Multiple Zone Systems

The most accurate method of modeling airborne contaminant concentrations in an HVAC system is by using a model that simulates as close as possible the specific HVAC system. However, the authors have observed past efforts for contaminant modeling that used simplified methods ranging from isolating individual zones to grouping all zones together. These "shortcuts" not only do not provide the best

information with which to model indoor air quality, but often significantly understate or overstate expected contaminant concentrations.

Limitations of these simplified methods as compared to actual system operation can be shown by evaluating a multiple zone HVAC system using three different models: 1) all zones isolated from each other, 2) all zones grouped into a single larger zone, and 3) all zones interacting with each other via recirculation of air within the HVAC system and transfer of air between zones.

For the examples that follow, the multiple zone ventilation system as described in Example 6-AA – "IAQ Procedure, Multizone Systems" (i.e. contaminant generation rates, outdoor air contaminant concentrations, airflows, zone types, etc.) in the Standard 62.1 User's Manual (ASHRAE 2005) was used. The examples include two simplified approaches and a third that more closely models actual system operation.

1. Using the Standard 62.1 equations with each space as an individual zone assuming no effects due to contaminant transfer attributable to recirculation from other zones.
2. Using the Standard 62.1 equations with all individual zone parameters (area, volume, contaminant sources, airflows, etc.) combined into a single larger zone.
3. Using the CONTAM<sub>SS</sub> software to model the zones as the HVAC system would actually operate, i.e. recirculation airflows transferring contaminants from one zone to another.

### Differences Observed in Multiple Zone Models

Examples 1 and 3 above used the zone described as "Zone 1 – Corridor" for this multiple zone system to compare differences in the percent of target contaminant concentrations. This parameter provides indication if the reduction in outdoor air intake rates and the air cleaner performance specified will be able to provide the equivalent air quality necessary to comply with the requirements of Standard 62.1.

The results shown in Table 5 indicate that this zone would have significantly lower concentrations of internally generated contaminants (averaging almost 10% lower) when modeled as an isolated zone as compared to what is closer to the actual system model when using CONTAM<sub>SS</sub>. The primary reasons for this are that this zone had the lowest contaminant generation rates of all the zone types listed (that included fitting rooms and sales areas) and had the third highest supply airflow per square foot. This results in a higher dilution rate than the system would be able to achieve with the actual HVAC system and a simultaneous lowering of the estimated contaminant concentrations.

Examples 2 and 3 are compared in Table 6 for the same "Zone 1 – Corridor". Again comparing the results obtained for the percent of target contaminant concentrations now shows that this zone would have somewhat higher concentrations (averaging almost 4% higher) of those internally generated contaminants when modeled as a combination of all zones.

These higher contaminant concentrations can be explained due to an increase in overall contaminant generation rates. This zone actually had the lowest contaminant generation rates, but when incorporated as part of a single large zone, the resulting contaminant generation rates increased due to the influences of the other zones. The airflow properties of the zone were also changed. Consequently, using a single large zone model will increase contaminant concentrations due to higher contaminant generation rates and less dilution than what would be expected when modeling the actual HVAC system.

## CONCLUSIONS

Building contaminants were modeled using three design methods: the formulas found in Appendix D of ASHRAE Standard 62.1-2004, and the Indoor Air Quality Design Tool and CONTAM (ver.2.4) software developed by NIST. For a single zone system, each of these tools achieves similar results with the differences mainly due to the details used in each method (e.g., contaminant generation and sink rates, occupancy schedule, outdoor air ventilation schedule, etc.). The Standard 62.1 equations are useful to determine steady state contaminant concentrations in a single zone. The IAQDT and CONTAM both allow the user to calculate either steady state or transient concentrations in a single zone. The results described above showed that contaminant concentrations over an eight-hour day approached, and in many cases equaled, the steady state values obtained using the Standard 62.1 formulas.

Modeling was also carried out on a multiple zone system. The results indicated that recirculation air from other zones needs to be modeled for an accurate representation of zone air contaminant concentrations. The Standard 62.1 formulas were used to model a single zone without considering the impacts of recirculating (i.e., the transferring of) air from other zones. CONTAM<sub>SS</sub> was also used to model the same zone, but as part of a multiple zone system. The recirculation (transfer) air significantly affected the contaminant concentrations in the space. Such information supports the fact that a multiple zone system requires a modeling tool capable of modeling contaminants and airflows from multiple zones.

Continuing to support the IAQ modeling process, NIST has created a series of model input databases for use in CONTAM (Howard-Reed and Polidoro 2006). As part of this effort, a standard data entry format has been developed, as well as a computer program to search the database for specific records and build a

CONTAM input library. These databases and tools can serve as a basis for building an extensive collection of model input parameters, assessing the quality and completeness of existing data sets, and allow for identification of significant data gaps.

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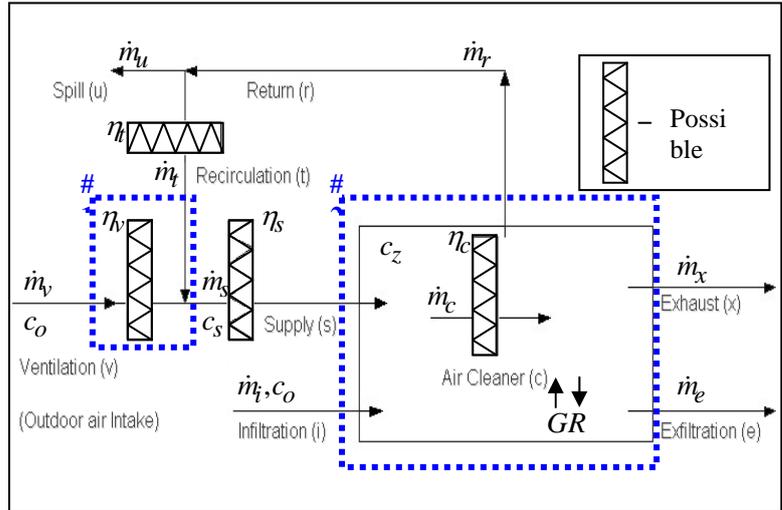
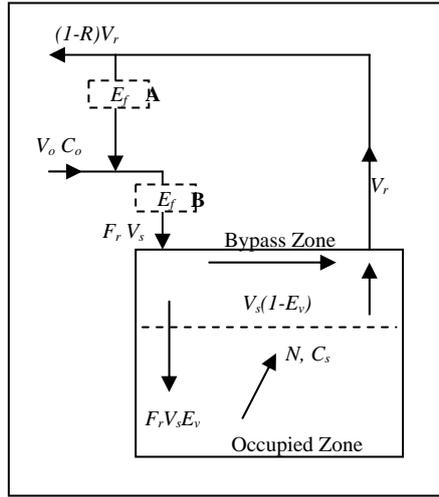


Figure 1 ASHRAE Standard 62.1-2004

Figure 2 Single zone system

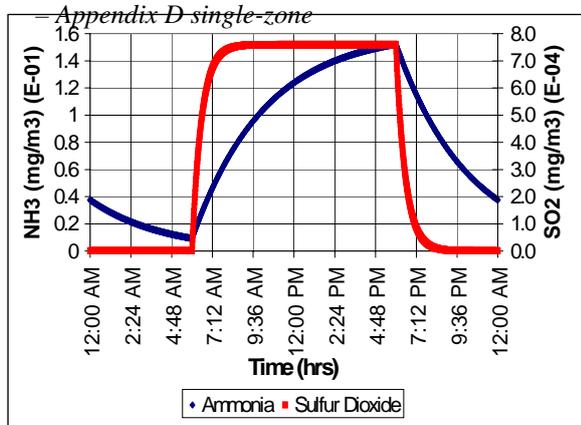


Figure 3 Contaminant concentrations versus time for ammonia and sulfur dioxide

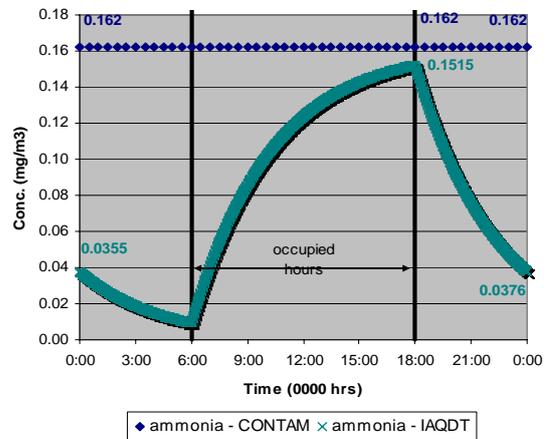


Figure 4 Ammonia transient concentrations for CONTAM & IAQDT

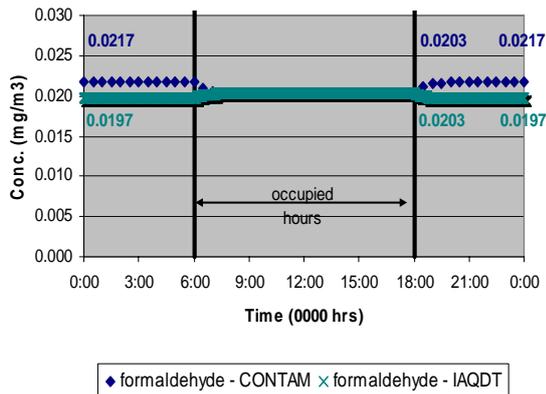


Figure 5 Formaldehyde transient concentrations for CONTAM & IAQDT



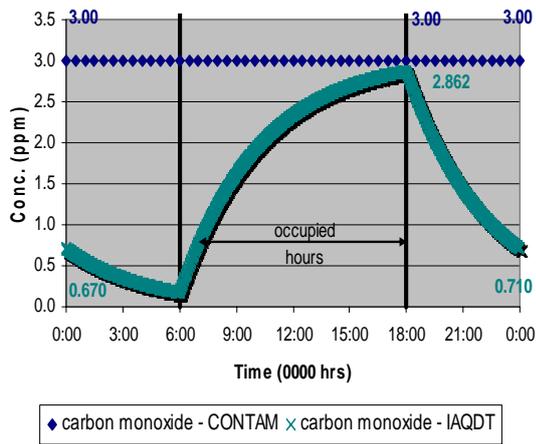


Figure 7 Carbon monoxide transient concentrations for CONTAM & IAQDT

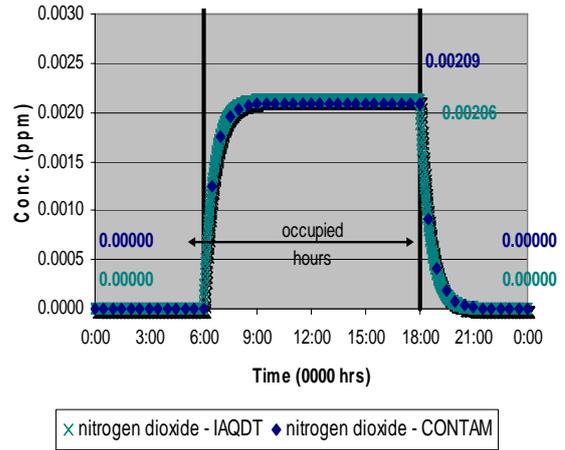


Figure 8 Nitrogen dioxide transient concentrations for CONTAM & IAQDT

Table 1 Single zone system properties used in models

Parameter	Description / Value	Schedule
<b>System Properties</b>		
Filter Location	Supply Airstream	n/a
HVAC Flow Type	Constant	n/a
Outdoor Air Flow Type	Constant	n/a
<b>System Values</b>		
Area (m <sup>2</sup> )	929	n/a
Volume (m <sup>3</sup> 2.7 m ceilings)	2,549	n/a
Occupancy (7 people /92.9 m <sup>2</sup> )	70	6 AM - 6 PM
Supply Airflow (cmh)	16,990	Always On
Ventilation Airflow (cmh)	595	6 AM - 6 PM

n/a: not applicable

Table 2 Outdoor air data used in models

Contaminant	Mol Wt (g/g-mol)	Concentration (C <sub>0</sub> )	
		value	units
<b>Criteria Contaminants in Outdoor Air<sup>+</sup></b>			
Carbon Monoxide	28.01	3.0000	ppm
Nitrogen Dioxide	46.01	0.0220	ppm
Ozone	48.00	0.1140	ppm
Sulfur dioxide	64.06	0.0030	ppm
<b>Bioeffluents &amp; Building Materials<sup>++</sup></b>			
Acetone	58.08	0.0166	mg/m <sup>3</sup>
Ammonia	17.03	0.0035	mg/m <sup>3</sup>
Formaldehyde	30.03	0.0068	mg/m <sup>3</sup>
Hydrogen sulfide	34.08	0.0005	mg/m <sup>3</sup>
Methyl alcohol	32.04	0.0000	mg/m <sup>3</sup>
Phenol	94.11	0.0004	mg/m <sup>3</sup>
TVOC	n/a	0.0685	mg/m <sup>3</sup>

<sup>+</sup> U.S. Environmental Protection Agency AIRS Database [Anon A.].

<sup>++</sup> [Brightman, et al. 1995; Girman, et al. 1995; Sheldon, et al. 1988; Womble, et al. 1995].

Table 3 Indoor contaminant concentrations and generation rates

Contaminant	Generation Rate	Schedule
<b>Bioeffluent Generation Rates (mg/day/person)<sup>+</sup></b>		
Acetone	50.7	6 AM - 6 PM
Ammonia	32.2	6 AM - 6 PM
Hydrogen Sulfide	2.73	6 AM - 6 PM
Methyl Alcohol	74.4	6 AM - 6 PM
Phenol	9.5	6 AM - 6 PM
<b>Building Generation Rates (mg/min/m<sup>2</sup>)<sup>++</sup></b>		
TVOC	0.01357	Always On
Formaldehyde	0.001657	Always On

<sup>+</sup> [Wang 1975]; <sup>++</sup> [Brightman, et al. 1995; Girman, et al. 1995; Sheldon, et al. 1988; Womble, et al. 1995].

Table 4 Comparison of resulting concentrations from the various models used

Contaminant	Maximum Concentration (Conc., 0600 - 1800 hrs)							Guideline Values <sup>a</sup>	Units
	Standard 62.1	IAQDT		CONTAM <sub>SS</sub> <sup>b</sup>		CONTAM <sub>T</sub> <sup>c</sup>			
	Conc.	Conc.	Difference <sup>d</sup>	Conc.	Difference	Conc.	Difference		
<b>Bioeffluents and Building Materials</b>									
Acetone	0.0331	0.0331	0.1%	0.0331	0.0%	0.0331	0.0%	5.9	mg/m <sup>3</sup>
Ammonia	0.161	0.152	-5.8%	0.162	0.4%	0.162	0.4%	0.5	mg/m <sup>3</sup>
Formaldehyde	0.0203	0.0203	0.0%	0.0203	0.0%	0.0217	6.8%	0.12	mg/m <sup>3</sup>
Hydrogen sulfide	0.00174	0.00174	0.0%	0.00175	0.6%	0.00175	0.6%	0.04	mg/m <sup>3</sup>
Methyl alcohol	0.0462	0.0462	0.0%	0.0463	0.2%	0.0463	0.2%	1.5	mg/m <sup>3</sup>
Phenol	0.00594	0.00594	0.0%	0.00594	0.0%	0.00594	0.0%	0.1	mg/m <sup>3</sup>
TVOC	0.168	0.168	0.0%	0.168	0.2%	0.178	6.1%	1	mg/m <sup>3</sup>
<b>Criteria Contaminants from Outdoor Air</b>									
Carbon monoxide	3.00	2.87	-4.2%	3.00	0.0%	3.00	0.0%	9	ppm
Nitrogen dioxide	0.00209	0.00213	1.8%	0.00209	0.1%	0.00209	0.1%	0.053	ppm
Ozone	0.0108	0.0110	1.6%	0.0108	-0.3%	0.0108	-0.3%	0.08	ppm
Sulfur dioxide	0.000286	0.00029	1.3%	0.000285	-0.4%	0.000285	-0.4%	0.03	ppm

<sup>a</sup> Alberta Environment 2004 (Anon.B), ASHRAE 2004, CARB 2003 (Anon.C), EPA 2005 (Anon.D), Newill 1977, Tucker 1988, VDI 1974; <sup>b</sup> CONTAM<sub>SS</sub> - steady state analysis from CONTAM; <sup>c</sup> CONTAM<sub>T</sub> - transient analysis from CONTAM utilizing schedules shown above; <sup>d</sup> Difference between the model used as compared to those obtained from Standard 62.1

Table 5 – Comparison of “Zone 1-Corridor” modeled as a single standalone zone using Standard 62.1 equations versus the same zone modeled with CONTAM as one portion of the entire ventilation system.

Contaminants	Standard 62.1 – “Zone 1”		CONTAM <sub>SS</sub> – “Zone 1”		Difference	Guideline Values	Units
	Conc.	% Target	Conc.	% Target			
<b>Bioeffluents and Building Materials</b>							
Acetone	0.004790	0%	0.06240	1%	1%	5.90	mg/m <sup>3</sup>
Ammonia	0.003480	1%	0.12800	26%	25%	0.50	mg/m <sup>3</sup>
Formaldehyde	0.015900	13%	0.02700	23%	9%	0.12	mg/m <sup>3</sup>
Hydrogen sulfide	0.000133	0%	0.00323	8%	8%	0.04	mg/m <sup>3</sup>
Methyl alcohol	0.000000	0%	0.08440	6%	6%	1.50	mg/m <sup>3</sup>
Phenol	0.000101	0%	0.01090	11%	11%	0.10	mg/m <sup>3</sup>
TVOC	0.221000	22%	0.29800	30%	8%	1.00	mg/m <sup>3</sup>
<b>Criteria Contaminants from Outdoor Air</b>							
Carbon Monoxide	6.40000	71%	6.40000	71%	0%	9.000	ppm
Nitrogen Dioxide	0.00231	4%	0.00231	4%	0%	0.053	ppm
Ozone	0.02710	34%	0.02710	34%	0%	0.080	ppm
Sulfur Dioxide	0.00173	6%	0.00173	6%	0%	0.030	ppm

Table 6 – Comparison of Standard 62.1 results for the whole system grouped as one zone to compared CONTAM results for “Zone 1-Corridor” with contaminants transferred from other zones.

Contaminants	Standard 62.1 – entire system		CONTAM <sub>SS</sub> – “Zone 1-Corridor”		Difference	Guideline Values	Units
	Conc.	% Target	Conc.	% Target			
<b>Bioeffluents and Building Materials</b>							
Acetone	0.0906	2%	0.06240	1%	0%	5.90	mg/m <sup>3</sup>
Ammonia	0.1450	29%	0.12800	26%	-3%	0.50	mg/m <sup>3</sup>
Formaldehyde	0.0286	24%	0.02700	23%	-1%	0.12	mg/m <sup>3</sup>
Hydrogen sulfide	0.00475	12%	0.00323	8%	-4%	0.04	mg/m <sup>3</sup>
Methyl alcohol	0.1300	8%	0.08440	6%	-3%	1.50	mg/m <sup>3</sup>
Phenol	0.0161	16%	0.01090	11%	-5%	0.10	mg/m <sup>3</sup>
TVOC	0.4050	40%	0.29800	30%	-11%	1.00	mg/m <sup>3</sup>
<b>Criteria Contaminants from Outdoor Air</b>							
Carbon Monoxide	6.40000	71%	6.40000	71%	0%	9.000	ppm
Nitrogen Dioxide	0.00231	4%	0.00231	4%	0%	0.053	ppm
Ozone	0.02710	34%	0.02710	34%	0%	0.080	ppm
Sulfur Dioxide	0.00173	6%	0.00173	6%	0%	0.030	ppm