

# Do We Have A Problem With Ozone Generating Air Cleaners?

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**IGERT**  
Integrative Graduate, Education  
and Research Traineeship

Yes.

# Motivation

- Demonstrate that Americans are using ozone generating air cleaners
- Characterize the amount of ozone that these devices emit
- Question the 50 ppb standard
- Eviscerate the UL methodology for ozone emission

# Caveats/Comments

- Not talking about intentional ozone generators
  - Terrible idea, no sound scientific basis, etc.
- Not an unbiased observer
  - Entangled in ugly lawsuit
- Disconnect between scientific opinion and perception
  - Questionable papers passing peer review
  - Scientists not being adequately challenged
  - Public is misinformed
- HVAC/air cleaner manufacturers staking claims

# How many ozone-emitting air cleaners are in use?

## Survey of the Use of Ozone-generating Air Cleaners by the California Public

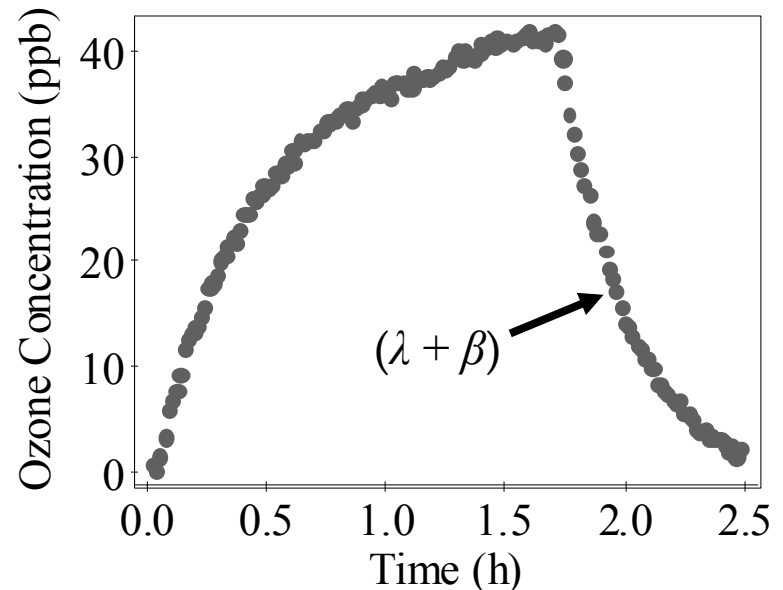
Final Report: Contract No. 05-301

- N = 2091, 14% have air cleaners
  - 70% (10% of total) emit ozone
    - 14% intentional, 86% unintentional

# Ozone Emission Methodology

- Ozone emission rate,  $E_{O_3}$  [mg/h]
  - Well-mixed 14.75 m<sup>3</sup> chamber
  - $C_{out} = 0$  ppb
    - Positively pressurized (0.5 Pa)
    - Inlet air through activated carbon

$$\frac{dC}{dt} = -\lambda C - \beta C + \frac{E_{O_3}}{V}$$



Steady-state

$$E_{O_3} = V(\lambda + \beta)C_{ss}$$

Time-dependent

$$E_{O_3} = \frac{V(\lambda + \beta)C(t)}{(1 - e^{-Lt})}$$

$C$  = Indoor ozone conc. [mg/m<sup>3</sup>]

$C_0$  = Initial indoor conc. [# /m<sup>3</sup>]

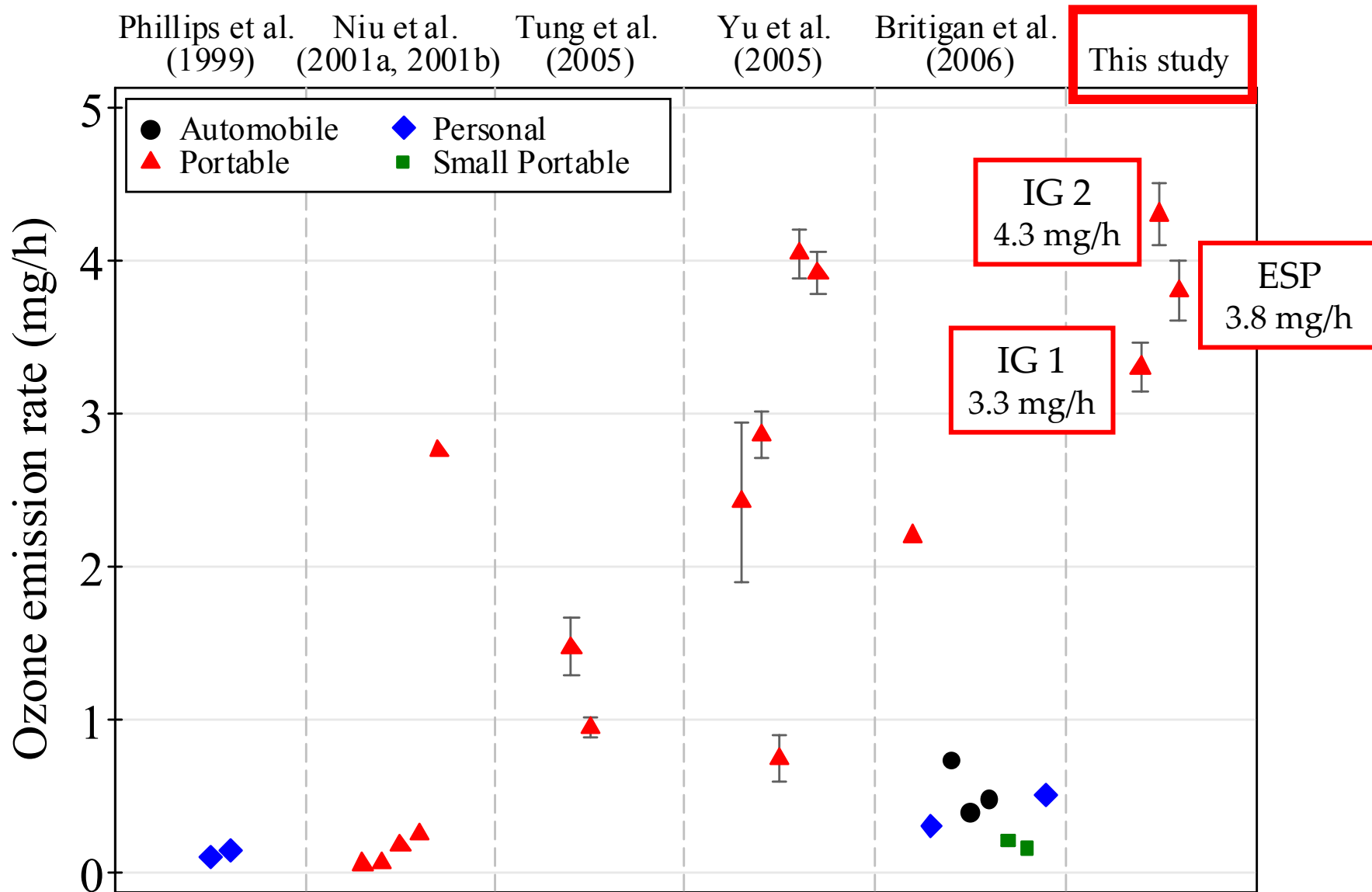
$t$  = Time [h]

$\lambda$  = Air exchange rate [1/h]

$\beta$  = Deposition loss rate [1/h]

$V$  = Chamber volume [m<sup>3</sup>]

# Ozone Emission Results



# Where does 50 ppb come from?

FEDERAL REGISTER, VOL. 37, NO. 124—TUESDAY, JUNE 27, 1972

12644

## PROPOSED RULE MAKING

### DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Food and Drug Administration  
[ 21 CFR Part 3 ]

#### OZONE GENERATORS AND OTHER DEVICES EMITTING OZONE

Proposed Statement of Policy

Accumulation of ozone above certain levels can be injurious to health. Undesirable physiological effects on the central nervous system, heart, and vision have been reported. The predominant physiological effect of ozone is primary irritation of the mucous membranes with sufficient irritation to the lungs to result in pulmonary edema.

In 1956, the American Conference of Governmental Industrial Hygienists established 0.1 part per million by volume of air as the maximum allowable concentration of ozone for an 8-hour industrial exposure. More recently the American Society of Heating, Refrigerating and Air Conditioning Engineers recommended that the maximum concentration in an air conditioning and ventilating system be 0.05 part per million in occupied areas, such as homes and hospitals, where people may be exposed continuously for up to 24 hours a day.

The variety and number of devices which emit ozone is on the increase. Such devices include ozone generators which are designed to produce and emit ozone and other generators which produce and emit ozone as a byproduct that is incidental to their intended function.

Data available to the Food and Drug Administration indicate that ozone has no useful medical application and that, in tests conducted to study the bactericidal properties of ozone, test animals have died before the bacteria were completely destroyed. The odor of ozone is not a reliable indication of its concentration since olfactory fatigue develops readily; moreover the onset of symptoms of over exposure to ozone may not take place until well after the time exposure has occurred.

Therefore in the interest of keeping the concentration of ozone in the atmosphere of living and working space within safe limits, pursuant to provisions of the Federal Food, Drug, and Cosmetic Act (secs. 301(c), 302(d), 701(e), 32 Stat. 1050, 1051, 1055; 21 U.S.C. 351(e), 352(d), 371(a)), and under authority delegated to him (21 CFR 2.100), the Commissioner of Food and Drugs proposes to amend Part 3 by adding the following new section:

§ 3. . . . . Maximum acceptable level of ozone.

(a) Ozone is a toxic gas with no known useful medical application in specific, adjunctive, or preventive therapy. In order for it to be effective as a germicide, ozone must be present in a concen-

tration far greater than that which can be safely tolerated by man and animals.

(b) Although undesirable physiological effects on the central nervous system, heart, and vision have been reported, the predominant physiological effect of ozone is primary irritation of the mucous membranes. Inhalation of ozone can cause sufficient irritation to the lungs to result in pulmonary edema. The onset of pulmonary edema is usually delayed for some hours after exposure; thus, symptomatic response is not a reliable warning of exposure to toxic concentrations of ozone. Since of factory fatigue develops readily, the odor of ozone is not a reliable index of atmospheric ozone concentration.

(c) A number of devices currently on the market emit ozone by design or as an incidental byproduct. Since exposure to ozone above a certain concentration can be injurious to health, any such device will be considered adulterated and/or misbranded within the meaning of sections 501 and 502 of the Federal Food, Drug, and Cosmetic Act under the following conditions:

(1) It is used or intended for use in such a manner that it emits ozone at a level in excess of 0.05 part per million by volume of air circulating through the device or causes an accumulation of ozone in excess of 0.05 part per million by volume of air in the atmosphere of enclosed living space or space intended to be occupied by people for extended periods of time (e.g., houses, apartments, hospitals, and offices). This applies to any such device, whether a portable or permanent system or part thereof, which generates ozone by design or as an inadvertent or incidental byproduct including electrostatic precipitators, home water purifiers, ultra-violet lamps used for germicidal or other medical purposes, etc. However, it does not include industrial type generators intended for occasional use in unoccupied living quarters (e.g., those used in postfire smoke odor removal).

(2) It is used or intended for use to produce and emit ozone into the atmosphere for deodorizing or for other purposes in hospitals or other establishments occupied by the ill or infirm.

(3) It is used or intended for use to produce and emit ozone into the atmosphere and does not indicate in its labeling the maximum acceptable concentration of ozone which may be emitted (not to exceed 0.05 part per million by volume of air circulating through the device) as established herein and the smallest area in which such device can be used so as not to produce an ozone accumulation in excess of 0.05 part per million.

(4) It is used or intended for use in any medical condition for which there is no proof of safety and efficacy.

(5) It is used or intended for use to produce a concentration of less than 0.05 part per million and it is labeled for use as a germicide or deodorizer.

(d) This statement does not alter the present threshold limit value of 0.10 part per million (0.2 mg./m.<sup>3</sup>) for an 8-hour day exposure of industrial workers as recommended by the American Conference of Governmental Industrial Hygienists.

Interested persons may, within 60 days after publication hereof in the *Federal Register*, file with the Hearing Clerk, Department of Health, Education, and Welfare, Room 6-38, 5600 Fishers Lane, Rockville, Md. 20852, written comments (preferably in triplicate) regarding this proposal. Comments may be accompanied by a memorandum or brief in support thereof.

Dated: June 15, 1972.

STAT D. FINE,  
Associate Commissioner  
for Compliance.

[FR Doc. 72-059 Filed 6-29-72; 45 am]

### DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[ 14 CFR Part 71 ]

[Aircraft Docket No. 72-50-83]

#### CONTROL ZONE AND TRANSITION AREA

##### Proposed Designation and Alteration

The Federal Aviation Administration is considering an amendment to Part 71 of the Federal Aviation Regulations that would designate the Rocky Mount, N.C. (Rocky Mount-Wilson Airport), control zone and alter the Rocky Mount, N.C., transition area.

Interested persons may submit such written data, views, or arguments as they may desire. Communications should be submitted in triplicate to the Federal Aviation Administration, Southern Region, Air Traffic Division, Post Office Box 20936, Atlanta, GA 30320. All communications received within 30 days after publication of this notice in the *Federal Register* will be considered before action is taken on the proposed amendment. No hearing is contemplated at this time, but arrangements for informal conferences with Federal Aviation Administration officials may be made by contacting the Chief, Airspace and Procedures Branch. Any data, views, or arguments presented during such conferences must also be submitted in writing in accordance with this notice in order to become part of the record for consideration. The proposal contained in this notice may be changed in light of comments received.

The official docket will be available for examination by interested persons at the Federal Aviation Administration, Southern Region, Room 754, 3400 Whipple Street, East Point, GA.

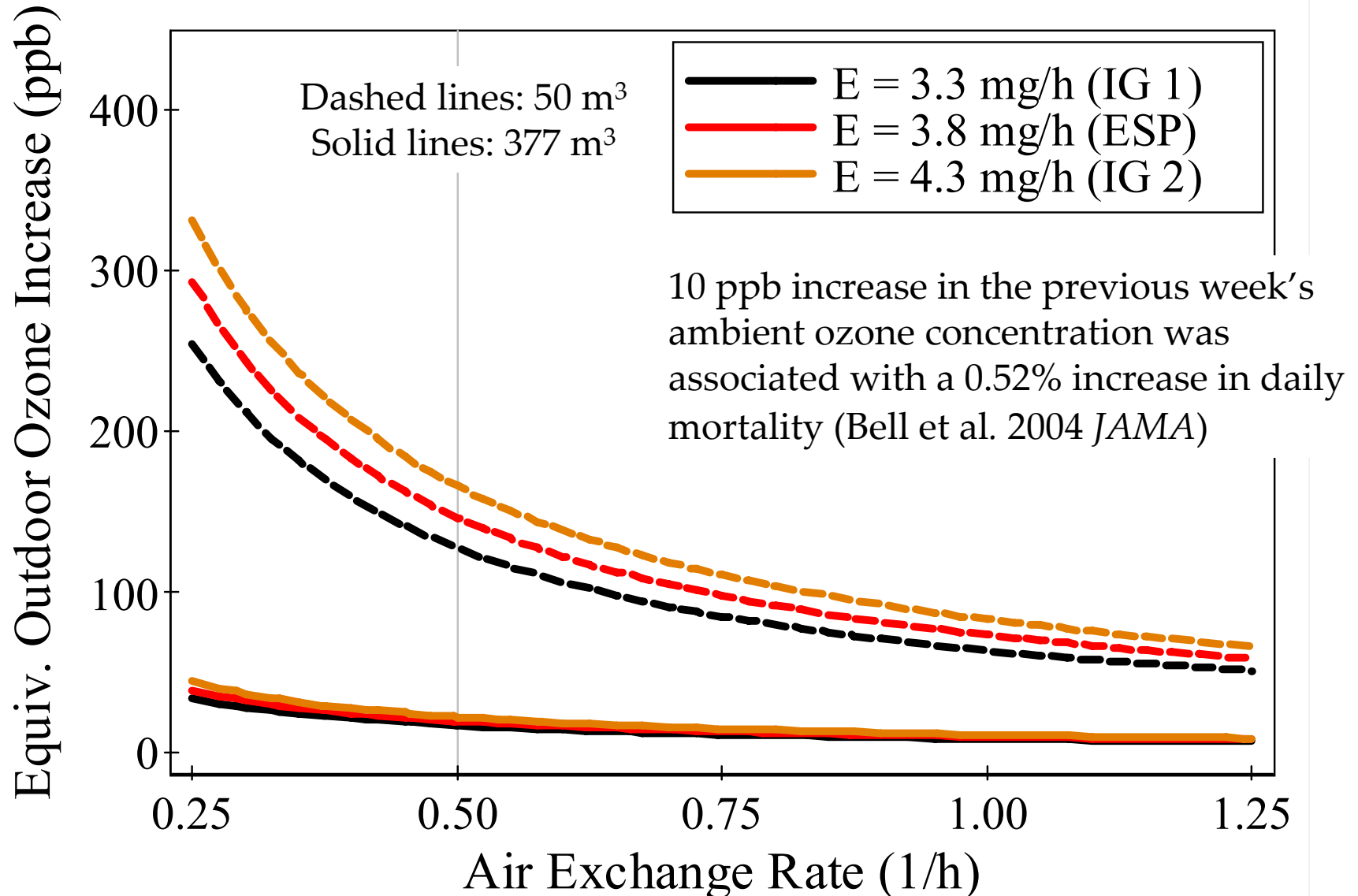
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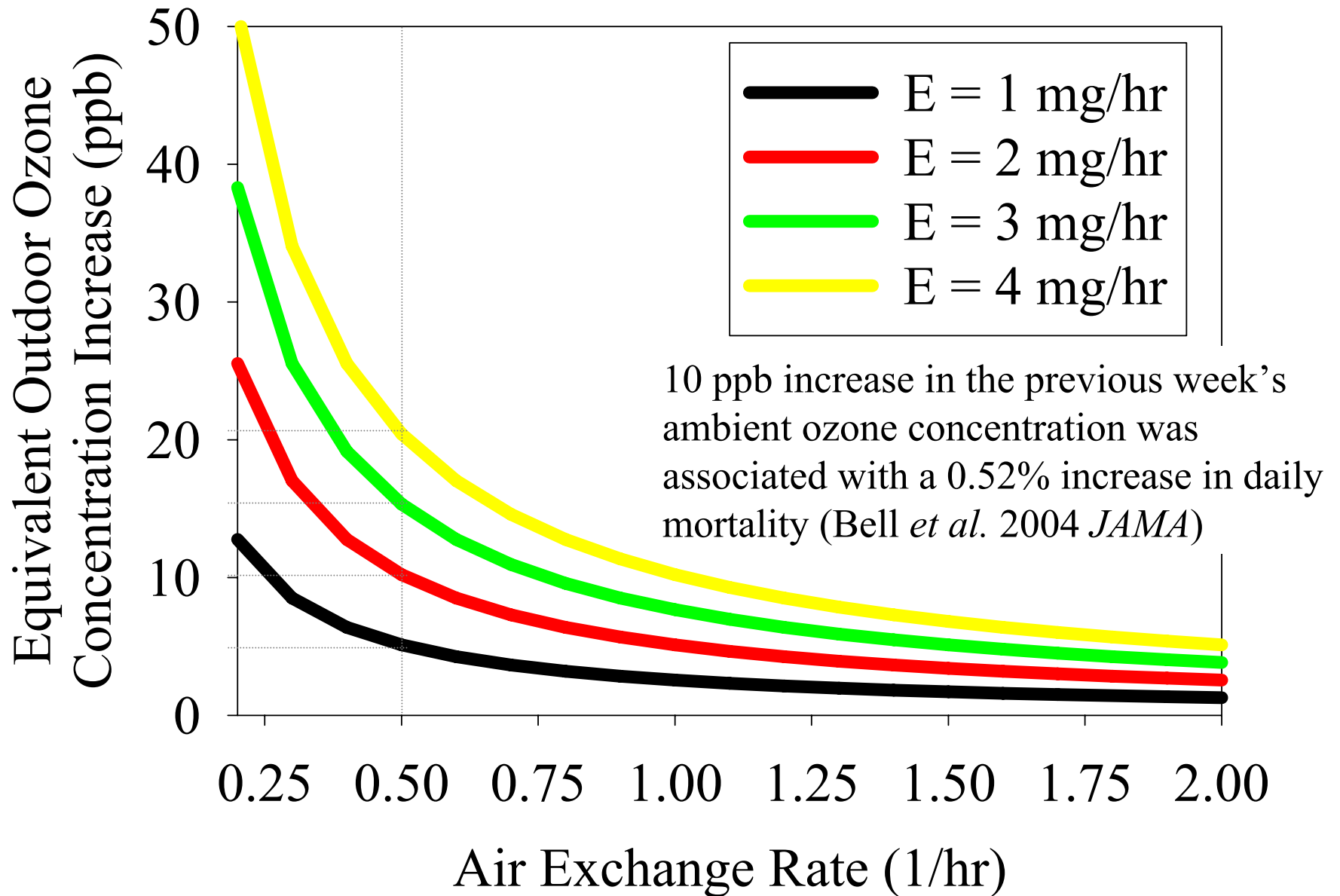
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# More Recent Health Literature

- Bell *et al.* (2004) *JAMA*
  - Significant health effects when **outdoor** ozone increases by 10 ppb
- Bell *et al.* (2006) *EHP*
  - Significant health effects for **any** increase in ozone (even less than 10 ppb)
- Gent *et al.* (2003) *JAMA*
  - 50 ppb is insufficient to protect children with asthma
- Triche *et al.* (2006) *EHP*
  - Infants are affected far below EPA standards

# Equiv. Outdoor O<sub>3</sub> Conc. Increase





# It Is Not Just Ozone

New Directions: Ozone-initiated reaction products indoors  
may be more harmful than ozone itself<sup>☆</sup>

*Atmos. Environ.* 2004 **38** 5715-5716

**Ozone's Impact on Public Health: Contributions from Indoor Exposures  
to Ozone and Products of Ozone-Initiated Chemistry**

*Charles J. Weschler*<sup>1,2</sup>

*EHP* 2006 **114** 1489-1496

- 25-60% ozone inhalation is indoors
- Ozone reaction byproducts are 30-200% of ozone intake

# The current standard...UL 867

## **37 Ozone Test**

- 37.1 A portable product for household use shall not produce a concentration of ozone exceeding **0.05 parts per million** by volume when tested as described in 37.2 – 37.7.

February 11, 2007  
Your Home

## How to Select an Air Cleaner

By JAY ROMANO

Julie Vallese, the director of information and public affairs for the **Consumer Product Safety Commission**, said that while her organization did not recommend one type of machine over another — and did not take a position for or against using an air purifier in the home — it had conducted a study on the health effects of ozone-generating devices.

**“We found that keeping ozone accumulation below 50 parts per billion is sufficient to protect human health,” she said.**



# Gaming UL 867

## 37 Ozone Test

- 37.1 A portable product for household use shall not produce a concentration of ozone exceeding **0.05 parts per million** by volume when tested as described in 37.2 – 37.7.
- 37.2 The test is to be conducted in a room having a **volume of 950 – 1100 cubic feet (26.9 – 31.1 m<sup>3</sup>)** with a minimum side dimension of 8 feet (2.4 m) and a maximum height dimension of 10 feet (3.0 m) without openings. **The test room walls and ceiling are to be covered with a sheet of polyethylene or aluminum. The floor is to be of a nonporous material such as vinyl tile or aluminum.**
- 37.3 During the test, the test room is to be maintained at a temperature of  $25 \pm 2^{\circ}\text{C}$  ( $77 \pm 4^{\circ}\text{F}$ ) and a relative humidity of  $50 \pm 5$  percent. Prior to the start of and immediately after this test, the ozone background level is to be measured with the product off. The background level average shall be calculated and subtracted from the maximum measurement during the test.
- 37.4 The product is to be located in the center of the test room floor and about 30 inches (762 mm) above the floor for a table-mounted product.
- 37.5 The ozone monitor sampling tube is to be located **2 inches (50 mm) from the air outlet** of the product and is to point directly into the air stream.
- 37.6 The emission of ozone is to be monitored for 24 hours to determine the concentration.
- 37.7 If the filter cell can be energized with any of its fans not functioning or with particle filters removed, the test described in 37.1 – 37.6 is to be repeated with the various components not operating or with particle filters removed.

# UL 867

- My pledge to air cleaner manufacturers...
- Send me your air cleaner and I can make it meet the UL standard
  - Volume of chamber (~20%)
  - Surface materials and cleanliness (~50%)
  - High air exchange (anything you want)
  - Controlled mixing/airflow (anything you want)
  - Presence of ozone sinks (anything you want)
  - Inadequate assessment of control technology
- Proof of concept – dedicate ozone generator (31.1 mg/hr) < 10 ppb ozone in chamber

# Another Ozone Emission Test

- Measure ozone at inlet and outlet
- Typically used for ducted systems, but can also be used for portable devices

██████████ also generates a minimal amount of ozone, less than 5 PPB (parts per billion), well below the 10 PPB FDA voluntary emission limit for medical devices and significantly below some ionic-type room appliances that may reach hundreds of PPBs.



- $2000 \text{ CFM} \times 1 \text{ ppb rise} \approx 2.4 \text{ mg/hr}$ 
  - Does not account for ozone reaction products
  - Instrument detection limit/sensitivity issues

# Best Practice For Ozone Emission Tests

- Well-mixed, passivated chamber
- Filtered air supply
- Positive pressure in chamber
- Two tests measuring ozone emissions
  - First, with ozone emitter on
  - Second, with ozone off to get deposition loss to surfaces
- Calculate emission rate

# AND.....

- Model parameters for real buildings
- Corsi did this (CPSC public comments)
  - Typical individual/environment (Base Case)
  - Compromised individual/environment (Worst Case)

	Base-Case		Worst-Case	
	E (mg/hr)	Limiting	E (mg/hr)	Limiting
Home (whole house)	17.5	ozone	0.45	SOA
Office	1.3	ozone	0.041	SOA
School	9.9	ozone	0.13	SOA

# Where does this leave us?

- Public is using ozone-generating devices
  - Support for their use
  - Inadequate consumer protection
- Many “unintentional” ozone emitters are problematic
- 50 ppb standard is inadequate (as is any concentration-based standard)
- Ozone emission test needs remedy

# Acknowledgements

- Funding
  - ISEA/IGERT/Consumers Union/Lawyers
- Insight/discussion/slide preparation
  - Rich Corsi, Michael Waring



# Issue with test

- What happens when manufacturers include a control technology
  - Activated carbon (Friedrich ESP)
  - Ozone catalyst (Sharper Image Ionic Breeze)
- Messes up the test considerably
  - Not sure that I know the answer
  - Do decay period with and without control device
  - Use w/o loss rate for calculations