

10-21-2016

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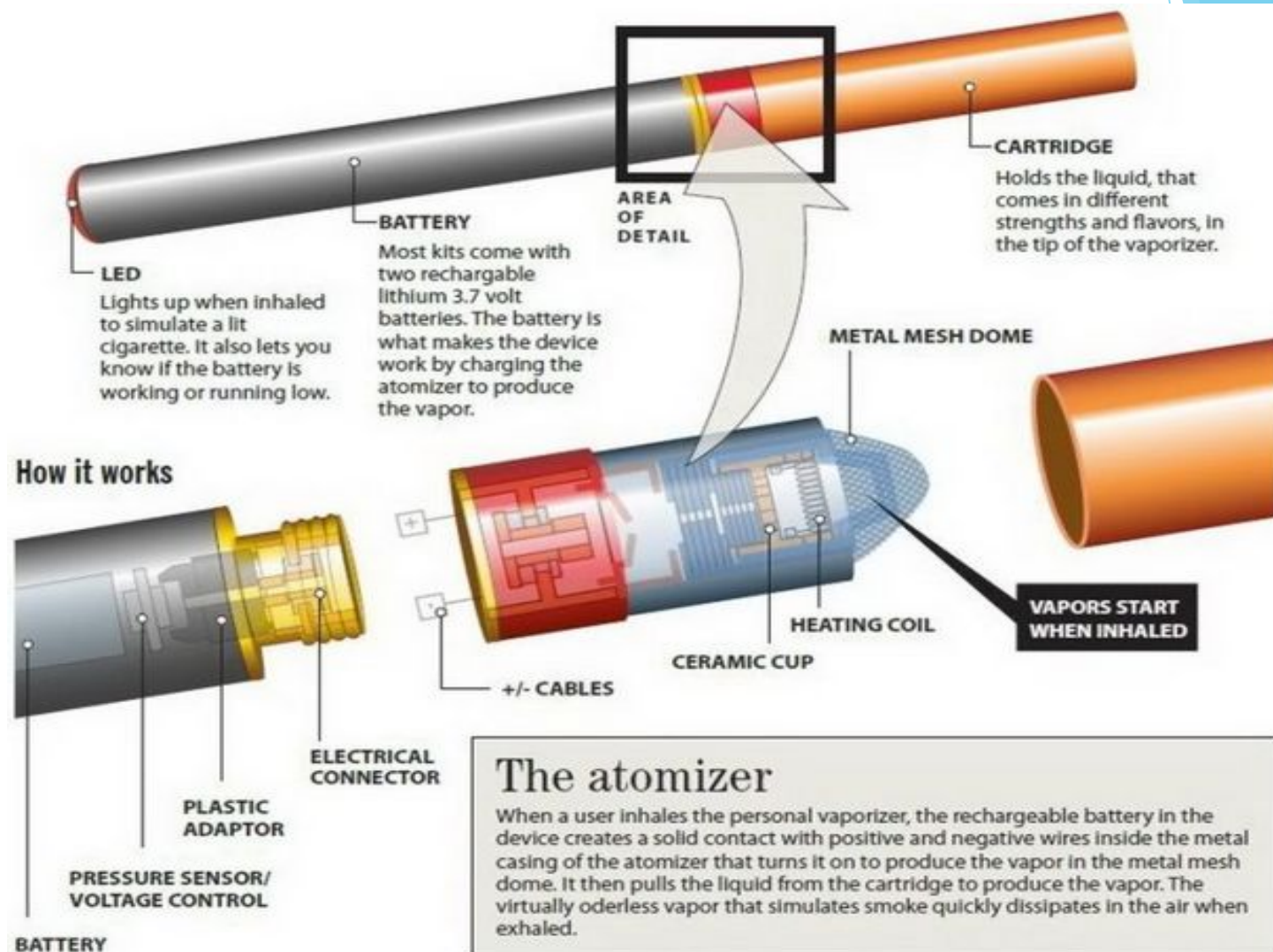
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Electronic Cigarettes in the Indoor Environment

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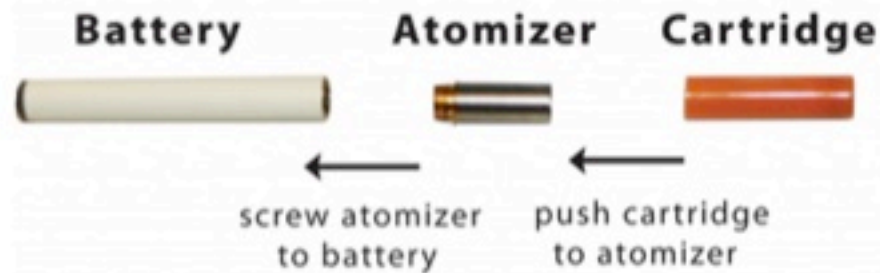
Anatomy of an E-Cigarette



First Generation ECs (‘cigalikes’)



- Disposable
- Re-chargeable with pre-filled cartridges



Second Generation ECs



- Refillable with liquids



Third Generation ECs ('mods')



Statistics

- More than 460 different e-brands on the market.*
- Over 7,700 unique e-cigarette flavors.** As of January 2014
- China produces approximately 90% of the world's e-cigarettes and 91% of US imports
- Chinese manufacturers shipped more than 300 million e-cigarettes to the US and Europe in 2014
- 2016 GAO import data are in dollars (includes parts, liquids, and devices) = \$342,257,308.00

Barboza, D. (2014, December 13). China's e-cigarette boom lacks oversight for safety. *The New York Times*. Retrieved from http://www.nytimes.com/2014/12/14/business/international/chinas-e-cigarette-boom-lacks-oversight-for-safety-.html?_r=0

U.S. Government Accountability Office. (2017, April 24). *Electronic cigarettes: US Imports in 2016*. Retrieved from <https://www.gao.gov/assets/690/684227.pdf>

Zhu, S. (2014). Four hundred and sixty brands of e-cigarettes and counting: Implications for product regulation. *Tobacco Control*. doi:10.1136/tobaccocontrol-2014-051670

Statistics

- E-cigarette sales in the U.S. were estimated at \$2.2 billion in 2014.
- Sales expected to grow nearly 50% per year through 2018.
- In 2014, an estimated 2.5 million middle and high school students used e-cigarettes.
- In 2015, this number increased to more than 3 million

Statistics

- There is some evidence that e-cigarette use is prospectively associated with increased risk of combustible tobacco use initiation during early adolescence
- An estimated 16% of U.S. tenth graders have tried e-cigarettes, of whom 43% have never smoked combustible cigarettes (August, 2015)
- Among high school students that were electronic nicotine delivery system (ENDS) users, 25% went on to be conventional tobacco product users, compared with 9% in the population that had never used an ENDS

Leventhal, A.M., Strong, D.R., Kirkpatrick, M.G., Under, J. B., Sussman, S., Riggs, N.R., Stone, M.D., Khoddam, R., Sarnet, J.M. & Audrain-McGovern, J. (2015). Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA*. doi:10.1001/jama.2015.8950

Rigotti, N.A. (2015). E-cigarette use and subsequent tobacco use by adolescents: New evidence about a potential risk of e-cigarettes. *JAMA*, 314(7), 673-674. doi:10.1001/jama.2015.8382



Primary Components



- Propylene Glycol/
Vegetable Glycerin
- Nicotine
- Flavorings

Propylene Glycol/Vegetable Glycerin

- Used in theatrical fog
 - Exposure may contribute to both acute and chronic health issues, such as asthma, wheezing, chest tightness, decreased lung function, respiratory irritation, and airway obstruction*



*Varughese, S., Teschke, M., Brauer, Y. Chow, C. Van Netten, C. & Kennedy, S.M. (2005) Effects of theatrical smokes and fogs on respiratory health in the entertainment industry. *American Journal of Industrial Medicine*, 47, 411–418

Propylene Glycol/Vegetable Glycerin

- Pyrolysis/heating glycerin forms acrolein, formaldehyde and acetaldehyde in the vapors

Geiss, O., Bianchi, I., Barhona, F., & Barrero-Moreno, J. (2014). Characterisation of mainstream and passive vapours emitted by selected electronic cigarettes. *International Journal of Hygiene and Environmental Health*, 281, 169-180

Goniewicz, M.L., Knysak, J., Gawron, M., Kosmider, L., Sobczak, A. Kurek, J., Prokopowicz, A. ...& N. Benowitz. (2013). Levels of selected carcinogens and toxicants in vapour from electronic cigarettes. *Tobacco Control*. 0:1-7 doi:10.1136/tobaccocontrol-2012-050859.

Lauterbach, J.H. & Laugesen, M. (2012). Comparison of toxicant levels in mainstream aerosols generated by Ruyan® electronic nicotine delivery systems (ENDS) and conventional cigarette products. *Toxicologist*, 126, 1

Lauterbach, J.H., Laugesen, M., Ross, B.B., 2012. Suggested protocol for estimation of harmful and potentially harmful constituents in mainstream aerosols generated by electronic nicotine delivery systems (ENDS). *Toxicologist*, 126, 1

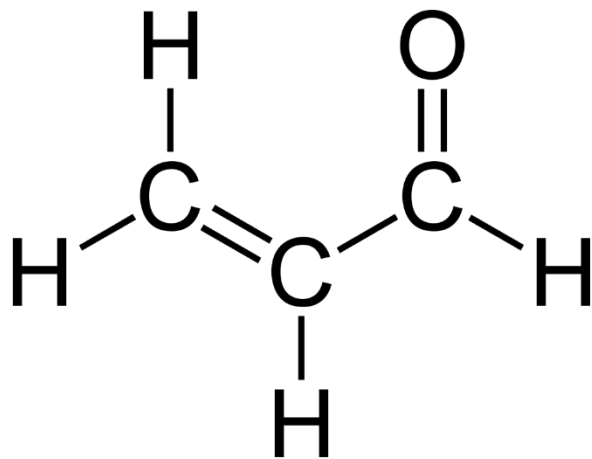
Uchiyama, S., K. Ohta, Y. Inaba, & N. Kunugita. (2013). Determination of carbonyl compounds generated from the e-cigarette using coupled silica cartridges impregnated with hydroquinone and 2,4-dinitrophenylhydrazine, followed by high-performance liquid chromatography. *Analytical Sciences*, 29 (12), 1219-1222

Formaldehyde

- A known degradation product of propylene glycol and glycerin
- Found in vapor and in small amounts in some studies of some liquids
- Higher airborne concentrations with higher voltage second and third generation units
- Known human carcinogen



Acrolein

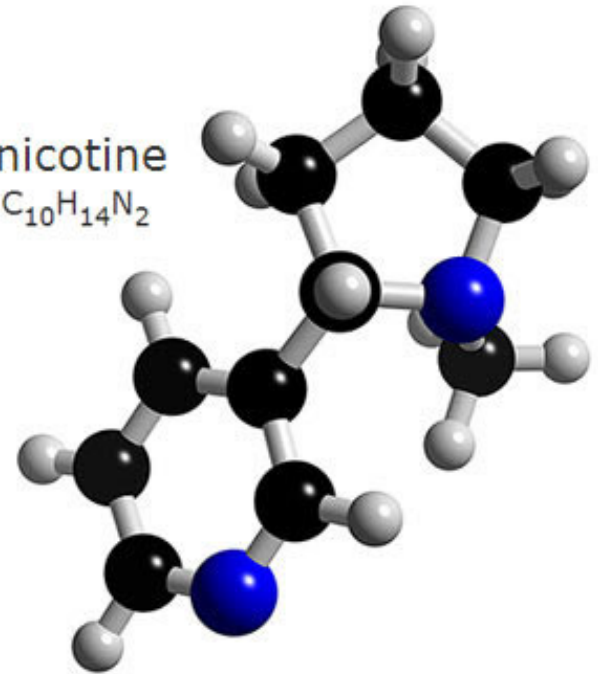


- Causes irritation to the nasal cavity, damage to the lining of the lungs and is thought to contribute to cardiovascular disease in cigarette smokers
- Found in vapor only (formed as a result of heating process)

Nicotine

- Health Effects
 - Addictive
 - Teratogenic
 - Increases heart rate, respiratory rate, blood pressure, and level of alertness
- E-Cig Labeling
 - Some cartridges labeled as containing no nicotine did, in fact, contain detectable levels of nicotine
 - Concentration and delivery inconsistencies
- Nicotine found in the vapor, but lower than found emitted from conventional cigarettes

nicotine
 $C_{10}H_{14}N_2$



Poison center calls involving e-cigarettes

250

200

150

100

50

0

215

Calls per Month

1

Call per Month

September 2010

February 2014





**Works
for You**

**NICOTINE POISONINGS UP AS E-CIG POPULARITY GROWS
ONE THIRD OF VICTIMS ARE TWO YEARS OLD**

The first reported child's death from accidentally ingesting e-liquid was in early December of 2014 involving a 1-year old in Fort Plain, New York.

Flavorings





Other Additives



Food and Drug Administration. (2010). Warning letter. Retrieved from <http://www.fda.gov/ICECI/EnforcementActions/WarningLetters/ucm225187.htm>

Other Additives



Generally Recognized as Safe (GRAS)?



Diacetyl as a food additive is GRAS, but aerosolized exposures can cause bronchiolitis obliterans



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[Int J Occup Environ Health](#). 2012 Jan-Mar;18(1):29-42.

Bronchiolitis obliterans and consumer exposure to butter-flavored microwave popcorn: a case series.

[Egilman DS](#), [Schilling JH](#).

Department of Family Medicine, Brown University, Providence, Rhode Island, USA. degilman@egilman.com

Abstract

Respiratory exposure to diacetyl and diacetyl-containing flavorings used in butter-flavored microwave popcorn (BFMP) causes lung disease, including bronchiolitis obliterans (BO), in flavorings and popcorn manufacturing workers. However, there are no published reports of lung disease among BFMP consumers. We present a case series of three BFMP consumers with biopsy-confirmed BO. We review data relating to consumer exposures, estimate case exposures, and compare them to diacetyl-containing flavoring-exposed manufacturing workers with lung disease. These consumer cases' exposure levels are comparable to those that caused disease in workers. We were unable to identify any other exposures or diseases known or suspected to cause BO in these cases. BFMP poses a significant respiratory risk to consumers. Some manufacturers have substituted diacetyl with other alpha-diketones that are likely to pose a similar risk. Simple consumer practices such as cooling the popcorn bag would eliminate the risk of severe lung disease.

PMID: 22550695 [PubMed - in process]

Diacetyl and Acetyl Propionyl

- Diacetyl and acetyl propionyl are GRAS but are associated with respiratory disease when inhaled
 - The risks associated with inhalation of acetyl propionyl may be as high as from diacetyl based on inhalation studies with rats
- 159 samples purchased from 36 manufacturer and retailers in 7 countries*
- Diacetyl and acetyl propionyl were found in 74.2% of the samples
 - Even found in samples from manufacturers who clearly stated that these chemicals were not present

*Farsalinos, K. E., Kistler, K. A., Gilman, G., Voudris, V. (2015) Evaluation of electronic cigarette liquids and aerosol for the presence of selected inhalation toxins. *Nicotine & Tobacco Research*, 168-174, doi: 10.1093/ntr/ntu176

Flavoring Concerns

- No research on potential health effects of aerosolized vapor exposure
- No research on pyrolyzation products of flavorings
- Manufacturing of many flavoring sources are outside the US (China)



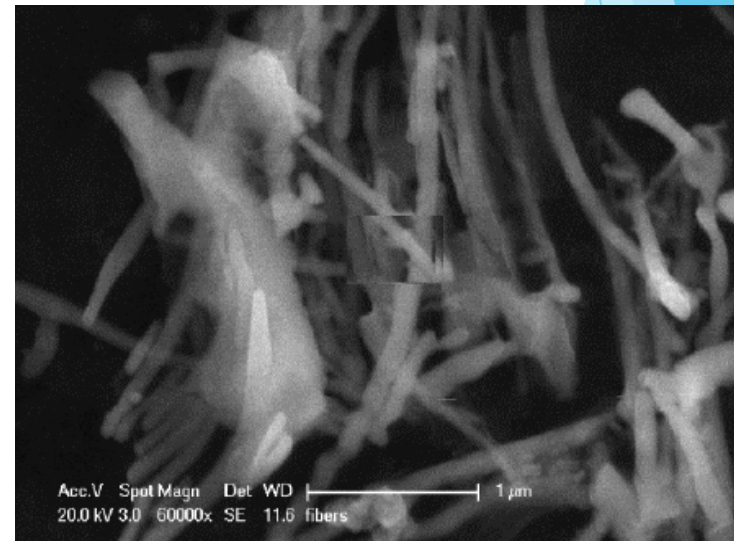
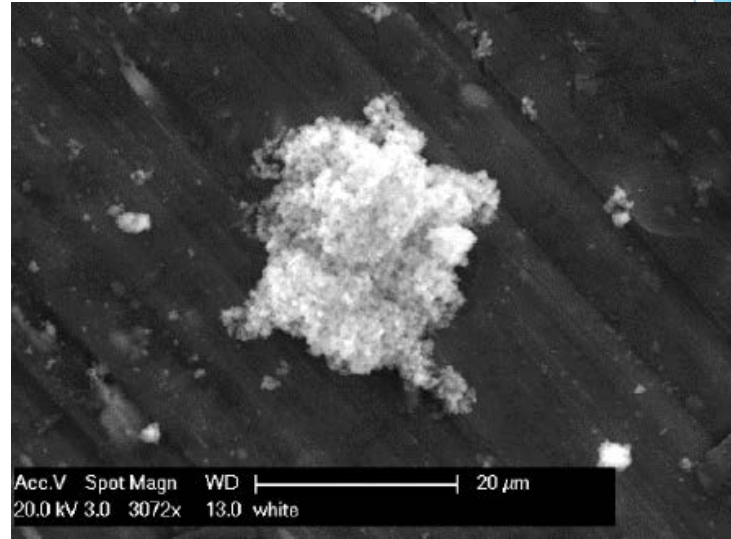
Flavoring Concerns

- Benzaldehyde was detected in cherry flavoring, but also in 75% of 145 e-cig refill liquids*
 - Cytotoxic and genotoxic to cell cultures
- Cinnamaldehyde present in 51% of 39 refill liquids*
 - Highly cytotoxic
- Methyl anthranilate was detected in grape flavoring
- 1-hexanol was detected in apple flavoring

Behar, R.Z., Luo, W., Lin, S.C., Wang, Y., Valle, J., Pankow, J.F. & Talbot, P. (2016). Distribution, quantification and toxicity of cinnamaldehyde in electronic cigarette refill fluids and aerosols. *Tobacco Control*. doi:10.1136/tobaccocontrol-2016-053224

Additional Potential Exposures

- Tin
- Lead
- Nickel
- Zinc
- Copper
- Chromium
- Silicon fibers
- Nanoparticles



Additional Potential Exposures

- ▶ Tobacco-Specific Nitrosamines (TSNAs)
- ▶ Acetic Acid
- ▶ BTEX
- ▶ Isoprene
- ▶ Diethylene Glycol (antifreeze)*

*Food and Drug Administration. (2009) FDA news release: FDA and public health experts warn about electronic cigarettes. Retrieved from www.fda.gov/newsevents/newsroom/pressannouncements/ucm173222.htm

Tobacco-Specific Nitrosamines (TSNAs)

- Some TSNAs are known human carcinogens and are suspected to contribute to the cancer burden of smokers
- Small amounts of TSNAs have been found in e-liquids and vapor
- Residual nicotine from tobacco smoke has been shown to react with ambient nitrous acid to form TSNAs over time
 - Third-hand exposure?

Second-Hand Exposure Concerns

- Nicotine (teratogen and addictive)
- Flavorings (nut and other allergies)
- Formaldehyde (carcinogen)
- Acrolein (listed as a Hazardous Air Pollutant by the EPA)
- Acetaldehyde (possible human carcinogen)
- Fine/Ultrafine Particles
- Tin, Lead, Nickel, Chromium



Cloud Chasing



<https://www.youtube.com/watch?v=ZgouBVNItQA>



When Cloud Chasing Spills Over: A different kind of 'vapor intrusion.'

- ▶ Floyd (2017) showed that e-cig aerosols can spread through HVAC systems to adjacent parts of a building.
- ▶ Nicotine contamination was found to be elevated on surfaces in shops adjacent to small vape shops.
- ▶ Cleaning regimens in the vape shops were very aggressive (daily or twice daily) and this seem to control surface contamination adequately within the shops, but adjacent shops did not clean display cabinets as frequently, resulting in elevated nicotine contamination.

Floyd, E. (2017). When cloud chasing spills over: A different kind of 'vapor intrusion.' American Industrial Hygiene Conference and Exposition, Seattle, Washington, June 6, 2017.

Some Reported Health Effects

- Mouth and throat irritation
- Dry cough
- Nausea
- Dizziness
- Changes in heart rhythm
- Changes in blood pressure

IT'S NOT JUST
"HARMLESS WATER VAPOR"

E-cigarette aerosol contains at least **10 chemicals** on California's Prop 65 list of chemicals known to cause **cancer, birth defects or other reproductive harm.**

TOLUENE
ACETALDEHYDE
BENZENE
CADMIUM
FORMALDEHYDE
ISOPRENE
LEAD
NICKEL
NICOTINE
N-NITROSONICOTINE



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Life Cycle Issues

- Some are single use or disposable
- Lithium ion batteries
- Nicotine (acute hazardous waste)
 - EPA: “unused (unsold, expired, or returned) nicotine-containing products, including patches, gums, lozenges, inhalers, nasal sprays, and e-cigarettes, are classified as P075 listed acute hazardous wastes when discarded.”
- Some manufacturers offer recycling programs
- There is at least one disposal company that is disassembling the components, recycling the batteries, metal, and plastic components that can be recycled, then disposing of the nicotine by incineration.



WHO

- The World Health Organization (WHO) has recommended that consumers be strongly advised not to use electronic nicotine delivery systems, including e-cigarettes, until they are deemed safe and effective and of acceptable quality by a competent national regulatory body.

Food and Drug Administration (FDA)

- August 8, 2016, the FDA regulation banning the sale of e-cigarettes to minors became effective.
 - Photo ID required
 - Retailers may not hand out free samples
 - No sales in vending machines
- The FDA now requires manufacturers, importers, and retailers to report ingredients and place health warnings on products and advertisements
- Vape shops that mix e-liquids will be regulated as a retailer and a manufacturer

Food and Drug Administration (FDA)

- **Manufacturers must:**
 - Stop distributing products that claim it is a modified risk tobacco product
 - Register their establishments and submit a list of products, including labeling and advertisements
 - Submit tobacco health documents by 2017
 - Submit ingredient listing by 2017
 - Submit a premarket application for “new” tobacco products

NIOSH

- NIOSH Current Intelligence Bulletin 67 published April 2, 2015 recommends that employers “establish and maintain smoke-free workplaces that protect those in workplaces from involuntary, secondhand exposures to tobacco smoke **and airborne emissions from e-cigarettes and other electronic nicotine delivery systems.**”

(emphasis added)

ANSI/ASHRAE 62.1

- ASHRAE Standard 62.1 contains requirements for ventilation of spaces that are free of environmental tobacco smoke (ETS).
- Also contains requirements for separation of an ETS-free area from any spaces containing ETS.
- Addendum c to ANSI/ASHRAE Standard 62.1-2013 clarifies that the definition of ETS “includes smoke produced from the combustion of cannabis and controlled substances **and the emissions produced by electronic smoking devices.**”
- “The existing requirements for separation of ETS-free spaces from ETS spaces remains unchanged.”

ANSI/ASHRAE 62.1

- ETS-free areas at positive pressure to ETS areas
- Solid walls, floors, ceiling, and doors with automatic closing mechanisms to separate ETS areas from ETS-free areas
- No recirculation or transfer of air from ETS area to ETS-free area
- Signage for ETS areas

White Paper: Electronic Cigarettes in the Indoor Environment



American Industrial Hygiene Association®



October 19, 2014

*Sponsored by the AIHA®
Indoor Environmental Quality Committee and
Risk Assessment Committee*

AIHA White Paper: Electronic Cigarettes in the Indoor Environment

Recommendation:

“E-cigarettes should be considered a source of volatile organic compounds (VOCs) and particulates in the indoor environment that have not been thoroughly characterized or evaluated for safety.”*

*Quoted by NIOSH in the 2015 Current Intelligence Bulletin 67 “Promoting Disease and Injury Through Workplace Tobacco Policies”

Bibliography

- **AIHA White Paper: *Electronic Cigarettes in the Indoor Environment***
https://www.aiha.org/government-affairs/Documents/Electronic%20Cig%20Document_Final.pdf
- **NIOSH *Current Intelligence Bulletin 67: Promoting Health and Preventing Disease and Injury Through Workplace Tobacco Policies* (NIOSH Publication No. 2015-113)**
http://www.cdc.gov/niosh/docs/2015-113/pdfs/fy15_cib-67_2015-113_v3.pdf
- **ANSI/ASHRAE Addenda a, c, j, k, q, r, and s to ANSI/ASHRAE Standard 62.1-2013: *Ventilation for Acceptable Indoor Air Quality***
https://www.ashrae.org/File%20Library/docLib/StdAddenda/62_1_2013_2015Supplement_20150203.pdf

QUESTIONS?