

สัมมนาวิชาการ

เรื่อง



การจัดการคุณภาพอากาศภายในอาคารและ มาตรฐานการระบายอากาศเพื่อคุณภาพอากาศ ภายในอาคารที่ยอมรับได้

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ผู้ช่วยศาสตราจารย์ ดร. ตุลย์ มณีวัฒนา เป็นวุฒิวิศวกรในสาขาวิศวกรรมเครื่องกลที่มีประสบการณ์ในการออกแบบระบบปรับอากาศ ระบายอากาศ และระบบเครื่องทำความเย็นขนาดใหญ่ ในอาคารและโรงงานต่างๆ มากกว่า 30 ปี ท่านเป็นอาจารย์ที่ภาควิชาวิศวกรรมเครื่องกล คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย มาตั้งแต่ปี พ.ศ. 2523 รายวิชาที่ท่านสอนอยู่ส่วนมากคือรายวิชาการทำความเย็นและการปรับอากาศสำหรับนักศึกษาในภาควิชาวิศวกรรมเครื่องกลชั้นปีที่ 4 และรายวิชาการทำความเย็นและการปรับอากาศขั้นสูงสำหรับนักศึกษาในระดับปริญญาโท/เอก ตำแหน่งต่างๆที่ท่านเคยดำรงมาในอดีตที่สำคัญก็มี อาทิเช่น หัวหน้าภาควิชาวิศวกรรมเครื่องกล คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย นายกสมาคมวิศวกรรมปรับอากาศแห่งประเทศไทย (ACAT) กรรมการบริหาร ASHRAE Thailand Chapter และ ที่ปรึกษาของสมาคมเครื่องทำความเย็นไทย (TRA) นอกจากนั้นแล้ว ในปีที่ผ่านมา ท่านก็ยังได้รับเลือกจากสมาคมวิศวกรรมปรับอากาศแห่งประเทศไทย ให้เป็น วิศวกรปรับอากาศดีเด่น ประจำปี 2560 อีกด้วย

ASHRAE
Standard
62.1-2016

ASHRAE
IAQ's Guide-
2009

IAQ
Management

STANDARD



ANSI/ASHRAE Standard 62.1-2016
(Supersedes ANSI/ASHRAE Standard 62.1-2013)
Includes ANSI/ASHRAE addenda listed in Appendix K

Ventilation for Acceptable Indoor Air Quality

See Appendix K for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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ISSN 1041-2336



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Ventilation for Acceptable Indoor Air Quality**

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NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

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Purpose

Set minimum ventilation rates and other measures to provide acceptable IAQ

4. Outdoor Air Quality

คุณภาพอากาศภายนอกอาคาร

ตารางที่ 1: National Ambient Air Quality Standard (NAAQS) ของประเทศสหรัฐอเมริกา
(ที่มา: ASHRAE Standard 62.1-2013)

สารมลพิษ	ค่ามาตรฐานหลัก	เวลาที่ใช้ในการเฉลี่ยค่า
ก๊าซคาร์บอนมอนอกไซด์ (CO)	9 ppm (10 mg/m ³)	8 ชั่วโมง ¹
	35 ppm (40 mg/m ³)	1 ชั่วโมง ¹
ตะกั่ว (Pb)	0.15 µg/m ³	3 เดือน (Rolling)
ก๊าซไนโตรเจนไดออกไซด์ (NO ₂)	100 ppb	1 ชั่วโมง ¹
	0.053 ppm (100 µg/m ³)	1 ปี (arithmetic mean)
ฝุ่นละอองขนาดไม่เกิน 10 ไมครอน (PM ₁₀)	150 µg/m ³	24 ชั่วโมง ¹
ฝุ่นละอองขนาดไม่เกิน 2.5 ไมครอน (PM _{2.5})	12 µg/m ³	1 ปี (arithmetic mean)
	35 µg/m ³	24 ชั่วโมง ¹
ก๊าซโอโซน (O ₃)	0.075 ppm	8 ชั่วโมง ¹
ก๊าซซัลเฟอร์ไดออกไซด์ (SO ₂)	75 ppb	1-ชั่วโมง ¹
	—	3 ชั่วโมง

5. System and Equipment

5. SYSTEMS AND EQUIPMENT

- Ventilation Air Distribution
- Exhaust Duct Location
- Ventilation System Controls
- Airstream Surfaces
- Outdoor Air Intakes
- Finned-Tube Coils and Heat Exchangers
- Humidifiers and Water-Spray Systems
- Access for Inspection, Cleaning, and Maintenance
- Building Envelope and Interior Surfaces
- Local Capture of Contaminants
- Combustion Air.
- Particulate Matter Removal
- Dehumidification Systems
- Drain Pans
- Buildings with Attached Parking Garages
- Air Classification and Recirculation.
- Requirements for Buildings Containing ETS Areas

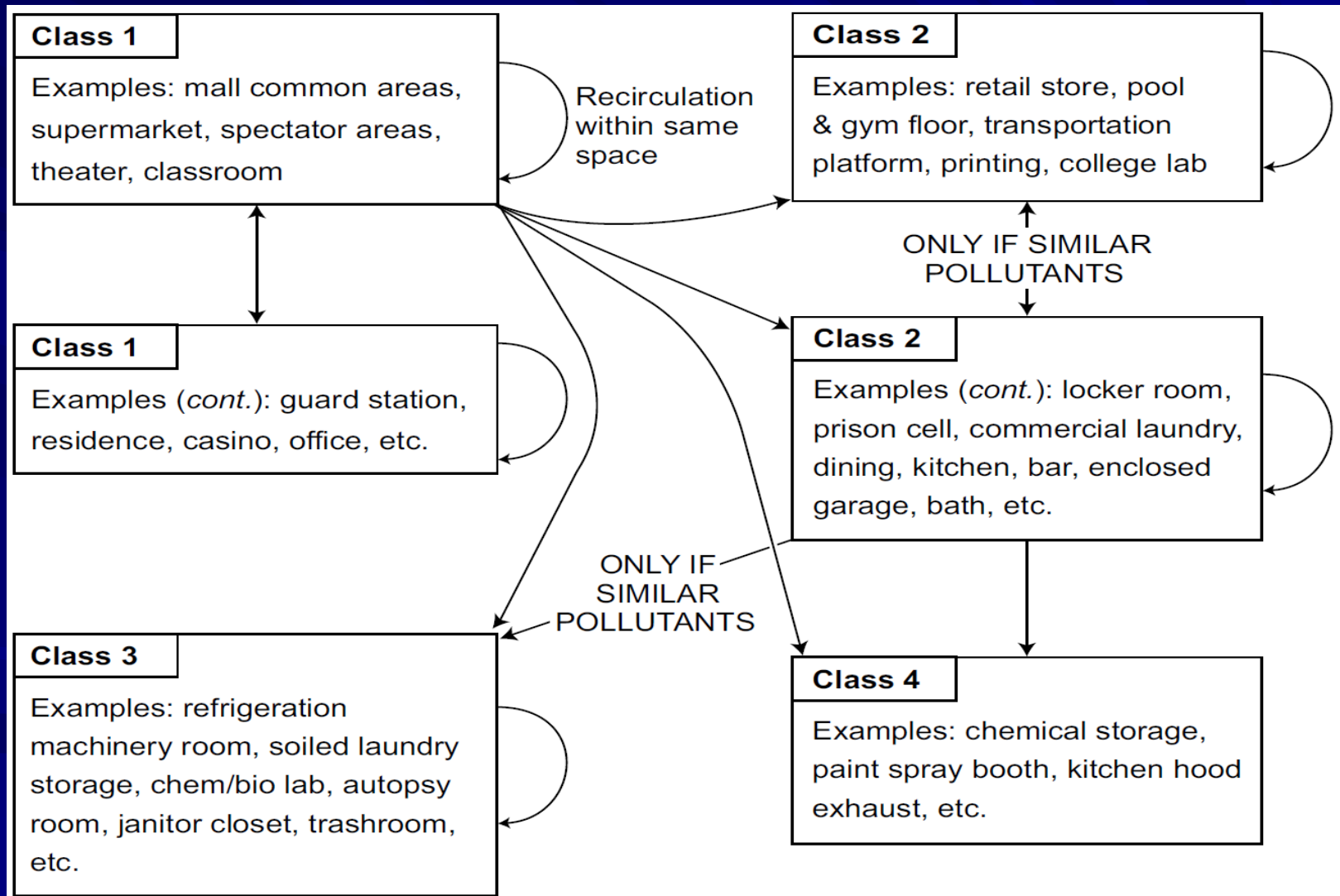
Air Intake Minimum Separation Distance

ชนิดของสิ่งที่ต้องอยู่ห่าง	ระยะห่างขั้นต่ำ, เมตร
ช่องระบายอากาศเสีย (Exhaust Air) หรือช่องระบายอากาศระบายออก (Relief Air) จากบริเวณที่มีมลภาวะระดับ 2 (Air Class 2) (ดูหมายเหตุ 1)	3
ช่องระบายอากาศเสีย (Exhaust Air) หรือช่องระบายอากาศระบายออก (Relief Air) จากบริเวณที่มีมลภาวะระดับ 3 (Air Class 3) (ดูหมายเหตุ 1)	5
ช่องระบายอากาศเสีย (Exhaust Air) หรือช่องระบายอากาศระบายออก (Relief Air) จากบริเวณที่มีมลภาวะระดับ 4 (Air Class 4) (ดูหมายเหตุ 2)	10
ช่องระบายอากาศจากระบบท่อสุขาภิบาล ที่อยู่สูงกว่า ช่องดูดอากาศบริสุทธิ์จากภายนอกอาคาร ไม่นเกิน 1 เมตร	3
ช่องระบายอากาศจากระบบท่อสุขาภิบาล ที่อยู่สูงกว่า ช่องดูดอากาศบริสุทธิ์จากภายนอกอาคาร อย่างน้อย 1 เมตร	1
ช่องระบาย หรือ ปล่องควันไฟ จากอุปกรณ์การเผาไหม้ (ดูหมายเหตุ 3)	5
ทางเข้าที่จอดรถ พื้นที่ขนถ่ายสินค้าขึ้นลงจากรถ หรือ ที่รถจอดต่อแถวรอคิว (ดูหมายเหตุ 4)	5
พื้นที่ขนถ่ายสินค้าขึ้นลงรถบรรทุก อยู่ หรือ ที่จอดหรือที่จอดรถของรถโดยสาร (ดูหมายเหตุ 4)	7.5
ทางรถวิ่ง ถนน สถานที่จอดรถ (ดูหมายเหตุ 4)	1.5
ถนนที่มีการจราจรคับคั่ง	7.5
หลังคา พื้นที่ลาดเอียง หรือพื้นผิวซึ่งอยู่ใต้ช่องดูดอากาศบริสุทธิ์จากภายนอกอาคารพอดี (ดูหมายเหตุ 5 และ 6)	0.3
ที่เก็บ หรือ ที่ขนถ่ายขยะ หรือ ถังขยะขนาดใหญ่	5
ช่องดูดอากาศ หรือ อ่างน้ำ ของหอผึ่งน้ำ	5
ช่องระบายอากาศทิ้งของหอผึ่งน้ำ	7.5

Dehumidification Systems

5.9.1 Relative Humidity. Occupied-space relative humidity shall be limited to 65% or less when system performance is analyzed with outdoor air at the dehumidification design condition and with the space interior loads (both sensible and latent) at cooling design values and space solar loads at zero.

Air Classifications



6. Procedures

วิธีคำนวณหาปริมาณการระบายอากาศ

มีสี่แบบคือ

1. Ventilation Rate Procedure (VRP)
2. IAQ Procedure (IAQP)
3. Natural Ventilation Procedure (NVP)
4. Exhaust Ventilation

6.2 Ventilation Rate Procedure (VRP)

Concept for Calculation of Design Ventilation Rate

Breathing
Zone
Outdoor
Air Flow =

People Component

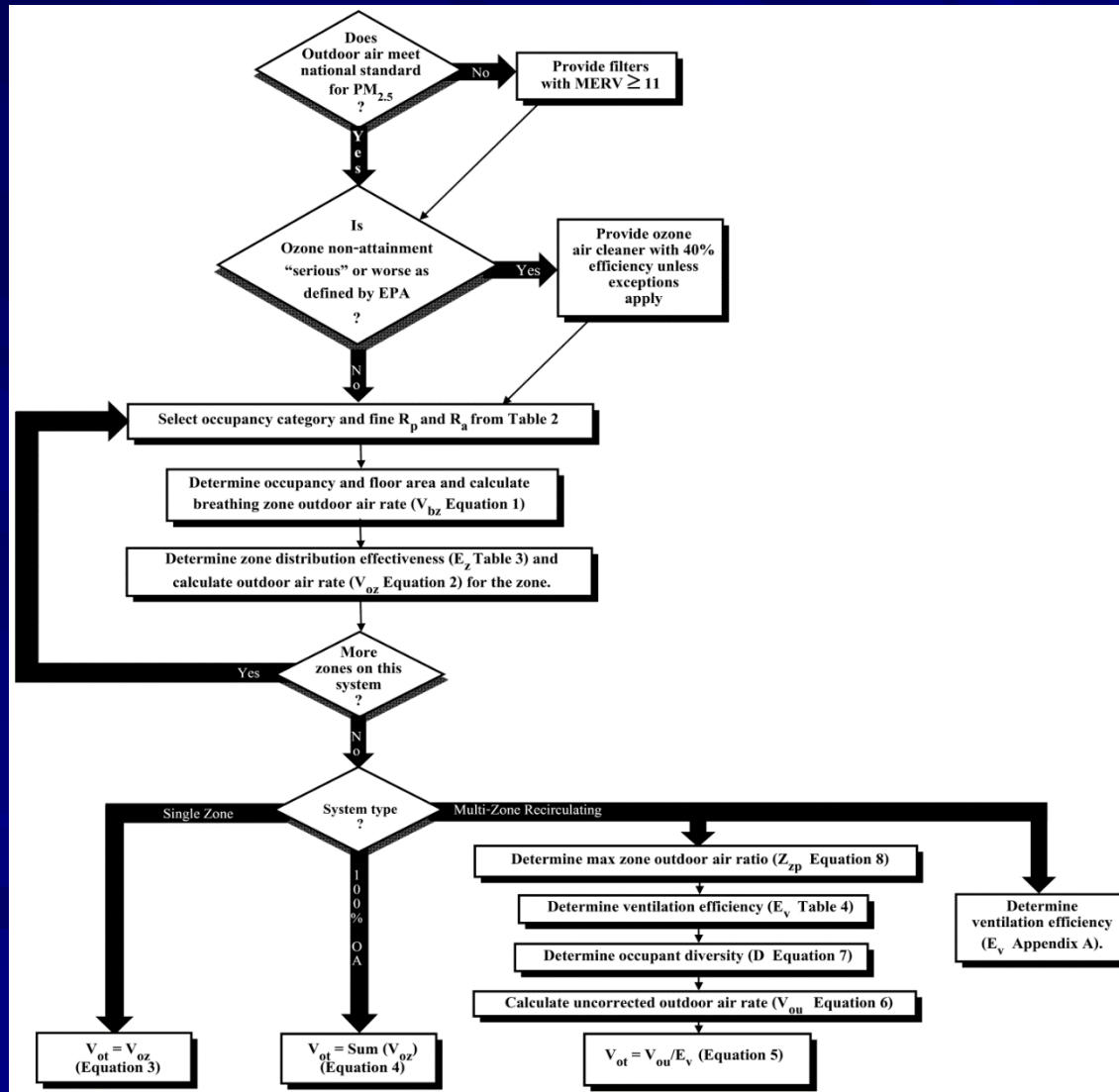


Building Component



$$V_{bz} = R_p \times P_z + R_a \times A_z$$

VRP Flow Chart



ประเภทการใช้งาน	People	Area	Notes	Default Values		Air Class
	Outdoor Air Rate R_p	Outdoor Air Rate R_a		Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)	
	cfm/p	cfm/ft ²		#/100 m ²	cfm/p	
สถานศึกษา (Educational Facilities)						
ศูนย์รับบาลเด็กเล็ก (ถึง 4 ขวบ) (Daycare (through age 4))	10	0.18		25	17	2
ห้องเด็กป่วยในศูนย์รับบาลเด็กเล็ก (Daycare sickroom)	10	0.18		25	17	3
ห้องเรียน (อายุ 5-8 ปี) (Classrooms (ages 5–8))	10	0.12		25	15	1
ห้องเรียน (อายุตั้งแต่ 9 ขึ้นไป) (Classrooms (age 9 plus))	10	0.12		35	13	1
ห้องเรียนแบบบรรยาย (Lecture classroom)	7.5	0.06		65	8	1
หอประชุมบรรยายขนาดใหญ่ (Lecture hall (fixed seats))	7.5	0.06		150	8	1
ห้องเรียนศิลปะ (Art classroom)	10	0.18		20	19	2
ห้องปฏิบัติการทางวิทยาศาสตร์ (Science laboratories)	10	0.18		25	17	2
ห้องปฏิบัติการในมหาวิทยาลัย (University/college laboratories)	10	0.18		25	17	2
ห้องปฏิบัติการงานไม้/งานโลหะ (Wood/metal shop)	10	0.18		20	19	2
ห้องปฏิบัติการคอมพิวเตอร์ (Computer lab)	10	0.12		25	15	1
ศูนย์สื่อสาร (Media center)	10	0.12	A	25	15	1
ห้องดนตรี/ละคร/เต้นรำ (Music/theater/dance)	10	0.06		35	12	1
ห้องประชุมเอนกประสงค์ (Multiuse assembly)	7.5	0.06		100	8	1

6.3 Indoor Air Quality Procedure (IAQP)

IAQP Flow Chart

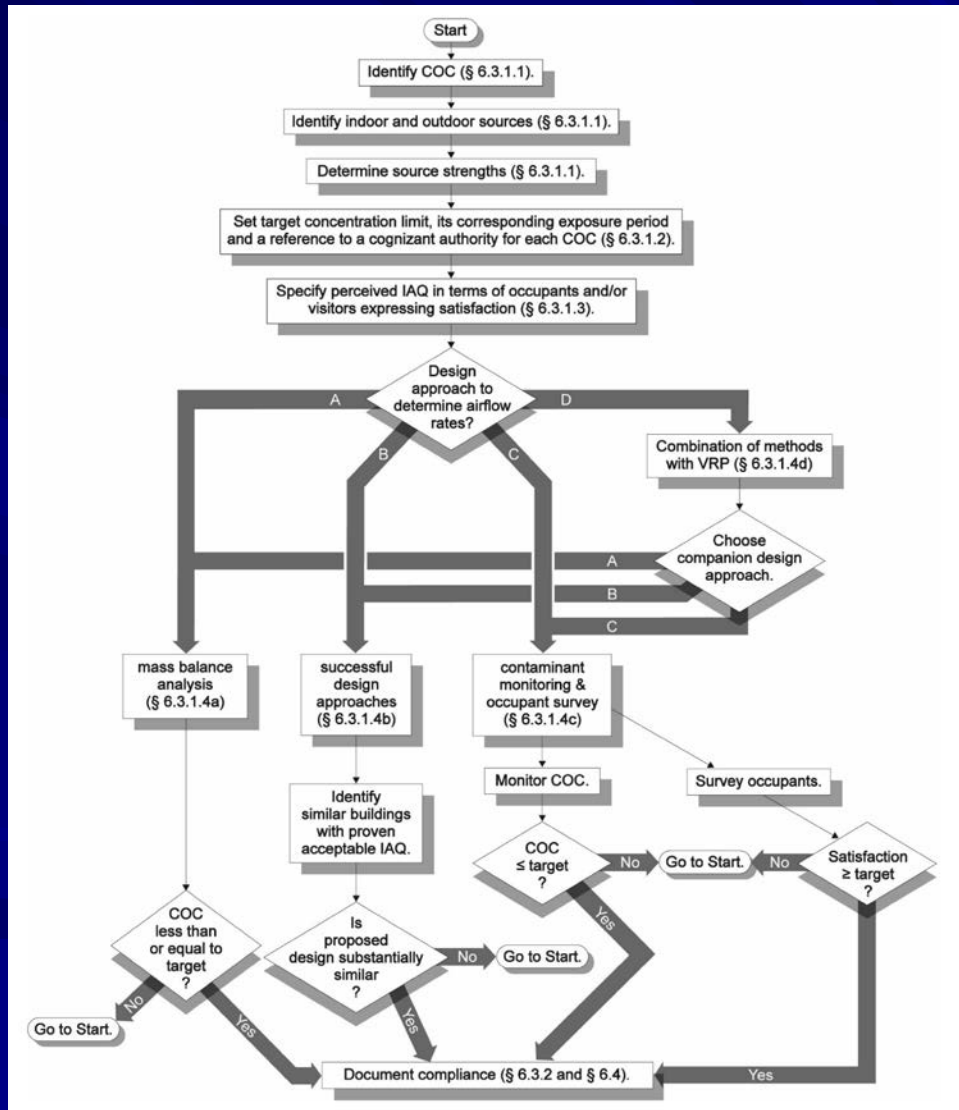


TABLE C-1 Comparison of Regulations and Guidelines Pertinent to Indoor Environments^a

(The user of any value in this table should take into account the purpose for which it was adopted and the means by which it was developed.)

	Enforceable and/or Regulatory Levels			Nonenforced Guidelines and Reference Levels			
	NAAQS/EPA (Ref. C-4)	OSHA (Ref. C-5)	MAK (Ref. C-2)	Canadian (Ref. C-8)	WHO/Europe (Ref. C-11)	NIOSH (Ref. C-13)	ACGIH (Ref. C-1)
Carbon dioxide		5000 ppm	5000 ppm 10,000 ppm [1 h]	3500 ppm [L]		5000 ppm 30,000 ppm [15 min]	5000 ppm 30,000 ppm [15 min]
Carbon monoxide ^c	9 ppm ^g 35 ppm [1 h] ^g	50 ppm	30 ppm 60 ppm [30 min]	11 ppm [8 h] 25 ppm [1 h]	90 ppm [15 min] 50 ppm [30 min] 25 ppm [1 h] 10 ppm [8 h]	35 ppm 200 ppm [C]	25 ppm
Formaldehyde ^h		0.75 ppm 2 ppm [15 min]	0.3 ppm 1 ppm ⁱ	0.1 ppm [L] 0.05 ppm [L] ^b	0.1 mg/m ³ (0.081 ppm) [30 min] ^p	0.016 ppm 0.1 ppm [15 min]	0.3 ppm [C]
Lead	1.5 µg/m ³ [3 months]	0.05 mg/m ³	0.1 mg/m ³ 1 mg/m ³ [30 min]	Minimize exposure	0.5 µg/m ³ [1 yr]	0.050 mg/m ³	0.05 mg/m ³
Nitrogen dioxide	0.05 ppm [1 yr]	5 ppm [C]	5 ppm 10 ppm [5 min]	0.05 ppm 0.25 ppm [1 h]	0.1 ppm [1 h] 0.02 ppm [1 yr]	1 ppm [15 min]	3 ppm 5 ppm [15 min]
Ozone	0.12 ppm [1 h] ^g 0.08 ppm	0.1 ppm	j	0.12 ppm [1 h]	0.064 ppm (120 µg/m ³) [8 h]	0.1 ppm [C]	0.05 ppm ^k 0.08 ppm ^l 0.1 ppm ^m 0.2 ppm ⁿ
Particles ^c <2.5 µm MMAD ^d	15 µg/m ³ [1 yr] ^o 35 µg/m ³ [24 h] ^o	5 mg/m ³	1.5 mg/m ³ for <4 µm	0.1 mg/m ³ [1 h] 0.040 mg/m ³ [L]			3 mg/m ³ [C]
Particles ^c <10 µm MMAD ^d	150 µg/m ³ [24 h] ^o		4 mg/m ³				10 mg/m ³ [C]
Radon				800 Bq/m ³ [1 yr]			
Sulfur dioxide	0.03 ppm [1 yr] 0.14 ppm [24 h] ^g	5 ppm	0.5 ppm 1 ppm ⁱ	0.38 ppm [5 min] 0.019 ppm	0.048 ppm [24 h] 0.012 ppm [1 yr]	2 ppm 5 ppm [15 min]	2 ppm 5 ppm [15 min]
Total particles ^c		15 mg/m ³					

a. Numbers in brackets [] refer to either a ceiling or to averaging times of less than or greater than eight hours (min = minutes; h = hours; y = year; C = ceiling, L = long-term). Where no time is specified, the averaging time is eight hours.

b. Target level is 0.05 ppm because of its potential carcinogenic effects. Total aldehydes limited to 1 ppm. Although the epidemiological studies conducted to date provide little convincing evidence that formaldehyde is carcinogenic in human populations, because of this potential, indoor levels should be reduced as much as possible.

c. As one example regarding the use of values in this table, readers should consider the applicability of carbon monoxide concentrations. The concentrations considered acceptable for nonindustrial, as opposed to industrial, exposure are substantially lower. These lower concentrations (in other words, the ambient air quality standards, which are required to consider populations at highest risk) are set to protect the most sensitive subpopulation, individuals with pre-existing heart conditions.

d. MMAD = mass median aerodynamic diameter in microns (micrometers). Less than 3.0 µm is considered respirable; less than 10 µm is considered inhalable.

e. Nuisance particles not otherwise classified (PNOC), not known to contain significant amounts of asbestos, lead, crystalline silica, known carcinogens, or other particles known to cause significant adverse health effects.

f. See Table C-2 for the U.S. EPA guideline.

g. Not to be exceeded more than once per year

h. The U.S. Department of Housing and Urban Development adopted regulations concerning formaldehyde emissions from plywood and particleboard intended to limit the airborne concentration of formaldehyde in manufactured homes to 0.4 ppm. (24 CFR Part 3280, HUD Manufactured Home Construction and Safety Standards). In addition, California Air Resources Board Regulation §93120, entitled "Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products" has specific chamber-based requirements for composite wood products sold in California^{C-47}.

i. Never to be exceeded

j. Carcinogen, no maximum values established

k. TLV for heavy work

l. TLV for moderate work

m. TLV for light work

n. TLV for heavy, moderate, or light workloads (less than or equal to two hours)

o. 62FR38652 - 38760, July 16, 1997

p. Epidemiological studies suggest a causal relationship between exposure to formaldehyde and nasopharyngeal cancer, although the conclusion is tempered by the small numbers of observed and expected cases. There are also epidemiological observations of an association between relatively high occupational exposures to formaldehyde and sinonasal cancer.

TABLE C-2 Concentration of Interest for Selected Contaminants (Continued)

(Note: References numbers that are followed by [c] and [m] list the concentrations of interest [c] and measurement methods [m]. The user of any value in this table should take into account the purpose for which it was adopted and the means by which it was developed.)

Contaminant	Sources	Concentrations of Interest	Comments	References
Lead (Pb)	Paint dust Outdoor air	1.5 µg/m ³	Based on adverse effects on neuropsychological functioning of children, average exposure for three months (WHO): 0.5–1 µg/m ³ for 1 year. Sources—leaded gasoline (being phased out), paint (houses, cars), smelters (metal refineries), manufacture of lead storage batteries. Health effects—brain and other nervous system damage; children are at special risk. Some lead-containing chemicals cause cancer in animals. Lead causes digestive and other health problems. Environmental effects—Lead can harm wildlife.	C-4 [c] C-4 [m] C-18
Nitrogen Dioxide (NO ₂)	Leaking vented combustion appliances Unvented combustion appliances Outdoor air Parking garages	100 µg/m ³	Based on providing protection against adverse respiratory effects, average exposure for one year. Sources—burning of gasoline, natural gas, coal, oil, etc. Cars are an important source of NO ₂ outdoors and cooking and water- and space-heating devices are important sources indoors. Health effects—lung damage, illnesses of breathing passages and lungs (respiratory system). Environmental effects—Nitrogen dioxide is a component of acid rain (acid aerosols), which can damage trees and lakes. Acid aerosols can reduce visibility. Property damage—Acid aerosols can eat away stone used on buildings, statues, monuments, etc.	C-4 [c] C-9 [m] C-18
		470 µg/m ³	24-hour average to prevent high exposures during use of combustion appliances such as space-heating devices and gas stoves.	C-41
Odors	Occupants VOC sources (including fungal sources such as mold) Cooking, food processing, sewage, biowaste facilities, etc.	Predicted (or measured) acceptability to 80% or more of occupants or visitors	CO ₂ concentration can be used as a surrogate for occupant odors (odorous bioeffluents). See Informative Appendix D for a discussion of indoor CO ₂ levels and ventilation rates. For sources other than people, source control is recommended.	C-12, 24, 29, 30 [c] C-9 (CO ₂), C-15 (odor) [m]
Ozone (O ₃)	Electrostatic appliances Office machines Ozone generators Outdoor air	100 µg/m ³ (50 ppb)	Based on 25% increase in symptom exacerbations among adults or asthmatics (normal activity), eight-hour exposure (WHO); continuous exposure (FDA). Ozone present at levels below the concentration of interest may contribute to the degradation of indoor air quality directly and by reacting with other contaminants in the indoor space. Ground-level ozone is the principal component of smog. Sources—outdoors, from chemical reaction of pollutants, VOCs, and NO _x ; indoors, from photocopiers, laser printers, ozone generators, electrostatic precipitators, and some other air cleaners. Health effects—breathing problems, reduced lung function, asthma, irritated eyes, stuffy nose, reduced resistance to colds and other infections. May speed up aging of lung tissue. Environmental effects—Outdoors, ozone can damage plants and trees; smog can cause reduced visibility. Property damage—Indoors and outdoors, ozone damages natural and synthetic rubbers, plastics, fabrics, etc.	C-6, 11 [c] C-6 [m] C-18
Particles (PM _{2.5})	Combustion products, cooking, candles, incense, resuspension, outdoor air, diesel exhaust, and parking garages	15 µg/m ³		C-4

a. USEPA has promulgated a guideline value of 4 pCi/L indoor concentration. This is not a regulatory value but an action level where mitigation is recommended if the value is exceeded in long-term tests.

Conversion Factors C-17

Parts per million and mass per unit volume:

Measurements of indoor airborne concentrations of substances are generally converted to standard conditions of 77°F (25°C) and 29.92 in. Hg (101.325 kPa) pressure. Vapors or gases are often expressed in parts per million (ppm) by volume or in mass per unit volume. Concentrations in ppm by volume can be converted to mass per unit volume values as follows:

$$\text{ppm} \times \text{molecular weight}/24,450 = \text{mg/L}$$

$$\text{ppm} \times \text{molecular weight}/0.02445 = \mu\text{g}/\text{m}^3$$

$$\text{ppm} \times \text{molecular weight}/24.45 = \text{mg}/\text{m}^3$$

$$\text{ppm} \times \text{molecular weight} \times 28.3/24,450 = \text{mg}/\text{ft}^3$$

6.4 Natural Ventilation Procedure (NVP)

Floor Area to Be Ventilated

Floor area to be naturally ventilated shall be located within a distance based on the ceiling height (H) as follow;

- Single Side Opening, $2H$, $A_w \geq 4\%A_o$
- Double Side Opening, $5H$, $A_w \geq 4\%A_o$
- Corner Openings, $5H$, $A_w \geq 4\%A_o$
- Adjoining Rooms, $A_w \geq 2.3 \text{ m}^2$ or $8\%A_o$

A_w = Opening Area, A_o = Occupiable Floor Area

6.5 Exhaust Ventilation

TABLE 6.5 Minimum Exhaust Rates

Occupancy Category	Exhaust Rate, cfm/unit	Exhaust Rate, cfm/ft ²	Notes	Exhaust Rate, L/s·unit	Exhaust Rate, L/s·m ²	Air Class
Arenas	—	0.50	B	—	—	1
Art classrooms	—	0.70		—	3.5	2
Auto repair rooms	—	1.50	A	—	7.5	2
Barber shops	—	0.50		—	2.5	2
Beauty and nail salons	—	0.60		—	3.0	2
Cells with toilet	—	1.00		—	5.0	2
Copy, printing rooms	—	0.50		—	2.5	2
Darkrooms	—	1.00		—	5.0	2
Educational science laboratories	—	1.00		—	5.0	2
Janitor closets, trash rooms, recycling	—	1.00		—	5.0	3
Kitchenettes	—	0.30		—	1.5	2
Kitchens—commercial	—	0.70		—	3.5	2
Locker/dressing rooms	—	0.25		—	1.25	2
Locker rooms	—	0.50		—	2.5	2
Paint spray booths	—	—	F	—	—	4
Parking garages	—	0.75	C	—	3.7	2
Pet shops (animal areas)	—	0.90		—	4.5	2
Refrigerating machinery rooms	—	—	F	—	—	3
Residential kitchens	50/100	—	G	25/50	—	2

7. Construction and System Start-up

Scope of Construction

7.1 Construction Phase

7.1.1 Application

7.1.2 Filters

7.1.3 Protection of Materials

7.1.4 Protection of Occupied
Areas

7.1.4.1 Application

7.1.4.2 Protective Measures.

7.1.5 Air Duct System

Construction

7.2 System Start-Up

7.2.1 Application

7.2.2 Air Balancing

7.2.3 Testing of Drain Pans

7.2.4 Ventilation System Start-Up

7.2.5 Outdoor Air Dampers

7.2.6 Documentation

8. Operations and Maintenance

Scope of O&M

8.1 General

8.1.1 Application

8.1.2 Building Alterations or Change of Use

8.2 Operations and Maintenance Manual

8.3 Ventilation System Operation

8.4 Ventilation System Maintenance

การบำรุงรักษา

TABLE 8.2 Minimum Maintenance Activity and Frequency for Ventilation System Equipment and Associated Components

Inspection/Maintenance Task	Frequency*
a. Investigate system for water intrusion or accumulation. Rectify as necessary.	As necessary
b. Verify that the space provided for routine maintenance and inspection of open cooling tower water systems, closed cooling tower water systems, and evaporative condensers is unobstructed.	Monthly
c. Open cooling tower water systems, closed cooling tower water systems, and evaporative condensers shall be treated to limit the growth of microbiological contaminants, including <i>legionella sp.</i>	Monthly
d. Verify that the space provided for routine maintenance and inspection of equipment and components is unobstructed.	Quarterly
e. Check pressure drop and scheduled replacement date of filters and air-cleaning devices. Clean or replace as necessary to ensure proper operation.	Quarterly
f. Check ultraviolet lamp. Clean or replace as needed to ensure proper operation.	Quarterly
g. Visually inspect dehumidification and humidification devices. Clean and maintain to limit fouling and microbial growth. Measure relative humidity and adjust system controls as necessary.	Quarterly
h. Maintain floor drains and trap primer located in air plenums or rooms that serve as air plenums to prevent transport of contaminants from the floor drain to the plenum.	Semiannually
i. Check ventilation and indoor air quality related control systems and devices for proper operation. Clean, lubricate, repair, adjust, or replace as needed to ensure proper operation.	Semiannually
j. Check P-traps in floor drains located in plenums or rooms that serve as air plenums. Prime as needed to ensure proper operation.	Semiannually
k. Check fan belt tension. Check for belt wear and replace if necessary to ensure proper operation. Check sheaves for evidence of improper alignment or evidence of wear and correct as needed.	Semiannually
l. Check variable-frequency drive for proper operation. Correct as needed.	Semiannually
m. Check for proper operation of cooling or heating coil for damage or evidence of leaks. Clean, restore, or replace as required.	Semiannually
n. Visually inspect outdoor air intake louvers, bird screens, mist eliminators, and adjacent areas for cleanliness and integrity; clean as needed; remove all visible debris or visible biological material observed and repair physical damage to louvers, screens, or mist eliminators if such damage impairs the item from providing the required outdoor air entry.	Semiannually
o. Visually inspect natural ventilation openings and adjacent areas for cleanliness and integrity; clean as needed. Remove all visible debris or visible biological material observed and repair physical damage to louvers, and screens if such damage impairs the item from providing the required outdoor air entry. Manual and/or automatic opening apparatus shall be physically tested for proper operation and repaired or replaced as necessary.	Semiannually
p. Verify the operation of the outdoor air ventilation system and any dynamic minimum outdoor air controls.	Annually
q. Check air filter fit and housing seal integrity. Correct as needed.	Annually
r. Check control box for dirt, debris, and/or loose terminations. Clean and tighten as needed.	Annually
s. Check motor contactor for pitting or other signs of damage. Repair or replace as needed.	Annually
t. Check fan blades and fan housing. Clean, repair, or replace as needed to ensure proper operation.	Annually
u. Check integrity of all panels on equipment. Replace fasteners as needed to ensure proper integrity and fit/finish of equipment.	Annually
v. Assess field serviceable bearings. Lubricate if necessary.	Annually
w. Check drain pans, drain lines, and coils for biological growth. Check adjacent areas for evidence of unintended wetting. Repair and clean as needed.	Annually
x. Check for evidence of buildup or fouling on heat exchange surfaces. Restore as needed to ensure proper operation.	Annually

* Minimum frequencies may be increased or decreased if indicated in the O&M manual.

** National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD.

TABLE 8.2 Minimum Maintenance Activity and Frequency for Ventilation System Equipment and Associated Components (Continued)

Inspection/Maintenance Task	Frequency*
y. Inspect unit for evidence of moisture carryover from cooling coils beyond the drain pan. Make corrections or repairs as necessary.	Annually
z. Check for proper damper operation. Clean, lubricate, repair, replace, or adjust as needed to ensure proper operation.	Annually
aa. Visually inspect areas of moisture accumulation for biological growth. If present, clean or disinfect as needed.	Annually
ab. Check condensate pump. Clean or replace as needed.	Annually
ac. Visually inspect exposed ductwork and external piping for insulation and vapor barrier for integrity. Correct as needed.	Annually
ad. Verify the accuracy of permanently mounted sensors whose primary function is outdoor air delivery monitoring, outdoor air delivery verification, or dynamic minimum outdoor air control, such as flow stations at an air handler and those used for demand-control ventilation. A sensor failing to meet the accuracy specified in the O&M manual shall be recalibrated or replaced. Performance verification shall include output comparison to a measurement reference standard consistent with those specified for similar devices in ASHRAE Standard 41.2 or ASHRAE Standard 111 ¹⁵ .	5 years
ae. Verify the total quantity of outdoor air delivered by air handlers set to minimum outdoor air mode. If measured minimum airflow rates are less than the design minimum rate documented in the O&M manual, $\pm$ a 10% balancing tolerance, (1) confirm the measured rate does not conform with the provisions of this standard and (2) adjust or modify the air-handler components to correct the airflow deficiency. Ventilation systems shall be balanced in accordance with ASHRAE Standard 111 ¹⁵ or its equivalent, at least to the extent necessary to verify conformance with the total outdoor airflow and space supply airflow requirements of this standard.	5 years

Exception: Units under 2000 cfm (1000 L/s) of supply air are exempt from this requirement.

* Minimum frequencies may be increased or decreased if indicated in the O&M manual.

** National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD.

- ASTM D3273-12, *Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber*. West Conshohocken, PA: American Society for Testing and Materials.
- ANSI/AIHA Z9.5-2013, *Standard for Laboratory Ventilation*. Fairfax, VA: American Industrial Hygiene Association.
- ANSI Z223.1/NFPA-54-2015, *National Fuel Gas Code*. Quincy, MA: National Fire Protection Association.
- NFPA-31-2011, *Standard for the Installation of Oil-Burning Equipment*. Quincy, MA: National Fire Protection Association.
- NFPA-211-2013, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*. Quincy, MA: National Fire Protection Association.
- UL 1995, *Heating and Cooling Equipment*, 4th Edition, 2011. Northbrook, IL: Underwriters Laboratories.
- AMCA 500-L-12, *Laboratory Methods of Testing Louvers for Rating*. Arlington Heights, IL: Air Movement and Control Association International, Inc.
- ANSI/ASHRAE Standard 52.2-2012, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*. Atlanta: ASHRAE.
- NSF/ANSI 60-2013, *Drinking Water Treatment Chemicals Health Effects*. Ann Arbor, MI: NSF International.
- Secondary Direct Food Additives Permitted In Food For Human Consumption*. Code of Federal Regulations, Title 21 Part 173.310 (21 CFR 173.310). *Boiler Water Additives*. U.S. Food and Drug Administration, 2012.
- ANSI/ASHRAE Standard 111-2008, *Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems*. Atlanta: ASHRAE.
- ASHRAE Standard 129-1997 (RA 02), *Measuring Air Change Effectiveness*. Atlanta: ASHRAE.
- ANSI/SMACNA 006-2006 *HVAC Duct Construction Standards Metal and Flexible*, 3rd Edition, 2005. Chantilly, VA: Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA).
- Fibrous Glass Duct Construction Standards*, 7th Edition, 2003. Chantilly, VA: Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA).
- NFPA-90A-2012, *Standard for the Installation of Air-Conditioning and Ventilating Systems*. Quincy, MA: National Fire Protection Association.
- NFPA-90B-2012, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*. Quincy, MA: National Fire Protection Association.

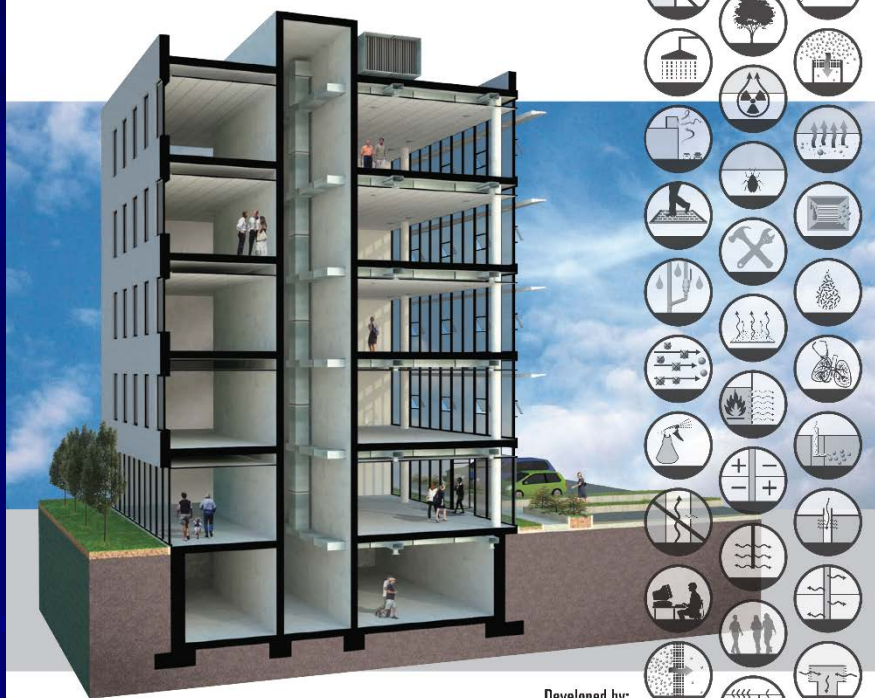
ASHRAE
Standard
62.1-2016

ASHRAE
IAQ's Guide-
2009

IAQ
Management

Indoor Air Quality Guide

Best Practices for Design, Construction,
and Commissioning



Developed by:

American Society of Heating, Refrigerating and Air-Conditioning Engineers
The American Institute of Architects
Building Owners and Managers Association International
Sheet Metal and Air Conditioning Contractors' National Association
U.S. Environmental Protection Agency
U.S. Green Building Council



Indoor Air Quality Guide

Best Practices for Design,
Construction, and Commissioning

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U.S. Green Building Council
U.S. Environmental Protection Agency

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IAQ
Management

มีอาคารหลังหนึ่ง อยากให้ **IAQ** ดี ต้องทำ
อย่างไรครับ?



เดินตรวจดูว่าภายในอาคาร มีแหล่งกำเนิดกลิ่น
ความสกปรก หรือมลพิษอื่นๆหรือไม่? ถ้าพบก็
ให้ทำความสะอาดและกำจัดเสีย
มาตรการนี้เป็นการกำจัดมลพิษที่แหล่งกำเนิด

- มาตรการนี้ควรทำหรือไม่?
- มาตรการนี้จะช่วยทำให้ IAQ
ในอาคารดี ขึ้นหรือไม่?



ตรวจสอบว่า

มีการระบายอากาศในอาคารอย่างถูกต้องหรือไม่

ระบบปรับอากาศและระบายอากาศมีการออกแบบ
ใช้งานและบำรุงรักษาอย่างถูกต้องหรือไม่

- มาตรการนี้ควรทำหรือไม่?
- มาตรการนี้จะช่วยทำให้ IAQ
ในอาคารดี ขึ้นหรือไม่?

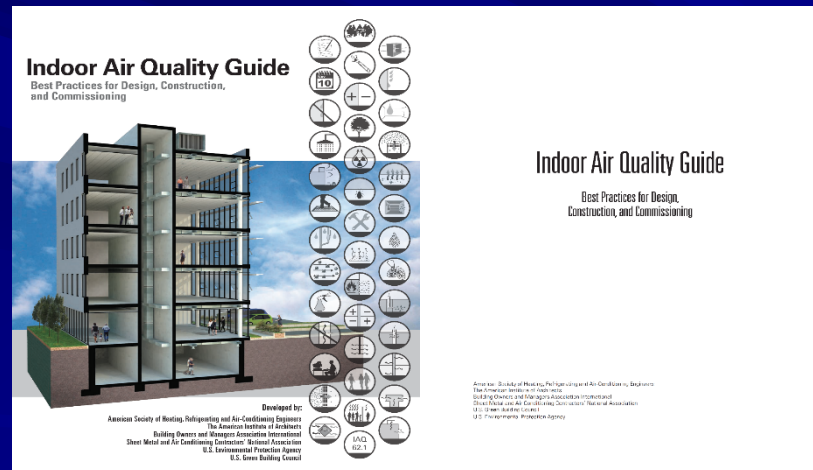


คนในอาคาร (ประชาชน) ต้องมีความรู้พื้นฐาน
เป็นอย่างดีเกี่ยวกับเรื่องของคุณภาพของอากาศ
ภายในอาคารและต้องทราบถึงผลกระทบต่อ
สุขภาพของมลพิษแต่ละตัวเป็นอย่างดี

- มาตรการนี้ควรทำหรือไม่?
- มาตรการนี้จะช่วยทำให้ IAQ
ในอาคารดี ขึ้นหรือไม่?



Strategies อื่นๆมีอยู่อีกมากมาย ดังแสดงอยู่ ใน ASHRAE IAQ's Guide





Indoor Air Quality Tools for Schools: Preventive Maintenance Guidance



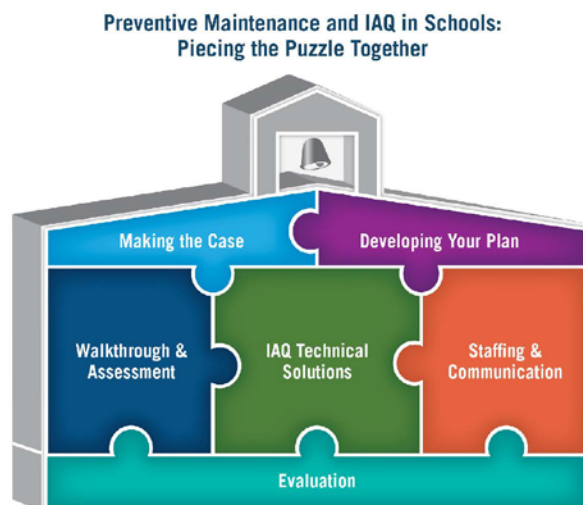
Indoor Air Quality (IAQ)

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Introduction

You can prevent many issues from becoming costly problems through preventive maintenance with thoughtful planning and regular maintenance for your buildings and facilities. This guide will walk you through straightforward steps to develop and implement a sustainable indoor air quality (IAQ) preventive maintenance plan for your school district (see **Graphic 1**). On the following pages, you will find powerful information to help you make the case for your plan and gain the buy-in you need from your school community. You also will find detailed guidance on walkthroughs and assessments of your facilities and how to address common IAQ issues by implementing IAQ Technical Solutions, including integrated pest management (IPM); green cleaning; heating, ventilating and air conditioning (HVAC) and equipment upkeep; mold and moisture prevention; and other pollutant source control activities. Finally, you'll find tips on staffing and communication, as well as evaluating your activities to make your IAQ preventive maintenance plan a success.



Graphic 1. These topics are covered in this guidance to help you develop an IAQ preventive maintenance plan.

Use this voluntary guide¹ to get started or enhance your own IAQ preventive maintenance activities. This guide, along with EPA's IAQ Preventive Maintenance Checklist and templates, can help you build a thorough program for keeping your school buildings healthy, reliable and efficient.² Even though this guide is focused on IAQ preventive maintenance, you can use the tools, tips and strategies found here in a more general preventive maintenance plan or your overall IAQ management program. EPA's *IAQ Tools for Schools* suite of guidance, including the *Indoor Air Quality Tools for Schools Action Kit* and the *Framework for Effective School IAQ Management*, provide additional proven and widely adopted guidance to help you create, adopt and sustain an IAQ preventive maintenance plan.

There are four important steps to take to develop an IAQ preventive maintenance plan (see **Graphic 2**). These steps can be followed in any order that fits your situation. Depending on the steps a school district has already taken to implement IAQ preventive maintenance best practices, the staff could start at any of these steps. For example, a school district might already have a committed team in place, as well as buy-in from the superintendent and staff, and therefore could start at [Develop Your Plan](#).



Graphic 2. Take these important steps to develop an IAQ preventive maintenance plan.

C. Walkthroughs and Assessments

The facility walkthrough and assessment can help you develop your IAQ preventive maintenance plan (i.e., taking inventory of your equipment and preparing checklists and schedules). You should conduct facility walkthroughs and assessments at least once per year to evaluate your plan and to make sure your plan is up to date. Inspecting your facilities during a walkthrough combined with an in-depth analysis of your inventory and equipment conditions will give you a full picture of needed and potential maintenance and repairs to reduce or avoid future problems.²¹ Use what you learn during a walkthrough to tailor your IAQ preventive maintenance program for your school district's specific needs. Learn more in the webinar "From Roof to Curb: Taking a Comprehensive Approach to IAQ Management Through Preventive Maintenance."²²

Several tools are available for your use when assessing your facilities:

- **Appendix A: IAQ Preventive Maintenance Checklist:** Once you have developed your tailored checklist, use it to assess your activities and take notes of items to update or add during a walkthrough of your facilities.
- **School IAQ Assessment Mobile App:** In addition to assessing IAQ preventive maintenance activities, you can use this mobile app to assess the IAQ management actions taken in your school buildings during a walkthrough. The app includes a set of easy-to-follow checklists; all you need is an internet connection. After your IAQ walkthrough, you can use the mobile app to submit your completed checklists by email to your school district's designated IAQ coordinator or the person who oversees IAQ management for review and follow-up action. You can attach photos and detailed notes in your completed checklist submission.

During your walkthrough and assessment, you can gather data on regular performance to identify areas for improvement and establish metrics to help track your program's impact over time. See the **Evaluation** section of this document.

The Framework for Effective IAQ Management in Schools

Many of the strategies suggested in this guide are grounded in the IAQ Framework. The **Key Drivers** of the Framework provide detailed information about proven strategies, organizational approaches and leadership styles that are fundamental to program effectiveness; the **Technical Solutions** define the most common issues that schools need to address to effectively manage IAQ risks.



D. IAQ Technical Solutions

Each school district will have unique IAQ challenges, but you likely will run into common IAQ issues that should be included in your preventive maintenance plan. This section will cover these common IAQ issues related to preventive maintenance (see **Graphic 4**) and key resources to address them.



Graphic 4. These Technical Solutions can be used to address common IAQ issues related to preventive maintenance.

For more in-depth information, see the *IAQ Tools for Schools Action Kit—Technical Solutions to Common IAQ Issues in Schools* and EPA's IAQ Professional Training Webinars for schools.

Creating green, clean and healthy schools requires mastering the school environment using a comprehensive approach to IAQ management. The web-based trainings in the *IAQ Master Class Professional Training Webinar Series* and *IAQ Knowledge-to-Action Professional Training Webinar Series* provide school district staff across the country with the knowledge needed to start, improve or sustain an IAQ management program within their school or school district. Each pre-recorded webinar features technical experts, industry leaders and model school districts, and is followed by a 30-minute mentoring question-and-answer session. Gain recognition for your knowledge achievement and commitment to action through certificates of completion and continuing education units for each training.

Key Technical Solutions for Common IAQ Issues

Learn more about the most common issues that schools need to address to effectively manage IAQ risks in the Framework—*Technical Solutions to Common Indoor Air Quality Issues in Schools*.





HVAC and Equipment

Monitoring your school's HVAC system using preventive maintenance is like an early warning system—doing so will help you find problems before they find you. When your HVAC system is working correctly, your facilities have better air circulation and odor control, as well as a reduced level of pollutants. Additionally, a well-maintained HVAC system can help your school save money from unexpected repairs. Regular inspection and keeping the system clean and exhaust systems clear help prevent problems that could require expensive repairs. For example, a missing filter could, over time, lead to plugged coils, reduce your HVAC system's effectiveness, contribute to poor IAQ, and result in substantial repair or replacement costs to HVAC system components. Routinely checking vents and HVAC ducts could reveal issues before they become problems, such as pests that can damage HVAC components that require expensive repairs.



Mold and Moisture

Conduct routine inspections for moisture. Take actions to address mold and moisture problems immediately to protect IAQ. The best way to control indoor mold growth is to control moisture. Mold can cause a variety of health problems, increase allergic reactions and cause asthma attacks. Mold can grow on any organic surface if enough moisture and oxygen are available. Facility neglect often leads to moisture problems, especially when roofs, plumbing or ventilation systems are not routinely inspected. Mold can discolor surfaces, deteriorate building material, and lead to health problems for students and staff.



Green Cleaning and Materials Selection

Green cleaning products and maintenance practices can increase a school building's life span and cut unexpected costs. They also can be less harmful to student and staff health and IAQ than traditional products and practices. Choose products with few effects on human health and the environment and that might contain recycled content. Also look for products and services that minimize waste, conserve energy or water, or reduce the amount of toxics used or left behind, such as products that meet EPA's Safer Choice Standard. When building a new school, talk about the materials selection with building planners and design architects. Making smart choices about materials upfront can have a big impact on creating healthy indoor environments.

Key Resources: HVAC

Technical Solutions to Common Indoor Air Quality Issues in Schools—Provide Quality HVAC

Ventilation Checklist from *IAQ Tools for Schools* Action Kit

Webinar: Better Together: Gaining Buy-In for Optimal Ventilation

Webinar: Clean Air in the Classroom: Improve Air Quality, Extend HVAC System Life With Preventive Maintenance

Key Resources: Mold and Moisture

Technical Solutions to Common Indoor Air Quality Issues in Schools—Mold and Moisture Control

Walkthrough Inspection Checklist from *IAQ Tools for Schools* Action Kit

Webinar: Mold, Moisture and Money: How to Secure Funding to Address and Prevent IAQ Issues

Key Resources: Green Cleaning and Materials Selection

Technical Solutions to Common Indoor Air Quality Issues in Schools—Effectively Clean and Maintain

Technical Solutions to Common Indoor Air Quality Issues in Schools—Make Smart Materials Selections

5 Steps to Green Cleaning in Schools

Webinar: Green, Clean and Healthy: Effective Cleaning and Preventive Maintenance for a Healthier School Environment

EPA's Safer Choice Product Information



Integrated Pest Management (IPM)

Pests can be a major, hard-to-manage problem in schools. Not only can they damage school facilities, but they also can cause IAQ and health problems for students and staff. Deferring maintenance of your building can cause it to start deteriorating, which gives pests easy entry points, such as wall cracks, and ideal living situations, such as leaky areas or poorly cleaned spaces. IPM is environmentally friendly and favors common-sense actions to prevent pests, using pesticides only as needed. IPM strategies remove things that pests need to survive—food, water and shelter—and block possible entry points to the building. Through routine inspections and keeping facilities and equipment in good working condition, IPM can keep pests at bay and prevent possible reentry.



Source Control

Eliminating or reducing individual pollution sources, such as chemicals, radon, pesticides, emissions, etc., can improve IAQ and student and staff health. Source control is critical for reducing pollutant exposures and expensive accidents. You can minimize the use of hazardous chemicals at schools by using pollution prevention principles and looking for safer alternatives. Consider the possible health, safety and environmental consequences before buying a particular chemical. Create a purchasing policy that promotes environmentally preferable products, and conduct periodic inventories of the chemical products in your school to identify hazards. Use and treat chemicals properly, including storage, labeling and disposal, and include that guidance in your IAQ preventive maintenance program. Place walk-off mats at entrances to prevent dirt and pollutants from being tracked into the school. Consider implementing tobacco-free and anti-idling school bus policies. Additionally, you can test for certain pollutants (e.g., radon) and mitigate if necessary.



Energy Efficiency

There is a close connection between IAQ, energy efficiency and preventive maintenance, and how they impact the school environment. (For more information, see *The Value of IAQ Preventive Maintenance Saving Costs With Healthy, Reliable and Efficient Buildings* section.) Poor energy management can create IAQ problems and lead to poor ventilation in occupied spaces. Preventive maintenance plans can include proactive actions to improve energy efficiency while ensuring that IAQ is protected. School districts also can include IAQ protections in their energy efficiency retrofits and other building upgrade projects to make the best possible improvements without risking student and staff health. The *Energy Savings Plus Health: Indoor Air Quality Guidelines for School Building Upgrades* guide provides in-depth information and guidance for incorporating IAQ into energy efficiency projects, and you can use the *Interactive Air Quality Planner* to create a checklist tailored to your school district's needs.

Key Resources: Integrated Pest Management

Technical Solutions to Common Indoor Air Quality Issues in Schools—Integrated Pest Management

Integrated Pest Management Checklist from *IAQ Tools for Schools* Action Kit

Introduction to Integrated Pest Management

Webinar: Smart, Sensible and Sustainable Pest Management in Your School

Key Resources: Source Control

Technical Solutions to Common Indoor Air Quality Issues in Schools—Source Control and Chemical Management

Walkthrough Inspection Checklist from *IAQ Tools for Schools* Action Kit

Webinar: Pollution Solution: How to Create IAQ Policies, Plans and Practices to Control Pollutant Sources in Your School District

Key Resources: Energy Efficiency

Protecting IAQ During School Energy Efficiency Retrofit Projects With Energy Savings Plus Health Guidelines

Webinar: Getting Started With Energy Savings Plus Health: How to Integrate Energy Efficiency With Health and Safety Outcomes in Your School

Webinar: Making the Connection: Linking IAQ, Energy Efficiency and Preventive Maintenance Together for Healthy Schools

การจัดการคุณภาพอากาศภายในอาคารของ สหรัฐอเมริกา

EPA does not regulate indoor air, but we do
offer assistance in protecting your indoor air
quality.

การจัดการคุณภาพอากาศภายในอาคารของฮ่องกง

Guidance Notes for the Management of Indoor Air Quality in Offices and Public Places

The Government of the
Hong Kong Special Administrative Region
Indoor Air Quality Management Group

January 2019

FOREWORD

In modern city life, the quality of air in the indoor environment has a significant impact on human health and comfort. People spend most of their time at homes, offices and other indoor environment. Poor indoor air quality (IAQ) can lead to discomfort, ill health, and, in the workplace, lead to absenteeism and lower productivity. Good indoor air quality safeguards the health of the building occupants and contributes to their comfort and well-being.

Indoor air pollution has received little attention in the past compared with air pollution in the outdoor environment. It has now become a matter of increasing public concern, prompted partly by the emergence of new indoor air pollutants, by the isolation of the indoor environment from the natural outdoor environment in well-sealed buildings, and by the investigation of so-called Sick Building Syndrome. The World Health Organization (WHO) also recognises that biological and chemical indoor air pollution as public health risks.

The health effects of individual indoor air pollutants are studied extensively. For example, the health impact of formaldehyde is well documented. Two guidelines were published by WHO in 2009 and 2010 respectively on mould and dampness, and selected indoor air pollutants. On the other hand, the health effects of a combination of indoor air pollutants are much less well understood and more difficult to tackle. This is due to the shortage of reliable data on the effects on human health; difficulties in accurately measuring air pollutants at low levels; potential interactions between pollutants; and wide variations in the degree to which building occupants are susceptible to air pollutants. There are also many external factors which may obscure the relationship between IAQ and its impact on the building occupants.

IAQ is not only technically complex, it is also complex from an administrative point of view. The many factors to be taken into consideration and strategies required to maintain good IAQ cut across a variety of disciplines—public health, occupational hygiene, employment practice, engineering standards, and government departmental responsibilities. In Hong Kong, ventilation systems and some other factors affecting IAQ are already subject to legislation. IAQ is also touched on in certain regulations and ordinances, most noticeably the Smoking (Public Health) Ordinance (Cap. 371) that prohibits smoking in all indoor workplaces and public places. **But Hong Kong does not have, or plan to introduce, legislation specifically addressing the issues of IAQ because it is considered that self-regulation can be effective and, given the complexities and uncertainties which still surround IAQ, is preferable to comprehensive regulation. Most of the countries/regions concerned with IAQ, such as the United States, Singapore, Canada and those European countries, have adopted the same approach.** The self-regulatory approach is consistent with Hong Kong's principle of small government.

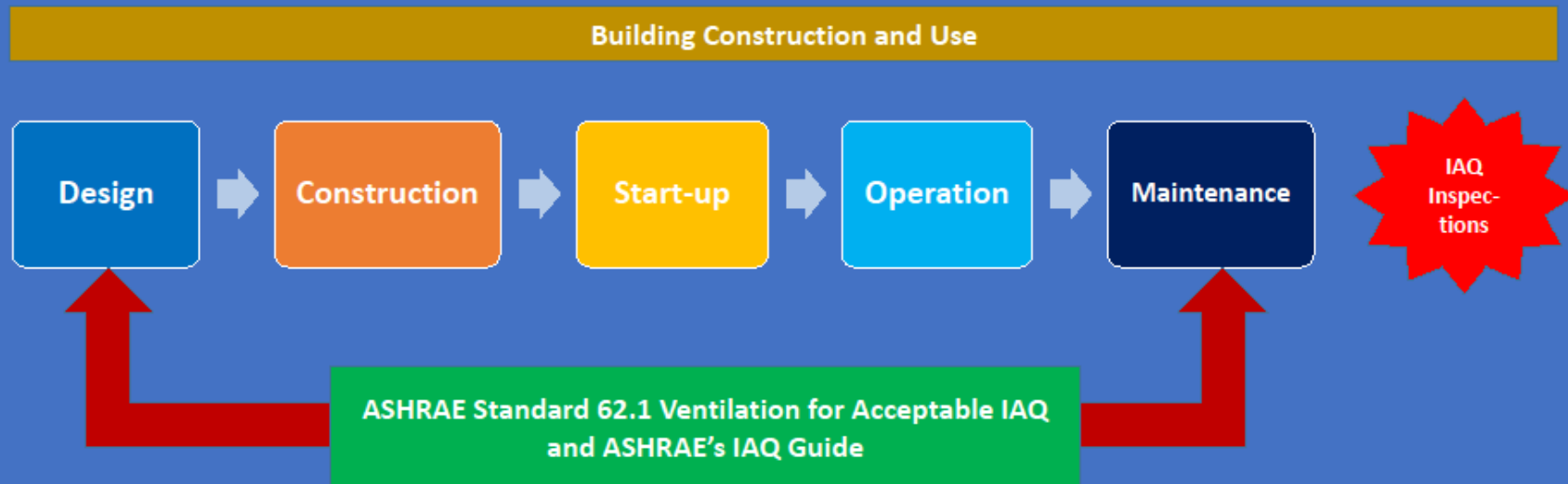
To coordinate the development on the control of IAQ in Hong Kong, the Government has set up an inter-department IAQ Management Group. Its membership comprises representatives from five government bureaux and fourteen departments:

- Civil Service Bureau
- Education Bureau
- Environment Bureau
- Food and Health Bureau
- Transport and Housing Bureau
- Architectural Services Department
- Buildings Department

ASHRAE IAQ

Process Control for Good IAQ

- We use Standard 62.1/IAQ Guide as Quality Assurances (QA)
- We use IAQ inspections/monitoring only as necessary



การจัดการคุณภาพอากาศภายในอาคาร

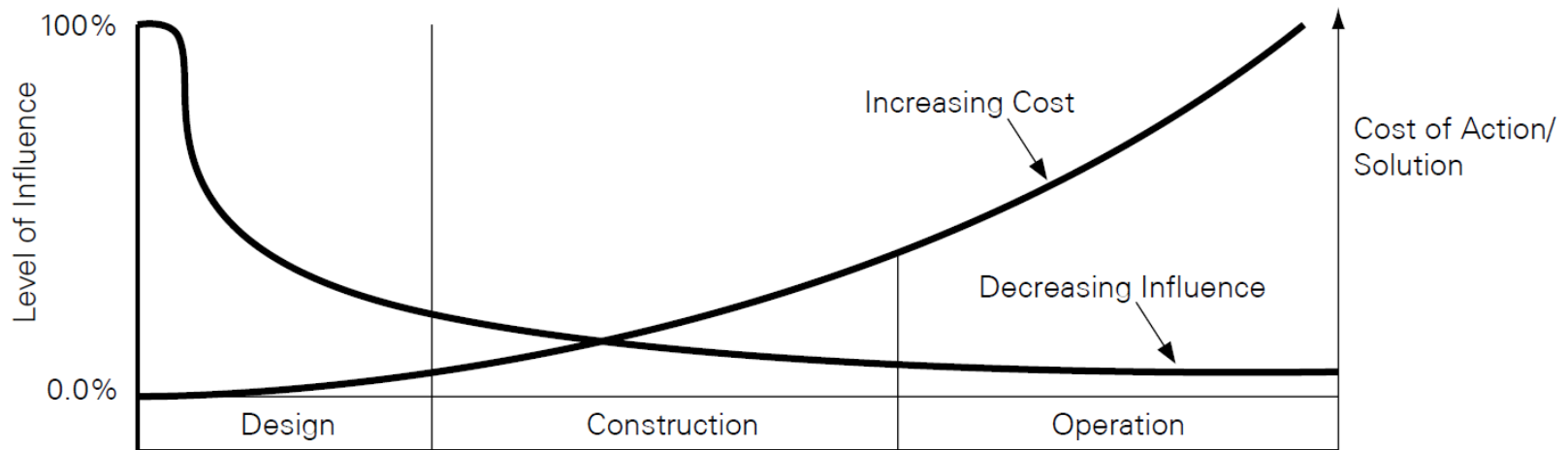


Figure 1.2-C Decreasing Ability to Influence Outcomes and Increasing Cost of Action as Project Proceeds
Adapted from a figure copyright CH2M HILL.

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Thank You for Your Attention!



Any Question?