TRANE™

1993/Vol. 22, No. 2

ASHRAE 62-89 Analysis
Part III: Indoor Air Quality Procedure

ASHRAE Standard 62-89, Ventilation Standard for Acceptable Indoor Air Quality, is widely viewed as the minimum ventilation standard to be met, regardless of local codes. This is the third of three ***Engineers Newsletters*** *that attempt to interpret the standard and offer suggestions for complying with it.*

The purpose of ASHRAE Standard 62-89 is to specify **minimum ventilation rates** and define acceptable **indoor air quality** to avoid adverse health effects. To accomplish this, the standard presents a series of general requirements for systems and equipment (Section 5.0), then offers two alternative procedures for providing acceptable indoor air quality (Section 6.0). The following analysis is presented to help designers and installers interpret the standard's diverse requirements, and is based on our best judgment of the meaning and purpose of the various provisions. **Ultimate responsibility for interpretation compliance, however, rests with the individual designer and installer.**

Section 5.0, Systems and Equipment, and Section 6.1, Ventilation Rate Procedure, were the subjects of previous **Engineers Newsletters**. Section 6.2, Indoor Air Quality Procedure, and Section 6.3, Design Documentation Procedures, are discussed in this issue.

General Terms

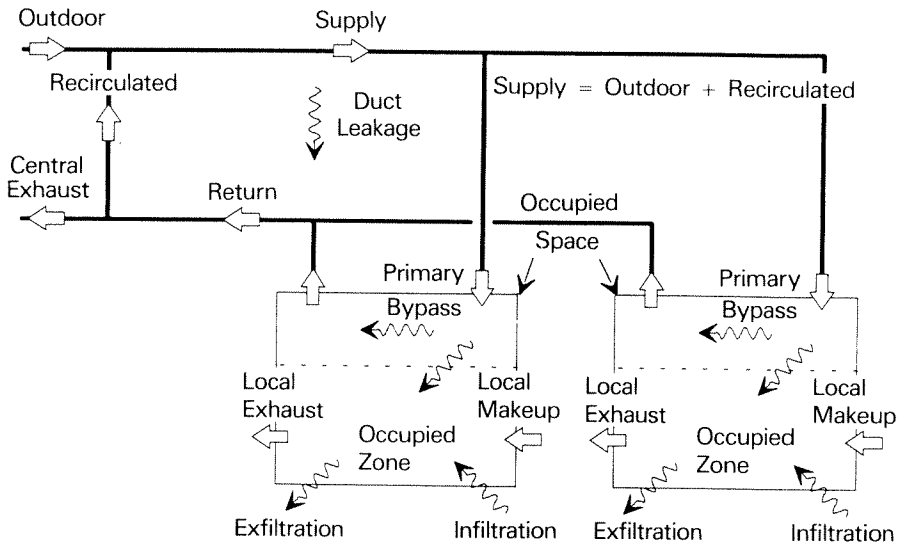
Requirements (denoted by **shall** and **must**) and **suggestions** (signaled by use of the words **should** and **may**) are presented throughout the standard. Conformance with the standard can only be claimed if all requirements are met. On the surface, it seems that suggestions need not be met for compliance. However, ignoring suggestions may not be **prudent**. After all, these suggestions reflect the consensus of experts in the HVAC industry and might, therefore, be viewed as the minimum criteria a prudent designer would follow when designing a ventilation system.

ASHRAE 62-89 makes several references to occupied space and occupied zone. Within this discussion, the occupied space refers to all inhabited areas . . . usually rooms . . . within the building. The occupied zone, on the other hand, refers to a defined region within the occupied space, ". . . between planes 3 and 72 inches above the floor and more than 2 feet from the walls."

The terms outdoor air and ventilation air are often used interchangeably. However, as used here, **outdoor air** is air from outside the building, while **ventilation air** is the portion of supply air used to maintain acceptable indoor air quality. Ventilation air may be either entirely outdoor air or a mixture of outdoor air and cleaned, recirculated air.

Engineers Newsletter

Figure 1: Typical Airflows for a Two-Space System



Primary air is the supply air delivered to each occupied space. For want of a better term, **actual air** is the amount of primary air that actually reaches the occupied zone within the occupied space. **Bypass air** is the portion of primary air that never reaches the occupied zone. Figure 1 illustrates several of these definitions.

Analysis of Section 6.2: Indoor Air Quality Procedure

To review, the Ventilation Rate Procedure (Section 6.1) presents "...one way to achieve acceptable indoor air quality"; namely, supplying each occupied space with ventilation air of specific quality and quantity. Outdoor air is used to dilute anticipated contaminants to acceptable concentration levels.

In contrast, the Indoor Air Quality Procedure (6.2) presents "...an alternative performance method...for achieving acceptable air quality" by quantitatively describing acceptable indoor air quality. It sets limits on the concentration of known and specifiable contaminants in an effort to achieve acceptable indoor air quality in the occupied zone in a more direct way than the Ventilation Rate Procedure.

More specifically, the Indoor Air Quality Procedure sets concentration limits for 10 contaminants, prescribes subjective analysis to determine acceptable odor levels, and describes the use of treated recirculated air to reduce the minimum outdoor airflow rates presented in the standard.

Key points presented in Section 6.2 are arranged by topic and discussed below in a question-and-answer format.

Determining Indoor Air Quality

•

What contaminants are specified by the standard, and what are the acceptable concentration levels of each? See Figure 2.

"Table 1 furnishes information on acceptable contaminant levels in outdoor air [and]]...also applies indoors for the same exposure times" (Section 6.2.1).

"Table 3 contains limits for four other indoor contaminants" (Section 6.2.1).

Tables 1 and 3 of the standard list 11 acceptable indoor concentration levels for 10 contaminants, presented here in Figure 2. By reference to the limits in these tables, the indoor concentration of the listed contaminants is **required** to be below the level listed.

•

If concentration levels in Tables 1 and 3 (defined primarily in Table C-1 and C-3) are maintained, is the indoor air quality acceptable? No, not necessarily.

"Tables C-1 and C-3 do not include all known contaminants that may be of concern, and these concentration limits may not, ipso facto, ensure acceptable indoor air quality with respect to other contaminants" (Section 6.2.1).

To a certain extent, this **observation** unravels the Indoor Air Quality Procedure as the performance-based path to acceptable indoor air quality. It implies that, even if the **known and specifiable** contaminants listed are controlled to the established concentration levels, indoor air quality still may not be satisfactory. In other words, if the building system is designed so that listed concentration levels are not exceeded, acceptable indoor air quality is not assured. The building designer has no clear, indisputable definition of **acceptable indoor air quality**. Acceptable IAQ is determined by the contaminant levels listed, as well as by unknown levels of unknown contaminants. Consequently, many designers choose to use the Ventilation Rate Procedure in which the requirements are clearer and compliance to those requirements is more easily demonstrated.

Figure 2: Summary of Tables 1 and 3

Indoor Air Quality Standards							
	Acceptable Exposure						
	Long-Term			Short-Term			
Contaminant	Concentration		Time	Concentration		Time	ASHRAE Table
	ug/m³	*ppm*	*years*	*ug/m³*	*ppm*	*hours*	
Carbon Dioxide	$1.8*10^6$	1,000	Cont.				3
Carbon Monoxide (USA)				40,000	35.0	1	1
Carbon Monoxide (USA)				10,000	9.00	8	1
Chlordane (maximum)	5.0	0.0003	Cont.				3
Lead	1.5		0.25				1
Nitrogen Dioxide	100.0	0.055	1.00				1
Oxidants (ozone, USA)				235	0.12	1	1
Ozone	100.0	0.05	Cont.				3
Particulate (total, USA)	50.0		1.00	150		24	1
Radon	4 p Ci/l		1.00				3
Sulfur Dioxide (USA)	80.0	0.030	1.00	365	0.14	24	1

•

If the carbon dioxide concentration is maintained below 1000 ppm, has acceptable indoor air quality been achieved? No. To avoid unacceptable odors, a carbon dioxide concentration below 1000 ppm is **recommended.**

"Carbon dioxide has been widely used as an indicator of indoor air quality. A limit of 1000 ppm CO_2 is recommended to satisfy comfort (odor) criteria" (Section 6.2.1).

While it observes that CO_2 measurements have been used to indicate acceptable air quality, the standard does not require or suggest that CO_2 concentration be used to control ventilation rate. However, it does recommend (or observe) that CO_2 concentrations below 1000 ppm are likely to be accompanied by acceptable odor levels.

•

Can acceptable indoor air quality be maintained by adjusting the outdoor airflow rate to control the CO_2 concentration level? No. If dilution is not used to control CO_2 level, consideration of the concentration level of other contaminants is **required.**

"In the event CO_2 is controlled by any method other than dilution, the effects of the possible elevation of other contaminants must be considered" (Section 6.2.1).

To implement the Indoor Air Quality Procedure, some building designers specify measurement and control of CO_2 concentration in the space. They use gaseous filtering techniques to remove CO_2 and measured CO_2 concentrations to modulate the outdoor airflow rate. If the outdoor airflow rate is less than the minimum rate specified in Table 2, however, indoor air contaminants are no longer diluted as required by the Ventilation Rate Procedure. Therefore, the building designer must consider that other contaminant levels may be at high levels and, presumably, must provide a means to control the concentration of these contaminants as well.

•

Can acceptable indoor air quality be determined solely by sensing contaminant levels? No. The quality of indoor air cannot always be determined by measuring contaminant levels; therefore, subjective evaluation of indoor air quality is **required.**

"To some degree, adequacy of control [of complex contaminant mixtures] must rest upon subjective evaluation" (Section 6.2.1).

From the designer's viewpoint, this requirement weakens the Indoor Air Quality Procedure considerably. For complex contaminant mixtures (usually characterized by odors), the contaminant-related quality of indoor air cannot be measured. It must be determined subjectively, based on the judgment of impartial observers. The building designer is required to design a system that adequately controls contaminants to a level that will be judged acceptable in subjective evaluation by impartial observers. So, a positive subjective evaluation is a system design requirement. But it can only occur after system installation and building occupancy. It is unclear how a building can be occupied before the system design is completed.

•

If contaminant levels are low enough and a subjective evaluation judges the air quality to be acceptable, is the building design in compliance with the IAQ Procedure? No, not necessarily.

"In the case of some odorless biological aerosols, subjective evaluation is irrelevant. Application of generally acceptable technology, and vigilance regarding adverse influences of reduced ventilation, must therefore suffice" (Section 6.2.1).

This **requirement** further weakens the Indoor Air Quality Procedure because it provides little concrete direction but adds substantially to the designer's burden of judgment with its attendant responsibility. Some contaminants can neither be measured quantitatively nor evaluated subjectively. The building designer is required to use **acceptable technology** and **vigilance** when the contaminants cannot be measured or perceived. What is **generally acceptable technology** at any given time? And, in what context must the designer be vigilant . . . on the alert . . . for the adverse effects of reduced ventilation: In general terms or on a job-by-job basis?

In summary, the Indoor Air Quality Procedure explains that acceptable indoor air quality is determined by three criteria:

1
Acceptable concentrations of all **known and specifiable contaminants.**
2
Acceptable subjective evaluation for all other contaminants which are not **known and specifiable,** but which can be detected by impartial observers.
3
Reasonable application of technology and caution regarding the adverse impact of reduced ventilation.

Again, as a result of this loose definition of acceptable indoor air quality, many building designers choose the more clearly defined Ventilation Rate Procedure.

Subjective IAQ Evaluation

•
Is a subjective IAQ evaluation required for compliance via the IAQ Procedure? Yes. If odor-causing contaminants cannot be measured objectively, a subjective evaluation is **required.**

"In the absence of objective means to assess the acceptability of such [odor-causing] contaminants, the judgment of acceptability must necessarily derive from subjective evaluation of impartial observers" (Section 6.2.2).

Many odor-causing contaminants cannot be measured in terms of concentration levels or do not have an established harmful concentration level. Therefore, a designer using the IAQ Procedure cannot comply with the standard without a successful subjective evaluation of the completed system.

•
Is a specific subjective IAQ evaluation method required? No. A method described in Appendix C is **suggested,** but not required.

"One method that may be used for measuring subjective response is described in Appendix C" (Section 6.2.2).

The suggested method states that the air quality is acceptable ". . . if 80 percent of a panel of at least 20 untrained observers deems the air to be not objectionable under representative conditions of use and occupancy." The observations are intended to detect offensive odors only.

•
If the system passes the subjective evaluation, is the air quality acceptable? No.

"Caution should be used in any subjective evaluation procedure to avoid unacceptable concentrations of other contaminants" (Section 6.2.2).

This **suggestion** warns the building designer that an acceptable odor level alone does not indicate satisfactory indoor air quality. Unacceptable concentrations of odorless contaminants (such as carbon monoxide and radon) can be present in a space, undetected by a subjective evaluation for odors.

Air Cleaning

Can cleaned, recirculated air be used to reduce the minimum outdoor air rates in Table 2? Yes, but the IAQ Procedure must be used to avoid contaminant accumulation in under-diluted spaces.

"Recirculation with air-cleaning systems is also an effective means for controlling contaminants when using the Indoor Air Quality Procedure. . . if cleaned, recirculated air is used to reduce the outdoor airflow rate below the values shown in Table 2, the Air Quality Procedure, 6.2, must be used" (Section 6.2.3 and Section 6.1.3.2).

To clean air returning from the occupied space, recirculate it as ventilating air and, thereby, reduce the minimum outdoor airflow rate listed in Table 2; the designer is **required** to use the Indoor Air Quality Procedure. . . not the Ventilation Rate Procedure. Some contaminants, particularly gaseous ones, may not be adequately cleaned from the recirculated air stream. These contaminants can accumulate in the occupied space, eventually reaching unacceptable concentration levels. Therefore, the acceptable indoor air quality must be determined using the IAQ Procedure. To avoid this necessity, many building designers do not specify use of recirculated air-cleaning solely to reduce the minimum outdoor airflow rate.

•
Is there a method for computing the reduced minimum outdoor airflow rate when recirculated air is used? Yes. The standard **suggests** the use of equations presented in Appendix E to calculate reduced outdoor airflow rates.

"The allowable contaminant concentration in the occupied zone can be used with the various system models in Appendix E to compute the required outdoor airflow rate" (Section 6.2.3).

When applying the IAQ Procedure, the standard allows the building designer to use equations from Appendix E to calculate required outdoor airflow rates. A detailed analysis of Appendix E is another full discussion in itself. It is important to note, however, that use of these equations is not a simple matter. Several key variables are very difficult to determine. For example, the contamination rate (pollution generation rate) for chemicals and furnishings within the space are not readily available, ventilation effectiveness is difficult to determine without testing and filter efficiency for gaseous contaminants may not be known. Also, the calculations must be repeated for each individual contaminant of concern.

•

Can recirculated air always be cleaned sufficiently to be used to reduce the outdoor airflow requirement? No. If any contaminant concentrations cannot be maintained to acceptable levels using air cleaning and reduced outdoor airflow, the designer is **required** to use the Table 2 rates.

". . . contaminants that are not appreciably reduced by the air-cleaning system may be the controlling factor in design and prohibit the reduction of air below that set by the Ventilation Rate Procedure" (Section 6.2.3).

The building designer must be aware of the cleansing capability of the air cleaning system. If the level of all contaminants in the occupied space cannot be reduced to acceptable levels by air cleaning, the designer must abandon the Indoor Air Quality Procedure and use the Ventilation Rate Procedure instead.

Analysis of Section 6.3: Design Documentation

Is the designer required to document ventilation-related calculations? Yes. Clear documentation of the design assumptions is **required.**

"Design documentation shall clearly state which assumptions were used in the design so that the limits of the system in removing contaminants can be evaluated by others before the system is operated in a different mode or before new sources are introduced into the space" (Section 6.0).

"Design documentation shall specify all significant assumptions about occupants and contaminants" (Section 6.1.3.1).

The building designer must document building design assumptions, calculations, selections and so on. This is design documentation which is in addition to the traditional building plans, equipment schedules and specifications. Good design documentation is required to enable future changes to building operation and usage without unexpected . . . and undesirable . . . indoor air quality consequences.

Throughout the standard, the building designer is required to document design assumptions, calculations and so on, so that the ventilation system can be operated and maintained properly. Also, with proper design documentation, the impact of future changes to the system or its use, (e.g., number of occupants in the space, indoor/outdoor contaminant sources, or space area) can be properly evaluated, resulting in a more accurate determination of system redesign needs.

•

Does the designer simply record the design, then file the documents away? No. The standard **suggests** that design documentation be delivered, presumably to the building owner or operator, after system installation.

"Design criteria and assumptions shall be documented and should be made available for operation of the system within a reasonable time after installation" (Section 6.3).

The building designer must include design documentation as part of the information delivered to the building owner. Normally, transfer of the plans and specifications for the building systems is sufficient, since design assumptions and calculations result in the information summarized in those documents. However, to comply with Section 6.3, additional design-related documentation such as notebooks, spreadsheets and memos must also be delivered. Furthermore, this design documentation must be delivered within a **reasonable** period of time after the system is installed; presumably before it is operated.

•

Specifically, what information must be documented? Documentation **requirements** and **suggestions** are sprinkled throughout the standard.

"See Sections 4 and 6, as well as 5.2 and 6.1.3 regarding assumptions that should be detailed in the documentation" (Section 6.3).

The building designer is required or advised to document the following:

"Whenever the Ventilation Rate Procedure is used, the design documentation should clearly state that this method was used and that the design will need to be reevaluated if, at a later time, space use changes occur or if unusual contaminants or unusually strong sources of specific contaminants are to be introduced into the space" (Section 4.2).

"The design documentation shall state assumptions that were made in the design with respect to ventilation rates and air distribution" (Section 5.2).

"Design documentation shall clearly state which assumptions were used in the design so that the limits of the system in removing contaminants can be evaluated by others before the system is operated in a different mode or before new sources are introduced into the space" (Section 6.0).

"Design documentation shall specify all significant assumptions about occupants and contaminants" (Section 6.1.3).

Summary

Section 6.2 of ASHRAE 62-89 attempts to help the building designer by imparting a method for direct control of indoor air quality. Unfortunately, it presents only a short list of acceptable contaminant levels; includes a requirement for a post-design, subjective evaluation for odors; and seems to require ongoing building system **vigilance** on the part of the designer. . . after the building is designed and operating.

In light of these shortcomings, it is our view that the IAQ Procedure fails to provide a well-defined, enforceable path to compliance with the standard. Until it is revised, this procedure is not likely to be widely used by building designers.

This concludes our three-part analysis of ASHRAE 62- 89. An overall summary of key requirements and suggestions is included in Figure 3.

Figure 3: Summary of Standard 62-89

General Requirements	Procedure Requirements	Additional Suggestions
Design for good room air distribution.	**Ventilation Rate Procedure**	Monitor outdoor airflow.
Document design assumptions and calculations.	Evaluate the outdoor air quality and treat as necessary.	Avoid intake of contaminated outdoor air.
Locate outdoor air intakes properly.	Provide the minimum outdoor airflow rates of Table 2.	Dehumidify (to less than 60% RH).
Design for easy air system cleaning.	For multiple-space systems, use Equation 6-1 to find minimum outdoor airflow.	Humidify with steam, if necessary (to more than 40% RH).
Provide local exhaust for stationary sources.	**IAQ Procedure**	Clean the supply air stream.
Provide makeup air for indoor combustion.	Control concentration level of 10 contaminants.	Use antimicrobial coatings where appropriate to prevent microbial growth.
Select filters properly.	For odors, conduct subjective evaluation after building is completed and occupied.	Use the Ventilation Rate Procedure for new construction.
Specify sloped drain pans with access for cleaning.	If recirculated air cannot be cleaned sufficiently, use Ventilation Rate Procedure.	Use time-of-day scheduling to minimize ventilation needs.
Follow either the Ventilation Rate Procedure or the IAQ Procedure.		Consider use of the IAQ Procedure for existing buildings.