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Field Research Results and ASHRAE Standards - Do They Conflict?

Researchers at the University of California, Berkeley, found that at "optimal" thermal comfort conditions (around 72.5°F or 22.5°C), 12% of office occupants surveyed were nonetheless uncomfortable with their thermal environment. This compares with only 5% predicted by equations from models based on laboratory studies.

The researchers also found that far more of the study building occupants were uncomfortable at temperatures near the upper end of the comfort range than predicted by the models. At temperatures of 78°F (25.5°C), more than 35% of the study occupants were uncomfortable. The models predicted that only 20% would be uncomfortable at 80°F (26.7°C) whereas nearly 50% of the study subjects were uncomfortable when the temperatures got that high.

At the lower end of the temperatures studied, the building occupants were less uncomfortable than predicted by one of the models and more than predicted by another. Overall, the study subject responses indicate that an optimal temperature is about 72.5°F (22.5°C) rather than the 76°F (24.5°C) predicted by the models. Both the ASHRAE thermal comfort standard, Standard 55-1981, and ISO thermal comfort standards are based on these same models that are derived from laboratory studies. They provide guidelines based on satisfaction of no less than 80% of building occupants.

These standards are the basis for modern building design in most of Europe and North America. Therefore, the study's findings raise important questions for architects, engineers, and building operators:

What is an optimal thermal environment?

What is an acceptable level of dissatisfied occupants?

If the standards are unreliable, what guidelines should designers follow?

Thermal Comfort

Virtually everyone concerned with building environmental conditions is familiar with ASHRAE's thermal comfort envelope, which is the portion of the psychrometric chart where people should be comfortable. The basis for the chart is a wealth of very careful laboratory studies done in the United States and in Europe. Figure 1 shows our version of ASHRAE's thermal comfort envelope.

Thermal comfort preferences vary significantly from one person to another. Age, gender, and other physiological differences all affect individual preferences. Even at near-optimal effective temperatures (ET*, as defined by either laboratory or field studies), some occupants will be too cold while others are too warm. These differences are hard for building designers and operators to control or predict. Individuals themselves control the more important factors of activity and clothing; laboratory studies cannot anticipate these variables.

Thermal sensations are produced by heat transfer to the environment and the resulting body temperatures and physiological adjustments. Environmental and personal factors govern the heat transfer. The environmental factors are air temperature, thermal radiation, air movement,

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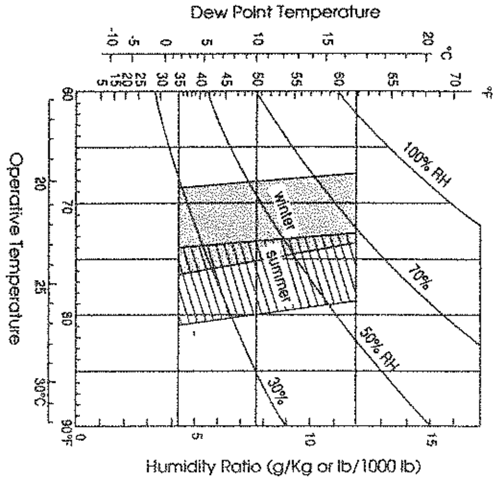

Figure 1 - ASHRAE Thermal Comfort Envelopes for Summer and Winter.
Redrawn by ***IAB*** and based on Standard 55-1981.

and humidity. The personal factors are individual physiology, activity, and clothing. David Wyon of Sweden, who has conducted many studies of thermal comfort, says that when are bodies are not in thermal neutrality, we get sick. (See ***IAB***, Vol. 1, No. 7 and Vol. 2, No. 1)

Thermal comfort is a subjective evaluation based on thermal sensations. Attitudes based on prior experience and current expectations affect how an individual registers and evaluates these sensations. Figure 2 shows a "two-way linked-chain" sequence for how the environment affects the thermal comfort experience. Note that this is a two-way cause-and-effect interaction; a feedback loop affects the factors on each side. Some of these interactions are conscious and others are autonomic responses that include the nervous, respiratory-circulatory, endocrine, and musculo-skeletal systems. Others require active intervention such as changing thermostat settings, window openings, clothing, or activity levels. While the importance of the variables in Figure 2 is widely recognized, the recent field research suggests that we may not adequately understand them.

UC Berkeley Field Study

The field study involved ten buildings with 2,342 visits to 304 workers in the San Francisco Bay Area. The work is reported in several articles referenced at the end of this one. Each office worker completed a 53 data-field thermal assessment survey addressing thermal sensation, thermal preference, comfort, mood, clothing, and activity. The survey used a six-point general comfort scale with 1, 2, and 3 equal to very, moderately, and slightly uncomfortable, and 4, 5, and 6 equal to slightly, moderately, and very comfortable respectively.

After filling in the survey, workers stepped away from their desks and mobile instrumentation was used directly at the workstations to characterize the thermal environment. Measurements included air temperature, dewpoint temperature, globe temperature, air velocity, radiant temperature asymmetry, and illuminance.

Researchers based thermal sensation predictions on two models, one by Fanger and one by Gagge (see references for more details). Fanger developed the commonly used index of Predicted Mean Vote (PMV) and Predicted Percent Dissatisfied (PPD). PMV predicts the thermal comfort responses of a large group of people exposed to the same thermal conditions. The voter used the seven-point ASHRAE Thermal Sensation Scale shown in Figure 3.

PPD is the predicted percentage of people who will express dissatisfaction with a given thermal environment. Dissatisfaction is assumed if the votes are either warm or hot (vote = 2 or 3) or cool or cold (vote = -2 or -3). Figure 4 shows the PPD distribution of a theoretical group of PMV votes.

Gagge developed a modified version of PMV called PMVg by Brager. It differs only in its treatment of dry heat transfer from the skin that is calculated from Gagge's

Environment
→ **Individual**
→ **Sensation**
→ **Perception**
→ **Attitude/Expectation**
→ **Evaluation: Satisfaction/Acceptability**

Figure 2 - Two-way Linked-chain Sequence of Environment/Human Thermal Comfort Interactions.

+3 . . . . . Hot
+2 . . . . . Warm
+1 . . . . . Slightly warm
0 . . . . . Neutral
-1 . . . . . Slightly cool
-2 . . . . . Cool
-3 . . . . . Cold

Figure 3 - ASHRAE Thermal Sensation Scale.
Developed by Fanger and used in many studies including the University of California field study.

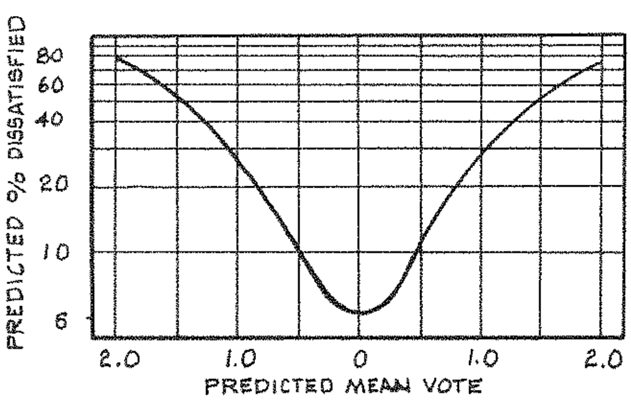

Figure 4 - Predicted Percentage of Dissatisfied (PPD) as a Function of Predicted Mean Vote (PMV).
Redrawn from *ASHRAE Handbook: Fundamentals* (1989).

own "two-node" model rather than from Fanger's empirically derived equation based on thermal neutral sensation at a given activity level. Figure 5 shows Brager's graph re-drawn by ***IAB***. The graph originally appeared in the April 1992 *ASHRAE Journal*.

Findings

Thermal comfort conditions are expressed as Effective Temperature (ET*) and are determined by a complicated mathematical expression that includes air temperature, surface radiant temperature, air movement, and relative humidity. Neutral temperature is the theoretical optimum where the least number of people is likely to experience thermal discomfort. It's determined by either measurement or mathematical models. Table 1 shows the study's results compared to the predicted values based on the Fanger and Gagge models.

Figure 5 shows a plot of the field study results and two of the more important equations based on the laboratory research. According to Brager, the Fanger and Gagge models both overestimate the optimal temperature by about 2°F (5°C) compared with the University of California field measurements. At the optimal temperature, they underestimate the percentage of occupants who will be uncomfortable by more than a factor of two. Brager and her colleagues' measurements indicate that 12% of the individuals would be dissatisfied at the optimal temperature of 74.3°F (23.5°C). This compares to the Fanger and Gagge models' 5% predicted dissatisfied.

The models underestimate the amount of dissatisfaction at warmer temperatures. The Fanger model severely underestimates the number of people who would be dissatisfied with temperatures above 76°F (24°C). Of particular interest is the very high level of dissatisfaction, around 50%, at the extremes of the ASHRAE comfort envelope. This raises troubling questions if it represents office workers generally. Can it be that workers in the San Francisco Bay Area are different from most other workers? Some people would quickly say yes - facetiously, we hope. However, the study subjects were typical and their office environments similar to those of their counterparts elsewhere.

Why the Discrepancies?

Why don't the Berkeley results agree with the predictions made by the models based on laboratory studies?

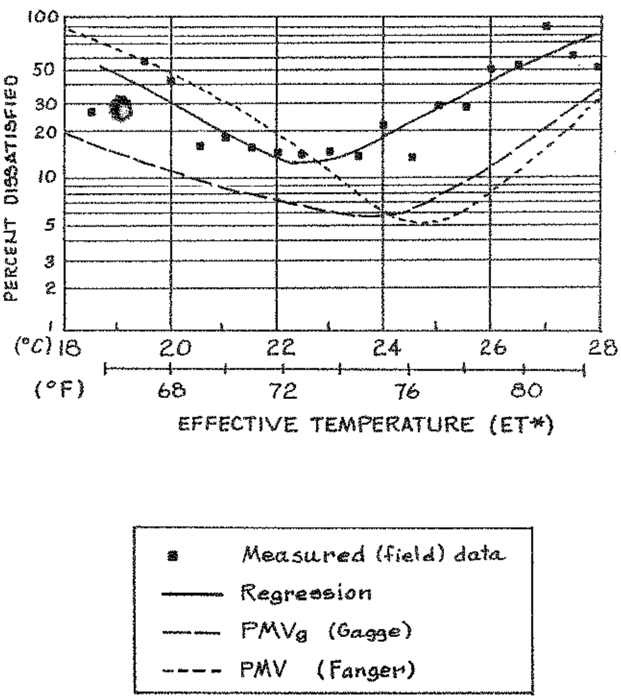

Figure 5 - Percent Dissatisfied versus ET*.
Redrawn from Brager (1992).

Neutral Temperature	Winter	Summer
Measured	22.0°F	22.6°F
PMV Predicted	24.4°F	25.0°F
PMVg Predicted	23.6°F	24.0°F
Neutral averages used for predictions		
Air temperature	22.8°F	23.3°F
Mean radiant temperature	23.0°F	23.6°F
Velocity	0.06 m/s	0.10 m/s
Clothing	0.58 clo	0.52 clo
Activity	1.12 met	1.14 met
Values required to match PMV-predicted and measured neutral temperatures		
Clothing	0.80 clo	0.72 clo
Activity	1.75 met	1.75 met

Note: a 0.06 m/s = 12 fpm; 0.10 m/s = 20 fpm.

Table 1 - Neutral Temperatures: Measured and Predicted.

According to the researchers, there are several possible explanations. One raised by both Ole Fanger and David Wyon was that the laboratory studies use wire chairs. These chairs are used to expose the subject's entire body without insulation from the chair itself.

However, typical office chairs do not expose the occupant to as much air and they also insulate; this may help explain why the laboratory studies found higher temperatures acceptable. David Wyon of Sweden, commented that the chair could insulate 20 to 25% of the body surface. Fanger, commenting on the *ASHRAE Transactions* version of the paper, said that modern upholstered office furniture could add 0.1 to 0.2 clo to clothing insulation values of the study subjects.

Another reason why the field measurements may differ from the model predictions is activity level. Office workers might be more active than laboratory study subjects who are not actively working. Both Professor Fanger and Bjarne Olesen, of Virginia Polytechnic Institute, raised this point.

Activity Level Estimates

Bjarne Olesen has spent a great deal of his career studying thermal comfort as a researcher, on ASHRAE committees, and for his former employer, Bruel and Kjaer, who manufacture thermal environment measurement equipment. He wonders if the researchers had determined the subjects' activity levels during the half hour or hour prior to the measurements. Olesen said that their metabolic rates could have been higher than was apparent from their activities when the measurements were made. A small increase in metabolism, say from 1.2 met to 1.4 met, could make a significant difference in the results, he said.

K. M. Cena of Australia, who also studies thermal comfort, says "the main problem is accurate assessment of the subjects' activity." It is easy to see that a small change in activity would have a significant impact on PMV. In fact, Cena writes, elderly people he studied in a residential thermal comfort survey "thermoregulated by increasing their activity rather than by increasing their clothing insulation."

In *ASHRAE Transactions*, Fanger also said that we need more realistic activity levels; the levels used in the study [and for ASHRAE Standard 55 as well] are based on very old research. Fanger suggests that in more modern offices with stressful work the activity may very well be 1.3 met. However, Brager et al. calculated that if all other factors were held constant, it would require a met value of 1.75 for the results to match those of the models. Even though underestimates of clo and met values may have occurred, increasing them to 0.7 clo and 1.3 met is still not sufficient to explain all of the differences between the field study results and the models. Table 1 shows this.

The important point is that small changes in activity level can make fairly large differences in thermal comfort. This presents some real challenges to the designer as well as the building operator.

Expectations

Expectation and prior experience may have a substantial influence. Cena's work in Australia supports this hypothesis. He conducted a survey of Perth office workers in buildings without air-conditioning where fans were used regularly. Average summer afternoon temperature at 2 PM was about 27°C, with a maximum recorded during the study at 34°C. The average response was between slightly and moderately satisfied. Furthermore, no respondent ranked air temperature as the most important attribute for a satisfactory office environment.

Female office workers ranked air temperature below lighting, air quality, office furniture, and comfort of chairs. Below air temperature they ranked amount of space available, type and levels of sound, provision of non-smoking areas, and color of walls. On average, study subjects considered air conditioning to be only occasionally useful.

Cena reports that Humphrey's (1981) compiled results from thermal comfort surveys in a "free running" building (without heating or cooling installations) indicate that people accept the climatic conditions to which they are accustomed. Cena says that may imply that people become "...habituated to the environments they experience over a much wider range than is usually considered desirable in air-conditioned buildings."

Designing for Comfort

Since "you can't please all the people all the time," the challenge for architects, engineers, and building operators is to design and maintain buildings with thermal conditions that the fewest number of occupants will find uncomfortable. They have to determine the acceptable range of thermal conditions and then figure out how to maintain them. To determine an acceptable range, it is important to know how many occupants will be uncomfortable at any given temperature (and how many will be uncomfortable even at an optimal temperature). Complicating the designers' and operators' tasks are the most important factors that determine people's responses to the thermal environment: individual physiology, activity, and clothing. The designer or operator cannot control any of these factors.

Integrating Environmental Variables

Everyone knows the importance of radiant temperature — how good the sun feels even on a chilly day. We know that on a hot day, it can be quite comfortable in the shade even though it is uncomfortable in the direct sun. We also know how uncomfortable it can be to sit near a very cold window even when air temperatures are in the comfort range.

Air movement is important because it increases the evaporation rate of moisture from the skin. It also carries heat away from the body more rapidly. ASHRAE's thermal comfort standard allows for warmer temperatures if the air speed is increased above normal; for instance, increasing air velocity from 50 fpm (0.8 m/s) to 160 fpm (an impractical solution in offices) allows for maximum summer temperature increases from 79°F to 82.5°F (from 26°C to 28°C).

Humidity is also important because cooling by evaporation from the skin is decreased as humidity increases. Skin wettedness is an important determinant of thermal comfort sensation. We all have experienced being chilled when emerging from a shower, bath, or swimming, even though the air temperature was quite warm. This is because the evaporation of moisture occurs so rapidly when we are very wet that we experience very large heat loss and we perceive as coolness of the environment.

All these relationships illustrate the fundamental principal that thermal comfort is a function of heat exchange with the environment. Based on extensive research, these environmental factors are combined, using appropriate constants to weight their impacts in complicated mathematical expressions, to determine the effective temperature. This formula, not just the air temperature, is the actual basis for ASHRAE's thermal comfort standard. That is why the so-called thermal comfort "envelope" encompasses a range of air temperatures, humidities and air velocities.

Figure 1 showed the thermal comfort envelope as defined by ASHRAE Standard 55-1981. The revised version, 55-1991, is due out soon and does not significantly change the envelope shown in the figure.

Activity Level

Activity level and physiological make-up determine metabolic rate and strongly affect thermal comfort. ASHRAE has published a table of metabolic rates associated with various activities. The rate varies from a reclining person's 0.8 met units to 3.0 to 4.0 met units for a high activity rate (vigorous work or calisthenics/exercise). Office activities range from 1.0 met units for reading or writing to 1.7 met units for walking about and 2.1 met units for lifting or packing. Basketball and competitive wrestling are near the top of the list with met units of 5.0 to 8.7. A met unit equals the production of 18.43 Btu per hour per square foot of body area (Btu/h ft^2). The average adult male checks in with about 1.8 m^2 or 19 ft^2 of body area and would produce about 350 Btu/hour at an activity level of 1.0 met.

Sedentary activity levels typical of office workers are the basis of the thermal comfort standards. These rate at 1.2 met. The adult male office worker produces about 420 Btu/hr. This is roughly the waste heat produced by a 150-watt fluorescent lamp (80% waste heat, or about 120 watts of heat). A 130-watt incandescent lamp (95% waste heat) illustrates this well — we all know that a 120 watt light bulb gets quite hot - too hot to hold comfortably.

Clothing Levels

Besides activity, clothing is the other most important factor. If all that heat is generated and must be dissipated to maintain comfort (thermal neutrality), then the clothing ensemble must permit the loss of that heat and not much more. ASHRAE has adopted a table of clothing values for use in thermal comfort calculations. They give a sense of the relative insulation values of various clothing ensembles as determined by researchers using heated mannequins.

The values are provided in clo units which represent thermal resistance in $°F \cdot ft^2 \cdot h/Btu$. One clo equals $0.88°F \cdot ft^2 \cdot h/Btu$. Table 2 shows some typical clo values (all including briefs or panties, socks, and shoes).

Although the importance of clothing is obvious, controlling it in building occupants is virtually impossible except in rare situations like the military, prisons, convents, and certain schools. Yet, clothing can have an enormous impact on the acceptability of the thermal en-

clo Value	Ensemble
0.5 clo	Fitted trousers and a short sleeve shirt.
0.54 clo	Knee length skirt, short-sleeve shirt, panty hose (no socks), and sandals.
0.96 clo	Fitted trousers, long sleeve shirt, and suit jacket.
0.77 clo	Sweat pants and a sweat shirt.
1.10 clo	Ankle length skirt, long-sleeve shirt, suit jacket, and panty hose (no socks).

Table 2 - Clo Values of Typical Clothing Ensembles.

vironment to building occupants, perhaps most importantly at non-ideal conditions. Assumptions about what people wear in winter and summer account for the two very different envelopes for the two seasons.

Application Is Difficult

So how can an architect, engineer, or building operator produce a building with the greatest occupant satisfaction and the fewest complaints?

In the past, we have relied on the laboratory studies of thermal comfort that try to identify the "optimal" temperature. These studies have been incorporated into design standards such as ASHRAE Standard 55-1981, "Thermal environmental conditions for human occupancy," and ISO Standard 7730, "Moderate thermal environments - Determination of the PMV and PPD indices and specification of the conditions of thermal comfort." Building codes and other regulations incorporate these standards, and they are used by manufacturers to develop HVAC equipment and for designing environmental control systems for buildings.

The standards provide a range of values that we expect to satisfy 80% to 95% of building occupants. Generally they cover the range from about 68°F to 76 or 80°F (about 20°C to 26°C) within certain humidity limits, normal air movement, and minimal radiant asymmetry. Studies done at Yale University reinforce the University of California research suggesting that the existing standards may establish upper boundaries that are too high. At temperatures above 76°F, complaints about IAQ begin to rise significantly and satisfaction with thermal comfort declines rapidly. (See ***IAB*** Vol. 1, No. 7 and Vol. 2, No. 1 for some of these reports.)

ASHRAE now has projects that address some of the concerns raised in this article and in articles by Brager and her co-workers. One project is going to get data for other climates. A part of that project is now beginning in Australia. There may be others later. A second project will review the Fanger and Gagge models and survey the field data and see how they relate. Then the researchers will try to validate existing models with all available data. Finally, the researchers will identify issues for further research.

IAB Comments

Rohles, Woods, and Morey (1989) introduced the idea that it is necessary to know how individuals rate the importance of various environmental factors as well as how they rate their satisfaction with the certain conditions of each. Thus, while some study population may rate the thermal comfort low or unacceptable, if they also indicate that thermal comfort is very important, this is far more significant than if they indicate other factors more important.

Different studies have found that different factors were rated as more important than others. There is no broad consensus from either of the studies that have been reported or from the investigators doing them. Among the most important factors, Rohles' subjects rated thermal environment more important than acoustics, lighting, and air quality. Clerical workers also attached more importance to air temperature.

The challenge to researchers is to develop laboratory studies that will more closely predict what occurs in the field. Models are essential because not all field conditions can be adequately studied in a rigorous manner - at least not economically. At the same time, standards writers must be aware of the differences between the conditions under which research is conducted and the "real world" conditions the study results will be used to predict. Somehow, standards must reflect these differences if they are to be useful and reliable.

References:

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ISO Standard 7730, "Moderate thermal environments - Determination of the PMV and PPD indices and specification of the conditions of thermal comfort," International Organization for Standardization, Geneva, Switzerland.

Note: Gail Schiller is now Mrs. Gail Brager.

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Brooks on Immunotoxicity

Clinicians and medical scientists have attributed several important immunological disorders to exposure to indoor air pollutants. These include allergic phenomena such as asthma and rhinitis, interstitial lung disease such as hypersensitivity pneumonitis, and what Brad Brooks calls in his new book, *Understanding Indoor Air Quality*, "murky pseudoscientific entities such as multiple chemical sensitivity and environmental illness."

There is no scarcity of books on IAQ these days — publishers are flooding the market. However, this book is important because Brooks is an immunotoxicologist. We believe that much of what evades our understanding in sick building syndrome involves the complex processes of immune system reactions.

Brooks works as an immunotoxicologist at IBM's Health Effects Research Department in Boulder, Colorado, where he has conducted extensive research relevant to IAQ. He studies the effects of vapors emitted by his company's products on laboratory animals. He also investigates IAQ problems within IBM's vast building facilities. Brooks' co-author is William F. Davis, an industrial hygienist also with IBM.

Immunotoxicity and SBS

Considering the complexity and diversity of modern environments interacting with the complexity and diversity of human immune system reactions, it is no wonder that researchers often can't find the causes of SBS complaints. Many SBS symptoms as well as other, better-understood adverse health effects caused by poor IAQ certainly involve the immune system in one way or another.

Understanding Indoor Air Quality is a comprehensive treatment of IAQ with chapters on causes, health effects, sampling methods, a collection of case histories, and solving IAQ problems. We focus our discussion on the health effects chapter and especially on immunotoxicology because the discussion benefits from Brooks' specialized knowledge and reflects his considerable experience resolving complaints at IBM. His treatment reflects strongly held views on the controversial topics of multiple chemical sensitivity and environmental illness as well as criticism of their diagnosis and treatment.

The authors begin their discussion of immunotoxicity by describing the importance of healthy immune system functioning to good health. [Nothing has made this apparent more poignantly than the AIDS epidemic.] The authors attribute the "considerable public concern over the effects of airborne pollutants ... [on] the human immune apparatus" to the importance of a healthy immune system. Exposure to "environmental chemicals and biologics including some found in indoor air" can alter immune system functioning resulting in "hypersensitivity disorders, auto-immune disorders, or immune deficiencies accompanied by increased incidence of secondary infection or neoplasia."

According to the authors, inconsistent clinical diagnostic criteria exist among laboratories and confuse rather than improve our understanding of immunological disorders. The authors also imply that diagnosticians do not necessarily differentiate between "exposure" and "clinical disease."

Allergy and Hypersensitivity

Brooks stated, "Hypersensitivity reactions can best be portrayed as exaggerated immune responses to foreign organic substances (antigens), commonly manifested as reduced threshold to the offending substance." In a lecture last March in Ispra, Italy, Brooks told an audience of scientists, physicians, and public health workers from the European Community member nations that chemically induced hypersensitivity pneumonitis (HP) is one of the most frequently mis- (under-) diagnosed diseases. Diagnosing the disease is difficult because it is easily confused with influenza or other respiratory infections, according to the book. Humidifier fever, a variant of HP, is frequently associated with microbial contamination of humidifiers, vaporizers, or saunas.

Allergy refers to "altered reactivity to antigen as a result of a previous exposure" and is defined by the following criteria:

- No symptoms upon initial exposure.
- A minority of exposed individuals become sensitized.
- Exposure to antigen levels below the threshold for irritancy induce allergy.
- After induction of allergy, smaller amounts of antigen than those required for sensitization elicit reactions.

The authors point out that allergic reactions are highly "individualized." This means that exposures that cause an allergic response in some people may have no effect on others. Several factors affect the human capacity to mount an allergic response. Most notable is genetic makeup;

others include route, dose, duration, and type of antigen exposure, age of individual, and lifestyle and habits of individuals.

One of the perplexing things about allergic responses is that they occur in multiple organ systems. Most of what is known about allergy comes from the study of responses to natural allergens such as pollens, fungi, bacteria, house dust, and animal dander. However, according to the authors it is clear that many common indoor pollutants "may elicit allergic reactions in susceptible persons."

Forty-million Americans suffer from some type of allergic disease, according to estimates. The authors point out that in an occupational setting, allergic diseases such as hay fever and asthma can cause frequent absence and low productivity. The authors note that there is an alarming growth in the number of asthma-related deaths in both industrialized and developing nations.

Besides their potential to sensitize and later trigger an allergic response, indoor chemical and biological contaminants can also have a synergistic effect upon allergy induction or exacerbate pre-existing allergies. For example, the synergy between respiratory infections and allergy is well-known. Irritant gases, microbial contaminants, and even "odors" can play a similar role.

Environmental Illness and Multiple Chemical Sensitivity

The authors are critical of clinical ecology and seem somewhat skeptical about the existence of MCS. On the other hand, they seem to believe that most sufferers of MCS have real symptoms and discomfort. They say that practitioners of clinical ecology usually misdiagnose the causes of these symptoms by using improper or inadequate diagnostic techniques. Their discussion of MCS departs in tone from much of the material that precedes it and seems rather colored by their assessment of clinical ecology.

However, they do not dismiss MCS out of hand. They say that "multifaceted symptoms might be due to some unknown form of exceptional nonimmunologic response to trace chemicals...." They cite the possible existence of clinical support for this hypothesis. They mention a recent clinical study that found MCS patients had greater nasal resistance when inhaling and exhaling than matched controls. Brooks and Davis say their experience is that classical allergy histories and clinical test results characterize many individuals diagnosed as MCS patients.

Conclusion

While we've discussed only a small section of the book, we found many other parts quite informative. Brooks has a rather unique and interesting way of expressing himself orally, and the book's writing reflects his style. At times the book seems like a tedious catalogue set in prose, but the style often relieves what might otherwise be tedious reading. The thorough referencing provides the reader interested in probing deeper with a wealth of possibilities from the published literature.

Reference:

Bradford O. Brooks and William F. Drake, 1992. *Understanding Indoor Air Quality*. Boca Raton: CRC Press. 189 pages.

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Ambient Air Quality

EPA Trends Report Shows Improvements

What do ambient air quality standards and levels have to do with IAQ? ASHRAE Standard 62-1989 states that outdoor air used to meet ventilation rate procedure requirements must meet the primary National Ambient Air Quality Standards (NAAQS - pronounced "knacks").

EPA established and periodically reviews these standards as required by law: to set the primary standards to protect public health. Secondary standards are set to protect public welfare such as effects of air pollution on vegetation, materials, and visibility. The NAAQS primary standards are listed in Table 3 from Standard 62-1989, Section 6, Procedures.

ASHRAE Ventilation and Outdoor Air Quality

ASHRAE Standard 62 (Section 6.1, Ventilation Rate Procedure) specifies that "outdoor air quality" must meet these standards in order to be used for compliance with the ASHRAE Standard. Section 6.1.2, Outdoor Air Treatment, states that if the outdoor air does not meet the NAAQS, "the air should be treated to control the offending contaminants." It goes on to specify that "appropriate air-cleaning systems should be used" to remove gases and vapors.

The standard goes on to say: "Where the best available, demonstrated, and proven technology does not allow for the removal of contaminants, the amount of outdoor air may be reduced during periods of high contaminant levels, such as those generated by rush-hour traffic." This language is permissive in tone with respect to reducing outdoor air supply when the NAAQS aren't met and can't be practically controlled; however, we read the "air should be treated to control the offending contaminants" statement as requiring such a reduction.

This means that building designers as well as operators must know what the outdoor air quality is and must respond accordingly. The only outdoor air contaminant for which practical control technology is not available is carbon monoxide (CO). Available technology can control the other contaminants, sulfur dioxide (SO_2), ozone (O_3), nitrogen dioxide (NO_2), and particles less than 10 microns in diameter (PM10) at a reasonable cost. The primary source of CO that will result in a violation is likely to be motor vehicle traffic, so during and after the morning rush hour and during the beginning of the evening rush hour, it might be necessary to reduce outdoor air ventilation.

What About Your Building?

Does your building or one you are designing require such control measures? To get a handle on this quickly, let's look at a recently published EPA report, "National Air Quality and Emissions Trends Report, 1990." This report is revised and issued annually, usually somewhat more than a year after the year reported.

Results for many of the nation's largest communities is listed in Table 4. It shows a summary of 1990 air quality data for selected major Metropolitan Statistical Areas in the US. The levels shown are the highest reported from all sites within the US. Population figures are 1987 estimates. Concentrations above the respective NAAQS limits are in boldface. For more detailed information on your community, obtain a free copy of the publication from EPA. Information on how to get this is available at the end of this article.

Overview Of Results

A quick look at the graph on the report's cover reveals that ambient air standard violations are concentrated in the populated areas of the country. Major violations occur on the west coast, northern Atlantic coast, and other industrialized or heavily populated areas of the United States. More of the significant violations occur for the ozone standard than for the other contaminants, but CO violations also occur in many of the same areas. This indicates the relationship between combustion and CO production.

SO_2, CO, NO_2, and PM10

Pittsburgh, Pennsylvania was the only large urban area to exceed the 24-hour NAAQS of 365 $\mu g\backslash m^3$ (0.014 ppm) of sulfur dioxide. Twelve urban areas had carbon monoxide levels exceeding the maximum 8-hour average value of 9 ppm CO. The highest was Los Angeles where the level exceeded 15 ppm. Los Angeles was the only urban area in the country to exceed the annual NO_2 mean concentration standard of 0.053 ppm. Nine of the urban areas with populations greater than 500,000 inhabitants exceeded the NAAQS second-highest 24-hour PM10 concentration of 150 $\mu g/m^3$. Eight urban areas exceeded the annual arithmetic mean PM10 concentration standard of 50 $\mu g/m^3$.

Ozone

In 1990, 39 of the largest 90 urban areas failed to meet the ozone standard which was based on a second-highest daily maximum 1-hour concentration of 0.12 ppm. The highest concentrations occurred in southern California, but high levels persist in the Texas Gulf Coast, the Northeast corridor, and other heavily populated regions, according to the EPA report.

Ozone is now recognized as a potentially important indoor pollutant, although historically it was not. When outside ventilation rates are increased above one air

Contaminant	Long term Concentration $\mu g/m^3$	Averaging ppm	Time	Short term Concentration $\mu g/m^3$	Averaging ppm	Time
Sulfur dioxide	80	0.03	1 year	365	0.14	24 hours
Particles (PM10)	50	-	1 year	150	-	24 hours
Carbon monoxide				40,000	351	1 hour
Carbon monoxide				10,000	98	1 hour
Oxidants (ozone)	235	0.12	1 hour			
Nitrogen dioxide	100	0.053	1 year			
Lead	1.5	-	3 months			

Table 3 - National Primary Ambient Air Quality Standards.

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
ANAHEIM-SANTA ANA, CA	2,219,000	108	48	0.003	0.01	10	0.047	0.21	
ATLANTA, GA	2,657,000	110	a 51	0.009	0.043	6	0.027	0.15	0.03
BAKERSFIELD, CA	505,000	197	79	0.006	0.014	8	0.032	0.16	ND
BALITMORE, MD	2,303,000	77	33	0.009	0.032	8	0.034	0.14	0.06
BERGEN-PASSAIC, NJ	1,294,000	94	45	0.01	0.042	8	0.031	0.13	0.04
BIRMINGHAM, AL	917,000	140	45	0.008	0.024	7	ND	0.13	b 1.68
BOSTON,MA	2,842,000	73	38	0.012	0.057	6	0.032	0.11	0.05
CHICAGO, IL	6,199,000	149	45	0.01	0.052	6	0.031	0.11	0.13
CINCINNATI, OH-KY-IN	1,438,000	108	35	0.017	0.075	5	0.028	0.15	1.22
CLEVELAND, OH	1,851,000	122	48	0.017	0.08	5	0.029	0.12	0.54
DALLAS, TX	2,456,000	88	35	0.006	0.022	5	0.018	0.15	c 1.62
DETROIT, MI	4,362,000	114	35	0.018	0.07	6	0.024	0.12	0.08
EL PASO, TX	573,000	179	54	0.012	0.06	14	0.017	0.14	0.42
FORT WORTH-ARLINGTON, TX	1,269,000	51	26	0.002	0.008	5	0.012	0.14	0.03
FRESNO, CA	597,000	238	66	0.004	0.015	8	0.026	0.15	ND
GARY-HAMMOND, IN	604,000	203	40	0.013	0.069	5	0.023	0.12	0.35
GRAND RAPIDS, MI	657,000	84	32	0.004	0.012	4	ND	0.14	0.03
HARTFORD, CT	748,000	61	25	0.009	0.039	9	0.019	0.15	0.04
HOUSTON, TX	3,228,000	82	30	0.009	0.039	8	0.029	0.22	0.04
INDIANAPOLIS, IN	1,229,000	85	38	0.013	0.047	5	0.02	0.11	d 1.68
LAS VEGAS, NV	600,000	162	69	ND	ND	14	0.037	0.11	ND
LOS ANGELES, CA	8,505,000	132	55	0.004	0.014	16	0.056	0.27	0.11
MIAMI-HIALEAH, FL	1,791,000	49	30	0.001	0.003	7	0.016	0.11	0.03
NEW HAVEN-MERIDEN, CT	519,000	157	41	0.014	0.056	7	0.027	0.16	0.08
PHILADELPHIA, PA-NJ	4,866,000	89	38	0.016	0.062	7	0.035	0.14	e 2.95
PHOENIX, AZ	1,960,000	127	46	0.003	0.011	10	0.017	0.14	0.06
PITTSBURGH, PA	2,105,000	191	43	0.028	f 0.171	8	0.031	0.11	0.08
PORTLAND, ME	210,000	48	23	0.009	0.034	ND	0.017	0.13	0.04
PORTLAND, OR-WA	1,168,000	80	27	0.005	0.019	8	IN	0.15	0.11
RICHLAND-KENNEWICK-PASCO, WA	150,000	382	IN	ND	ND	ND	ND	ND	ND
RIVERSIDE-SAN BERNARDINO, CA	2,119,000	278	80	0.007	0.032	7	0.041	0.3	0.05
SACRMENTO, CA	1,336,000	143	42	0.006	0.012	13	0.024	0.16	0.11
ST. LOUIS, MO-IL	2,458,000	164	82	0.015	0.064	7	0.026	0.13	g 2.34
SAN ANTONIO, TX	1,307,000	55	28	ND	ND	5	ND	0.1	0.07
SAN DIEGO, CA	2,286,000	70	38	0.005	0.015	8	0.029	0.17	0.13
SAN FRANCISCO, CA	1,590,000	93	34	0.002	0.01	7	0.022	0.06	0.13
SAN JOSE, CA	1,415,000	138	40	ND	ND	11	0.03	0.12	0.09
SEATTLE, WA	1,796,000	119	36	0.009	0.026	10	ND	0.13	52
SPOKANE, WA	355,000	268	48	ND	ND	12	ND	0.07	ND
STEUBENVILL-WEIRTON, OH-WV	149,000	135	43	0.039	0.131	21	0.02	0.09	0.08
TULSA, OK	733,000	79	27	0.012	0.056	6	0.015	0.12	0.11
VANCOUVER, WA	216,000	69	IN	0.005	0.021	11	ND	0.11	ND
WASHINGTON, DC-MD-VA	3,646,000	83	34	0.015	0.036	8	0.03	0.13	0.08

PM10 = HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
= HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NMQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-H0UR CONCENTRATION (Applicable NAAQS is 9ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
ND = INDICATES DATA NOT AVAILABLE   IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC
PPM = UNITS ARE PARTS PER MILLION   UGM = UNITS ARE MICROGRAMS PER CUBIC METER

a - Impact from localized construction activity.
b - Impact from an industrial source in Leeds, AL. Highest site in Birmingham, AL is 0.17 ug/m3.
c - Impact from an industrial source in Collin County, TX. Highest site in Dallas, TX is 0.36 ug/m3.
d - Impact from an industrial source in Indianapolis, IN. Highest population oriented site in Indianapolis is 0.91 mg/m3.
e - Impact from industrial sources in Philadelhpia, PA. Highest population oriented site in Philadelphia is 0.39 ug/m3.
f - Impact form a localized industrial source in Pittsburgh, PA.
g - Impact from a lead smelter in Herculaneum, MO. Highest site in St. Louis is 0.23 ug/m3.

Table 4 - 1990 Air Quality Data for Selected Major Metropolitan Statistical Areas.

change per hour, indoor ozone concentrations rise until they reach 70-80% of outdoor concentrations at ventilation rates of seven to ten air changes per hour. Recent health effects research indicates that acute effects occur at concentrations well below the 0.12 ppm standard, and chronic effects may occur at lower concentrations. Some discussion of lowering the limit continues, and EPA is several years behind in its mandated periodic review of the standard. The State of California already has lowered the limit to 0.09 ppm, and many scientists believe it should be no higher than 0.08 ppm.

Ozone can be removed effectively by using activated carbon filters.

Implications

ASHRAE Standard 62-1989 is intended to be a design standard. However, some states and other jurisdictions have adopted it as an operational standard. Since compliance with the standard in design and performance of buildings is becoming an increasingly important criterion, architects, engineers, and their clients must be prepared to address ambient air quality.

Air cleaning and filtration must be designed to remove NAAQS pollutants that are likely to exceed the regulatory limits, and building operators must be able to ascertain when the contaminant levels will violate the standards. This is no trivial task; it involves monitoring or other means of determining ambient air contaminant concentrations. It may be that at some future date, local networks will be developed to provide on-line, real-time monitoring to building operators. In the meantime, designers must determine the ambient air quality at the sites and design-in equipment capable of controlling it.

Reference:

"National Air Quality and Emissions Trends Report, 1990." EPA-450/4-91-023. November 1991. Office of Air Quality Planning and Standards, U. S. EPA, Research Triangle Park, NC 27711. Copies are free on request.

New IAQ Group

International Society of Indoor Air Quality and Climate Formed

The International Society of Indoor Air Quality and Climate (ISIAQ) is a newly formed association of practitioners, scientists, and policy makers concerned with IAQ and climate. The principal organizers of the five past and the planned sixth triennial international indoor air conferences formed the group.

The ISIAQ purpose is to advance the science and technology of IAQ and climate relative to building design, construction, operation, and maintenance and to air quality measurement and health. It will also try to simplify access to basic knowledge on how to build and maintain healthy buildings. Through publications, conferences, and news dissemination, the Society hopes to focus diverse, dispersed, and fragmented information from around the world.

Organizers

Thomas Lindvall of Sweden is ISIAQ's first president and will oversee the organization's activities. Lindvall was president of the Third International Conference on Indoor Air Quality and Climate held in Stockholm in August 1984. He also was a principal organizer of the first Healthy Buildings Conference in Stockholm in September 1988, and he was a major contributor to the Healthy Buildings '91 conference held in Washington, D.C. last September.

Douglas Walkinshaw of Canada is ISIAQ's secretary, and he has done much of the work to establish the Society. Walkinshaw was president of the Fifth International Conference on Indoor Air Quality and Climate, Indoor Air '90 in Toronto. ISIAQ's list of sponsors, affiliated organizations, and founding members is lengthy and impressive. While most of the founders are from North America and Europe, there are also representatives from Russia, China, Japan, Australia, and South Africa among the more than 90 founding members. The Society has established formal associations with a variety of scientific and professional societies around the world.

Membership Information

Membership is open to all, and the costs are very reasonable. The $100 (US) annual fee includes a subscription to *Indoor Air*, the Society journal. A subscription to the journal alone costs well over $150 per year, and it is clearly the most important single journal in the indoor air field today. Student memberships are only $60 per year. There are benefits to two- and three-year memberships, and all members become eligible for a discount on subscriptions to the ***IAB***. Current ***IAB*** subscribers will receive a discount when they renew.

For more information on the Society or a membership application, contact ISIAQ, PO Box 22038, Sub 32, Ottawa, Canada K1V 0W2.

"Effects of Indoor Air Pollution on Human Health"

IAQ's most important and least understood aspects are the health effects of exposure to common indoor air pollutants. Effects are reasonably well understood for a few important pollutants: especially the most common inorganic chemical contaminants. However, much less is known about the effects of most individual organic chemicals found in indoor air; and, even less is understood about the effects of the complex mixtures often encountered indoors.

A new report from the Commission of the European Community (CEC) provides a general understanding of indoor air pollutants based on the health effects themselves. "Effects of Indoor Air Pollution on Human Health" is the tenth in a valuable series of reports from the European Community. The 43-page report is a very readable, very useful summary and digest.

The authors conclude that clear relationships between exposures to indoor air pollution and adverse health effects have been reported in the world literature. These health effects include respiratory disease (particularly among children), allergy (particularly to house dust mites), and mucous-membrane irritation (particularly due to formaldehyde). They also indicate that these pollutants affect a large number of people.

Respiratory Effects

Air pollution affects the respiratory organs more directly than any other. Apart from carcinogenic and allergic effects, lower-respiratory effects include acute and chronic changes in pulmonary function, an increased number of respiratory symptoms, and sensitization of the airways to allergens. Also, two factors may increase the incidence of respiratory disease due to indoor exposure to infectious agents and other pollutants. One, ventilation systems can distribute infectious agents and indoor pollutants more effectively. Two, there are smaller air-mixing volumes available indoors to dilute concentrations of infectious agents.

Combustion products, environmental tobacco smoke (ETS), and infectious biological agents are all implicated in serious respiratory system effects. Children and elderly people are especially susceptible. Authorities consider children's respiratory systems to be more susceptible, and children risk greater exposures due to faster metabolic and respiratory rates. Elderly people often have impaired pulmonary functions and/or weakened defense systems; this puts them at greater risk than healthy adults. Smoking may also increase susceptibility, the report says.

Once sensitized, allergy sufferers "are orders of magnitude more sensitive to allergens and to some other pollutants than the non-sensitized population." Asthmatics and others with "nonspecific bronchial reactivity" are also at increased risk. Individuals whose defenses are already compromised by poor health status have enhanced susceptibility to infection when exposed to infectious agents. Examples include AIDS and cancer patients, persons with chronic obstructive pulmonary disease, the elderly, and young children.

The public health significance lies in the fact that large numbers of people are exposed to ETS, biological contaminants, and combustion products from unvented appliances. Where smoking is prevalent, as in Europe, over 50% of households are exposed to ETS, according to the report. The significance of exposure to infectious agents depends on the preventability of such exposures by reducing microorganism proliferation through such measures as improved building operation and maintenance, reduced crowding, immunization, or disinfection of contaminated air.

Effects on Skin and Mucous Membranes of the Eyes, Nose, and Throat

Indoor air pollutants acting on the skin and mucous membranes may cause sensory system effects and result in tissue changes. "Each of these may subsequently lead to the other," according to the report. Thus, it continues, two types of sensory irritation appear in the literature on indoor air pollution: direct stimulation of sensory cells by environmental exposures causing "primary sensory irritation," and "secondary irritation" that follows changes in the skin, mucous membranes, or other tissues.

Irritative changes are attributed to common indoor contaminants including formaldehyde, volatile organic compounds, and ETS. Other factors, such as poorly controlled temperature and humidity, influence the level of eye and nose irritation ETS causes in non-smokers. Other than for formaldehyde and ETS, little is known of the link between exposure to indoor air contaminants and irritative effects such as those seen in SBS cases.

The report indicates an absence of information on the proportion of people who are more susceptible to formaldehyde. [However, a recent California report suggests that asthmatic and allergic members of the population are more susceptible to irritation from formaldehyde exposure. See *IAB*, Vol. 1, No. 6.]

Sensory and Other Nervous System Effects

The CEC report defines sensory effects as "the perceptual response to environmental exposures." The sensory systems mediate sensory perceptions. Through the various receptors, signals are transmitted to the higher levels of the central nervous system (CNS), then a conscious experience of smell, touch, itching, etc. occurs.

The report says the reason sensory effects are typically observed in buildings with indoor climate problems is "because many chemical compounds found in the indoor air have odorous or mucosal irritation properties." They note that when the concentration is high enough, most indoor air chemicals with a measurable vapor pressure will be odorous. Yet there is no relationship between odor detection thresholds and "other adverse health effects."

The report cites four reasons why sensory effects are important for those interested in controlling IAQ. First, they can indicate undesirable health effects such as environmentally induced sensory dysfunctions. Second, adverse environmental perceptions such as annoyance may simply be undesirable in themselves or may be precursors of disease such as hypersensitivity reactions. Third, they may provide sensory warnings such as odor and mucosal irritation that can indicate exposures to toxic sulfides or formaldehyde respectively. Fourth, sensory effects can be tools in sensory bioassays; one can use odor criteria to develop ventilation requirements or for screening building materials for volatile organic compound emissions.

The report groups sensory perceptions into two types: perceptions of the surrounding environment and perceptions of the body's reaction to the environment. They can be either adverse or not, and building occupants' perceptions of the body's response may or may not be attributed to the surrounding physical environment. Sensory systems are tuned to changes, not to absolute levels. Many of the senses that respond to the surrounding environment are at or near the body surface. Besides hearing, vision, smell, and taste, the senses responding to the environment include the skin and mucous membranes.

Some responses depend on accumulating a sufficient dose while others, such as odor perception, are immediate and even subject to olfactory fatigue with prolonged exposure.

Human beings integrate different environmental stimuli to evaluate total perceived air quality and to assess comfort and discomfort. [See the article on thermal comfort in this issue.] By definition, comfort and discomfort are psychological so that the related symptoms, even when severe, must be documented by subjective reports. Most such reports involve multiple senses, and different environmental exposures can cause the same sensations and perceptions. We add that these facts make elucidating SBS symptom causes very difficult.

Perceptions of air quality depend on stimulation of both the olfactory and the trigeminal nerves. Some odorous compounds are also mucosal irritants, especially at higher concentrations. The olfactory system warns of potential danger by detecting the presence of odors. Without instruments sensitive enough to detect the odors, or absent any instrumental monitoring, the sense of smell provides an important protective function. We add that it also gives many "false alarms" that confuse building occupants and operators alike.

Effects of Solvents

The effects of organic solvents on the nervous system are well known from studies of occupational exposures. These effects include irreversible nerve cell damage. They are exposed to hazardous compounds more than most other body tissues because they metabolize intruding chemicals slowly. We add that solvents have a ubiquitous presence (at low concentrations) in indoor air.

Many solvents have narcotic effects on the nerve cells by affecting the transmission of nerve signals. Yet suspicions that environmental hazards cause some disorders of the CNS such as Parkinson's disease and Alzheimer's disease are not presently supported by documentation of causes related to exposure to indoor air pollutants, according to the report.

Cardiovascular Effects

The report says that the only indoor air pollutants associated with cardiovascular effects are ETS and carbon monoxide (CO). There is controversy about interpreting the evidence regarding ETS; however, recent reports do indicate increased relative risks of death from cardiovascular disease among non-smokers living with smokers. The evidence of carbon monoxide's effect is less ambiguous. Susceptible groups include persons with angina pectoris or obstructed coronary arteries as well as those with disorders such as anemia that reduce the oxygen-carrying capacity of the blood.

The public health relevance of indoor air pollutants and cardiovascular disease stems from the very large number of people exposed to ETS and a far smaller number of people exposed to high levels of CO when "unfavorable circumstances," primarily in residential environments, combine to produce exposure. Preventing both of these types of exposures is technically straightforward by using proper ventilation, exhaust of combustion byproducts, and smoking curbs. However, the social and institutional barriers are substantial.

Allergic Responses And Other Effects

The significance of indoor air pollutants and allergic responses is discussed in detail in the article on immunotoxicity in this issue. The CEC report identifies the causes of allergic asthma as preventable indoor air pollutants, primarily in the home environment. Properly maintaining humidifier systems and preventing excessive humidity conducive to mold growth in commercial buildings are also important measures. The importance in terms of public health involves the very large number of affected individuals and the cost of care for diseases such as preventable asthma and allergic reactions.

The report also addresses cancer and the effects of indoor air pollutants on reproduction. Lung cancer from radon and ETS exposure are the major effects of concern. Problem indoor air pollutants other than radon and ETS include asbestos, some pesticides, polycyclic aromatic hydrocarbons, benzene, and formaldehyde. Again, the public health concern relates to the exposure of a large number of non-smokers to ETS, especially in the home. Also, the risk from high levels of radon is substantial for significant numbers of people in countries where radon levels are highest.

Organization of the Report

The CEC booklet is organized into a summary, preface, and eight chapters based on human organ systems or health effects. The chapter topics are as follows:

- General aspects of assessment of human health effects of indoor air pollutants.
- Effects on the respiratory system.
- Allergy and other effects on the immune system.
- Cancer and effects on reproduction.
- Effects of the skin and mucous membranes in the eyes, nose, and throat.
- Sensory effects and other effects on the nervous system.
- Effects on the cardiovascular system.
- Systemic effects on the liver, kidney, and gastro-intestinal system.

Each effect is described according to the following format:

- Definition of the effect.
- Indoor agents that may cause it.
- Evidence linking the effect to indoor air pollutants.
- Susceptible groups in the population.
- Relevance for public health.
- Methods available for the assessment of the effect.
- Major research needs.

Conclusion

The discussions in the report are not very detailed, and it does not provide data on pollutant concentrations or dose and exposure response. Therein might reside the strength and value of the report. The discussion is of a general nature providing an excellent, comprehensive overview of the subject. Pollutants are discussed according to broadly grouped categorical health effects. This sort of approach is very useful in placing the significance of indoor air pollution in a larger, public health perspective. The paucity of numerical data does not undermine the usefulness of the discussion which represents a consensus of leading IAQ experts from fourteen European countries.

All in all, the CEC report is interesting and informative. As a summary document it provides a valuable overview that is harder to extract from more detailed treatments of the subject.

Reference:

European Concerted Action: Indoor Air Quality and Its Impact on Man. (formerly COST Project 613). Environment and Quality of Life: Report No. 10, "Effects of Indoor Air Pollution on Human Health." 1991, EUR 14086EN. Published by and available at no charge from the Commission of the European Communities, Directorate for Science, Research, and Development, Joint Research Centre, Environment Institute, Ispra, Varese, Italy 20120. Available in the United States by request from the Commission of the European Communities, Washington, D.C., Monday - Thursday, 10 AM - 4 PM, (202) 862-9500, or Joanee Lewis, (202) 862-9545.

Publications

Ventilation Directory Lists Codes, Standards

Although now somewhat out of date, the *Ventilation Directory*, 1990 Edition still provides the most comprehensive and accessible listing of relevant codes, standards, and regulatory criteria affecting ventilation and IAQ. Published by the National Conference of States on Building Codes and Standards, the 60-page directory summarizes the relevant requirements in ASHRAE standards, building codes, and several state laws.

The directory presents the information in useful charts that allow comparison of the various requirements. It begins with flow charts providing a general overview and flow of compliance procedures for the model codes and ASHRAE Standard 62 (including the 1973, 1981, and 1989 versions). Then a table of statewide ventilation codes identifies the relevant laws and codes in each state.

There are separate tables for natural ventilation, mechanical ventilation, and exhaust/supply requirements for the Standard Building Code, Uniform Building Code, and National Building Code/National Mechanical Code. In each table, the codes are compared with the requirements of the three versions of ASHRAE Standard 62 and the codes of Massachusetts, New York, South Florida, and Wisconsin.

To Obtain a Copy

At $40/copy the directory seems overpriced, but the information it contains is not available elsewhere in comparable form. Architects, engineers, IAQ consultants, and regulators concerned with variations among the states and codes will find it extremely helpful. To order, send $40 to NCSBCS, 505 Huntmar Drive, Suite 210, Herndon, VA 22070, (703) 437-0100, fax (703) 481-3596.

Calendar

Domestic Events

June 21-24, 1992. **85th Annual Convention and The Office Building Show**, Building Owner's and Manger's Association (BOMA) International, Washington State Convention and Trade Center, Seattle, Washington. Contact: BOMA Int'l, P.O. Box 79330, Baltimore, MD 21279-0330, tel. (202) 408-2689, fax (202) 371-0181. *Promotional material indicate "ADA, IAQ, and CFC's top list of seminar topics" at this year's convention.*

June 21-26, 1992. **85th Annual Air & Waste Management Association Meeting and Exhibition,** Kansas City, MO. Contact A&WMA at P. O. Box 2861, Pittsburgh, PA 15230. (412) 232-3444, fax (412) 232-3450. In Canada, A&WMA Annual Meeting, P. O. Box 11149, Postal Station A, Toronto, Ontario M5W 2G5.

June 27-July 1. **ASHRAE Annual Meeting,** Baltimore, Maryland. Contact: ASHRAE Meetings Dept., 1791 Tullie Circle N.E., Atlanta, GA 30329, (404) 636-8400.

July 12-17, 1992. **"Asbestos Measurement, Risk Assessment, Laboratory Accreditation."** Johnson State College, Johnson, Vermont. Sponsored by ASTM Committee D-22 on Sampling and Analysis of Atmospheres. Contact: George Luciw, ASTM, 1916 Race Street, Philadelphia, PA 19103, (215) 299-5471.

July 14-15, 1992. **"Indoor Air Quality for Facility Managers."** Sponsored by International Facility Managers Association (IFMA), Boston, Massachusetts. Contact: Susan Biggs, IFMA, 1 East Greenway Plaza, 11th Floor, Houston, TX 77046-0194, (800) 359-4362, fax (713) 623-6124. *Instructor is **IAB** Editor Hal Levin.*

July 14-16, 1992. **Orientation to Indoor Air Quality**, Sponsored by Office of Continuing Professional Education, Rutgers University, New Brunswick, New Jersey. Contact: Continuing Education, Cook College, P. O. Box 231, New Brunswick, NJ 08903-0231, (908) 932-9271, fax (908) 932-8726. *This 2-1/2 day course is designed to address the training needs of state and local government officilas, health professionals, and other members of the environmental community working to resolve indoor air pollution problems.*

August 5-7, 1992. **"Environmentally Sound Architecture: New Technologies for Healthful, Efficient Buildings."** Harvard Graduate School of Design. Contact: Professional Development, Harvard GSD, 48 Quincy Street, Cambridge, MA 02138. 617-495-1680, Fax 617-495-5967. *Three day course: Day 1 - Indoor Air Quality by Design; Day 2 - Energy Efficient Lighting; Day 3 - Housing Energy Efficiency. Tuition/materials: $675, or $250/day.*

August 19-20, 1992. **International Energy and Environmental Congress (Conference and Exposition)**, sponsored by the Association of Energy Engineers, Hyatt Regency O'Hare Exposition - Rosemont O'Hare Convention Center, Chicago, Illinois. Contact: Association of Energy Engineers, 4025 Pleasantdale Road, Suite 420, Atlanta, GA 30340. (404) 447-5083, fax (404) 446-3969. *"Designing and Operating Healthy Buildings" is the title of a two-day course being offered in conjunction with the Conference. Course registration is $685 for AEE members, $785 for non-members. Conference and exposition registration is $595 for AEE members, $695 for non-members. Booths are available for $14.50 per square foot.*

August 30 - September 5, 1992. **"Achieving Technical Potential: Programs and Technologies that Work!"** ACEEE 1992 Summer Study on Energy Efficiency in Buildings, Asilomar Conference Center, Pacific Grove, California. Sponsored by The American Council for an Energy-Efficient Economy. Contact: ACEEE 1992 Summer Study Office, 2140 Shattuck Avenue, Suite 202, Berkeley, CA 94704. *The ten topics include "human dimensions" of which indoor air quality, health and comfort are a part.*

September 15-17, 1992. **Orientation to Indoor Air Quality**, sponsored by Office of Continuing Professional Education, Rutgers University, New Brunswick, New Jersey. *See listing under July 14-15.*

September 22-25, 1992. **International Symposium on Radon and Radon Reduction Technology**, Minneapolis, Minnesota. Contact: For registration information, Diana, Conference of Radiation Control Program Directors, Inc., (502) 227-4543, Fax (502) 227-7862.

September 30 - October 2, 1992. **"Lead-Tech '92: Solutions for a Nation at Risk,"** Hyatt Regency Hotel, Bethesda, Maryland. Sponsored by IAQ Publications, Inc. Contact: Mary Lou Downing, Conference Manager, Lead-Tech '92, 4520 East-West Highway, Suite 610, Bethesda, MD 20814. (301) 913-0115; Fax (301) 913-0119. *The sponsors say this is the first industry-wide lead detection and abatement conference and exposition. The conference will cover technical and regulatory issues.*

October 5 - 8, 1992. **ASTM Subcommittee D22.05 on Indoor Air; Fall Meeting**, contact George Luciw, Staff Manager, ASTM, 1916 Race Street, Philadelphia, PA 19103-1187, (215) 299-5571, fax (215) 299-2630.

October 18-20, 1992. **IAQ 92 - Environments for People,** Golden Gate Holiday Inn, San Francisco, California. Sponsored by ASHRAE, ACGIH, and AIHA. Contact; Jim Norman, Manager of Technical Services, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle NE, Atlanta, GA 30329, (404) 636-8400.

October 19-21, 1992. **Indoor Air Quality Continuing Education Course**, American Industrial Hygiene Association, Salt Lake City, Utah. Contact: Continuing Education, AIHA, P.O. Box 8390, White Pond Drive, (216) 873-2442. Fax (216) 873-1642.

October 28-30, 1992. **World Environmental Engineering Congress**, Sponsored by Association of Energy Engineers (AEE), Atlanta, Georgia. Contact: AEE, 4025 Pleasantdale Road, Suite 420, Atlanta, GA. 30340. (404) 447-5083, fax (404) 446-3969. *Registration fee: $550 AEE Member, $650 AEE non-member. Booths are available for $16.50 per square foot.*

International Events

July 22-24, 1992. **1992 International Symposium on Ventilation Effectiveness,** Tokyo, Japan, sponsored by the Institute of Industrial Science, The University of Tokyo. (co-sponsored by ASHRAE). Contact ASHRAE in the US.

September 2-4, 1992. **Roomvent '92, The Third International Conference on Air Distribution in Rooms**. Aalborg, Denmark. sponsored by Danish Association of HVAC Engineers. Contact: Danish Association of HVAC Engineers, Ørholmvej 40B, DK-2800 Lyngby, Denmark.

October 12-16, 1992. **Second International Course on Sick Building Syndrome**, sponsored by the Nordic Institute of Occupational Health (NIVA). Hotel Oranje Boulevard, Noordwijk aan Zee, The Netherlands. Contact: Gunilla Ahlberg, NIVA, Topeliuksenkatu 41 a A, SF-00250 Helsinki, Finland. Tel +358 0 474 498. Fax +358 0 414 634. *A five day course intended for occupational safety and health experts and industrial hygienists working in the field of indoor air quality. Enrollment limited to 50.*

February 17-19, 1993. **"Building Design, Technology & Occupant Well Being in Cold and Temperate Climates,"** Palais des Congrés, Brussels, Belgium. Contact: ATIC-CDH, chausee d'Alsemberg 196, B-1180 Brussels, Belgium. Tel. 32-2-348-05-50; Fax 32-2-343-98-42. *Abstracts of no more than 300 words are due by August 15, 1992. The official languages will be English, French, and Flemish.*

July 4-8, 1993. **Sixth International Conference on Indoor Air Quality and Climate, Indoor Air '93**, Helsinki, Finland. For more information, a copy of the conference announcement, or the call for papers, contact the confeence secretary at: Indoor Air '93, P.O. Box 87, SF-02151 Espoo, Finland. Fax +358-0-451-3611. *This most importa[illegible] indoor air conference is held every three years and is always a very exciting and rewarding event.*

Indoor Air BULLETIN

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