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CIAR will provide grants twice annually. Applications for July 1, 1990, funding are due December 31, 1989.

Concerns about the objectivity and independence of scientists often surface when tobacco industry funding is involved in research or public policy debates involving IAQ. We have heard from several respected researchers that those who accept funding from CIAR will be tainted because the organization is sponsored by the tobacco industry.

There seem to be three issues for potential applicants to consider. First, will the grant applications be fairly and objectively evaluated on the basis of their scientific merit and public health significance? Second, will the research results and their publication be affected by the funding source? Third, will the investigator's reputation or conscience be affected by the funding source?

To try to answer some of these questions, we called CIAR. We asked about the nature of the grant application review process and about approval of reports for publication. We spoke with Lynn Kosak-Channing, Ph.D., staff scientist at CIAR, who had originally sent us the CIAR "Request for Applications" and asked that we publish an announcement. Dr. Kosak-Channing told us the reviews will be conducted by competent scientists and based on objective criteria. Publication of results is the responsibility of the investigators, and it will not depend on CIAR approval of results.

Subsequently, CIAR Executive Director Dr. Max Eisenberg called us to offer some additional information.

Eisenberg told us that CIAR has already received more than 70 letters of intent from virtually every major U.S. research institution. This is not surprising, since there really are no other significant sources of funding for unsolicited research proposals on indoor air quality. Also, most of the public agencies and private organizations that fund extramural research are having difficulty obtaining funding to support the work they have started.

Whether funding by CIAR will affect an investigator's reputation or conscience is not easily addressed by anyone but the individual involved. While the tobacco industry clearly has a point of view and a large economic interest, much good science has come from direct industry-funded research. All industries conduct research to enhance their own position, and the concerns raised here are not limited to the tobacco industry by any means. Even funding from certain government agencies carries the potential for bias; good science is often a matter of point of view or underlying values.

For more information, contact: Center for Indoor Air Research, 1099 Winterson Road, Suite 280, Linthicum, MD 21090; (301)684-3777. ♦

On the Horizon

Ozone and Indoor Air: Myth and Reality

Last year, the prestigious journal *Science* published an article that stated, in part, that "human exposure ... [to ozone] is limited to time out of doors because structures protect occupants" (Milton Russell, 9 September 1988, p. 1275). Now Morton Lippman of the New York University Medical Center has reinforced the myth that people's exposure to ozone is primarily outdoors.

Writing in the May 1989 issue of *JAPCA* (*Journal of the Air Pollution Control Association*), Lippman states: "Indoor concentrations of O_3 are almost always substantially lower than those outdoors due to the efficient scavenging by indoor surfaces and the lack of indoor sources." The truth of this statement depends on two factors: (1) how one understands the word "substantially," and (2) how much time is spent in well-ventilated versus poorly-ventilated structures; the more time spent indoors in a well-ventilated room, the greater the fraction of ozone exposure.

High Indoor Ozone

Research at Bellcore (Bell Communications Research in Red Bank, New Jersey) has recently demonstrated that indoor ozone concentrations are frequently a significant fraction of outdoor values. These findings are supported by a number of earlier studies. Since most people spend greater than 90% of their time indoors, the Bellcore researchers hypothesize that indoor ozone exposure (concentrations x time) is usually greater than outdoor exposure.

Importance

Why is this important to those concerned about indoor air quality? One reason is that research has recently shown that deleterious health effects occur at ozone exposure levels far lower than previously believed. Effects of short-term exposure to elevated levels of ozone include increased pulmonary irritation. There is mounting evidence of chronic effects from longer-term or recurring exposures at lower levels.

Lower Standards?

Another reason is that scientists (Lippman included) are calling for lower ambient air quality limits for ozone. Some scientists suggest reducing the current one-hour limit of 120 ppb to 80 ppb. Building ventilation complying with ASHRAE Standard 62-1981 (or the soon-to-be-published Standard 62-1989) will need to control ozone when outdoor levels exceed legal limits. If the limit is lowered, buildings in most inhabited areas of the United States will be subject to ozone control requirements if they are to comply with ASHRAE Standard 62.

Furthermore, ozone levels exceeding the present outdoor limits now occur in rural as well as urban areas. An article in the June 20, 1989, issue of the *Journal of Geophysical Research* reported that ozone levels frequently exceeded 80 ppb in nearly every site monitored and occasionally exceeded 120 ppb in most sites.

Ozone Formation

Ozone forms when atmospheric NO_2 and hydrocarbons interact in the presence of strong sunlight. Hydrocarbon sources are abundant; plant metabolism, industry, consumer products, and fossil fuel combustion are among the major sources. NO_2 sources are primarily motor vehicle emissions. While most high ozone level episodes occur in the summer, ozone values exceeding 90 ppb were found in October and November in some rural sites.

Ozone "Scavenging"

In his article, Lippman cites "efficient scavenging by indoor surfaces" as a major ozone control. However, "scavenging" by indoor surfaces requires a significant contact time between the ozone and the surfaces. Ozone scavenging by indoor material surfaces usually requires a time scale of an hour or more, depending on the materials involved, the ratio of material surface area to volume, and the ozone air concentration. There is also some "natural" decay of ozone in a confined space that occurs through interaction of the ozone with other constituents of the air. However, this decay is negligible in even minimally-ventilated buildings.

Table 3 — Measured Values of Ozone Decomposition Rates for Several Common Surfaces

Material	K ft^3/ft^2 – min	
Cotton muslin	0.214	→0.029
Lamb's wool	0.208	→0.008
Neoprene	0.19	→0.03
Plywood (1 side varnished)	0.06	→0.01
Nylon	0.063	→0.001
Polyethylene sheet	0.048	→0.020
Linen	0.0185	→0.0107
Lucite	0.012	→0.001
Aluminum	0.002	→0.001
Plate glass	0.002	→0.001

A simple equation to characterize indoor ozone levels looks something like this:

Indoor ozone level = [(rate of supply of outside air) (ozone concentrations in outside air)] - [(decomposition rate for each material) (surface area) (contact time)]

This oversimplified equation ignores indoor sources of ozone such as copying machines, laser printers, electrostatic precipitators, and other electrical arcing devices. These sources are not normally major contributors to indoor ozone levels, although they can be under certain circumstances.

Table 3 shows relative decomposition rates for several common materials. The "K" values represent an experimentally derived rate constant, and the numbers allow comparisons of the listed materials. The values at the left are the decomposition rates at the beginning of the test. The values at the right are the rates after the materials had been exposed to ozone in the test chamber for several hours.

These results indicate that a rapid reaction occurs when materials are initially exposed to ozone, and that the reaction products slow subsequent ozone decomposition. These longer-term rates that indicate a slower decomposition are the ones that interest us. They show us that Lippman has overstated the removal effectiveness of material surfaces, especially where a reasonable ventilation rate is maintained.

Ventilation and Ozone

The ventilation rate is critical to ozone removal by material surfaces. Where ventilation rates are very low, say less than 0.4 or 0.5 air changes per hour (ACH), indoor ozone levels will stay substantially lower than outdoor levels. This is because there is less new ozone-filled air overwhelming the capacity of material surfaces to remove ozone.

Indoor ozone decomposition was identified more than 15 years ago. Research done since the early 1970s shows that indoor levels often range from 20 to 80% of outdoor levels. With people spending about 90% (on average) of their time indoors, even where indoor ozone is only 20% of outdoor levels indoor ozone exposure is significant. With indoor levels usually ranging from 30 to 70% of outdoor levels, it is clear that the greatest total human ozone exposure is indoors.

The relevance of this otherwise picky point is that recent research, some of it cited by Lippman, shows that adverse health effects occur at ozone concentrations as low as 80 ppb for time periods as short as one hour. Outdoor ozone levels often exceed 100 ppb in many urban and some rural U.S. locations. Therefore, a large portion of the U.S. population is exposed to unhealthy ozone levels, particularly when building ventilation rates exceed one ACH or more. At this ventilation rate, indoor ozone will usually exceed 50% of outdoor levels.

Ozone Control

There are practical ways to remove ozone, particularly through the use of charcoal filters. However, the technology is not commonly used in commercial and residential structures. Adding the cost of ozone filtration to a building construction and operating budgets will arouse considerable resistance from building owners and developers. The cost of constructing and operating a building will increase due to the costs associated with large fans to overcome the resistance of added filters. Furthermore, the effectiveness of filters will need to be monitored.

Potential Problems

Also, collecting moisture and particulate matter on charcoal filters may lead to microbiological contamination. Controlling this potential problem will require frequent inspection and periodic evaluation of microbial emissions from the charcoal filters. The problem can be lessened by reducing the particle and moisture loading on the charcoal. This is done by filtering air more efficiently upstream from the charcoal filters. Limiting humidity in the air stream will also extend the useful life of the filters and reduce the potential microbial contamination.

All of these solutions require further investigation. Designers and building operators must become more aware of the ozone problem, and reliable performance evaluations of commercially available products such as filters must become available. Ozone is a significant problem; however, control is within the means of current knowledge.

For more information:

Rolf Sabersky et al., "Concentration, Decay Rates, and Removal of Ozone and Their Relation to Establishing Clean Indoor Air," *Environmental Science and Technology*, Vol. 7, No. 4, April 1973, pp. 347-353.

Marjorie Sun, "Tighter Ozone Standard Urged by Scientists," *Science*, Vol. 240, (24 June 1988) pp. 1724-1725.

Milton Russell, "Ozone Pollution: The Hard Choices." *Science*, Vol. 241, (9 September 1988) pp. 1275-1276.

Morton Lippmann, "Health Effects of Ozone: A Critical Review," *JAPCA* (*Journal of the Air Pollution Control Association*), May 1989, pp. 672-695. ♦

Practical Research Briefs

NASA's VOC Emissions Database

Designers, researchers, product manufacturers, and policy-makers are all interested in obtaining information on the volatile organic compound (VOC) emissions of building materials, furnishings, and consumer products. The number of potential sources is enormous. Testing products and developing a useful database is an overwhelming task. Indoor air researchers and industry have investigated only a fraction of the products used indoors.

However, one large database exists that could provide a great deal of information. NASA conducted the largest known investigation into VOC sources to test for potential contaminants in spacecraft. NASA was more interested in the possibility that VOC would plate out on electrodes in spacecraft equipment and cause operational problems than in any possible health impact on the astronauts. But the rationale for doing the work is unimportant; NASA created a large body of data that may impact IAQ work greatly. Michael Baechler and his colleagues at Harvard University have partially evaluated the NASA database for its usefulness for IAQ control. It is hard to compare much of the NASA data with existing data because the testing methodologies are very different. However, once the database is thoroughly evaluated and "translated" to conform with existing measurement standards, we think it will make a substantial contribution to IAQ knowledge.