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ABSTRACT FOR A BRIEF PRESENTATION AT THE

CONFRENCE ON CHARACTERIZATION OF CONTAMINANT EMISSIONS FROM INDOOR SOURCES

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An broad testing program is in progress for a large new office building in California. Tests have been conducted on materials and components of furnishings and on air quality indoors in the initially occupied spaces of the phased building project.

In some instances, potential products have been tested prior to selection to assist designers in choosing stable, nontoxic or nonirritating products. Other materials have been screened by reviewing Manufacturer's Safety Data Sheets (MSDS) to identify potentially problematic substances. Discussions with manufacturers and suppliers of some products have resulted in modifications intended to reduce unstable chemical content or emissions inside the completed structure. Test results have been used to predict indoor pollutant concentrations in the completed building.

Tests have been conducted using an environmental chamber, bulk testing, and headspace sampling. Variations in temperature have been used to assist in the prediction of emission rates in the building environment and to form the basis for recommended ventilation system protocols.

Results from various test methods are consistent with each other and comparable to tests conducted elsewhere for certain products. The age of materials being tested has been known within reasonable limits and results confirm the significance of age on emission rates and material content. Of particular interest is the very rapid decline in formaldehyde content and emission rates for carpet samples.

The work identifies significant contributions material testing can make to building design, material selection, and mechanical system operations. Further work is needed to identify organic compounds and validate temperature effect testing.

INDOOR POLLUTION

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BACKGROUND

Indoor pollution is older than building itself. In fact, when cavepeople first used fire they became the first indoor polluters. However, modern new buildings or changes in old ones introduce chemical contaminants and other sources of stress which may cause health and comfort problems. The human body's organs must cope with all forms of stress to which they are subjected: noise, light and other electromagnetic pollution, and chemical air pollutants. And psychological factors affect the functioning of the body's normal defense mechanisms. Problems related to workload, relations with supervisors, peers or employees, personal problems, or fear of the health consequences of an environment can affect resistance to chemical, physical and biological agents.

Recent investigations of office and school buildings have shown that malfunctions in building ventilation systems are common during the "launching" period of a new building. More attention to adequate design, installation and system balancing before occupancy can avert some of the problems. In other instances problems relate to the ordinary process of 'breaking-in' a new building and the engineers who operate it. When malfunctions do occur, reduced outside air supply volumes are often inadequate to provide removal of the many pollutants generated by building materials, contents, and occupants.

In new or remodelled homes, indoor pollution problems often result from paints; adhesives containing formaldehyde which are used to bond particle, hardwood panelling, and plywood; from carpeting or carpet pads; and from a myriad of other new building materials and furnishings. Gas combustion appliances, if not properly vented to the outdoors, will produce fumes which have been shown to cause irritation and respiratory problems. Radon gas which emanates from soil often builds up to dangerous levels inside energy-conserving homes without adequate ventilation. And many older homes contain asbestos in various forms which, when they are disturbed or deteriorate, can result in air contamination.

And in both residential and non-residential environments, tobacco smoke, cosmetics and consumer products can be sources of indoor air pollution.

Indoor pollution problems can be classified as follows:

1. Building Sickness, or Tight Building Syndrome.
2. Chemical contamination.
3. Biological contamination.
4. Physical contamination.
5. Combination or general contamination.

BUILDING SICKNESS

Building sickness or "Tight building syndrome" occurs in newly-constructed or remodelled buildings with low designed ventilation rates, or by ventilation malfunction or both, resulting in elevated levels of chemical contaminants which are associated with a complex of symptoms usually including the following:

- eye, nose and throat irritation
- sensation of dry mucous membranes and skin
- erythema (reddening of the skin)
- mental fatigue
- headaches, high frequency of airway infections and cough
- nausea, dizziness

A great deal of the recent attention to indoor pollution has focused on "tight building syndrome." The proliferation of building materials, furnishings and equipment as well as consumer products containing unstable synthetic organic chemicals results in low level air concentrations of large numbers of such chemicals in most modern buildings. While definitive information on many of these substances is not available, a significant percentage of them are known irritants or carcinogens. Particularly problematic are solvents, adhesives, paints and carpets. The exposure of materials to heat, moisture, ultraviolet light and other environmental conditions can accelerate the off-gassing process resulting in elevated airborne concentrations.

Very troubling is the fact that many of the hundreds of substances which have been found in indoor air are known to be carcinogens, teratogens, or mutagens. Thus, even when ventilation is changed to improve efficiency or after some of the irritating or toxic volatile compounds in new materials have volatized and been removed by ventilation, there still are low concentrations of many compounds which may affect building occupants or their unborn children. Public health officials and regulators attempting to establish "safe" contaminant levels or permissible limits of exposure are unable to determine the additive or synergistic effects of most toxic compounds.

CHEMICAL CONTAMINATION

Chemical contamination occurs when a construction material or other chemical product is used inappropriately or inadver- tently enters a building. Examples include the transformer explosion and fire at One Market Plaza in San Francisco which resulted in the spread of PCBs (Polychlorinated biphenyls), a now-banned, highly-toxic compound used as insulating fluid in electrical transformers, and its fiercely toxic combustion by-product, 2378-TCDF (tetrachlorodibenzofuran). This resulted in the temporary closing of the entire building and over $30 million in remedial work for the lower seven floors which were closed for 10 months. Even after the re-opening of the building there remain serious questions about the methods used to determine the safety of the building for reoccupancy.

BIOLOGICAL CONTAMINATION

Well-known incidents such as the 1976 Legionnaires' disease epidemic may only be the tip of the biological contamination iceberg. Legionnaires' disease, a pneu- monia-like illness, went undiagnosed until investigators isolated the bacteria responsible after the famous outbreak in Philadelphia which claimed 34 lives and affected a total of 221 people, 72 of whom were not involved in the Legionnaires' convention. This bacteria, Legionella pneumophila, is a soilborne organism which appears to reach the cooling towers of buildings during construction or on windy days; once

there, it breds in that hospitable warm, moist environment. Under certain conditions, it is transferred from the cooling towers into the building through entrainment in the building's air supply system. The Public Health Service estimates that the 52,000 cases reported annually substantially underestimate the actual occurrence of the illness. They estimate that approximately 100,000 Americans are affected each year.

PHYSICAL CONTAMINATION

Physical contaminants include noise, ultrasonics and vibration (mechanical energy); visible light, infrared and ultraviolet light, radio frequency and microwave radiation, ionizing radiation, and extremely low radio frequency radiation (electromagnetic radiation); and, magnetic and electrostatic fields. While some or most of these physical factors are present in all buildings, extraordinary levels or divergence from normal distribution patterns can result in untoward physiological, psychological and health effects. Many of them can be controlled but many are not commonly measured when building occupants suffer from their effects.
Noise has been an historical architectural concern. The shift to open planning in homes, offices and schools increases archi- tectural concern about noise. It interferes with communication and can affect cardio- vascular functioning.

Light is the instrument of visual perception. It is probably the most controversial physical factor. The health effects of different spectral distributions are widely discussed and disputed, though research in the subject is sadly lacking. What are often considered matters of personal preference may have profound physiological and health effects as well as significant psychological effects. Visible light is critical to the performance of most indoor work and other activities. As is the case with many indoor contaminants, it is a matter of balance and appropriateness for each individual.

COMBINATION OR GENERAL INDOOR POLLUTION

While research on individual pollutants, their characteristics, distribution, health effects and control is necessary, people's actual exposure is to the combined effects of all the factors acting simultaneously. The human body integrates all of the environmental forces, stresses, toxins, etc. to which it is exposed. If it is overloaded, either physiologically or psychologically, it cannot respond in a healthy way. The body is more sensitive than many instruments used to measure environmental parameters. For this reason, many building epidemics have not been resolved by researchers, but scientific work has established that the complaints and symptoms were "building-related." We must be aware that all aspects of the indoor environment affect human well-being.

OCCUPANT OR USER CONTROL

In designing indoor environments, comfort ranges for temperature, humidity, odors, chemical concentrations in air, lighting levels and source characteristics, privacy, views, and a whole host of other parameters are established as design objectives. These are usually based on criteria of acceptability to some percentage of people. In the end, it is likely that the building environment will create uncomfortable or even unhealthy conditions for at least some of the building occupants. The occupants' control over their environment could alleviate some problems, but it is usually limited in most building types.

Eliciting occupant/employee participation in the process of identifying and resolving building problems is an effective strategy in dealing with comfort and health complaints. Occupants often are better positioned to detect problems than architects, building operators or engineers.

CONCLUSION

It is apparent that society will become more involved in dealing with indoor pollution in the coming years. Building form, materials, furnishings, environmental control systems, launching, and monitoring will all require changes. Design, regulations, products, procedures for occupying buildings, and ways of investigating building-related health complaints are changing already. The problems are legion, and they seem overwhelming at present. But progress is being made in scientific research and it is being incorporated into building design and use.

The message of ecology is becoming meaningful to architects who are learning to apply it in their work. The future practice of architecture, architectural education and research will all be more concerned with building ecology: The inter-relationship of the designed environment to its natural surroundings and it's human occupants.
