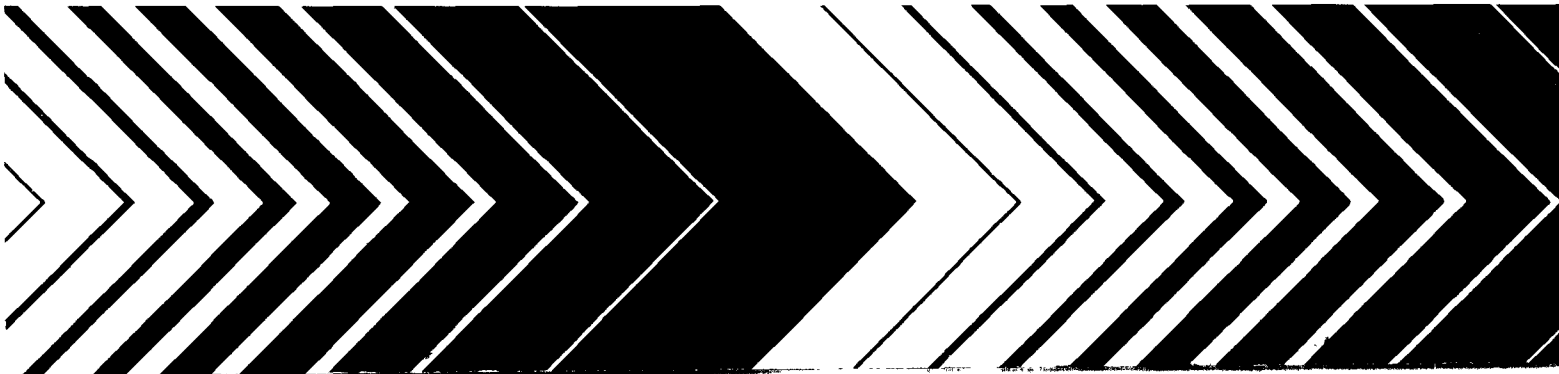

Research and Development



EPA Indoor Air Quality Implementation Plan



EPA Indoor Air Quality Implementation Plan

A REPORT TO CONGRESS

UNDER

TITLE IV OF THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986:

RADON GAS AND INDOOR AIR QUALITY RESEARCH

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REPORT TO CONGRESS
INDOOR AIR QUALITY IMPLEMENTATION PLAN

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INDOOR AIR QUALITY IMPLEMENTATION PLAN

I. SUMMARY

This Report to Congress is being submitted under Title IV of the Superfund Amendments and Reauthorization Act (SARA) of 1986. The Report sets forth EPA's overall indoor air policy and strategy and provides a near-term plan for implementing Title IV.

The Report is comprised of a main body which concisely establishes the policy context for indoor air research and the Agency's near-term implementation plan. The report also contains five appendices which provide a summary of current information on indoor air quality, a description of the Agency's current indoor air research projects, a detailed description of the Agency's radon activities, EPA's indoor air resource history, and a compilation of indoor air literature references.

EPA's indoor air program is geared toward identification, characterization, and ranking of indoor air problems and assessment and implementation of appropriate mitigation strategies. EPA's research and analytical activities will pursue both source-specific and generic approaches to indoor air pollution. From a source-specific standpoint, the Agency will identify high risk pollutant sources and characterize the exposures and health risks of various populations to those sources. At the same time, the Agency will also pursue broad, cross-cutting strategies aimed at assessing the total exposure of people to indoor air pollutants and developing mitigation strategies which can address multiple pollutants simultaneously through improved building design and management techniques.

EPA will assess appropriate federal actions to mitigate health and environmental risks associated with indoor air quality problems. EPA will also take actions under existing statutes to reduce significant health risks, will refer problems to other federal agencies with appropriate regulatory authorities, or will request separate regulatory authority from Congress, if appropriate.

EPA's indoor air program will also emphasize information dissemination strategies to communicate information to a wide variety of audiences with roles to play in indoor air pollution. Ultimately, the Agency hopes to increase the capabilities of state and local governments, the private sector, and individuals to identify and solve immediate health problems associated with pollutants in indoor environments and to reduce overall health risks.

The Agency's research, regulatory, and program implementation activities are closely coordinated with the Department of Energy (DOE), the Department of Health and Human Services (DHHS), and the Consumer Product Safety Commission (CPSC) as well as other federal agencies involved in indoor air quality activities. The Agency will continue to seek both scientific and policy input from organizations and individuals representing a broad spectrum of interests. In addition, EPA will coordinate its activities with other organizations where there are common concerns and objectives.

II. PURPOSE

This Report to Congress has been prepared and is being submitted pursuant to Section 403(d) of the Superfund Amendments and Reauthorization Act of 1986, Title IV -- Radon Gas and Indoor Air Quality Research. This provision requires the U.S. Environmental Protection Agency (EPA) to submit to Congress a plan for implementing the indoor air and radon research program mandated under Title IV. On April 10, 1987, the Agency submitted to Congress a partial description of its implementation plan, including the detailed radon gas component and a description of the Agency's plans for coordinating the indoor air and radon programs. This document supplements that report by providing a substantially more detailed assessment of the current state of knowledge about indoor air pollution and the Agency's near-term plans for fulfilling the statutory requirements of Title IV.

III. ORGANIZATION

The main body of this report provides information on the conduct of EPA's indoor air program, including the Agency's policy on indoor air, federal activities to date, and research needs which are currently being addressed by EPA. It also discusses at some length the choices which face EPA and other federal agencies concerned with indoor air pollution. This discussion revolves around the recently completed Preliminary Indoor Air Pollution Information Assessment and its companion document, the Research Needs Statement, still undergoing reviews. These documents are discussed further in the following sections.

A set of appendices accompany the report and provide valuable back-up documentation. These include:

- ° The Preliminary Indoor Air Pollution Information Assessment, which describes in detail existing knowledge on indoor air quality;
- ° Descriptions of all projects conducted as part of EPA's 1987 indoor air research program.
- ° The Agency's radon program description from the interim Report to Congress submitted on April 10, 1987.
- ° An updated resource history, showing expenditures from FY'84-87 for research and program development activities.
- ° A bibliography of indoor air quality literature containing over 2,000 entries.

IV. APPROACH

In developing an appropriate plan for implementing Title IV and carrying out an effective indoor air quality research program within a

policy context, the Agency's Office of Research and Development (ORD) first prepared the Preliminary Indoor Air Pollution Information Assessment (hereinafter referred to as "the information assessment"). That document is attached as Appendix A. EPA's goal in producing the information assessment was to assemble and synthesize all available sources of information on indoor air pollution from work being done by the research community within EPA and other federal agencies, state and local governments, universities, and individuals and research institutions throughout the world. The document is intended to serve the dual purposes of recognizing the multi-disciplinary nature of the indoor air problem and identifying research and information gaps. From the data compiled in the information assessment, EPA was able to prepare the near-term implementation plan presented in this report and begin the process of formulating a long-term implementation plan which would identify the research questions remaining.

V. BACKGROUND

When the Clean Air Act was passed in 1970, the air pollution problems of greatest concern to the nation were out-of-doors. The "mounting dangers to the public health and welfare," as described by the Congress in Title 1 were perceived to be caused by "urbanization, industrial development, and the increasing use of motor vehicles....". Consequently, the law that was intended to protect and enhance the quality of the nation's air resources gave EPA authority to control a wide variety of air emissions sources and air pollutants that contributed to the degradation of ambient air. EPA interpreted the term "ambient" to apply to outdoor air only.

The quality of the indoor air was not addressed in the law. At that time, except for studies of specialized environments like submarines, space capsules, and the industrial workplace, virtually no scientific research had been done on indoor air quality. Indoor air pollution and its associated health effects were considered neither serious enough nor pervasive enough to merit national attention.

However, in the early 1970s, indoor air pollution received increasing public attention when the government instituted energy conservation measures. During this time, formaldehyde was identified as the cause of acute irritant reactions, primarily eye and nose irritation and respiratory distress, in individuals living in homes insulated with urea-formaldehyde foam insulation, and mobile homes constructed with large quantities of particleboard and plywood. This led to additional research to assess the types and quantities of air pollutants found in various indoor environments, all of which came to the same conclusion: for certain pollutant types, concentrations were often much higher indoors than they were outdoors. Furthermore, when high exposure levels were coupled with the fact that most people spend more of their time indoors than outdoors, the risk to human health from indoor air pollution was shown to be greater than previously thought. For some pollutants, the exposure may be greater indoors than outdoors. Certain potentially susceptible people -- children, persons with lung diseases or impaired immune systems, and the elderly -- may be at considerable risk.

As the general problem of indoor air pollution was drawing more and more nationwide attention as a potential health hazard, a particular type of indoor air pollution -- radon -- was causing immediate concern in certain parts of the country. Epidemiological studies of underground miners had established a link between exposure to elevated levels of radon and the development of lung cancer. In the late 1960s and early 1970s, EPA investigated homes in Grand Junction, Colorado, contaminated by uranium mill tailings, a by-product of uranium mining. The elevated radon levels found in those homes led to the issuance of the Surgeon General's guidelines regarding remedial action in houses built on or with uranium mill tailings.

During the 1970s, EPA also investigated instances of elevated radon levels in houses built on reclaimed phosphate mines in central Florida. In 1979, EPA issued guidelines to the State of Florida for remedial action in existing homes and for new home construction. In 1983, the Agency began to clean up, under the Superfund program, a number of homes in New Jersey that were built on industrial radium waste sites.

National attention was focused on the problem of indoor radon in 1984 when a worker at a nuclear power plant in Pennsylvania was found to be living in a house that was contaminated by extremely high levels of radon. In this case, the radon was being emitted by the natural soil on which the house was built. Subsequent investigations revealed that thousands of homes in the Reading Prong, a geological formation that runs from Pennsylvania through New Jersey and into New York, were contaminated by naturally-occurring radon. Public concern over the potential health effects of radon exposure, and the realization that such exposures could be occurring over wide areas, led to the establishment of EPA's Radon Action Program directed specifically at the indoor air pollution problem caused by radon.

Within the federal government, there has been considerable debate concerning the role of EPA and other federal agencies in researching and regulating indoor air pollution. Beginning in 1984, Congress began appropriating resources for EPA to perform research on indoor air quality and radon mitigation but did not provide guidance as to its role. To help determine the most appropriate direction to take, in 1986 EPA asked its Science Advisory Board (SAB) to review its ongoing indoor air research program and its plan for developing an indoor air research strategy. The SAB responded by establishing an ad hoc indoor air quality research review panel and in September 1986, this review was conducted. The results of that review, appended to the April 10, 1987 submission to Congress, were largely favorable and the SAB encouraged EPA to pursue its plan to develop a long term research strategy. The first step in this process was to produce the Preliminary Indoor Air Pollution Information Assessment.

Subsequent to the SAB review of EPA's indoor air program, Congress passed the Superfund Bill (PL 99-499) which included the Radon Gas and Indoor Air Quality Research Act as Title IV. Title IV provides a clear Congressional mandate for an EPA indoor air research program.

Section 403 of the Superfund legislation in part directs the Administrator of the Environmental Protection Agency to establish an indoor air quality research program designed to contribute to the understanding of health problems associated with indoor air pollutants. The statute also directs that EPA coordinate with federal, state, local, and private sector research and development efforts related to improvement of indoor air quality and assess appropriate federal actions to mitigate environmental and health risks associated with indoor air quality problems. Section 403 of the statute encourages EPA to disseminate information regarding indoor air pollutant sources and concentrations, high risk building types, measurement instruments, and health effects, as well as recommended methods for the prevention and abatement of indoor air pollution.

VI. INDOOR AIR POLICY OBJECTIVES AND STRATEGY

The Environmental Protection Agency's ultimate goals in addressing indoor air quality problems are to adequately characterize and understand the risks to human health which pollutants pose in indoor environments and reduce those risks by reducing exposure to indoor pollutants and to do so through efficient utilization of available resources.

The Agency's indoor air program will seek to reduce the risks to human health posed by indoor air pollution through the pursuit of the following policy objectives:

1. The Agency will conduct research and analysis to further refine its assessment of the nature and magnitude of the health and welfare problems posed by individual air pollutants as well as pollutant mixtures indoors. Such research will focus in the near term on improvement of exposure data, continued development and testing of modeling tools necessary to perform essential risk assessments and the development and consolidation of data bases. Development of appropriate ranking and risk assessment tools will be a top priority in this effort.

2. The Agency will identify and assess the full range of mitigation strategies available to address high priority indoor air pollution problems. Equal emphasis will be placed on strategies which reduce or eliminate the source of the risk as well as on more generic strategies which may reduce exposures, and thus risks, to multiple pollutants simultaneously (e.g. ventilation-related strategies).

3. For identified high risk, high priority problems, the Agency will adopt and execute appropriate mitigation strategies. These mitigation strategies may involve one or more of the following:

- issuing regulations (under existing regulatory authorities (e.g. TSCA, FIFRA, Safe Drinking Water Act);
- building State and local government and private sector capability to address indoor air quality problems through

non-regulatory programs of information dissemination, technical assistance, guidance, and training;

- referring problems to other Federal agencies with appropriate statutory authority (e.g. CPSC, HUD);
- requesting separate indoor air regulatory authority from Congress if deemed appropriate.

The Agency's strategy for implementing the provisions of Title IV and achieving the policy goals delineated above is based upon several guiding principles.

Although EPA's historical and traditional approach to environmental problem solving has been primarily regulatory in nature, the indoor air issue presents unique problems and issues for which regulatory solutions may not always be the most effective.

Since indoor air pollution problems are primarily a function of the products and materials used within specific building settings, the character of the problem will be different in each setting and the most appropriate mitigation strategy will depend on a variety of factors. In many instances, the Agency hopes to be able to achieve its indoor air policy goals through non-regulatory approaches which will include research and development, information dissemination, and technical assistance and training. To a large extent, the Agency's success in reducing the risks to human health from indoor air pollution will depend upon how successfully the Agency is able to build public and private sector capability to investigate, assess, and solve indoor air quality problems, to affect change in product purchasing and use, and to change building design and operation to minimize the risks from indoor air pollution.

To the extent that specific chemicals or materials may be identified as posing significant risks to human health, the Agency will, if appropriate, utilize existing statutory authorities (e.g. TSCA, FIFRA, Safe Drinking Water Act) or refer the problem to other Federal agencies to mitigate those risks.

Title IV of SARA requires the Agency to assess appropriate federal actions in the indoor air field. Part of this assessment will involve an analysis of whether additional regulatory authority is appropriate and should be recommended to deal with indoor air pollution.

The Agency will be striving for maximum efficiency in the expenditure of resources in order to produce information directly useful for characterizing both acute and chronic health risks in the indoor environment and for reducing exposures that pose the most significant health risks. Since the information and guidance developed as an outgrowth of the research program must have practical and timely utility to the various public and private audiences concerned about indoor air pollution, some resources will be targeted in the short term to the development and dissemination of information on well documented problems and solutions.

Third, the Agency will seek to pursue a dual-approach research program in order to achieve a balance of generic and source-specific mitigation strategies to achieve maximum risk reduction. While reducing or eliminating exposures to specific sources known to pose significant health risks will be a high priority, the Agency also intends to undertake research and develop strategies which can address multiple pollutants or mixtures simultaneously (e.g., through programs that address building management strategies).

Fourth, the Agency's research and information dissemination program will seek to maximize coordination and information sharing among various private and public agencies and organizations, especially among agencies with existing regulatory authority over indoor air problems.

VII. ACTIVITIES AND ACCOMPLISHMENTS TO DATE

The Agency has been conducting both regulatory and non-regulatory indoor air activities as well as research into indoor air problems for the past several years. From a regulatory standpoint, the Agency has addressed a number of chemicals, including several pesticides, found indoors through the use of the Toxic Substances Control Act (TSCA) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). These statutes enable EPA to obtain information on chemical substances from manufacturers and processors when there is reason to believe that the use of these substances may present an unreasonable risk to human health and the environment. Based on assessments of risks and benefits, the Agency determines whether or not an unreasonable risk exists for a specific compound and, if so, it can take action to control exposure to the substance, restrict its use, or ban the substance entirely.

To date, the Agency has taken a number of actions under various statutes on specific chemicals that have been found to pose risks indoors. EPA has issued the Asbestos Worker Protection Rule to protect public employees not covered by OSHA from exposure to asbestos during abatement activities. The Agency has also proposed to phase out commercial uses of asbestos over a ten year period. This proposed rule -- known as the Asbestos Ban and Phase Down Rule -- will significantly reduce future uses of asbestos and exposure to asbestos fibers in all environments, including indoors. The proposed Asbestos in Schools Rule was just issued under the Asbestos Hazard Emergency Response Act (AHERA) passed by Congress in October 1986. This rule will require schools to inspect for asbestos, prepare management plans, and take appropriate response action when friable asbestos is found.

In 1986, EPA prohibited the use of pentachlorophenol as a wood preservative for treatment of logs for log-home construction. Creosote and pentachlorophenol were also prohibited as preservatives indoors, with very few exceptions.

In 1983, EPA issued a phase-out of fumigating devices containing the pesticide lindane, used to control pests in residences. As of May 1986, such use of lindane is prohibited. The Agency is currently evaluating monitoring data received from manufacturers on chlordane as well as examining the health effects and benefits data for chlordane and other termiticides, such as heptachlor and aldrin/dieldrin to determine if further regulatory action is necessary. A decision is expected on these compounds in 1987.

On April 16th, the Agency announced the results of its risk assessment on formaldehyde, a probable human carcinogen. While decision-making options are being considered, studies are being conducted of formaldehyde emissions from plywood and particle board used in mobile and conventional homes. The findings of these and other studies are being shared with the Occupational Safety and Health Administration (OSHA) and with the Department of Housing and Urban Development (HUD) for their use in considering regulatory action.

Under the Safe Drinking Water Act (SDWA), EPA is currently considering establishing maximum contaminant levels for volatile organic compounds. Such compounds vaporize in hot water and are then inhaled.

Through the Agency's air research program, progress has been made on several fronts. For example, through EPA's Air Toxics research effort, the Total Exposure Assessment Methodology (TEAM) was developed and validated. TEAM studies rely on state-of-the-art personal and ambient exposure monitors, plus a unique blend of scientific approaches to determine human exposure to pollutants. The initial TEAM studies, which focused on volatile organic compounds (VOCs), provided critical evidence of the extremely high concentrations of VOCs indoors. In some cases, these indoor concentrations exceeded outdoor levels by 500%. The TEAM approach is currently being expanded to address exposure to particulate emissions. In addition, this approach is being used in a study of pesticide exposure.

Through the innovative Integrated Air Cancer Program, EPA has been able to develop and field test instruments and methods to characterize carcinogens in ambient and indoor air, to identify the sources of these emissions, and to evaluate complex mixtures of pollutants to discover the most potent components of these mixtures and screen for possible health effects.

As part of a cooperative effort with the Peoples Republic of China, EPA is conducting a study of lung cancer in Xuan Wei, a county in south-eastern China. It is thought that the county's abnormally high rates of lung cancer are linked to indoor exposure to particle-bound organic compounds from the coal and wood cooking and heating fuels used by the residents of Xuan Wei. Through this study, EPA has already developed and tested a medium volume sampler to test ambient indoor air and developed a prototype personal exposure monitor for particles. Both of these devices are being used now in the Integrated Air Cancer program and in the Agency's studies of indoor air quality. Also as a result of the study in China, EPA has been able to test innovative bioassay techniques. Some of these are being refined and will be further used in studies of indoor air health effects.

Several significant advances have been made through specific health effects and source characterization studies. For instance, the exposure portion of a clinical study of children whose parents smoke cigarettes has just been completed. A pilot field study has been initiated to examine the levels of nicotine in children of smoking parents as well as to evaluate indoor levels of nicotine and other pollutants in the homes where the children live.

EPA has a special testing chamber in which the Agency has pioneered research to determine the composition and rate of pollutant emissions for several common building materials and consumer products. Among the products tested so far are construction adhesives, flooring materials, paints, floor waxes, and moth crystals.

Significant progress has also been made in the standardization of emission testing procedures and in the development of much needed personal and fixed monitoring equipment for assessing human exposures to indoor air pollutants. EPA is also conducting studies to develop a model which can be used to estimate exposure from volatilization of chemicals from tap water into the home.

EPA's research on indoor air quality is complemented by important research being conducted by other federal agencies. For example, the Consumer Product Safety Commission (CPSC) has advanced knowledge about emissions from sources commonly found in homes, including combustion appliances and products containing formaldehyde and methylene chloride. CPSC has also initiated studies on humidifiers, which can spawn biological contaminants.

In addition, the Department of Energy has conducted studies on the relationship between indoor air quality and energy conservation, including measurement and modeling for both large and small buildings. DOE is also conducting basic radon studies, including health effects, epidemiological, and building science studies. EPA and DOE are close to finalizing a Memorandum of Understanding (MOU) to coordinate the two programs. Under this MOU, DOE will have primary responsibility for basic research, with a primary focus on health effects. EPA will be responsible for applied research, technical studies, and operational programs dealing with the states and the private sector.

The Department of Health and Human Services coordinates and provides the major funding for a large joint federal study of health effects from exposure to indoor and outdoor pollutants which is known as the Harvard "Six Cities" study. In addition, the National Institute for Occupational Safety and Health (NIOSH) has conducted over 400 investigations of sick building complaints.

Historically, EPA has recognized the need for interagency approaches to pollution research, as illustrated by its continuing cooperation in the Harvard "Six Cities" study and associated efforts. Likewise, EPA was a major player in the highly praised exposure assessment studies in Kingston-Harriman, Tennessee. This philosophy continues in EPA, perhaps

best illustrated by the Agency's current plans to participate in the Third National Health and Nutrition Examination Survey (NHANES-III), sponsored by the National Center for Health Statistics. In addition, EPA participated in the National Academy of Science (NAS) study which led to the Surgeon General's recent announcement on environmental tobacco smoke and health.

VIII. NEAR-TERM IMPLEMENTATION PLAN

As a result of preparing the information assessment, EPA was able to identify several categories of research and programmatic activities which require immediate attention and which appear to be clearly in EPA's jurisdiction. These categories can be grouped as follows:

A. Problem Characterization -- determining the extent of the indoor air pollution problem, identifying pollutants and sources of particular concern, and assessing the health and welfare risks to the general population and particularly susceptible subsets of the population.

B. Mitigation -- developing methods, guidelines, and equipment for mitigating indoor air pollution and determining where pollutants can be controlled at their source.

C. Information Dissemination -- providing the information gathered to the appropriate audiences in a usable format.

EPA's plan to implement a near-term indoor air quality program draws on the extensive amount of information amassed in the information assessment (Appendix A). The implementation plan also reflects insights gained from the report, Indoor Air Pollution: The Magnitude and Anatomy of Problems and Solutions, prepared for the Office of Air and Radiation, and currently being circulated for comment by technical reviewers inside the Agency. Finally, the plan attempts to establish realistic priorities for carrying out an indoor air research and information dissemination program within the framework of current resources.

It should be noted that research activities now being conducted reflect research priorities as they were understood at the time when individual project funding decisions were being made. Descriptions of these specific research projects are provided for the FY 1987 EPA indoor air research program in Appendix B. While each of the research projects now underway will add significantly to the Agency's understanding of indoor air pollution, subsequent funding decisions will be made on a task-by-task basis as the Agency's long-range implementation plan evolves.

In pursuing their responsibilities within this implementation plan, both OAR and ORD will seek to make the best use of the resources now available. Other EPA offices also contribute to the coordinated indoor air program. For example, the Office of Pesticides and Toxic Substances can provide significant information about exposure, health effects, and such things as total exposure assessment, multiple sources and exposure, and other critical issues from data which that office has collected from

manufacturers of products and pesticides. EPA also recognizes that many other public and private sector organizations are making significant, and often pioneering, contributions in this field. Wherever possible EPA intends to coordinate its activities with those of other organizations working toward common goals.

1. PROBLEM CHARACTERIZATION

EPA will refine its understanding of the scope and magnitude of the indoor air pollution problem by increasing the available knowledge about indoor air quality problems and then ranking those problems for further research and mitigation in order to make efficient use of available resources. EPA's priority near-term activities in this area are as follows:

A. Develop models and data bases to estimate indoor concentrations and exposure.

The potential for developing indoor air quality models and supportive data bases useful in understanding the nature and magnitude of the indoor air quality problem is great. Relying solely on monitoring efforts to fill in the information gaps on the number of pollutants and range of building types would be prohibitively expensive. EPA will support the development of models that will identify important sources and building factors affecting indoor air quality, that will quantify exposure reductions to be achieved from different mitigation options, and that will serve as an important tool for public or private building investigators to use in identifying and solving problems found in specific problem buildings. The Agency will also examine the extensive data bases maintained by the Office of Pesticides and Toxic Substances to determine their utility in assessing indoor air exposures and health risks.

The titles of specific research projects now underway which support this effort are listed below:

- ° General Indoor Air Pollution Concentration Model
- ° Receptor Models for Assessing Indoor Levels and Sources of Respirable Particulates
- ° Measurement of Indoor Spatial and Temporal Concentration Gradients for Indoor Environments
- ° Initiate Investigation of the Composition of the Indoor Particulate Size Distribution
- ° Limited Scale Field Study to Test Survey Methodology and Relate Indoor Air Quality to Exposure
- ° Indoor Source Emissions Data Base

- Evaluation of Field Methods to Estimate ETS Exposure in Epidemiological Studies
- Personal Activity Related Exposure to ETS in Airliner Cabins and Other Transportation Related Environments
- Develop and Test Revised Screening and Source Use Questionnaires for Indoor Air Quality Studies
- Field Evaluation of Sampling and Analysis for Organic Pollutants in Indoor Air
- Evaluation of Sampling and Analytical Methods for Nicotine and PAHs
- Field Evaluation and Final Modification of Prototype Dual Channel Particulate Sampler
- Assess the Effectiveness of Currently Available Screening Techniques for Indoor Pollutants
- Initiate Methods Development for Polar Organic Compounds
- Development of Electrochemical Real Time Detector for NO₂
- Methods Development/Intercomparison for VOCs
- Development of a Versatile Unobtrusive Indoor Air Quality Sampling Package

B. Develop health-based information for individual indoor air pollutants.

A high priority need is the development and review of indoor air quality exposures and health effects data. Such information is a necessary ingredient of improved risk assessments, priority setting, and decision-making. In addition, such health-based criteria could play an essential role in the diagnosis and mitigation of problems in buildings. The Agency intends to hold a specialized workshop on exposure data and analysis. EPA's Integrated Risk Information System (IRIS) will be expanded to include inhalation reference dose levels for air pollutants found indoors. Improvements in risk assessments of carcinogenic pollutants will also be done.

The following research projects are ongoing to support this near-term objective:

- Biological Markers for ETS in Human Exposure Assessment
- Development of Biological Markers for Molecular Dosimetry Resulting from Exposure to ETS

- Evaluation and Improvement of Cotinine as a Biomarker of ETS Exposure in Children and Adults
- Indoor Air Studies of the Mutagenic and Carcinogenic Emissions from Unvented Combustion Sources
- Effect of Peak Exposure to NO₂ on Respiratory Symptoms and Pulmonary Function
- Respiratory Effects of Indoor Formaldehyde Exposure

C. Improve knowledge about the health and productivity effects of volatile organic compound (VOC) mixtures commonly found indoors.

Recent studies in Denmark show that VOC mixtures at levels similar to those found in homes may cause sensory irritation and behavioral effects such as memory loss. This research is provocative because the effects are similar to those described by building occupants suffering from "Sick Building Syndrome." In addition, the effects observed cannot be explained by the presence of any single pollutant. Research on health and productivity effects of VOC mixtures has the potential for increasing understanding of sick building syndrome, improving risk assessments on mixtures, and assessing the effectiveness of generic control strategies affecting multiple pollutants and sources. EPA will undertake a modified replication of the Danish studies of VOC mixtures.

Three research projects are underway in this area. They are:

- Neurobehavioral and Sensory Irritant Effects of Complex VOC Mixtures in Humans
- Trigeminal Sensitivity of "Sick Building" Responders
- Genetic Bioassay Studies of Volatile Organic Chemicals Emitted from Building Materials

2. MITIGATION

EPA will assess potential mitigation and prevention strategies and will implement those it deems appropriate under existing statutory authorities for high priority problems. Mitigation efforts will address both "generic" mitigation needs and source-specific needs. The near-term program priorities in assessing mitigation options and taking actions to reduce or prevent risks are as follows:

A. Develop guidelines and protocols for diagnosing, assessing and mitigating indoor air quality problems.

EPA will focus on developing methods and protocols for diagnosing, assessing, and mitigating indoor air quality problems. Such tools will increase the capacity of the public and private sector to identify and solve indoor air quality problems of immediate and local concern. EPA will cooperate with other federal agencies and the private sector in the standardization of protocols and diagnostic and remedial services. Examples of needed equipment and techniques which EPA may work singly or in combination with others to produce are: 1) an air exchange rate monitor; 2) measurement protocols; and 3) occupant survey instruments to assess whether and how exhibited symptoms are building related.

EPA has one research project currently ongoing in this area:

- ° Indoor Air Quality Evaluation of Three Office Buildings

B. Identify measures to improve ventilation efficiency and issue guidance to encourage use of these measures, as appropriate.

Improvements in ventilation efficiency (the efficient delivery of air through the ventilation system to building occupants) have the potential to substantially reduce the exposure of building occupants to harmful indoor air quality. Such improvements may include some or all of the following: insuring delivery of air that meets codes, insuring the proper location of intake and exhaust registers, adding circulating fans and air cleaners where appropriate, and installing heat recovery systems for energy conservation, and insuring the proper design of interior spaces to improve air movement. In the near term, EPA will assemble and distribute existing information and, in cooperation with others, such as DOE, the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) and others, will identify methods of improving ventilation efficiency.

One research project is underway in support of this area:

- ° Develop Low Cost Easy-to-Use Procedures for Determining Air Exchange Rate

C. Identify problems associated with specific sources, and develop source control strategies, as appropriate.

The Agency has undertaken, or is considering, programs to reduce risks from specific sources (e.g. asbestos, radon, formaldehyde). Because of the variety of indoor sources, EPA will concentrate on identifying and assessing risks associated with sources common to all building types with a known potential for high risk. At this time, three source categories have been identified for targeted actions.

1. Environmental tobacco smoke (ETS): ETS is known to cause high individual and aggregate risks. Published risk estimates of lung cancer deaths in nonsmokers from ETS range from about 500 to 5000 per year¹ and total mortality estimates range from about 4,000 to 50,000 deaths per year² and ³. Although not based on quantitative risk reductions, recent reports by the Surgeon General and the National Academy of Science have confirmed the fact that ETS poses a range of health threats to nonsmokers. While additional specialized research needs have been identified by the scientific community on ETS (e.g., in assessing the value of cotinine as a biological marker, and dose-response relationships), sufficient information already exists on ETS to indicate that a shift in emphasis from research to providing guidance on mitigating risks is appropriate.

2. Biological Contaminants: Some biological contaminants (e.g., Legionella) are responsible for mortality from acute exposures; others (e.g., mycotoxins) may pose chronic health risks. Biologicals are common to all buildings. Frequent sources of biologicals are the heating, ventilation, and air conditioning system and humidifiers (units that either stand-alone or within HVAC systems). EPA will work closely with the Department of Health and Human Services (DHHS) and others to get unresolved issues identified and addressed. The Agency is planning a workshop on health effects of biologicals to be held in FY89 under the sponsorship of the Task Force on Environmental Cancer and Heart and Lung Disease.

3. Common Sources of VOCs: Chronic exposure to some VOCs is suspected to contribute to mortality from cancer. Many VOCs are cancer-causing agents. Common sources of VOCs found in most buildings include building materials and furnishings, paints and related products, cleaning, disinfecting, and odor control products, and pesticides. EPA will conduct research on building materials and furnishings in chamber laboratories and a test house; other common VOC sources are also candidates for targeted research over the next two to five years. Other offices within EPA (e.g., Office of Drinking Water) will also have significant information on exposure and health effects associated with VOCs.

The following research projects currently support this effort:

- ° Support for the Canadian Multipollutant Indoor Air Quality Study
- ° Test House Studies of Indoor Sources

¹ Repace and Lowery. Quantative Estimate of Non-Smokers' Lung Cancer Risk from Passive Smoking. Environment International, Volume 11, pp. 3-22.

² Fong. Hazards of Cigarette Smoke to Non-Smokers. Journal of Biological Physics, Volume 10, pp. 65-73.

³ Russell, Jarvis, and West. Use of Urinary Nicotine Concentrations to Estimate Exposure and Mortality from Passive Smoking in Non-Smokers. British Journal of Addiction, Volume 81, pp. 317-323.

- ° Engineering Evaluations of Air Cleaners for Indoor Organic Vapors
- ° Support of the Library of Congress Sick Building Syndrome Study
- ° Chamber Studies of Organic Emissions from Unvented Combustion Sources
- ° Chamber Studies of Organic Emissions from Material Sources

3. INFORMATION DISSEMINATION

A non-regulatory program depends upon informing people of the nature of the problem, the associated risks, and the options for taking preventive or corrective actions as the means to achieve risk reduction. Therefore, a major section of this implementation plan is devoted to outlining the types of information which EPA intends to produce.

Information that EPA provides in the near term will focus on increasing the capability of public and private sector organizations to diagnose and solve indoor air quality problems by providing materials based on existing information. EPA will also identify key groups (e.g. architects, builders, building owners and managers, and health, consumer and environmental organizations) to build information programs that will inform their membership and the public about significant indoor air quality problems and solutions. EPA intends to produce the following priority materials:

1. Public policy statement: EPA plans to issue a public policy statement (e.g., press release) that identifies the major risks to public health from indoor air and the steps that EPA is taking to reduce those risks. The policy statement will be based on the policy goals and objectives described above.

2. Brochures for the general public: The first general interest publications which EPA is planning to produce are: 1) a directory of resources at the Federal, State, and local level to which the public can go for information on indoor air quality problems; and 2) a brochure on practical, readily available steps that the public can take to reduce exposure to indoor air pollution, especially in their homes.

3. State and local technical assistance: EPA will offer support to state and local governments, within constraints of funding and staff, as the primary levels of government to which the public should turn for help in assessing and solving their immediate indoor air quality problems. The Agency is planning to undertake a series of activities in cooperation with state and local officials to identify their priority needs.

4. Comments on standards, guidance or codes established by other public and private sector organizations: EPA has offered technical comments on the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard for Acceptable Indoor Air Quality (ASHRAE 62-81) and the indoor air quality policy which the General Services

Engineers (ASHRAE) Standard for Acceptable Indoor Air Quality (ASHRAE 62-81) and the indoor air quality policy which the General Services Administration is writing for federal buildings. EPA's input is particularly valuable because of the Agency's understanding of the health implications of the many technical issues under discussion. EPA will continue to offer comments on guidance or regulations developed by other organizations.

5. Guideline development: EPA will offer technical guidance to other public and private sector organizations including: 1) a manual on diagnosis, prevention, and mitigation of indoor air quality problems, to be developed jointly with several private sector organizations; and 2) a manual on risk reduction strategies for environmental tobacco smoke to be jointly developed with DHHS.

Three research tasks are being conducted which contribute to the Agency's efforts to disseminate information. They are:

- ° Annual Review of Existing Indoor Air Quality Data to Determine Direction of Future Programs
- ° Review Symposium of Indoor Air Quality Research Assessment Document
- ° Support to Committee on Indoor Air Quality

IX. LONG-TERM RESEARCH NEEDS

One recommendation which came out of the SAB's review of EPA's indoor air research program was that EPA should evaluate existing data and develop a research needs statement for indoor air. The first result of this was production of the Preliminary Indoor Air Pollution Information Assessment, which evaluated relevant data reported from over 2,000 studies. This document was peer-reviewed at a workshop held at Harvard University in January 1987. The reviews were generally favorable and essentially all of the suggested changes have been incorporated in the document as it exists now. It is not final, however, and additional workshops will be held in 1987 to ensure that the document is complete and up-to-date.

It was from this assessment that the first draft of the Research Needs Statement (RNS) was derived. When final, the RNS will provide a foundation on which to build EPA's indoor air quality research program and, EPA believes, the research programs of other interested federal agencies as well. The RNS attempts to classify general areas of research needs related to indoor air and identify specific activities which should be carried out to complete the data bases. This document takes a two-track approach to indoor air research by dividing needs into two broad categories, source-specific needs and "generic" needs. The generic needs category includes such things as total exposure assessment, multiple sources and exposure routes, the contribution of human activity patterns to exposure.

Although the draft RNS was prepared by EPA as a logical follow-up to the information assessment, it does not address only those research needs which EPA considers to be within its area of concern. Instead, the document focuses strictly on perceived research needs, and makes no attempt to identify which agencies, if any, should be responsible for addressing each need. This was done deliberately, to provide a picture of what appears to be the whole spectrum of indoor air research needs. In this way, the respective agencies can identify what has been done, what they will address, what will be addressed by others, and what is perhaps not being addressed at all.

The first draft of the RNS was circulated to the CIAQ agencies in April 1987. The initial comments received were generally favorable, but the agencies are still engaged in a detailed review of the document. The RNS is not submitted as part of this report to Congress. There are several reasons for EPA's decision not to include the RNS. The RNS reflects more than just EPA-related research needs. Also, the document is still in review by federal agencies and has not yet been submitted to scientific peer review. Since the RNS has a scope which far exceeds EPA's exclusive responsibilities, it is necessary to involve other agencies in any further development of the document. EPA does intend to submit the draft RNS to the SAB, however, as promised in response to the SAB recommendations on EPA's indoor air quality research program.

Currently, several internal discussions are being planned within EPA to discuss the role that the CIAQ should play in further development of the RNS and the role that the RNS should play in research planning efforts by other agencies. The next CIAQ meeting is scheduled for July 10, 1987. The largest part of the agenda will be devoted to further discussions of these issues. At the present time, EPA intends to recommend that the RNS be used to drive the development of long range research plans for all affected federal agencies. In that case, further development of the document should be made with input from the CIAQ, with EPA having lead responsibility.

In the meantime, the Agency's Science Advisory Board is proceeding with the establishment of a standing subcommittee to provide advice to EPA in carrying out its indoor air quality research program. Membership on this subcommittee will consist of scientifically credentialled representatives from academia, industry, consumer groups, state and local agencies and other interested organizations. EPA will ask this group to review the current draft of the RNS as well as the information assessment. EPA will then integrate the comments from CIAQ agencies and the SAB Advisory Subcommittee into a needs document which can be a valuable tool for everyone in the indoor air research community.

During the next year, EPA will be developing a long-term plan for its indoor air research and program activities. EPA is actively encouraging all of the CIAQ agencies to do likewise. In October 1988, EPA is required under the provisions of SARA Title IV to submit another report to Congress

on indoor air. This report must identify the indoor air quality activities carried out under Title IV and make appropriate recommendations. The report will also identify what EPA believes to be the role of the federal government in addressing indoor air quality problems. To do this, it will be necessary for EPA to coordinate with each of the concerned federal agencies to identify and articulate their long-term roles in indoor air quality.

X. MANAGEMENT AND COORDINATION

A. Coordinating Committees

EPA will use several committees in an advisory and coordinating capacity. Through them, OAR and ORD will develop and coordinate indoor air-related activities.

- ° Coordination of indoor air quality policy and programmatic activities within EPA is accomplished through an ad-hoc task force with representatives from all concerned program offices. In the future, this task force will meet on a regular basis to exchange information and review and comment on the policy and program plans of involved offices.

- ° Title IV of SARA directs EPA to take a number of steps to ensure that the Agency's indoor air activities are well coordinated with the scientific community and other public and private sector interests. Title IV requires a broadly-based committee made up of representatives from the non-federal public and private sectors to advise the Agency on research and policy actions to implement the indoor air program. OAR and ORD are making arrangements for such a committee, to be established under the auspices of the Agency's Science Advisory Board.

- ° SARA Title IV also requires a federal advisory committee. This committee is constituted as the Interagency Committee on Indoor Air Quality (CIAQ). CIAQ, co-chaired by EPA, the Department of Energy, the Department of Health and Human Services and the Consumer Product Safety Commission, coordinates research on indoor air quality, provides for the exchange of information among federal agencies, and develops federal responses to indoor air quality issues.

B. Roles of EPA Offices

A number of offices within EPA have responsibilities related to indoor air quality:

- ° The Office of Program Development (OPD) within the Office of Air and Radiation (OAR) has primary responsibility for establishing indoor air policy and coordinating the activities of various EPA offices. In addition, OPD serves as the focal point for Agency policy coordination with other federal agencies, state and local governments, and the private sector.

° The Office of Research and Development (ORD) has primary responsibility for the technical aspects of the indoor air quality research program called for under Title IV of SARA as well as other research related to indoor air quality. In this capacity, ORD assesses research gaps, establishes research priorities in cooperation with the Office of Program Development (OPD), and carries out research to fulfill established program and policy objectives, and coordinates research with other Federal agencies and the private sector.

° The Office of Radiation Programs (ORP) within the Office of Air and Radiation has primary responsibility for implementing the Agency's Radon Action Program and carrying out the radon research program mandated by SARA Title IV. ORP coordinates its activities through the Radon Work Group and the Radon Management Committee. (ORD is responsible for the radon mitigation demonstration portion of the Radon Action Program.)

° The Office of Pesticides and Toxic Substances (OPTS) is responsible for regulating pesticides and toxic substances, some of which are used indoors and contribute to indoor air pollution. Chemical testing by industry under TSCA and FIFRA and research and surveys done through OPTS programs provide needed information on exposure and health risks. In addition OPTS authorities have been and can be used for mitigating chemical-specific problems such as the use of asbestos as a building material.

° The Office of Policy, Planning and Evaluation (OPPE) has general responsibility for reviewing policy developed by the program offices.

° The Office of Air Quality Planning and Standards (OAQPS), although not directly involved in indoor air quality activities, has developed some expertise on indoor air and human activity patterns in implementing the ambient air programs. Their knowledge and data will be drawn on in developing the indoor air quality program.

° The Office of Water (OW) sets standards for pollutants in drinking water, some of which are of concern for their ability to volatilize and contribute to the indoor air pollution problem.

° The EPA regional offices serve as the contact between EPA and State and local governments.

C. Roles and Responsibilities of Other Federal Agencies

EPA is only one of many federal agencies that are either actively engaged in indoor air research or vitally interested in the research being conducted. While a more comprehensive description of the relative roles of various federal agencies will be developed utilizing the CIAQ in the context of the October 1988 Report to Congress, a brief description of the areas of concern of the various CIAQ members follows:

° Consumer Product Safety Commission (CPSC) has regulatory authority over most sources of indoor air pollution. In that capacity, CPSC focuses on the determination and reduction of health risks posed by the use of structural materials, combustion sources, consumer products, and chemicals used in the home and schools. The Consumer Product Safety Act (CPSA) and the Hazardous Substances Act (HSA) provide the basis to establish standards and institute recalls or bans in order to address identified hazards.

° Department of Energy (DOE) conducts a variety of activities related to indoor air quality in support of DOE policies to encourage the use of advanced energy conservation measures while maintaining a safe and healthful indoor environment. These activities include identifying indoor air pollutant sources and factors affecting human exposure, determining the relationship between indoor air quality and energy conservation, and developing control and mitigation techniques. Bonneville Power Administration (BPA), part of DOE and also a member of CIAQ, conducts similar research in the Northwest.

° Department of Health and Human Services (DHHS) investigates buildings for indoor air quality problems (through NIOSH), provides funding for a major health study of people exposed to indoor and outdoor pollutants in various areas of the country ("Six Cities Study"), and conducts health effects studies and develops health data bases (through NIEHS).

° Department of Housing and Urban Development (HUD) is responsible for establishing and enforcing standards for properties being financed with HUD/Federal Housing Administration-insured mortgages or assisted through one of the HUD assisted or directed loan program; HUD also establishes, manages, and enforces the Federal Manufactured Housing Construction and Safety Standards. Past research efforts have included developing and instituting standards for formaldehyde emissions in materials in manufactured housing; investigating the problems of radon infiltration in housing built on mine tailings in Grand Junction, CO and Butte and Helena, MT; and arranging for tests of radon mitigation approaches on Florida phosphate lands.

° Tennessee Valley Authority's (TVA) indoor air program is primarily concerned with investigating the interrelationships among building construction characteristics, energy use, conservation, and indoor air quality, and with developing public information dissemination approaches. In addition to establishing these general relationships, exposures of specific population groups to unique indoor environments, such as those found in public housing, commercial buildings, and rural housing are being studied. Indoor air quality in commercial buildings operated by TVA, as well as the environment in the industrial workplace, is being investigated.

° General Services Administration (GSA), develops indoor air quality policies for federally owned buildings.

° National Aeronautics and Space Administration (NASA) conducts studies and maintains an extensive data base on pollutants found in indoor environments.

° National Bureau of Standards (NBS) develops measurement standards and through its Center for Building Technology (CBT) conducts laboratory, field, and analytical research and develops models to predict, measure, and test the performance of building materials, components, systems, and practices.

Other federal agencies on the CIAQ include the Department of Defense (DOD), the Department of Justice (DOJ), the Department of Transportation (DOT), the Occupational Safety and Health Administration (OSHA), and the Small Business Administration (SBA).

COMMON INDOOR POLLUTANTS, THEIR SOURCES, AND KNOWN HEALTH EFFECTS *

POLLUTANT CATEGORY	POLLUTANT	SOURCES	KNOWN HEALTH EFFECTS
I. Inorganic gases	nitrogen dioxide	gas stoves, garages, outdoor air	eye and respiratory irritation, respiratory function impairment, allergic/infectious diseases, immune effects
	carbon monoxide	HVAC systems, garages, tobacco, outdoor air gas stoves	neurotoxicity, heart function, blood effects
	sulfur dioxide	HVAC systems, kerosene heaters, garages	eye and respiratory irritation, respiratory function impairment
II. Non-biological particles	fine particles (including metals)	combustion	eye and respiratory irritation, respiratory function impairment, allergic/infectious diseases
	coarse particles	tracked-in dirt, dusting, vacuuming,	eye and respiratory irritation, respiratory function impairment, allergic/infectious diseases
	asbestos	building materials, drinking water	eye and respiratory irritation, respiratory function impairment, cancer, asbestosis, mesothelioma
	environmental tobacco smoke	human activity	eye and respiratory irritation, respiratory function impairment, developmental effects, cancer, other organ effects, allergic/infectious diseases
III. Biological pollutants	animal dander	human activity, pets	respiratory irritation, allergic/infectious diseases, immune effects

* The pollutants listed have been shown to cause the health effects listed. However, it is not necessarily true that the effects noted occur at indoor exposure levels. In many cases the exposure data are insufficient to determine the levels at which listed effects would occur.

COMMON INDOOR POLLUTANTS, THEIR SOURCES, AND KNOWN HEALTH EFFECTS *

POLLUTANT CATEGORY	POLLUTANT	SOURCES	KNOWN HEALTH EFFECTS
IV. Radioactive	bacteria, viruses	human activity, pets, water supply, outdoor air, HVAC systems	Legionnaire's disease, pneumonitis
	animal excreta	mammals, insects, arachnids	respiratory irritation, allergic/infectious diseases
	fabric fibers	materials/furnishings	respiratory irritation, allergic/infectious diseases, immune effects
	molds, mildew	HVAC systems	respiratory irritation, allergic/infectious diseases, immune effects
	radon	soils/rocks, drinking water	cancer
V. Gas-phase ("volatile") organic compounds	electromagnetic radiation	appliances, TV, human activities	SUSPECTED OF CAUSING reproductive/developmental, neurobehavioral effects, cancer
	kerosene	pesticides, automotive products, combustion fuel, hobbies, solvents	neurotoxicity
	mineral spirits	automotive products, painting supplies, hobbies, solvents,	neurotoxicity
	(Aliphatic hydrocarbons)	n-hexane	eye and respiratory irritation, developmental effects.
		heptane	eye and respiratory irritation

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COMMON INDOOR POLLUTANTS, THEIR SOURCES, AND KNOWN HEALTH EFFECTS *

POLLUTANT CATEGORY	POLLUTANT	SOURCES	KNOWN HEALTH EFFECTS
(Aromatic hydrocarbons)	n-decane	printed material	cancer promoter
	n-dodecane	printed material	cancer promoter
	toluene	cleaners/waxes, painting supplies, automotive products, hobbies, building materials, outdoor air, drinking water	eye and respiratory irritation, neurotoxicity, liver/kidney effects, mutation
	styrene	tobacco smoke, furnishings, drinking water	blood effects
	ethylbenzene	building materials, drinking water	liver/kidney effects
	benzene	tobacco smoke, garages, drinking water	leukemia, anemia
	xylene	ink, paints, glues	neurobehavioral effects, headache, eye and respiratory effects
(Halogenated carbons)	p-Dichlorobenzene	moth crystals, air fresheners, toilet deodorizers, drinking water	liver/kidney effects, cancer in animals
	perchloroethylene	cleaners, dry cleaning solvents, drinking water	liver/kidney effects, cancer in animals
	methylene chloride	cleaners, painting supplies, hobbies, solvents, drinking water	liver/kidney effects, cancer
	1,1,1-trichloroethane	cleaners, dry cleaning solvents, drinking water, spray can propellants, fabric protectors	liver/kidney effects, cancer

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COMMON INDOOR POLLUTANTS, THEIR SOURCES, AND KNOWN HEALTH EFFECTS *

POLLUTANT CATEGORY	POLLUTANT	SOURCES	KNOWN HEALTH EFFECTS
	propylene dichloride	painting supplies	liver/kidney effects
	chlordane	pesticides, drinking water	neurotoxicity, liver/kidney effects, cancer
	ethylene dichloride	hobbies, pesticides	liver/kidney effects
	polyvinyl chloride	building materials	liver/kidney effects, cancer
	vinyl chloride	furnishings/apparel, outdoor air, drinking water	liver/kidney effects, cancer
	freon	appliances, drinking water	heart function
	polychlorinated biphenyls	appliances, drinking water, power supplies	mutation, cancer
	methyl chloride	tobacco, drinking water	liver/kidney effects
	carbon tetrachloride	cleaners/waxes, furnishings/apparel, solvents, drinking water	liver/kidney effects, cancer in animals
	trichloroethylene	solvents, outdoor air, drinking water, cosmetics, secretarial aids, drinking water	liver/kidney effects, cancer in animals
	chloroform	outdoor air, drinking water, chlorine bleach, chlorine scouring powder	liver/kidney effects, cancer
(Alcohols)	isopropanol	cleaners/waxes, cosmetics, automotive products, hobbies	eye and respiratory irritation

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COMMON INDOOR POLLUTANTS, THEIR SOURCES, AND KNOWN HEALTH EFFECTS *

POLLUTANT CATEGORY	POLLUTANT	SOURCES	KNOWN HEALTH EFFECTS
(Ketones)	ethanol	cleaners/waxes, cosmetics, hobbies, printed materials, laboratories	developmental effects
	methanol	painting supplies, hobbies, outdoor air, office equipment, laboratories	neurotoxicity
	ethylene glycol	automotive products, outdoor air	liver/kidney effects
	benzyl alcohol	hobbies	liver/kidney effects
	phenol	tobacco, outdoor air	liver/kidney effects
	cresol	outdoor air	liver/kidney effects
	acetone	cleaners/waxes, adhesives, cosmetics, hobbies, tobacco, outdoor air, laboratories	eye and respiratory irritation
	methyl ethyl ketone	cleaners/waxes, painting supplies, adhesives, automotive products, outdoor air, drinking water	developmental effects
	methyl isobutyl ketone	painting supplies, pesticides, hobbies, outdoor air	developmental effects

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COMMON INDOOR POLLUTANTS, THEIR SOURCES, AND KNOWN HEALTH EFFECTS *

POLLUTANT CATEGORY	POLLUTANT	SOURCES	KNOWN HEALTH EFFECTS
(Aldehydes)	formaldehyde	plywoods/particle boards, insulation	eye and respiratory irritation, cancer
	acetaldehyde	adhesives, cosmetics, hobbies, combustion	eye and respiratory irritation, cancer
	acrolein	combustion, tobacco	eye and respiratory irritation
(Ethers/esters)	alkyl ethoxylate	cleaners/waxes	developmental effects
	DEHP	hobbies, building materials, furnishings, apparel, drinking water	developmental effects, cancer
	urethane	building materials	mutation, cancer
	dioctyl phthalate	furnishings, hobbies, outdoor air	developmental effects, cancer
(Organic nitrogen/phosphorous)	malathion	pesticides, drinking water	neurotoxicity
	unspecified amines	adhesives	eye and respiratory irritation
	triethanolamine	cleaners/waxes, cosmetics, automotive products	eye and respiratory irritation
	isopropanolamine	automotive products	eye and respiratory irritation
	ethylene diamine	hobbies	eye and respiratory irritation
	acrylonitrile	furnishings/apparel, outdoor air, drinking water	eye and respiratory irritation, neurotoxicity

* The pollutants listed have been shown to cause the health effects listed. However, it is not necessarily true that the effects noted occur at indoor exposure levels. In many cases the exposure data are insufficient to determine the levels at which listed effects would occur.

COMMON INDOOR POLLUTANTS, THEIR SOURCES, AND KNOWN HEALTH EFFECTS *

POLLUTANT CATEGORY	POLLUTANT	SOURCES	KNOWN HEALTH EFFECTS
(Polynuclear aromatic compounds)	methylamine	tobacco	eye and respiratory irritation
	pyridine	tobacco, outdoor air	eye and respiratory irritation, liver/kidney effects
	aniline	tobacco, hobbies	liver/kidney effects, cancer
	nitrosodimethylamine	tobacco	cancer
	hydrazine	tobacco	cancer
	parathion	pesticides, outdoor air, drinking water	neurotoxicity
	endosulfan	outdoor air, drinking water	neurotoxicity
	acrylamide	outdoor air, drinking water	eye and respiratory irritation, cancer, neurotoxicity
	phenanthrene	HVAC systems, drinking water	cancer, mutation
	benzo(a)pyrene	tobacco, combustion, garages, outdoor air, drinking water	cancer, mutation
(Miscellaneous gas-phase organics)	phosphoric acid	painting supplies	eye and respiratory irritation
	acetic acid	adhesives	eye and respiratory irritation

* The pollutants listed have been shown to cause the health effects listed. However, it is not necessarily true that the effects noted occur at indoor exposure levels. In many cases the exposure data are insufficient to determine the levels at which listed effects would occur.