

**Defining Safe Building Air**  
**Criteria for Safe Air and Water in Buildings**  
**ASHRAE Winter Meeting**  
Chicago, IL  
January 27, 2008

**by**  
**Francis (Bud) J. Offermann PE CIH**  
**Indoor Environmental Engineering**  
**San Francisco, CA**  
**(415)-567-7700 [www.IEE-SF.com](http://www.IEE-SF.com)**

# Safe Building Air Criteria - Outline

- **Purpose and Intent**
- **Limitations**
- **Scope**
- **Exposure Criteria**
- **Exposure Limits for Select Indoor Air Contaminants**
- **Validation Methods**
- **Appendices**
  - **Baseline Concentration Data**
  - **Building Risk Factors**
  - **IAQ Management Plan**

# Safe Building Air - Purpose and Intent

- **Purpose and Intent**

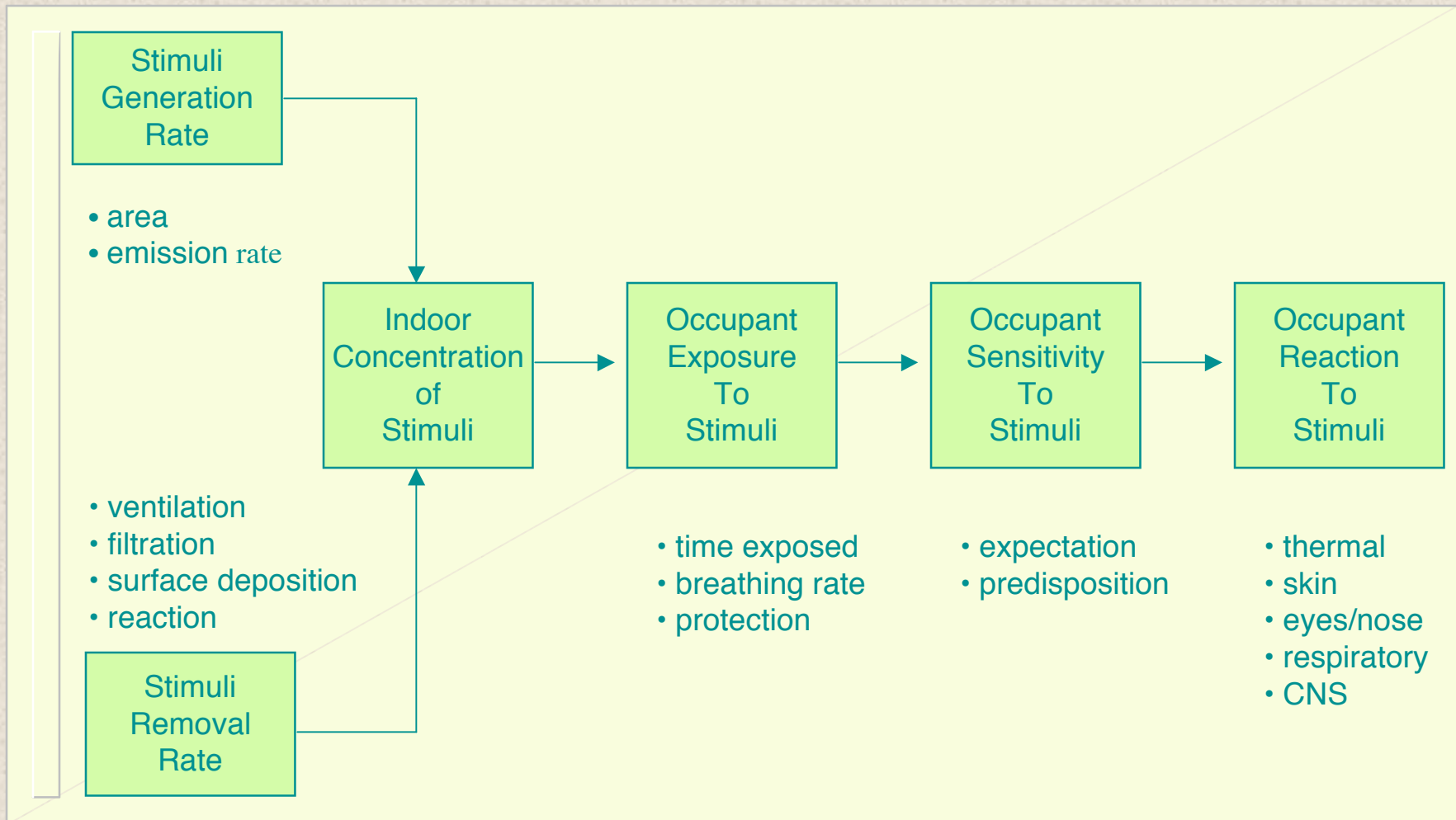
To review and assess indoor air contaminant exposure data suitable for :

- providing a framework for the design of healthy and energy efficient buildings (e.g. implementation of ASHRAE Standard 62 IAQ procedure)

- providing a framework for the assessment of the health acceptability of indoor air in existing buildings

**“Safe building air” is defined as indoor air that is “not unhealthy”.**

# Understanding IAQ - Biophysical Model



# Exposure Criteria Development



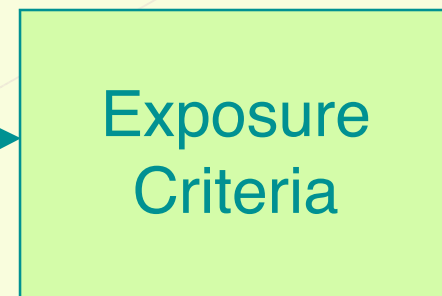
**Collect exposure data**

- measurement capability
- exposure studies



**Collect health effect and exposure data**

- epidemiological studies
- bio assay tests
- biophysical modeling



**Produce exposure criteria from correlations of exposure and health effect data**

- epidemiological studies
- bio assay tests
- biophysical modeling



# Safe Building Air - Limitations

- **Limitations**

**Insufficient information for determining indoor air is safe (i.e. not unhealthy)**

- **insufficient analytical capabilities to assess all indoor air contaminant exposures**

- **insufficient health based exposure criteria for interpreting acceptability of measured indoor exposures.**

# Safe Building Air - Limitations

**Starfleet Tricorder**  
circa 2268



**TR-590 Tricorder**  
circa 2370



# Safe Building Air - Limitations

- **Limitations**

**At this time, only single contaminant exposures.**

**- insufficient current knowledge to assess combinations of contaminant exposures which can result in health effects that are:**

- independent**
- additive**
- antagonistic**
- synergistic**



## Safe Building Air - Limitations

- **Example of unhealthy air NOT diagnosable by air testing.**

**Indoor Environment: Laser printer test lab.**

**Occupant Symptoms: Respiratory irritation/chest tightness (some employees wear disposable respirators and achieve some relief)**

**Air Test Results: VOC's (MS-TD-GCMS), Aldehydes (DNPH-HPLC), PM<sub>2.5</sub> and PM<sub>10</sub> (SSI-Gravimetric), Ozone (UV-Spectrometry), all BELOW non-industrial health guidelines and LESS than the median concentrations in the EPA BASE study of office buildings.**

## Safe Building Air - Limitations

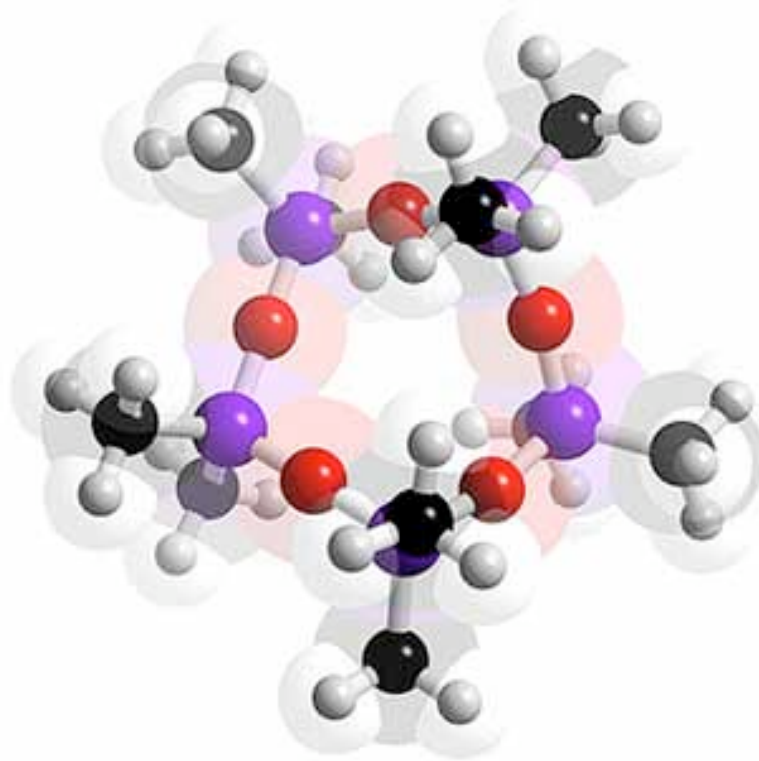
- **Example of unhealthy air not diagnosable by air testing.**

**Hypothesis:** respiratory irritation caused by exposure to ultra-fine (i.e. 0.06 to 0.1  $\mu\text{m}$ ) particles of cyclic siloxanes, oily substance vaporized in printing process and then condensed into particles.

**Currently, NO health exposure guidelines exist for these silicone compounds.**

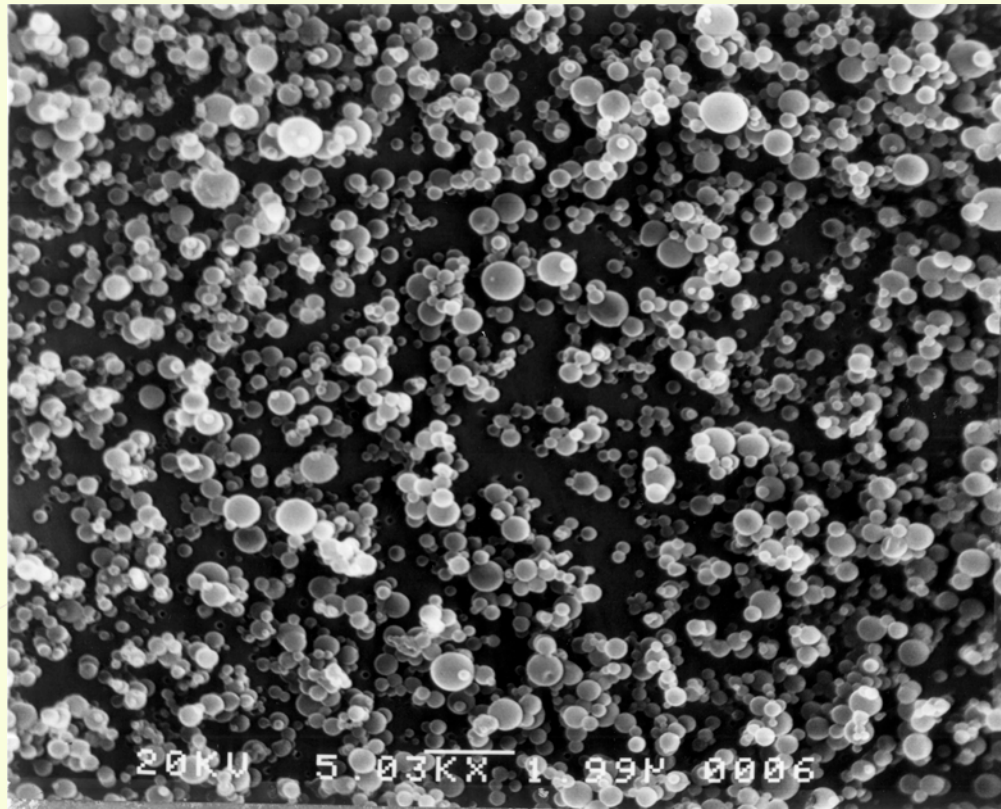
# Safe Building Air - Limitations

**Decamethylcyclopentasiloxane (D5)**  
**MW 370.77**



# Safe Building Air - Limitations

Electron microscope photo of sub-micron particles formed by condensation.





# Safe Building Air - Limitations

- **Limitations**

**We can, however, determine if the air is unhealthy for those air contaminants that are :**

- **measurable and**
- **have health based exposure criteria and**
- **excluding combined exposure effects**

**Air contaminant concentrations below established health based exposure criteria constitute “**necessary but insufficient**” criteria for declaring the air in a building is safe.**



# Safe Building Air - Scope

- **Scope**

**Air contaminant exposures related to the following health end points:**

- non-cancer health effects including irritant effects
- cancer effects
- reproductive toxicity effects

**NOT included are odor and thermal comfort factors, since these are criteria for “acceptable IAQ” and not “safe air”.**

**Limited to non-industrial indoor environments (e.g. offices, schools, residences, health care, etc.)**

# Safe Building Air - Exposure Criteria

- **Non-Cancer Health Effect Exposure Criteria**

- **California OEHHA CREL's for volatile organic compounds including formaldehyde**

- **EPA NAAQS for outdoor criteria air contaminants (e.g. carbon monoxide, sulfur dioxide, nitrogen dioxide, PM<sub>10</sub> and PM<sub>2.5</sub> particle, ozone, and lead)**

**These criteria have been established for the protection of sensitive individuals (e.g. asthmatics, children, elderly).**

# Safe Building Air - Exposure Criteria

- **Cancer Health Effect Exposure Criteria**
  - **California Proposition 65 - No Significant Risk Levels (NSRL provides  $< 1/100,000$  excess cancer case)**
  - **EPA AHERA requirements for asbestos**
  - **EPA requirements for radon gas.**

# Safe Building Air - Exposure Criteria

- **Reproductive Toxicity Health Effect Criteria**
  - **California Proposition 65 - Maximum Allowable Dose Levels (MADLs are  $< 1,000$  the no observable effect dose)**

# Safe Building Air - Exposure Limits

- **Exposure Limits for Select Indoor Air Contaminants**

**Construct a short list of indoor air contaminants and the recommended exposure limits based upon :**

- **frequently encountered indoor air contaminants with**
- **significant health risks**

**The European Commission “The INDEX Project” has produced a short list which we will draw upon and perhaps include a few additional air contaminants**



# Safe Building Air Exposure Limits ( $\mu\text{g}/\text{m}^3$ )

	OSHA 8-hour PEL	OEHHA CREL NC	NSRL C	MADL R	Minimum Criteria	Residential Median	Office Median
Acetaldehyde	360,300	140	4.5	-	4.5	20	7.2
Benzene	3,200	60	0.7	-	0.7	1.1	3.6
Formaldehyde	920	9	2	1.2	1.2	36	15
d-Limonene	-	-	-	-	-	11	7.1
Naphthalene	52,400	9	0.3	-	0.3	0.2	0.7
a-Pinene	36,000	-	-	-	-	11	0.6
Styrene	426,000	900	-	-	900	0.9	0.9
Toluene	753,700	300	-	350	300	8.5	8.7
Xylene	434,200	700	-	-	700	5.4	7.2

Health Effects:      NC      Non-cancer  
                                   C      Cancer  
                                   R      Reproductive toxicity

Residential: California ARB - 2006, 108 New Home Study  
 Office: EPA - 1994, 100 Office Building BASE Study

# Safe Building Air - Validation

- **Validation Methods**

- **EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air with associated EPA specific analytical methods (e.g. TO-15/17 for VOC'S, ASTM 5197 for formaldehyde and other aldehydes)**
- **EPA methods for asbestos and radon.**

# Safe Building Air - Appendices

- **Baseline Concentration Data**

**Provide baseline indoor air contaminant concentration data (e.g. EPA BASE study of air contaminant concentrations in 100 non-problem office buildings)**

**Present data as percentiles (e.g. minimum, 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, 90<sup>th</sup> maximum)**

# Safe Building Air - Appendices

- **Building Risk Factors**

- Do not constitute data that the building air is **NOT** safe.

- Are known to increase the risk of unsafe building air.

# Safe Building Air - Appendices

## • Building Risk Factors

Present a list of building risk factors, which while by themselves do not constitute data that the building air is not safe, are factors which are known to increase the risk of unsafe building air.

- inadequate supply of outdoor air
- visible moisture condensation (e.g. mold)
- odors (e.g. mold, ETS, chemicals)
- concentrations of mold spores statistically significantly higher indoors than outdoors on a general basis



# Safe Building Air - Appendices

- **Building Risk Factors**

- concentrations of carbon monoxide statistically significantly higher indoors than outdoors

- surface accumulations of dust

- reliance on total VOC concentration measurements (should measure individual VOC concentrations)

- lack of an occupant complaint-response system (i.e. the backbone of an IAQ Management Plan)

# Safe Building Air - Appendices

- **IAQ Management Plan**

**Recommend implementation of an IAQ Management Plan as describe in the EPA publication “Building Air Quality: A Guide for building owners and Facility Managers.”**

# Safe Building Air - Conclusions

- **Concentrations below exposure criteria do NOT equal the air is “safe” because of:**
  - **insufficient analytical capabilities to assess all indoor air contaminant exposures**
  - **insufficient health based exposure criteria for interpreting acceptability of measured indoor exposures.**

# Safe Building Air - Conclusions

**Thus, at this time:**

**We should not, in the pursuit of energy efficiency, reduce outdoor air ventilation rates in buildings.**

**Instead we should minimize the energy impacts with heat recovery strategies.**

## **Safe Building Air - Conclusions**

- **At this time, we can determine if the air is unhealthy for those air contaminants that are :**
  - **measurable and**
  - **have health based exposure criteria**
- **Concentrations below the recommended exposure criteria can NOT be said to represent “Safe Air”.**
- **Reducing “Risk Factors” and following the upcoming ASHRAE IAQ Design Guide, can reduce the probability of “Unsafe Air”.**



## **Safe Building Air - Conclusions**

**For energy efficient healthy buildings with reduced outdoor air ventilation rates (e.g. the IAQ Procedure), we MUST first overcome the limitations of insufficient:**

- measurement capability (i.e. develop new analytical instruments – real time mass and chemical analyses of ppb concentrations of all air molecules and particles)**
- health effect exposure knowledge (i.e. using exposure and health data develop health based exposure criteria)**

## **Safe Building Air - Conclusions**

**With the new instrumentation and the associated health based exposure criteria, we can confidently develop energy efficient buildings with lower, or no, outdoor air ventilation, through:**

- **implementation of new air cleaning technologies**
- **reducing the indoor air contaminant emission rates**

**Defining Safe Building Air**  
**Criteria for Safe Air and Water in Buildings**  
**ASHRAE Winter Meeting**  
**Chicago, IL**  
**January 27, 2008**

**by**  
**Francis (Bud) J. Offermann PE CIH**  
**Indoor Environmental Engineering**  
**San Francisco, CA**  
**(415)-567-7700 [www.IEE-SF.com](http://www.IEE-SF.com)**