Report on
Safe, Appropriate Uses for
Filtered Self-Contained Enclosures

The need for alternatives to fume hoods

Until the past decade, laboratory directors and safety officers have had only one option for protecting workers in the laboratory from exposure to chemical fumes and vapors: exhaust contaminants using a fume hood connected to ductwork leading from the hood to the outside of the building.

In most uncontrolled situations, fume hoods remain the equipment of choice for ventilating hazardous airborne materials from the laboratory. But there are situations when installing a ducted hood is impractical or has undesirable consequences because of any of the following:

- Flexibility in placement of the ducted fume hood is limited. Laboratories located in the center or bottom of a several story building may not have a ducting option.
- Some laboratories are “air-starved” and the make-up air available is insufficient to accommodate a ducted fume hood.
- Loss of conditioned air results in a less energy efficient heating and cooling system, increasing costs.
- The initial expense for ductwork and installation is significant.
- Portability is essential.

The ideal solution: a non-ventilated fume hood

Lab designers searched for years for alternatives to ducted fume hoods. The solution appeared to be small, benchtop hoods which did not require ducting to the outside. Instead, they worked on the principle that fumes released within the hood would be filtered and exhausted through the hood, returning clean, breathable air to the laboratory. In the 1980’s various models of “ductless” hoods came onto the market.

The advantages were immediately obvious and attractive to laboratory designers and managers:

- Much greater flexibility and many more options exist for placement location.
- Since air is recirculated to the laboratory, negative pressure is not created in “air-starved” laboratories.
- Operation is more energy efficient because no conditioned air is lost.
- Installation is simpler and less expensive.
- Portability is achieved.

Problems with the 'solution'

To the disappointment of many laboratory directors and safety officers, however, it was soon learned that the performance of many ductless hoods did not parallel ducted fume hoods and did not meet the design criteria and guidelines of recognized regulatory groups. Research published in the *American Industrial Hygiene Association Journal (AIHA Journal)* found that the general design of some of the early ductless hoods was "inadequate" to contain vapors and therefore greatly reduced overall worker protection.[1]

In order to improve the protection of workers, specific design concerns were addressed, including the following:

- The limited capacity of the filter.
- The need for sampling of exhaust air.
- Face velocities insufficient to contain contaminants generated within the hood.
- Contaminant leakage from the hood due to inadequate hood design.
- Safeguards to determine filter saturation such as a chemical breakthrough monitor.

In 1992, after eight years of studying the major issues involved in laboratory ventilation design, the AIHA published a comprehensive set of guidelines for laboratory ventilation. Its first criterion was to make the laboratory a safe place to work. The subsequent published requirements, known as Z9.5-1992, are considered "the minimum necessary" to ensure the safety of laboratory workers.[2]

Based on research published in the *AIHA Journal*, the bottom line is this: Success of the ductless hood involves a complete contaminant control unit.[3] To accomplish this, the limitations of the ductless hoods must be honestly addressed.

The Filtration System

From the beginning, industry watchdogs have been concerned that air filtered through a carbon filtered ductless fume hood be safe for employees to breathe. An *AIHA Journal* article noted "When using a recirculating system in series with a filter bed, the use of a filter breakthrough monitor is crucial."[4]

Although monitors capable of detecting organic vapors in the filter bed are now available, their capabilities are often misleading or misunderstood. What the monitors can effectively do is alert users when organic vapors at a concentration of 50 ppm or greater are sensed within the filters. They do not issue alarms for ammonia, formaldehyde, acid gases or other non-organic fumes. In its 1992 publication, AIHA cautioned that "Ductless fume hoods have limited application in the laboratory because of the wide variety of chemicals used in laboratories."[5] AIHA mandated that adsorption properties of the air filtration technique used in the ductless hood must be evaluated for each chemical. No filter system removes all contaminants.

Most monitors on ductless hoods are placed within the filter bed itself and therefore cannot detect when breakthrough occurs. AIHA has also cautioned that "the warning properties (i.e., odor, taste) of the chemical being filtered must be adequate to provide an early indication that the filtration media is not operating properly."[6] Since monitors are not a fail-safe method of assuring that the hood's exhaust air is chemical-free, the user must be selective in the materials used in the enclosure and must be certain that the laboratory has adequate air changes (4-20 changes per hour).[7]

AIHA expressed further concern that gases and vapors of low molecular weight would be stripped from the carbon and would re-enter the room. Where this situation exists, the *AIHA Journal* says that the laboratory's air is to be "evaluated carefully by qualified persons."[8] Research in the *AIHA Journal* also indicates that filter alarm systems must take into consideration "the mix of chemicals being used in the laboratory as well as the time spent in the laboratory."[9]

The conclusion to be drawn: Regardless of some manufacturers' claims about filtration systems, ductless hoods are not appropriate for every application.

Labconco's Position

Labconco has been a manufacturer of ducted fume hoods and other ventilation products for over 55 years. Our reputation for building safe and reliable fume hoods is without question. For years, Labconco engineers rejected the notion of designing a "ductless" hood. Our concerns revolved around the limitations of the filters and potential for misuse of the enclosure as mentioned in the above discussion.

However, Labconco engineers recognized that in some situations a filtered enclosure was appropriate. What was lacking was a meaningful way to determine when carbon filtration was acceptable. The body of knowledge that influenced us to re-evaluate filtered enclosures as a viable product was the National Institute of Occupational Safety and Health (NIOSH) guidelines on the use of face respirators.[10] Identical in principle, smaller in scale, cartridge respirators were used as a model for the Labconco Paramount® Filtered Enclosure.

As per NIOSH guidelines for chemical cartridge respirators, suitable applications include the following:

- Use of small amounts of organic compounds which release low concentrations of vapors effectively adsorbed or treated by carbon based filters and with inlet concentrations which never exceed the IDLH (Immediately Dangerous to Life and Health) concentrations.
- Procedures performed on the open bench that would be made safer by being performed inside an enclosure.
- Treatment of specific chemicals that are carcinogens or suspected carcinogens.
- Situations where the use of a face respirator with filter is currently used.
- Odoriferous, non-toxic vapor-producing procedures which are a nuisance.
- Repetitive procedures that involve the use of the same chemical(s) each time.
- Use in areas where only knowledgeable users have access or a safety officer regularly monitors performance of the enclosure.

Other applications, not fitting the above guidelines, would be better suited to a ducted fume hood or device which allows for exhausting to the outside. With all applications, the Paramount should be used for work by knowledgeable users and where performance of the enclosure is closely monitored.

We believe only ducted fume hoods or other specialized ventilated enclosures should be used in applications involving:

- Most carcinogenic or suspected carcinogenic materials. (See the discussion below on the use of chemical carcinogens).
- Gases not effectively trapped by filters.
- Any gaseous material that cannot be clearly detected by odor at a level that is safe to breathe (such as carbon monoxide). In other words, chemicals with a detectable odor above its time weighted exposure limit (TWA).
- Situations where procedures change frequently or where inexperienced or unknowledgeable users are not closely supervised.
- Situations not monitored by a safety officer.

What chemicals are appropriate

Below is a general set of rules to determine appropriateness of chemical usage in the Paramount Filtered Enclosure.

- Organics must have time weighted average exposure limits (TWA) of 1 ppm or greater.
- Chemicals must have a detectable odor below the TWA for the chemical.
- Chemicals must be designated by NIOSH guidelines as acceptable for use with chemical cartridge type respirators. (The exception is formaldehyde or carcinogens.) Chemicals not listed in the NIOSH Pocket Guide To Chemical Hazards or in Labconco's Paramount Chemical Guide must be approved by a Labconco Technical Specialist.
- Chemicals must have a recommendation by NIOSH of at least Escape GMFOV (Gas Mask for Organic Vapors).
- When evaporating a mixture of chemicals, the chemical having the lowest TWA will be the concentration used to determine if the mixture meets the guidelines.
- Organic vapors are adsorbed with the type AC Filter Cells.
- Low concentrations of formaldehyde are acceptable with the type CI Filter Cells.
- Hydrochloric, nitric and sulfuric acid gases from non-forced evaporation are treated with the type ST-1 Filter Cells.
- Ammonia and low molecular weight amines are treated with the type CX Filter Cells.
- Selected organic chemicals considered to be occupational carcinogens by NIOSH can be used in the Paramount with restrictions. (See the guidelines that follow).

Use of chemical carcinogens

The use of a vented hood is always recommended when working with carcinogens. A filtered enclosure should be used only as a last resort when there are no vented hoods available. Selected carcinogens may be appropriate for use in a filtered enclosure under these rigid restrictions:

- must be listed in the NIOSH Pocket Guide To Chemical Hazards as "Ca," meaning that the chemical is considered to be a potential occupational carcinogen by NIOSH.
- must have a TWA of 1 ppm or greater.
- must have minimum respirator recommendation of Escape GMFOV.
- must have an odor threshold significantly lower than its TWA.
- must have an inlet concentration or evaporation rate that never exceeds TWA.

Determining Application Suitability

We believe selecting the proper enclosure for any given situation requires consultation with technical specialists qualified to evaluate the various options available. Labconco, as a manufacturer of a full range of ventilation products, is in a unique position to offer this assistance. Our primary concern is the safety of our customers.

Using NIOSH guidelines and our exclusive computerized Carbon Filter Modeling Program, our ventilation specialists can create a report called the Paramount Profile based on the following input from the customer: chemical(s) to be used, amount of chemical evaporated over the operating time, room air changes and electrical requirements. The Paramount Profile includes helpful information such as odor threshold and approximate time until odor is detected, estimated filter life based on saturation or TWA, inlet concentration estimation in ppm, chemical classification such as carcinogens or suspected carcinogens, recommended Paramount model and Filter catalog numbers to order, and technical contacts at Labconco. When the Paramount is not an appropriate product choice, Labconco specialists can offer ventilation alternatives that safely meet the customer's needs.

Monitoring Filter Cell Life

Color-Smart™ Filter Cells are charcoal based, made of activated coconut shell carbon or carbon treated for specific applications. The Labconco filter cell system has these unique features:

- The filters are color-coded to match NIOSH face respirator cartridges for instant at-a-glance identification from the front of the enclosure.
- Vibration-packed filters offer a more homogeneous bed, with less risk of fissures or "weak" areas where vapors could escape, so filter life is extended.
- The Paramount uses two large, 4-inch thick filter cells rather than smaller individual filter packs that require rotation.
- A well located in the final one-fourth of the filter bed provides an area for early detection by a sensor or detector tube of saturation of the filter cell.

Four filter types are currently available:

- Type AC, for organic vapors.
- Type ST-1, impregnated for the neutralization of acid gases.
- Type CI, impregnated for the removal of formaldehyde and formalin.
- Type CX, impregnated for the removal of ammonia and low molecular weight amines.

Three limiting factors affect filter life. Filters should be changed when:

1. concentration in the well is equal to or greater than the TWA for the chemicals being used.
2. the exhaust concentration equals the inlet concentration, indicating filter saturation.
3. the odor of the chemical is detected (in some cases) or when the odor in the work area is no longer tolerable.

There are five means of determining when filters should be changed.

1. Odor. Sensitivity to odor, tolerance to odor and comfort level under odoriferous conditions vary from individual to individual. While odor is an indicator that chemicals are passing through the filter, several points need to be understood:
    a. Smell within the room is not necessarily an indication of saturation or hazardous exposure concentrations.
    b. Odor can be used as a prompt to do other checks of the chemical concentration in the filter well.

c. Organic chemicals approved for use in the Paramount have detectable odors before reaching the time weighted exposure limits.

d. Labconco will advise users, or potential users, of how and when odor may play a part in limiting the life of the filter.

2. Safety-First™ Sensor. In Paramount models designed for use with organic vapors, electronic sensors signal when the concentration of the chemical in the well or in the exhaust is 50 ppm or greater (sensor response based on ethyl alcohol). The sensitivity of the sensors is usually different for each chemical. The sensors do NOT alert users to "saturation" of filters for applications where the inlet concentration of organics is less than 50 ppm therefore other detection means are necessary. (For those applications with inlet concentrations less than 50 ppm, sensors should be considered as a warning system only in event the enclosure is overtaxed and receives a heavy dose of chemicals as in the case of a large spill.)

3. Time. For applications that have very consistent inlet concentration and operating time, "time" can be used to anticipate saturation or TWA levels based on prior experience. However, this method does not replace the need for sampling. Detector tubes, Safety-First Sensors or analytical instrumentation should always be used to determine concentrations in the filter well. While not a definitive method of detection, the "time" function serves the purpose of providing a basis for setting filter check intervals and illustrates, through the display, the relative age of the filter. Initial programming of the times should be based on estimates from a Labconco Technical Specialist. We will recommend that the filters be checked at intervals of 20% of the total estimated life. The exception to the 20% recommendation is formaldehyde and any carcinogen or suspected carcinogen. These very hazardous chemicals must be checked at least every 10% of the total estimated time.

4. Detection Tubes. Color change indicators can be used to measure the presence of the chemical in the filter well (3" level of the carbon bed) or in the exhaust if desired. A kit including syringe pump and tubing is included with each Paramount. A "starter kit" of three Detector Tubes is included with each pair of Type ST-1, CI and CX Color-Smart™ Filter Cells. The Detector Tubes measure either ammonia, acid gases or formaldehyde depending on the Filter Cells purchased. Due to the wide variety of organics, and varying TWA's, we do not supply Detector Tubes with Type AC Filter Cells but recommend Detector Tubes specific to the chemical in use be purchased from a supplier, such as Sensidyne or Dräger. Generic organic Detector Tubes are not quantitative and can be used only as a rough indication of filter saturation. The vast majority of Detector Tubes available start measuring at the chemical's TWA. When a user observes a color change in the tube, he/she should replace the filter immediately.

5. Analytical Instrumentation. This method is the most accurate means of measuring concentrations of any chemical. Analytical instrumentation is required when no Detector Tubes are available or the Safety-First Sensor is not applicable. It is also required when saturation is below the measurement range detectable by Detector Tubes or the Safety-First Sensor. Due to the broad range of chemicals and instrumentation available, Labconco cannot make specific recommendations on the equipment or procedure.

Consequences of Paramount Misapplication

Only one scenario exists where the Paramount's misapplication would result in a hazardous condition. This situation is a compilation of the following factors:

1. the inlet concentration is greater than the TWA,
2. the filter becomes saturated,
3. the user continues to operate, and
4. the ventilation of the room is insufficient to dilute the exhaust of the Paramount to below the TWA for the chemical.

When the inlet concentration is greater than the TWA, extra measures must be taken to monitor the filter exhaust and number of air room exchanges. Frequently monitoring and changing the filters is strongly advised.

Accumulation of contaminants from the Paramount's exhaust can occur only when the rate of generation exceeds the rate of room exhaust. For a saturated filter, the following mathematical equation can be used:

$$\text{Inlet Concentration (PPM)} \times \text{Paramount Air Flow (275 CFM)} < \text{TWA (PPM)} \times \text{Room Exhaust (CFM)}$$

By equating both sides of the equation, the unknown will be the maximum allowed inlet concentration to not exceed the TWA for the chemical.

Labconco's Paramount® Filtered Enclosure

In late 1996, Labconco introduced the Paramount Filtered Enclosure. The name reflects the preeminent, "paramount" priority Labconco places on laboratory safety.

The Paramount Enclosure includes the following safety features:

- Front air foil and rear baffle for contaminant containment. The baffle forces the contaminants to mix with air prior to reaching the filters, providing evenly distributed filter loading.
- Performance compliance with the safety standards set by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and American National Standards Institute (ANSI).
- Blower mounted downstream from the filter system with filters under negative pressure.
- 100 feet per minute face velocity with sash opening of 10.5".
- Compliance of all construction materials (with the exception of the carbon filter media) with National Fire Protection Association (NFPA) Standard 45.11.
- Filter clamping mechanism that applies uniform pressure across the entire top surface of the filter cells providing a safeguard against vapor leaks.

Other features include:

- Open bottom for placement over sink or existing bench.
- Epoxy-coated aluminum framework for corrosion-resistance and durability.
- Tempered safety glass sides and sash allowing full vision and resisting scratching and discoloration.

References

[1] Abrams, David S., Reist, Parker C., and Dement John M., "An Evaluation of the Effectiveness of a Recirculating Laboratory Hood," *American Industrial Hygiene Association Journal.* 1986

[2] Foreword, *American National Standard for Laboratory Ventilation;* ANSI/AIHA Z9.5-1992, Secretariat, American Industrial Hygiene Association; Approved September 15, 1992.

[3] "An Evaluation of the Effectiveness of a Recirculating Laboratory Hood," *American Industrial Hygiene Association Journal.* 1986.

[4] Ibid.

[5] ANSI/AIHA Z9.5.15-1992.

[6] Ibid.

[7] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. *1991 ASHRAE Handbook, HVAC Applications, Inch-Pound Edition*. Atlanta: 1991.

[8] "An Evaluation of the Effectiveness of a Recirculating Laboratory Hood, " *American Industrial Hygiene Association Journal.* 1986.

[9] U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, and National Institute for Occupational Safety and Health, *NIOSH Pocket Guide to Chemical Hazards.* Washington, D.C.: 1995.

[10] National Fire Protection Association, *NFPA Fire Protection for Laboratories Using Chemicals 1992*. Quincy, MA: 1992.

For more information, please contact us:

ExpotechUSA
10700 Rockley Road
Houston, Texas 77099
USA

281-496-0900 [voice]

281-496-0400 [fax]

E-mail: sales@expotechusa.com

Website: www.ExpotechUSA.com