LBID-085
EEB-Vent 79-18

CONTAMINANT CONTROL IN THE BUILT ENVIRONMENT: STATE-OF-THE-ART SUMMARY

Ralph G. Langenborg

Energy Efficient Buildings Program
Energy and Environment Division
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720
July 25, 1979

The work described in this report was funded by the Office of Buildings and Community Systems, Assistant Secretary for Conservation and Solar Applications of the U.S. Department of Energy under contract No. W-7405-ENG-48.

CONTAMINANT CONTROL IN THE BUILT ENVIRONMENT: STATE-OF-THE-ART-SUMMARY

Prepared by

Ralph G. Langenborg
Energy Efficient Buildings
Energy and Environment Division
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94270
July 25, 1979

As a result of the increasing price and scarcity of primary energy supply, conservation has assumed a more prominent role in the formulation of national energy policy. An extensive sector for the application of conservation techniques exists in residential, institutional, and commercial buildings, which together account for approximately 1/3 of the energy consumed annually in the United States. More than 1/2 of this energy is used to maintain human comfort conditions through heating, cooling, and ventilation of buildings. Significant energy savings can be realized by 1) changing the thermal properties of the structure and 2) reducing the natural and mechanical ventilation rates.

The introduction of energy-saving measures, however, may adversely affect indoor air quality. In particular, reduced fresh air ventilation may allow build up of chemical contaminants emitted from building materials and other indoor pollutant sources. Remedies include restored ventilation (spot or generalized) and/or installation of contaminant control devices (source control or generalized). Given that a solution of increased ventilation is rather energy demanding, alternative solutions deserve investigation.

To date, effective contaminant control devices have found little application in the built environment. Large commercial and institutional structures usually have coarse fiber filters installed in their ductwork, as may centrally heated homes. The introduction of electrostatic precipitators and/or activated charcoal filters in medium to large air handling systems has seen very limited use in the U.S., though the practice is becoming more common abroad (particularly Japan).

Broadly speaking, air contaminant control devices have been developed for military, transportation, spacecraft, and industrial applications. Many systems are custom-designed, energy intensive, and require considerable capital investment. As such, appropriate technology transfer to the building sector should be carefully evaluated. The following is a brief generic overview of contaminant control equipment:

1) Filters

   A. nomenclature: fabric, fiberous, HEPA,...
   B. target contaminant: particulates (all sizes)
   C. effectiveness: varies with filter type
   D. current application: very widespread, ranging from coarse particulate control (metal grease filters) to maintenance of sterile conditions in operating rooms (HEPA)
   E. cost: low to high initial, low to high operating
   F. notes: most widely used particulate contaminant control device other than direct exhaust ventilation

2) Electrostatic precipitators

   A. nomenclature: electronic filters
   B. target contaminant: particulates (all sizes)
   C. effectiveness: varies with application, 90%+ (down to 0.5-1 microns, if desired)
   D. current application: a) high-voltage for industrial use b) low-voltage for residential use (medical applications e.g. allergy)
   E. cost: medium initial, low operating
   F. notes: may generate ozone during operation

3) Mechanical (dry) dust collectors

   A. nomenclature: cyclones, settling chambers
   B. target contaminant: particulates greater than 15 microns
   C. effectiveness: 50-95%
   D. current application: medium to large industry
   E. cost: low initial, low operating
   F. notes: target contaminant generally not a problem in indoor environments

4) Scrubbers (absorbers)

   A. nomenclature: spray towers, packed towers, flooded-bed, venturi, flooded disk
   B. target contaminant: particulates (down to approx. 1 micron), toxic gases, odors
   C. effectiveness: 50-95%
   D. current applications: industry
   E. cost: medium to high initial, medium to high operating
   F. notes: fairly energy intensive to attain high efficiencies, toxic gases may be selectively absorbed by varying the composition of the scrubbing fluid

5) Absorbers
   A. nomenclature: activated charcoal, activated carbon, activated silica
   B. target contaminant: toxic gases, odors
   C. effectiveness: varies with substrate and gas, 95%+ is possible
   D. current application: general toxic gas, odor control in industry and military
   E. cost: medium to high initial, medium to high operating (replacement or regeneration of adsorbent)
   F. notes: ineffective on CO, (carbon monoxide) and other inorganic contaminants

6) Contaminant Combustors
   A. nomenclature: combustion chambers, catalytic converters
   B. target contaminant: combustible organic contaminant
   C. effectiveness: 95%+ is possible
   D. current application: transportation (engine emission control) military (submarines)
   E. cost: high initial, high operating
   F. notes: very energy intensive

Operating under the constraints imposed by energy conservation and consumer acceptance (economy, convenience, reliability) criteria, the application of contaminant control technology to the indoor environment is non-trivial. Further research is indicated in the following areas:

1) analysis and transfer of large-scale industry technology to small-scale, low contaminant level application in buildings. Technology areas that appear to offer best immediate prospects are electrostatic precipitators, absorbers and scrubbers to remove fine particulates and odors. Common indoor air pollutants and their sources should be identified, and appropriate industry technology assessed in terms of energy savings, most production feasibility, modification and production costs, consumer marketability.

2) use of spot or automatic ventilation activated by indoor activities (e.g., gas stove use) or air pollutant sensors. Research efforts should concentrate on a comparison of selective exhaust ventilation vs. the application of contaminant control devices necessary to maintain an equivalent level of indoor air quality.

3) incorporation of heat exchangers into ventilation systems. Potential problems requiring investigation include performance degradation due to leakage of the heat exchanger element, pollutant cross-over within the heat exchanger unit, and assessment of optimum models and operating cycles for heat exchangers as applied to various climatic regions of the country.

4) evaluate points 1, 2, and 3 (above) in terms of system application of established contaminant control components (e.g., utilize activated charcoal to reduce pollutant cross-over in heat exchangers). This approach could deal with a wide variety of indoor air pollutants, reduce industrial production lead time, and restrain capital outlays required by individual investors.

5) design improvement of existing contaminant control devices to reduce maintenance and increase reliability. This would include areas such as materials research, installation procedures, quality control, service contracts, equipment certification, etc.

The above R&D recommendation list is far from complete. New areas for investigation will undoubtedly surface as issues revolving around indoor air quality expand. However, considering the potentially adverse health impacts associated with various energy conservation proposals, it would seem prudent to address the question of indoor air contaminant control as quickly as possible.