ASHRAE Ventilation and EPA Air Quality Standards – Cleaning Air of Ozone for Building Indoor Air Quality

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Presentation Overview

• Ozone is a Pollutant by Definition
• Indoor/Outdoor Ozone Concentrations
• Indoor Ozone Chemistry
• EPA NAAQS Ozone Standards
• ASHRAE Standard 62.1 Requirements
• Standard Implementation Scenarios
• Effected State Areas
• Air Cleaners for Ozone Removal
• Research Needs
Ozone is a Pollutant, per EPA …

- $\text{O}_3$ is gas composed of 3 oxygen atoms
  - chemical reaction of nitrogen oxides ($\text{NO}_x$) and volatile organic compounds (VOCs)
  - sunlight and hot weather form ground-level ozone in harmful concentrations as “smog”
- Breathing air containing ozone impairs health
  - reduce lung function, aggravating respiratory conditions and increasing infection susceptibility
    - medicine use by asthmatics and doctors visits
    - emergency department visits and hospital admissions
  - premature death in people with heart/lung disease
… and Buildings are Our Refuge

- Under higher outdoor ozone levels, at-risk individuals remain indoors to limit exposures.
- However, “indoor exposures to ozone represent a major fraction of total ozone exposures” (Weschler 1989).
  - “I/O [indoor/outdoor ozone] ratios range from 0.05 in buildings that are tightly sealed or use charcoal filtration to 0.85 in buildings that have very high air exchange rates [via infiltration or ventilation].
  - Excluding the extremes, the I/O ratio is more often in the range of 0.2 to 0.7” (Weschler 2000).
I/O Ozone Levels in Offices

Outdoor/Indoor Ozone Levels

Outdoor Ozone (ppb)
Indoor Ozone (ppb)

I/O = 0.32
I/O Ozone Levels in Schools

Outdoor/Indoor Ozone Levels

Outdoor Ozone (ppb)
Indoor Ozone (ppb)

Hour
Ozone (ppb)

I/O = 0.68
Ozone Indoor Air Chemistry

• “Under normal conditions, the half-life of ozone indoors is 7 to 10 minutes and is determined primarily by surface removal and air exchange [infiltration or ventilation] …

• … and only a small fraction [10%] of the other indoor air pollutants react with ozone at a rate fast enough to compete with air exchange, … [but] their reactions with ozone have the potential to be quite significant as sources of … compounds that are often quite odorous … [and] potentially damaging to both human health and materials” (Weschler 2000)
EPA NAAQS Ozone Standard

Non-Attainment 8 Hour Design Value Classifications

- **Extreme Area**: 187 ppb and above
- **Severe 17 Area**: 127 up to but not including 187 ppb
- **Severe 15 Area**: 120 up to but not including 127 ppb
- **Serious Area**: 107 up to but not including 120 ppb
- **Moderate Area**: 92 up to but not including 107 ppb
- **Marginal Area**: 85 up to but not including 92 ppb

Attainment 8 Hour Design Value Classification

- **Current standard** of 80 ppb is effectively expressed as 84 ppb when rounding conventions are applied
Current Non-Attainment Areas

http://www.epa.gov/air/ozonepollution/pdfs/20070621_maps.pdf
EPA Proposed Ozone Rulemaking

- Mounting scientific evidence indicates that adverse public health effects occur following exposure to ozone at levels below the current standard, particularly in those with respiratory illnesses.

- In 2007, EPA proposed to set the primary (health) standard to a level within the range of 70 - 75 ppb (a reduction up to 15 ppb from 85 ppb).
Future Non-Attainment Areas?
ASHRAE Standard 62.1 History

Ventilation for Acceptable IAQ

• 2001 - required an assessment, but only recommendations for outdoor air cleaning
• 2004 - introduced requirements for air cleaning of ozone for building ventilation
• 2007 - outdated EPA 1-hour ozone design values need to be replaced

• Addendum our for public review #
  #1 & 2) 8-hour Serious classification threshold
  # 3) lowering to non-attainment threshold?
“Air-cleaning devices for ozone shall be provided when the building is located in an area with a ‘design value’ of 107 ppb or more … an area designated as ‘Extreme’, ‘Severe’, or ‘Serious’ by the U.S. EPA has a ‘design value’ of 0.107 ppm or more.

A list of areas designated as described is available at http://www.epa.gov.

Such air-cleaning devices shall have a minimum ozone removal efficiency of 40% … [and] be operated whenever the 8-hour average outdoor ozone levels are expected to exceed 80 [85] ppb.

This forecast is available in local media or at the AIRNow Web site, http://www.airnow.gov.”
ASHRAE Standard 62.1 Addendum
Public Review #3 PENDING

• Incomplete voting by SPC 62.1 during ASHRAE Meeting last month in NYC
  • Motion on table to lower both the installation and operation threshold level to a ‘design value’ of 80 [85] ppb or more – essentially requiring all non-attainment areas to install (and operate) air-cleaning devices
• Absent member votes being secured on very close vote for 2/3 approval to send revised addendum out for public review
Ozone Standards Scenarios

1. “Serious” Scenario
   A. ASHRAE Public Review #1/2 Addendum
   B. Above with EPA Proposed Rulemaking

2. “Non-Attainment” Scenario
   A. ASHRAE Pending Public Review #3
   B. Above with EPA Proposed Rulemaking
“Serious” Scenario 1A – California ONLY Requirement

- Based on latest EPA design values, limited to
  - Los Angeles area counties with large population
  - Interior valley counties with limited population

<table>
<thead>
<tr>
<th>Nonattainment Area</th>
<th>State</th>
<th>2004–2006 Design Value (ppb)</th>
<th>2000 Population</th>
<th>Affected # of Counties</th>
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</thead>
<tbody>
<tr>
<td>Los Angeles South Coast Air Basin, CA</td>
<td>CA</td>
<td>121</td>
<td>14,593,587</td>
<td>4</td>
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<tr>
<td>San Joaquin Valley, CA</td>
<td>CA</td>
<td>110</td>
<td>3,191,367</td>
<td>8</td>
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<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>17,784,954</td>
<td>12</td>
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</tbody>
</table>
“Serious” Scenario 1B – Cascading EPA Rule on ASHRAE

- EPA rule cascading effect could bring areas in 8 states previously designated Moderate to Serious classification, i.e., $107 - 15 = 92$ ppb

### Ozone Design Value for Areas $>92$ ppb and $<107$ ppb

<table>
<thead>
<tr>
<th>Nonattainment Area</th>
<th>State</th>
<th>2004-2006 Design Value (ppb)</th>
<th>2000 Population</th>
<th>Affected # of Counties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amador and Calaveras Cos (Central Mtn), CA</td>
<td>CA</td>
<td>93</td>
<td>75,654</td>
<td>2</td>
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<tr>
<td>Baltimore, MD</td>
<td>MD</td>
<td>93</td>
<td>2,512,431</td>
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<tr>
<td>Dallas-Fort Worth, TX</td>
<td>TX</td>
<td>96</td>
<td>5,030,828</td>
<td>9</td>
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<tr>
<td>Houston-Galveston-Brazoria, TX</td>
<td>TX</td>
<td>103</td>
<td>4,669,571</td>
<td>8</td>
</tr>
<tr>
<td>Los Angeles-San Bernardino Cos(W Mojave), CA</td>
<td>CA</td>
<td>103</td>
<td>656,408</td>
<td>2</td>
</tr>
<tr>
<td>Nevada Co. (Western Part), CA</td>
<td>CA</td>
<td>96</td>
<td>77,735</td>
<td>1</td>
</tr>
<tr>
<td>Philadelphia-Wilmin-Atlantic Ci, PA-NJ-MD-DE</td>
<td>PA-NJ-MD-DE</td>
<td>93</td>
<td>7,333,475</td>
<td>18</td>
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<tr>
<td>Riverside Co. (Coachella Valley), CA</td>
<td>CA</td>
<td>102</td>
<td>324,750</td>
<td>1</td>
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<tr>
<td>Sacramento Metro, CA</td>
<td>CA</td>
<td>97</td>
<td>1,978,348</td>
<td>6</td>
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<tr>
<td><strong>TOTAL</strong></td>
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<td></td>
<td>42,293,322</td>
<td>77</td>
</tr>
</tbody>
</table>
“Non-Attainment” Scenario 2A – Equating EPA & ASHRAE Levels

• ASHRAE matches air cleaning threshold to the current EPA non-attainment 85 ppb level

• 130 million people
• 104 counties
• 23 states
“Non-Attainment” Scenario 2B – Cascading EPA Rule on ASHRAE

- EPA rule cascading effect could lower non-attainment classification, i.e., $85 - 15 = 70$ ppb

- TBD million people
- 533 counties
- 42 states
Air Cleaners for Ozone Removal

- Typically active carbon (sorbent) filters
  - Granular beds or impregnated media
  - Likely reaction NOT sorption process
  - Carbon gasification occurs at ppb level per
    \[ \text{O}_3 + 2\text{C} \rightarrow \text{CO} + \text{CO}_2 \]
  - Alter chemistry with fast reactant pollutants
- Past air cleaner research completed
  - Insightful small scale sorbent sample tests
  - But dated and limited full scale filter tests
Research Needs

• Defined by ASHRAE Environmental Health Committee at 1/08 NYC Meeting
• 3 areas identified but unfunded
  1. Situation and Cost/Benefit Analysis
  2. Air Cleaner Technical Evaluation
     1. Sorbent sample testing (ASHRAE Std. 145.1)
     2. Air cleaner testing (ASHRAE Std. 145.2)
  3. Field Intervention with Air Cleaners
     1. Leaky buildings
     2. Tight Buildings
Summary

• SITUATION IS DYNAMIC!
  • EPA 3 year rolling average ozone design data
  • EPA proposed ozone standard rulemaking
  • ASHRAE 62.1 standard public review process

• BUT DIRECTION IS CLEAR!
  • EPA ozone standard to be reset downward
  • ASHRAE threshold for air cleaning is trending downward as well, possibly dramatically so
  • Not just a California requirement in the future

• AND RESEARCH IS NEEDED!

• Upcoming white paper (and Indoor Air 2008 Conference paper) due out soon!