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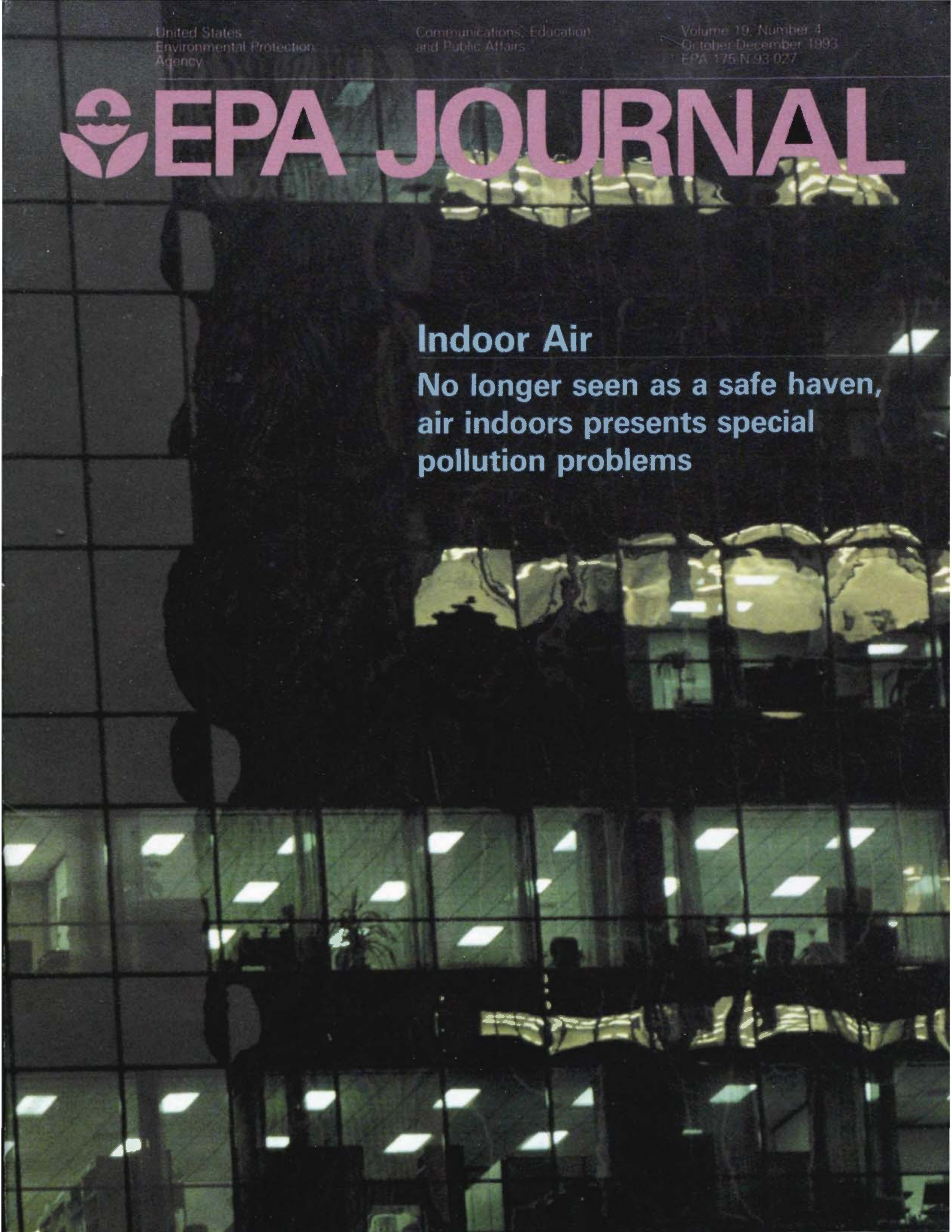

Indoor Air

No longer seen as a safe haven, air indoors presents special pollution problems

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Some sad news: New England and EPA lost a true advocate for the environment with the death of Paul G. Keough, Deputy Regional Administrator in Region 1. Paul was well known as a tough enforcer, a fair administrator, and a superb communicator. He was also a national leader in promoting environmental education and EPA's human resources, as Administrator Browner recognized by creating the Paul G. Keough Award for Administrative Excellence. He will be sorely missed.

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From the Editors

Mention air pollution, and most of us think of *outdoor* air pollution and regulatory standards under the Clean Air Act. Those of us who live in certain urban areas may think of "inversion" effects and smog alerts, when we may be advised against exercising out of doors.

But what about indoor air? Comparatively recent exposure monitoring studies, based on a concept called "total exposure assessment," have called into question the notion that indoor environments are a safe haven from air pollution. In fact, certain pollutants, such as benzene (a component in environmental tobacco smoke, or ETS) are sometimes found at higher levels indoors than outside. The implications of these findings are compelling. After all, 90 percent of our time, on average, is spent in indoor environments including residences and workplaces, various public and commercial buildings, and private and public transport vehicles (cars, buses, subway and other trains, and airplanes).

Outdoor ambient air-quality standards do not apply to indoor air. Even if they did, however, few observers believe that a traditional, pollutant-by-pollutant approach would be adequate to solve indoor air pollution problems. Among other reasons, many more pollutants are involved (4,000 in ETS alone) than are regulated in outdoor air, and there are many unanswered questions about such phenomena as "sick building syndrome" and multiple chemical sensitivity. What, then, is the best approach for protecting indoor air quality? Not everyone agrees, but several contributors to this issue of *EPA Journal* explore this question. Related articles discuss cutting edge research, regulatory and nonregulatory initiatives, and proposed legislation. Take a deep breath, and stay with us. □

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The U.S. environmental Protection Agency is charged by Congress to proteect the nation's land, air, and water systems. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

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Contributions and inquiries are welcome and should be addressed to: **Editor, *EPA Journal* (1704), Waterside Mall, 401 M Street, SW, Washington, DC 20460.**

IAQ: Whose Responsibility?

The problem is not energy conservation

by Hal Levin

A popular myth holds that energy conservation measures, implemented since the oil crises of the 1970s, cause indoor air pollution problems. This myth ignores the fact that most indoor air pollutant sources have little or nothing to do with energy conservation. In at least one study conducted before 1973, the air inside buildings was found to be more polluted than outdoor air even during severe air pollution events. In fact, only two types of conservation measures directly increase indoor air pollutant concentrations: inappropriately reducing ventilation and using sealants and caulks that emit pollutants.

The myth ignores the fundamental responsibility (and ability) of architects, engineers, and building operators to create indoor environments that are both habitable and environmentally responsible. Achieving good indoor air quality (IAQ) is as essential as providing comfortable, healthy thermal conditions and functional, aesthetically sound lighting and acoustical environments.

How Ventilation Affects IAQ

Changes in ventilation rates generally affect IAQ only indirectly. What directly impacts IAQ is the *relationship* between ventilation and pollutant sources. Consider the following three factors.

First, there would be no indoor air contamination if there were no pollutant sources. The sources have changed in number and kind during the past 45 years or so; abundant, harmful pollutant sources have resulted from new building materials, furnishings, equipment, and consumer products.

Second, thermal control has become the dominant driving force in system design. The need to maintain good IAQ by adequate outdoor air exchange has become incidental.

Finally, in the majority of buildings with IAQ problems, ventilation systems do not function as designed. Many of these failures result from problems in operation and maintenance. As many as 75 percent stem from design and construction flaws because designers simply did not place enough emphasis on IAQ.

Thermal Control vs. Air Quality

Historically, ventilation requirements were set to maintain air quality. In the 19th century, before people began to bathe frequently and use personal deodorants, rates were specified to keep human body odor at acceptable levels. Traditionally, architects and engineers designed mechanical or natural building ventilation on the basis of established outside air requirements for assumed occupant loads and activities in the building program.

With the advent of variable air volume systems in the 1950s, thermal control objectives came to drive system design. The shift became more important as buildings became larger. There was more space remote from the envelope, or exterior, of the building and concomitant lost access to daylight and ventilation through windows. This shift has led to the notion that "energy conservation causes indoor air pollution." At most, reduced air exchange to conserve energy exacerbates IAQ problems, but, for the most part, the causes of indoor air pollution are not the direct result of energy conservation.

Determining Loads

Maintaining a healthy, safe, and productive environment requires that ventilation be sufficient to maintain a quality. The amount of ventilation required depends on the occupant density, the types of activities that tal place in the building, and the strengt of pollutant sources (from equipment building materials, and consumer products). Since these factors vary independently, it is difficult to provid universally applicable ventilation rate: The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) sets minimum ventilation values, but these assume r "unusual sources" of indoor pollutant The burden is on designers to determine the nature of pollutant sources and whether they require moı than the recommended minimums.

Sources of Indoor Air Pollutants

There are many sources of pollutants in buildings, and they vary considerably from building to building For that reason, addressing these sources effectively must be part of the design process. Simply following the general guidance for ventilation as a means of controlling pollutants means choosing the default solution; it does not represent the best effort of a good designer.

It is important to understand the relative contributions of various sources and to address the strongest ones. We must go after the ones with the most surface area, the most mass, and the emissions that we know or believe to be most irritating or toxic.

Emissions from new building materials far exceed emissions from aged materials. However, maintenance refinishing, and replacement activities do result in significant increases in

(Levin is a California research architect and editor of Indoor Air Bulletin.)

The fundamental responsibility of architects, engineers, and building operators is to create habitable indoor environments. *Mike Brisson photo*

pollutant emissions. Therefore, the durability of a material impacts IAQ significantly. It is important to note that "wet" products such as paints, adhesives, caulks, cleaners, waxes, and polishes emit very large fractions of their mass into the building air, and usually soon after application. However, even after these products are functionally dry, they continue to emit very slowly for a very long time.

In the past 40 years, building materials have changed in ways that make them stronger sources of indoor air pollutants than "traditional" materials. For example, composite wood products have replaced solid wood materials, bringing binders, adhesives, and other chemical additives indoors. The best-known and perhaps most widely used examples are particleboard, plywood, and other composite wood products based on urea-formaldehyde resins. Fortunately, these resins are being replaced by more stable phenol-formaldehyde resins, and some manufacturers are developing and even marketing products that use no formaldehyde-based resins at all.

New low-emitting adhesives are now available for installing flooring products. Paints that use far less organic solvent are also becoming more common. However, replacing a strong emitter with a nondurable, low-emitting product may result in more maintenance and replacement. This can mean more frequent, short-term emissions. Durability can therefore be a very important determinant of IAQ.

Architects' and Designers' Roles

Architects and designers can substantially reduce indoor air pollution by proactively minimizing undesirable sources. They can limit chemicals with known toxic effects to levels that will not cause adverse reactions. For example, the California Air Resources Board recommends that formaldehyde levels not exceed 50 parts per billion. Since it's known that most particleboard, plywood, hard-board fiberglass insulation batts and boards, some textiles, and many other building products emit formaldehyde, architects and designers must try to limit their quantities, select lower-emitting products, or choose substitute materials. They can calculate emissions from these products based on test data. Knowing ventilation rates, they can estimate formaldehyde concentrations in indoor air and change specifications if necessary.

This approach, although it seems rather unscientific and not very specific, is, in fact, similar to the way we design illumination and acoustic and thermal control. This brings us back to our title topic. We don't say that energy efficiency causes poor lighting or visibility problems in buildings; instead we determine what lighting levels are necessary to perform the task for which the building is designed and built, then we attempt to achieve those levels in an energy-efficient manner. We must recognize the need to apply the same approach to IAQ. □