#3324

μg/m³, more than 50 times EPA's standard of 150 μg/m³ for particles less than 10 microns in diameter over a 24-hour period.

While we don't know the health effects of breathing air containing high levels of minerals, CPSC is talking about what needs to be done to find out, according to CPSC's Sandra Eberle. Eberle told us that if lead or asbestos is in the water, there might be a significant health issue when that water is used for humidifiers. Ingested or inhaled lead is known to be a serious health threat; ingested asbestos is of undetermined health significance. But inhaled asbestos would be a more serious concern than asbestos ingested in water, Eberle said.

Humidifier manufacturers usually provide instructions covering most or all of what CPSC has recommended to minimize the potential problems. But, we now know that many consumers use tap water in humidifiers due to the expense and inconvenience of buying and using distilled or demineralized water.

CPSC Recommendations:

- Only distilled or demineralized water should be used, never tap water.
- Room humidifiers should be drained and cleaned well and often.
- Humidifiers should not be allowed to raise humidity above 60%, since fungi and bacteria are more likely to thrive at levels above that.
- Humidifier users should obtain a hygrometer to monitor relative humidity levels and maintain them between 30% and 50%; RH should never exceed 60%.

Part of CPSC's alert is shown in Figure 1. ♦

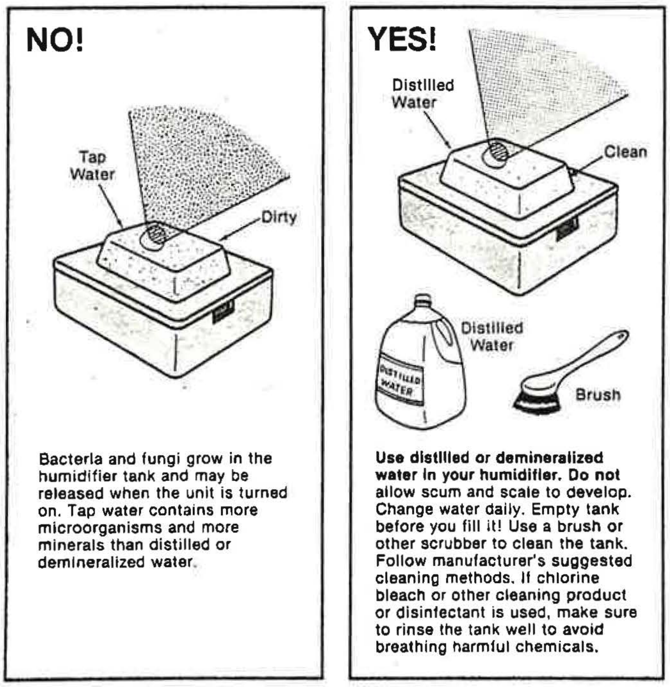

Figure 1

Feature

Selecting "Safe" Materials to Improve IAQ

New building materials, products, and furnishings emit a large number of chemicals into indoor air. Building occupants exposed to such chemicals often complain of irritation and discomfort. Exposure to contaminated indoor air apparently causes symptoms resembling the flu and known as sick building syndrome. Building-related illnesses such as hypersensitivity pneumonitis might also be caused by chemicals emitted by building materials and furnishings. We do not understand the health effects of many of these chemicals very well, but a significant percentage of them are known or suspected human irritants and many are suspected human carcinogens.

Designers, builders, owners, operators and occupants are increasingly concerned about indoor air pollution caused by these chemical emissions. They want to know which building materials and furnishings are safe and which ones aren't. Manufacturers are also worried about their legal exposure from unsafe building products and materials. Unfortunately, the answers are often not simple, clear cut or easy to obtain. However, some information is available on product contents and emissions. And there are tests which can provide more such information. We and others have devised procedures for evaluating products based on contents, emissions data, and published health effects data. This type of review can give you a basis for informed product selection, application, and use.

Building products and materials emissions testing has resulted in changes in building practices. Solutions to IAQ problems from chemical emissions include the following:

- Product selection — Designers and builders can use special procedures to select and specify products.
- Product modification or treatment — Manufacturers can change material components and design, seal surfaces, or "bake-out" harmful chemicals.
- Increased ventilation — Suppliers and contractors can increase ventilation of products during transport, installation, or use of materials with high initial emissions.

Selecting building products and furnishings involves many tasks. The newest, and for some people one of the most important, is evaluating the impacts of building materials on indoor air quality. We divide the evaluation of the IAQ impact of materials into four major phases:

1. Review products and materials and identify those likely to emit toxic or irritating chemicals in the completed building.
2. Screen target products and materials based on printed information from manufacturers and on published information.
3. Test selected materials to determine chemical content, emissions rate, or change in composition due to environmental exposure.
4. Make recommendations to the building owner and architect for material selections, modifications, or handling to control indoor air contamination.

Phase 1. Reviewing Target Products

A. Familiarization with Project

The first step is to become familiar with the overall design program (owner's requirements and directions to the designers), building design, and construction schedule. It is important to know how the building will be used and how the materials or products in question will be used.

The scheduling of construction and occupancy can also affect material choices and specifications for their installation. If construction takes place when major interior furnishings and workstations components are already installed, problems may arise. Airborne contaminants emitted during construction can remain on large-surface-area materials such as carpets and textiles and remain there until long after initial occupancy.

B. Reviewing Material Selections

The quantities and applications contemplated for materials will affect their potential emissions and impacts. Therefore, the next step is to review the intended uses of major interior materials or materials which will be exposed to the flow of ventilation air. Some of the most important materials are floor coverings, wall coverings, ceiling systems, HVAC duct materials, and furnishings. All "wet" application materials such as paints, adhesives, caulks, and sealants should also be considered.

The amount of surface area presented by a material to the circulating indoor air will also affect air quality. The more actual surface area, the higher the emission rate and the greater the adsorption and re-emission of volatile organic compounds (VOC) from other sources. Fabrics, insulation, and carpeting are very textured surfaces and present very high ratios between true-surface-area and plane-geometry surface area. These materials provide a virtually infinite surface area for adsorption and re-emission. They act like a sponge and retard the evacuation of off-gassing chemicals from the new building.

There are various criteria other than air quality for selecting certain products (for example, maintenance, initial cost, acoustics, aesthetics, and functional performance). We are concerned here only with learning about differences among functionally equivalent materials or products. But other considerations may require the use of certain types of products. In these cases, functionally equivalent products can still be compared to find the preferred one from the air quality perspective.

Products with clearly stable compositions such as metals and glass are not normally pollutant sources. Soft plastics, adhesives, textiles, composite wood products, fibrous insulations, and many weatherproofing compounds are often strong emitters.

The final step in the review phase is to identify products and materials that might emit toxic or irritating chemicals in the completed building. At this point, consider all questionable products and materials for further screening.

Phase 2. Screening Target Products

Based on the materials identified in Phase 1, begin screening major components of the building and furnishings by determining the following:

A. Quantitative assessment: their quantity and distribution in the building.

B. Chemical assessment: their chemical composition.

C. Chemical stability: the stability of chemical substances of concern.

D. Toxicity assessment: the toxic or irritation potential of their major chemical constituents.

The screening process can help determine which products and materials should be considered for further investigation.

A. Quantitative Assessment

Assessing quantitative use and distribution assessment involves determining the amount of material used per unit floor area or building volume. No standards have been established for the units to be used in these calculations. We think unit area and unit weight per unit of floor area are the most useful terms.

On the unit area or weight per unit area or volume basis, materials such as floor coverings and ceiling tiles are significant due to the large extent of their use; each has close to 100% coverage, (100 sq. ft. of material per 100 sq. ft. of floor area) in occupied open office areas of the building. If both the upper and the lower surfaces of the ceiling tiles are exposed to the circulating indoor air, the ceiling tiles would approach 200% (of floor area) coverage minus the area removed for lights, ventilation grills, etc. However, because ceiling tiles are not in close proximity to the building occupants, their significance is diminished. Air distribution patterns can also affect their significance.

Office workstation "work surfaces" (desktops) usually have between 20 and 35% coverage. In modern workstation component systems, desktop material is often used for workstation closet shelving. This can add an additional 10% to 20% to the coverage ratio. This material is usually exposed on both upper and lower sides, resulting in a total coverage of 60% to 110 % of the workstation area.

The net coverage would be calculated by including circulation space in the total calculation. Then the coverage ratio is about 50 to 85% of floor area. The work surface is considered especially significant due to the large amount of contact or close proximity between the office workers and the product. Also, the air circulates freely around all sides of the product (except, in some cases, the bottom), thereby increasing emission rates.

The work surface is often a plastic laminate covering a wood and particleboard core. If the laminate does not completely seal the unit, the interior materials are exposed to the airstream and emissions are greater. Completely sealed units will have much lower emissions from the materials inside the core.

The coverage of workstation interior partitions (normally about half-height on three and one-half sides of each workstation) varies with occupant or workstation density but approaches or exceeds 100% of the floor area in open office areas. Again, two sides of the product are exposed to the indoor air, and the product is in close proximity to the office workers.

B. Chemical Content

Next, assess the chemical content of candidate products. Use published general information on building products and materials and information from the building's interior designers, or from manufacturers' and suppliers' product literature and data sheets.

Obtain Manufacturer's Safety Data Sheets (MSDSs) by requiring all potential vendors to provide them for their products. MSDSs are

Table 1. Typical Materials of Concern, Especially in Office Buildings

Site Work and Foundations:
- insecticides and other soil treatments
- waterproofing, particularly petroleum derivatives

Structure and Envelope:
- wood preservatives
- concrete sealers, curing agents
- caulking
- sealants
- joint fillers
- glazing compounds or gasketry

Insulations:
- thermal insulation
- fire proofing
- acoustic insulations

Interiors and Finishes:
- subfloor or underlayment
- flooring or carpet adhesive
- carpet backing or pad
- carpet or resilient flooring
- wall coverings
- adhesives
- paints, stains
- paneling
- partitions
- furnishings
- ceiling tiles

HVAC systems:
- duct insulations
- duct sealants
- chemical water treatment

documents mandated by the Occupational Safety and Health Administration (OSHA), which list all hazardous substances contained in the products they cover. MSDSs are available for most building products.

OSHA requires that all relevant MSDSs be available to workers exposed to hazardous substances. Whether in a factory or at a construction site, each substance used in building materials, products, and furnishings is theoretically covered by an MSDS.

Right-to-know laws are resulting in more ready availability of MSDSs. However, the information contained in them is not always sufficiently specific. Also, some authorities believe it is not always very accurate.

If important questions are not resolved by the information in MSDSs, ask the vendors to provide it. If they want to make the sale, they will probably cooperate. Specific information requests will get specific answers, so be as clear as possible in making your request.

If a particular product is assembled by a manufacturer from chemical or material components supplied by others, require the manufacturer to provide the names of suppliers of each product incorporated in the product assembled by them. Also, require potential vendors to provide contact information for each of their suppliers and to request the contact individual to cooperate with the design team. Contact these secondary suppliers and manufacturers to obtain additional MSDSs and other information.

Some materials will be composed of a large number of chemicals. For example, typically over 30 chemicals are used in the production of fabrics covering free-standing interior partitions. However, not all of the chemicals are in the end product; some may be part of the processing of the fabric but are removed before completion. It is important to determine the function of each constituent chemical and how much is present in the finished product.

So, in addition to the MSDS, request that the name of each chemical or material in the product be identified. Ask for a description of its function in the manufacturing process or the finished product. For example, in the free-standing office partition, the fabric is attached to a metal, lumber, or tempered hardboard frame, usually by an adhesive. The panel usually contains acoustic material such as fibrous glass batting or urethane foam glued to a hardboard sheet. There are also metallic components used for the exposed frame of the panel and for the adjustable legs that support the panel above the floor.

In general, our experience has been that aspiring vendors are very cooperative in providing the required information. But this is not always the case, and designers should not be put off by one manufacturer's unwillingness to cooperate. Unwillingness to divulge chemical content information may not indicate something to hide; it may be that the information is not readily available or that proprietary considerations limit the advisability of responding. However, we have seen unwillingness that appeared to be a clear case of having something to hide.

The larger the project, the more likely it is that vendors will cooperate. Designers working on smaller projects might consolidate the information collection process for several projects at once. Or, they might spread out the effort over a one- or two-year period to increase the size of the market potential to induce manufacturer cooperation.

Clearly, as more architects, engineers, and interior designers ask for information, the more readily available it will become. As time passes, standard tests, reporting requirements, and formats will be established and the type of information we are describing will be available as standard operating procedure for product suppliers and specifiers.

C. Chemical Stability

Chemical stability refers to the rate of emissions, the total emissions, and the length of time required for emissions to diminish to a long-term, reasonably steady rate. Emission rates vary not only with different products but also with different environmental conditions or exposure. Also, the product history prior to installation in a building can significantly affect the level of emissions once the product is in the building.

In general, the warmer the environment, the higher the emission rate. This is easily understood by considering water evaporation in warm weather and in cold weather. However, even in cold weather, if the air is very dry, water will evaporate rather quickly. This is because the difference between water pressure in the container and in the air will affect the tendency of water to evaporate. This is true of all chemicals to some degree.

Stability (chemical emissions) assessments are not easy to do without using test information. Only a handful of materials have been tested. (Testing is discussed in the following sections.) However, it may be useful to review written information when determining potential emissions. Assessments are done by reviewing the vapor pressure and molecular weight data for the hazardous chemicals identified on the MSDSs. The data is available from many sources (see the list of references at the end of this article).

Emission factors can vary significantly up to a factor of 1,000 for different brands of similar products. Therefore, it is important to obtain as much information as possible about the identity and quantities of constituents in a specific product. While such a paper evaluation cannot be definitive, it can be useful in screening products. It also can be useful by identifying specific compounds to be measured by emission testing.

Theory of Chemical Emissions

The tendency of a chemical to evaporate from a product into the air is a function of its vapor pressure and the quantity of the chemical present. Vapor pressure of a chemical in a particular material depends on the characteristic vapor pressure of the chemical, the concentration of the chemical in the material, and the temperature of the material. Emission is a function of the difference between the vapor pressure of the chemical at the surface of the material and the concentration of the chemical in the air immediately above the surface. The higher the vapor pressure, the more it will evaporate at a given temperature. Vapor pressures for some common substances in indoor air are given in Table 2.

This theory is primarily of interest to those doing studies of emissions or to those formulating products. In practice, designers must rely on test results, and these tests must be done under standardized or comparable conditions to be useful in making choices.

EPA Emission Test Data

Only limited data are available on emission rates, primarily from EPA, the Saskatchewan Research Council, Lawrence Berkeley Laboratory, and Oak Ridge National Laboratory. Interest and work in the area are currently surging, and substantially more information will be available in the next few years. Some sample data is provided in Table 3.

EPA is now developing a database on building material emission rates. NASA has developed a large database for spacecraft design and operation. Work currently in progress will make both of these databases accessible and useful to the design professional at this point in the product evaluation process.

D. Toxicity Evaluation

You can evaluate the toxicity or irritation potential of constituent compounds by using standard reference sources. For example, Irving Sax's *Dangerous Properties of Industrial Materials* lists a "summary of toxicity statement" or rating (THR) for each substance covered. It gives ratings of "none," "low," "moderate," "high" or "unknown". The book describes routes of entry for specified toxic effects. LD_{50} (lethal dose for 50% of experimental animals) are given for various exposure routes and experimental species. It also lists human irritation potential and target organs or sites and reports carcinogenic and mutagenic assessments.

NIOSH's *Registry of Toxic Effects of Chemical Substances, 1981-1982, Volumes 1-3 (RTECS)* plus the *RTECS 1983-4 Supplement* (two volumes) provide an annotated listing of toxicity and irritation research for tens of thousands of chemical substances. *RTECS* also provides a comprehensive list of alternative trade and generic

Table 2. Vapor Pressures of Some Representative Indoor Air Chemicals

Chemical	Vapor Pressure[a] (mmHg @ T°C)
Acetone	89 @ 5 400 @ 39.5
Acetic acid	11 @ 20
Benzene	75 @ 20
Butadiene	910 @ 20
Chlorpyrifos	0.0000187 @ 20
Ethylacetate	76 @ 20
Ethylbenzene	7.1 @ 20
Napthalene	0.05 @ 20
Paradichlorobenzene	0.6 @ 20
Pentachlorophenol	0.0002 @ 20
Styrene	4.5 @ 20
Tetrachloroethylene	14 @ 20
1,1,1 Trichloroethane	100 @ 20
Toluene	22 @ 20
Undecane	1 @ 32.7
Xylenes	7/9/9[b] @ 20

(a) mmHg @ T°C = millimeters of mercury at temperature in Celsius

(b) These are the values for each of the three isomers of xylene, ortho-,meta-, and para-xylene.

names by which products may be known or marketed, chemical formulas, and cross references to the Chemical Abstracts Service (CAS) number for each chemical.

RTECS has been updated, but we have not yet seen the current version. You should contact NIOSH or a Government Printing Office bookstore to obtain a copy. This is the most comprehensive source we know of for toxicity data. It consists of several thick telephone-book-size volumes with print even smaller than in the phone book. It is reasonably priced (less than $100), and lists every commercial chemical with synonyms and names in other languages. It contains the results of relevant toxicity studies with references to the original publications.

From your review of toxicity, determine which materials will require laboratory testing. A combination of high volatility and moderate toxicity would call for further investigations of the substance and the product. A very low volatility and moderate toxicity calls for consideration of the quantity of the product to be used and the quantity of the hazardous substance present in that product. No algorithm has been established for this evaluation; a qualitative assessment is the most reasonable approach given the limited amount of data currently available.

Results from Screening

The results of this screening process allow you to identify the products most likely to emit significant quantities of irritating or toxic substances. Based on our experience, these are likely to be the carpet system (carpet, pad or backing, and adhesive), workstation (office furnishings), work surfaces and interior partitions, and ceiling tiles. Shelving materials, adhesives, sealants, caulking compounds, and some wood finishes

Table 3: Typical Emission Rates for Sources in a 400 m^2 Office Area (total vapor-phase organic compounds, except as noted)

Source*	Condition	Emission Factor (mg/m^2-h)**	Assumed Amount (m^2)	Emission Rate (mg/h)
Silicone caulk	<10 hours	13	1	13
Silicone caulk	10-100 hours	<2	1	<2
Floor adhesive	<10 hours	220	30	6,600
Floor adhesive	10-100 hours	<5	30	û
Floor wax	<10 hours	80	100	8,000
Floor wax	10-100 hours	<5	100	
Wood stain	<10 hours	10	100	1,000
Wood stain	10-100 hours	<0.1	100	<10
Polyurethane wood finish	<10 hours	9	100	900
Polyurethane wood finish	10-100 hours	<0.1	10	<10
Floor varnish or lacquer	NA	1	100	100
Particleboard	2 years old	0.2	300	60
Particleboard (HCHO)	new	2	300	600
Plywood paneling (HCHO)	new	1	1,000	1,000
Chipboard	NA	0.13	300	39
Gypsum board	NA	0.026	1,000	26
Wallpaper	NA	0.1	1,000	100
Latex-backed carpet (4-PC)	1 week old	0.15	400	60
Latex-backed carpet (4-PC)	2 weeks old	0.08	400	32
Moth cake (para)	23°C	14,000	0.1	1,400
Dry-cleaned clothes (perc)	0-1 day	1	6	6
Dry-cleaned clothes (perc)	1-2 days	0.5	6	3

Notes:
Para = paradichlorobenzene
HCHO = formaldehyde
Perc = perchloroethylene (tetrachloroethylene)
4-PC = 4-phenylcyclohexene, an odorous constituent of some latex-backed carpets
NA = not available

*Emission data shown are typical only for the specific brands, models, or units that have been tested; the data do not represent all products of the source listed. Product-to-product variability can be very high.

**Typical values selected by Tucker, W.G., cited in references for this article on data in "Database of Indoor Air Pollution Sources" are also materials worthy of concern. These materials can be evaluated by emissions testing.

Step 3. Testing Selected Materials

Test methods for building materials and furnishings include bulk testing and air sampling from environmental chamber and headspace testing. Air sampling can also be done in the completed building prior to, during, and after materials installation to develop air quality profiles of the installation.

Bulk Testing

Bulk testing involves extracting chemical contents with a solvent and then analyzing the chemical content of the solvent. The test can be performed on new materials and again on aged materials. The difference in the results before and after aging indicates the emissions that have occurred in the interim. Results will be limited to the substances that can be extracted by the solvent chosen. Different solvents can be used to obtain a more complete profile.

Chamber Testing

There are two basic types of chamber tests: 1) screening or comparative testing, and 2) emission rate determinations.

Screening tests involve fewer samples, less time, and naturally, less expense. You can use them effectively to compare two or more products, but you must be careful to define the time period in which you are interested. You can use emission rate determinations to calculate probable air concentrations, air concentration changes over time, and air concentration changes due to fluctuations in ventilation rates, temperature, and other factors.

Chambers

Chamber sizes vary from very small chambers (less than 0.1 cubic meter) to full room-size chambers. Small chambers are more common than larger ones. The purpose of the testing and the nature of the materials to be tested will determine the appropriate chamber size. The availability and cost of testing will also determine chamber size.

An advantage of using a medium or room-size chamber capable of accommodating full-size samples is elimination of the need to cut samples. When samples are cut, their edges are exposed and the test material is no longer as fully representative of the product that will be in the building. A disadvantage to using larger chambers is the difficulty of closely controlling the chamber environment, the need to sample and analyze more air, and the increased costs of the chamber and its use.

A guide for emissions testing in small chambers is being developed by ASTM (see *IAQU*, December 1988).

Test Conditions

Ratios of material surface area and weight to chamber volume and wall area should be reasonably similar to the ratios found in actual building situations. Multiple material tests may also be run to determine "sink" effects — the tendency of materials to adsorb airborne substances on their surfaces and re-release them to the air.

Air movement in a chamber should be at air exchange rates which approximate those found in buildings — between 0.5 and 8 air changes per hour. Humidity should be controlled during the chamber tests. Relative humidity is generally in the 50% to 55% range in most chamber tests.

Airflow should be controlled within the chamber to assure good mixing and to minimize unusually high velocities at material surfaces. Air should be introduced and removed from the chamber to induce complete mixing. This can be done through perforated headers placed diagonally from each other at the bottom and top of opposite chamber side walls. Alternatively, two opposing surfaces may be fully perforated and serve as inlet and outlet.

Material Handling and Conditioning

In order to best meet the purpose of the testing, handling of the material should resemble the handling that is employed in actual installations of the materials in buildings. Products should be stored in factory containers until testing, and once opened, kept in a normally ventilated room containing typical new office furnishings until additional testing is conducted. Complete and careful record keeping is essential to the correct interpretation of testing results.

Pre-Conditioning Test Materials

When you are performing laboratory testing or field testing, it is important to consider the history and aging of the products being tested. Any exposure to the environment after manufacture constitutes aging. Materials which are in sealed containers tend not to age very much. However, containers may change the distribution of chemicals within or on the products without affecting the total quantity of each chemical present. For example, chemicals may migrate within a container, creating surface contamination from chemicals being emitted from the interior or the back of a product.

Materials can be aged in environmental conditions resembling the building where they will be installed, or the aging process can be accelerated by heating, exposure to high ventilation rates, or exposure to ultraviolet light. Each of these will potentially accelerate the aging process.

To condition material samples before chamber testing, place them in the chamber at a controlled temperature and under forced air circulation for several hours or even days prior to testing. Needless to say, all materials being tested for comparative purposes should be conditioned similarly.

Headspace Testing

Headspace testing is really small chamber testing, but the test does not evaluate dynamic performance of materials under controlled airflow conditions. Instead, it is most useful as a screening test to identify the predominant compounds and to grossly characterize the strength of the emission source. Researchers often use it prior to chamber testing to enable design of appropriate test period, collection media, sampling rates, and other important aspects of the chamber testing.

For headspace testing, materials are placed in a sampling container and allowed to offgas for a given period of time. Then, the air above the sample within the container is drawn (pumped) through sample collection media such as charcoal, tenax, XAD-2 resin, ambersorb, or a cryogenic sampling train, and/or it is injected directly into a gas chromatograph for analysis.

The Clean Glass Jar Test

In a previous ***IAQU*** article, "Are There Any Safe Carpets" we described a subjective, no-cost method for evaluating carpet samples called the "sniff" test. Subjective evaluation of odors has been systematized and made more reliable and repeatable by the work of Ole Fanger from Denmark with his olf and decipol ratings. (See "Fanger, the olf and the decipol" in ***IAQU***, October 1988.)

The sniff-test method, summarized below, applies to materials other than carpets. It tests plywood, particleboard, fabric, ceiling tile, virtually any solid material. Finishes, paints, caulks, sealants, adhesives, and other "wet" materials can also be tested that way as well as in the chamber.

For wet materials, ideally the product is applied to a sample of the material it will be applied to in the actual building. Paint is applied to sheet rock or wood, caulking on wood, etc. That way, if there are "secondary" chemical reactions between the wet material and the surfaces receiving them, the test allows these to occur and be evaluated. This is true of headspace testing and chamber testing as well as the glass jar test.

How to Conduct a "Sniff Test"

Place the samples from each product in separate clean glass jars. Seal the jars with aluminum foil, dull side facing the sample. Leave the samples at least overnight. Moderate heating (not more than 100F) for a few hours might be helpful. Do not overheat the samples as that will distort the emissions compared to those which will occur in the building situation. The effort is to replicate the conditions to which the sample will be exposed. The jar test concentrates the emissions and the heating accelerates the process.

Next, open the jars in an odor-neutral environment with good ventilation and sniff the samples. Rate the samples for strength of odor, degree of pleasantness or unpleasantness, and any irritation or other physiological effects you might experience. You can have several people participate, and you can repeat the process two or three times. You might try doing the test "blind," without the people knowing which sample they are sniffing.

If you have several jars and several samples, you can do comparisons. But remember, your reactions will change during the first few seconds you smell the odors. So do not linger over any one jar. And keep the jars closed except when you are actually sniffing.

Of course, all of this effort is useful only if your samples are representative of what will be in the building. Know what you are getting, where it is coming from, and how representative it is. For example, don't take showroom samples. They may have been sitting around for a long time. Get pieces cut from rolls or from the middle of the box for carpet tiles.

Results

You need to summarize all of the information gathered during the various steps in the evaluation and integrate into some useful form for decisionmaking. There will be few cases where the choices are easy or where all of the desired data are available. However, by organizing the information into a consistent

For More Information

Many publications are available which can be useful in evaluating materials. Here are a few which we frequently use in our work:

ACGIH, 1980. *Documentation of the Threshold Limit Values*, 4th ed. Cincinnati: American Conference of Governmental Industrial Hygienists Inc.

ACGIH, 1982. *Industrial Ventilation, a Manual of Recommended Practice*, 17th ed. Cincinnati: American Conference of Governmental Industrial Hygienists Inc.

Clayton, G.D., and F.C. Clayton, eds. 1981. *Patty's Industrial Hygiene and Toxicology*, 3d rev. ed, Volumes 1-3. New York: John Wiley & Sons.

Hawley, G.G., 1981. *Condensed Chemical Dictionary*, 10th ed. New York: Van Nostrand Reinhold Company.

ILO. 1983. *Encyclopaedia of Occupational Health and Safety*, 3d rev. ed., L. Parmeggiani, technical ed., 2 vols. Geneva: International Labor Office.

Gosselin, R.E., R.P. Smith, H.C. Hodge, and J. E. Braddock, 1984. *Clinical Toxicology of Commercial Products*, 5th ed. Baltimore: Williams and Wilkins.

Kent, J.A., ed. 1983. *Riegel's Handbook of Industrial Chemistry*, 8th ed., New York: Van Nostrand Reinhold Publishing.

Matthews, T.G., and R.R. Westley, 1983. "Determination of Formaldehyde Emission Levels from Ceiling Tiles and Fiberglas Insulation Products," Project Report. Oak Ridge, Tenn.: Oak Ridge National Laboratory.

National Academy of Sciences, 1975. *Principles for Evaluating Chemicals in the Environment*, Washington, D.C.: National Academy of Sciences.

NIOSH, 1983. *Registry of Toxic Effects of Chemical Substances, 1981-2, Volumes 1-3*. Cincinnati: National Institute of Occupational Safety and Health, U.S. Public Health Service.

NIOSH, 1985. *Registry of Toxic Effects of Chemical Substances, 1983-4 Supplement, Volumes 1-2*. Cincinnati: National Institute of Occupational Safety and Health, U.S. Public Health Service.

NIOSH. 1985. *Pocket Guide to Chemical Hazards*, Cincinnati: National Institute of Occuational Safety and Health, U. S. Public Health Service.

Olin, H.B., J.L. Schmidt, and W.H. Lewis, 1980. *Construction: Principles, Materials, and Methods*, 4th ed. Chicago: The Institute of Financial Education and the Institute of Printers and Publishers.

Roytech, 1988. *Suspect Chemicals Sourcebook*, Burlingame, California.

Sax, N.I., 1979. *Dangerous Properties of Industrial Materials*, 5th ed. New York: Van Nostrand Reinhold.

Sittig, M., 1985. *Handbook of Toxic and Hazardous Chemicals and Carcinogens*, Park Ridge, N.J.: Noyes Publications.

Tucker, W. G., 1988, "Emissions of Air Pollutants from Indoor Materials: An Emerging Design Consideration." Presented at the 5th Canadian Building and Construction Congress, Montreal, Canada, November 27-29. (Available from W.G. Tucker, EPA, Research Triangle Park, NC 27711 (919) 541-2746.

Verschueren, K., 1983. *Handbook of Environmental Data on Organic Chemicals*, 2nd ed. New York: Van Nostrand Reinhold.

Watson, D.A. 1980. *Construction Materials and Processes*, 2d ed. New York: McGraw-Hill Book Company.

format for comparison, you can bring some rationality to the decision process.

Some of the information will immediately suggest mitigation measures or control measures for products, and you can often implement those without substantial additional cost to designer, owner, or builder. Others may require changes in materials, design, treatment or installation. Following are some types of recommendations we have made in past evaluations.

Phase 4. Making Recommendations

You can recommend any of the following actions:

- Modify the product to change its emissions rate or content.
- Condition the product prior to bringing it into the building.
- Condition the product in place in the building.
- Change the installation procedure.
- Isolate the product within the building to reduce occupant exposure to unavoidable emissions.
- Assure adequate ventilation wherever the product is used or whenever occupants are in the areas where it is used.
- Collect additional information.
- Evaluate other brands of a product or material.
- Consider using a different type of product or material.
- Conduct further testing.
- Modify the product to change its emissions rate or content; this might involve using different materials, different assemblies or different manufacturing processes.

Condition the Product Prior to Installation

An added step in the manufacturing or a change in the packaging, storage, shipping, and handling of a product could provide opportunities for emissions to occur before it is brought into the building, rather than once the product is inside. It is hard to obtain and maintain good IAQ when large quantities of organic chemicals are released from products inside the building, where they can be adsorbed on surfaces and re-emitted in a long-term, continuing process.

Condition the Product in Place

Maintaining ventilation rates at a maximum during installation and afterwards can effectively remove initial emissions from many products. Heating the material (use caution) will also accelerate the emissions process. The longer the bake-out or airing-out time period, the more effect it will have.

Change the Installation Procedure

Many floor covering installations including carpeting, resilient tile, wood, ceramic tile, or other materials set in adhesive, will be safer if you reduce the amount of adhesive used. Manufacturers of the flooring usually supply the specification for installation and adhesive. Advise the manufacturer's technical representative that you wish to use their product but only if they will provide a specification involving the minimum amount of adhesive that will perform the required function. Further, ask the manufacturer to specify an adhesive with the minimum of toxic or irritating chemicals in the adhesive product.

Isolate the Product Within the Building

You should locate unavoidable emissions within the building so that air exhausted from the area around them is vented to the outside, not recirculated. This can be done on a temporary basis during construction or on a long-term basis, where required.

Assure Adequate Ventilation

Many office buildings now operate under special ventilation protocols prior to or shortly after initial occupancy to "bake out" chemicals from materials, products, and furnishings.

Products and Services

Enkavent: For Quick, Easy Radon Mitigation

A new product for radon control looks like it is easy to install, economical, and effective. It is for use in a subslab depressurization system. While most useful in new construction, there are many existing structures where it may be far more practical than the alternatives. In some, it may even be the only feasible alternative.

The product literature we received says:

"Enkavent Radon Control Mating is a synthetic geomatrix composite consisting of nonwoven geotextile heat bonded to a durable and resilient nylon core of open construction."

What is a "synthetic geomatrix composite"? It is a three-dimensional plastic wire mesh that is strong enough to support a concrete slab placed on top of it and open enough to allow gas to pass through it. In fact, it is mostly open space and provides less resistance to the flow of soil gas than drain rock or gravel. And, it is certainly easier to handle and quicker to place.

Installation

(see Enkavent figures)

1) 2) 3)

Figure 1

1. Unroll the Enkavent matting with fabric side down. Lay a continuous strip of Enkavent along the basement perimeter.
2. Nail to the wall at Enkavent hinge. Adhere expansion joint stripping above the Enkavent through the center of the parallel to the longest wall. Overlay the subfloor with a vapor barrier extending up the wall to meet the expansion joint stripping.
3. Cut a three-inch hole in the vapor barrier eight inches from the most appropriate corner. Glue a four-inch flanged riser pipe with a detachable cap to the vapor barrier. Pour the slab.

Additional Measures

Also from the sales brochure are the following "Common sense mitigation tips."