A Guide to Ductless Fume Hoods

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INTRODUCTION

Fume hoods are ventilation devices which exhaust chemical fumes, vapors, gasses, dust, mist and aerosols. Fume hoods also serve as physical barriers between reactions and the laboratory, offering a measure of protection against inhalation exposure, chemical spills, run-away reactions and fires.

However, unlike conventional fume hoods, ductless fume hoods filter out chemical fumes using activated carbon filters and recycle the air directly back to the working environment. Personnel protection is provided by drawing air at a controlled rate across a front opening into the hood, preventing toxic vapors generated during reactions from escaping into the general laboratory environment.

Although fume hoods remain the equipment of choice for ventilating hazardous airborne materials from the laboratory, there are situations that make ductless fume hoods a logical solution, such as:

- Flexibility in placement of ducted fume hoods 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 and increased costs.
- The initial expense for ductwork and installation is significant.
- Portability is essential.

However, it should also be remembered that ductless fume hoods are not without limitations. Carbon based filters are processed or treated to adsorb specific types of chemicals at low evaporation rates, thus ductless fume hoods are not commonly used in any applications involving a broad array of chemicals or forced evaporation. Another limitation is carbon filter saturation monitoring, which can prove to be difficult.

ADVANTAGES OF A DUCTLESS FUME HOOD

- They protect the environment since toxic fumes are not released to the environment unlike in conventional fume hoods. Activated Carbon filters retain / neutralize pollutants eliminating harmful discharge to the environment.
- Fully installed systems ready to operate are available at a lower cost than bulky conventional fume hoods. A ductless fume hood can be placed on a bench and connected to an electrical supply. No external ducting, building work or changes to heating and ventilation systems are necessary.
- An expensive ducting and external blower system that is often difficult to maintain is not required.
- They are mobile and can be relocated easily to meet your changing needs; perfect for schools and educational institutes. The hood may be easily re-positioned or filters changed to suit new requirements at anytime.
- They allow energy savings since air which is costly to air-condition, or heat, is not removed from the laboratory. Recirculatory airflow eliminates the need for laboratory make-up air and integration into ventilation systems.

ACTIVATED CARBON FILTRATION

Activated carbon (activated charcoal, activated coal) is a form of carbon that has been processed to make it extremely porous, thus giving it a very large surface area for adsorption or chemical reactions. One gram of activated carbon has a surface area around 500 m² (5400 sq.ft.).

The effectiveness of activated carbon as an adsorbent is attributed to its unique properties, including large surface area, a high degree of surface reactivity, universal adsorption effect, and favorable pore size.

Other than filtration of chemical fumes, activated carbon is often used in purification, deodorization, decolorization and separation.

Activated carbon is usually derived from wood, coal, coconut shell, or peat.

Common Applications for Activated Carbon:

1. Environmental applications

Carbon adsorption has numerous applications in removing pollutants from air or water streams both in the field and in industrial processes such as spill cleanup, groundwater remediation, drinking water filtration, air purification, and many other processes.

2. Medical applications

Activated carbon is used to treat poisonings and overdoses following oral ingestion. Tablets of activated charcoal are still used as a folk remedy and over-the-counter drug to treat diarrhea, indigestion, and flatulence.

Activated charcoal is also used for bowel preparation by reducing intestinal gas content before abdominal radiography to visualize bile, pancreatic and renal stones.

3. Fuel storage

Gas storage in activated carbons is an appealing gas storage method because the gas can be stored in a low pressure, low mass, low volume environment that could be much more feasible than bulky on board compression tanks in vehicles.

4. Gas purification

Filters with activated carbon are usually used in compressed air and gas purification to remove oil vapors, odors, and other hydrocarbons from the air. Activated carbon filters are also used to retain radioactive gases from a nuclear boiling water reactor turbine condenser.

A. Production of Activated Carbon

1. Chemical Activation

This technique is generally used for the activation of peat and wood based raw materials. The raw material is impregnated with a strong dehydrating agent; typically phosphoric acid or zinc chloride mixed into a paste and then heated to temperatures of 500 °C - 800 °C to activate the carbon. The resultant activated carbon is washed, dried and ground to powder.

2. Steam Activation

This technique is generally used for the activation of coal and coconut shell raw material, which is usually processed in a carbonised form. Activation is carried out at temperatures of 800 °C - 1100 °C in the presence of steam.

B. Main Cause of Physical Adsorption

London Dispersion Forces:

- It is a type of Van der Waals' force.
- Intermolecular interaction exists between all molecules (both polar and nonpolar), but is extremely short ranged.
- It is responsible for condensation of most gases to liquid and physical adsorption on activated carbon.

Characteristic Properties of London Forces:

- Nonspecific - existing between all molecules.
- Temperature Independence from -273 °C to 1000 °C.
- Additive - the sum of all interactions.
- Short ranged - the magnitude of the interaction is sensitive to the separation of the molecules.

These characteristics make London dispersion forces analogous to gravitational forces, but short ranged.

The adsorption process takes place in steps:

- Macro transport: The movement of organic material through the macro-pore system of the active carbon (macro-pore >50nm).
- Micro transport: The movement of organic material through the meso-pore and micro-pore system of the active carbon (micro-pore <2nm; meso-pore 2-50nm).
- Sorption: The physical attachment of organic material on the surface of active carbon in the meso-pores and micro-pores of the active carbon.

C. Four Step Mechanism for Adsorption Kinetics

- Bulk or Inter-particle Diffusion Step
- Boundary Layer or Film Diffusion Step
- Inter-particle or Pore Diffusion Step
- Surface Diffusion or Rate of Chemical Reaction Step on Surface

D. Adsorption Parameters of Activated Carbon

- Particle Size: Smaller particles provide quicker rates of adsorption.
- Temperature: Lower temperatures increase adsorption capacity except in the case of viscous liquids.
- Concentration of Adsorbate: Adsorption capacity is proportional to the concentration of adsorbate.
- pH: Adsorption capacity increases under pH conditions, which decrease the solubility of the adsorbate (normally lower pH).
- Contact Time: Sufficient contact time is required to reach adsorption equilibrium and to maximize adsorption efficiency.
- Nonspecific: existing between all molecules.
- Temperature Independence from -273 °C to 1000 °C.
- Additive: The sum of all interactions.
- Short ranged: The magnitude of the interaction is sensitive to the separation of the molecules.

COMMON DUCTLESS FUME HOOD APPLICATIONS

Education

- Ductless fume hoods are useful for secondary and post secondary education, science classes and in laboratories where activated carbon filtration offers safety from selected aerosols and vapors.
- Hoods are easily assembled, portable and configured for high visibility to improve classroom participation.
- Installation costs are minimal; no ducting required.

Life Sciences

- Ductless fume hoods are ideal for protocols using small quantities of solvents.
- Depending on the solvents used, numerous vapor-generating laboratory processes such as HPLC preparation and biochemistry protocols can be performed with improved safety and comfort.

Forensics

- Forensic laboratories frequently use sterilants and preservatives. Formaldehyde, often mixed with alcohols or phenols, is commonly used. OSHA has a specific standard for formaldehyde that stipulates initial and periodic monitoring, protective equipment and clothing, training and designating regulated areas among others.
- Common chemicals used:
  - formaldehyde
  - methyl methacrylate
  - ammonia

Clinical/Hospital

- Industrial and commercial applications range from quality control in cosmetic production to photo-chemicals, solvent extraction, purification and other processes where fumes or vapors are generated.

Cleanrooms

- Ductless fume hoods will not remove tempered air from the cleanroom. A secondary HEPA filter can be installed to prevent particles generated during the work process from being recirculated to the cleanroom.

Other Examples of Applications:

- Touch Up Painting
- Microscopy
- Slide Preparation
- Histology
- Fingerprinting
- Dental Laboratory
- Spray Adhesives
- Solvent Cleaning

DUCTLESS FUME CABINETS - SAFETY PRECAUTIONS

- Ductless fume hoods should not be used for laboratory work in which chemicals of different types are used repeatedly. For example, the hood should not be used for acid emitting processes where hydrocarbon type filters are installed. Ductless fume hoods should not be specified or used for unknown chemicals or to contain byproducts of reactions for which the characteristics are not known.
- Ductless fume hoods should not be used for multiple chemical processes where two or more chemicals could combine in the filter and cause reactions with toxic, exothermic or explosive properties. The chemicals may react later when the second chemical is adsorbed even if the chemicals are not present in the ductless fume hood base at the same time.
- Ductless fume hoods should not be used with certain types of chemicals, virus or bacterial emissions, high concentration acid emissions or processes with very high levels of chemical emissions such that the filter life would be very short. For such types of applications, standard fume hoods, glove boxes, biological safety cabinets should be used. Consult Esco for more information.
- Extreme caution should be taken when working with ignition sources inside a ductless fume hood. Ignition sources such as electrical connections; controllers and open flame can be used inside a ductless fume hood as long as there are no operations involving flammable or explosive vapors. If possible, ignition sources should remain outside the hood at all times.
- Ductless fume hoods are potential locations for fires and explosions due to the types of reactions conducted in these hoods. The location of the ductless fume cabinets should be within the laboratory so that in the event of a fire or explosion within the fume hood, exit from the laboratory would not be difficult. Depending on the types of reactions, plastic hoods, which may not physically withstand a fire, should not be used.
- Ductless fume hoods should be located away from high traffic lanes within the laboratory because personnel walking past the hood may disrupt the flow of air into the hood and cause turbulence, drawing fumes into the laboratory.
- Safety devices such as drench showers, eye wash stations, fire extinguishers, first aid kits and fire blankets should be located convenient to the hood. Proper instructions should be posted as to their use and function.

PROPER WORKING PROCEDURE

- Ensure the hood is operating correctly before commencing work.
- Use appropriate personal protective equipment including goggles and gloves.
- Keep your head outside of the hood. The operator should work at least 15 centimeters (six inches) beyond the plane of the sash.
- Work as far into the hood as possible and with slow, deliberate movements, to minimize airflow disturbances. The operator should attempt to slowly approach and withdraw from the ductless fume hood. The opening and closing of the sash should be done slowly.
- Work with the sash as fully lowered as possible, utilizing the sash as a natural barrier to accidents which may occur in the hood. The operator should make sure that the head and upper body remains outside the plane of the hood opening at all times.
- The contaminants and equipment above the work surface of the hood should be elevated so as to enable flow beneath and around the obstructions.
- Do not use the hood as a storage area. Items can block airflow and interfere with containment.
- Laboratory personnel traffic should be kept to a minimum while working in the ductless fume hood. Substantial cross drafts can be generated which may affect containment.
- The sash should be shut when not working in the hood.
- Filter saturation should be checked regularly, at least once every 60 hours of use.

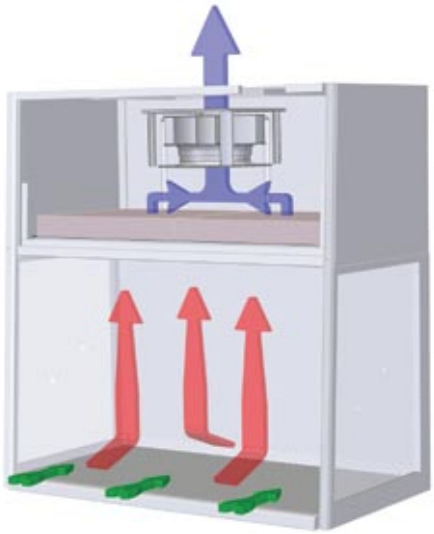
DUCTLESS FUME HOOD TESTING

The ASHRAE 110 test (a method of testing the performance of laboratory fume hoods) can be adapted for testing and certification of ductless fume hoods. There are three test procedures incorporated in the ASHRAE 110 test; the first is the face velocity grid test, the second is the flow visualization or smoke test and the third is the tracer gas containment test.

ANSI / ASHRAE 110-1995 Tests
1. Flow Visualization - Local Smoke Visualization, Gross Smoke Visualization
2. Face Velocity Measurement- Cross Draft Velocity
3. Tracer Gas Test- Static Tracer Gas Test, Surface Scan Test, Sash Movement Effect

Another test that is applicable for the ductless fume hood is BS 7989:2001 Filter Efficiency and Capacity Test. This test is to ensure that the ductless fume hood is capable of meeting

the filter capacity requirements specified in 8.5.2 of the BS 7989:2001 Standard.



Airflow System Inside The Ascent Max Ductless Fume Hoods

AIRFLOW PATTERN IN ESCO DUCTLESS FUME HOODS

Ductless fume hoods provide operator and environmental protection from toxic vapors, gases and fumes.

- The inflow moves from the ambient environment into the work zone through the hood front opening with an average velocity of 0.5 m/s or 100 fpm. Additional inflow air taken through the AutoPurge™ perforations at the back of the work zone prevents fume accumulation for better operator protection. Negative pressure is created in the hood's work zone, which ensures operator protection.
- The inflow flushes the entire work zone of the hood. Within the main chamber of the hood, negative pressure (relative to the ambient environment) is maintained in order to ensure that no chemical fumes or vapors escape the work zone.
- Air is taken through a pre-filter and an activated carbon filter mounted in the interior. The pre-filter is built into the activated carbon filter. This helps prolong carbon filter life by removing large particulates before they enter the carbon filter. The carbon filter removes all fumes from the exhaust air stream and filtered clean air is exhausted directly back to the room from the top of the hood.
- The ductless fume hood can be remotely exhausted to the external atmosphere via an airtight ducting system (optional). The hood provides protection for the operator from volatile toxic chemicals used in trace amounts, which normally would not be removed by the exhaust ULPA filter.

SALIENT FEATURES OF ESCO'S DUCTLESS FUME HOODS

(Left to Right) Esco Ascent™ Max Ductless Fume Hood and Esco Ascent™ Opti Ductless Fume Hood

A. Ergonomic Features

Esco's ductless fume hoods exhibit extremely low noise (less than 56dBA) and vibration levels due to proprietary construction and mounting technology. Sloped front design minimizes glare in the viewscreen and improves user comfort during extended operations. Service fixture provisions are offset and staggered for easier reach and access to service fixtures. Most Esco hoods come with two factory-prepared service fixture provisions on each side wall of the hood. Esco Retrofit Kit™ system allows for convenient on-site installation of electrical outlets and service fixtures on most models. Large, spacious work zone and high internal work ceiling accommodate many laboratory procedures and instruments. Tempered transparent glass sides are suitable for demonstrations and benchtop operations in the classroom. (Optional transparent glass back wall is available for maximum visibility into the work zone during demonstrations).

B. Safety and Maintenance Features

Auto-Purge™ slots at the back of the work zone improve containment and operator protection by preventing the accumulation of fumes in the work zone. All hood service and filter replacement can be carried out from the front allowing the hood to be placed against walls in the laboratory to save space. Front service panel opens up easily for immediate access for all maintenance functions. Designed to meet the general safety requirements of the IEC 61010-1 / EN 61010-1 / UL 61010A-1 / CSA C22.2 No. 1010.1-92. Hoods are shipped fully-assembled. Simply plug the unit into a power source for operation - no local installation is required. 10 international plug types are available.

C. Construction Features

Industrial-grade main body and dress panels constructed from electrogalvanized steel is durable. The all-metal frame is reinforced, welded and expertly gasketed, thus ensuring an airtight carcass for better safety to the operator and the environment. The unique electrolytic zinc coating on the steel provides an additional barrier of protection against corrosion and rust as compared to conventional uncoated cold-rolled steels in order to maximize the service life of the hood. All parts are finished in a specially selected, abrasion resistant thermoset powder coating process that is both environmentally friendly (compared to conventional paints), as well as, resistant to common disinfecting chemicals. The permanently lubricated direct drive centrifugal blower(s) and energy efficient external rotor type design reduces operating costs. An industry exclusive backward-curve motorized impeller design guarantees better airflow uniformity, lower noise and lower overall energy consumption. Built-in solid state variable speed controller(s) (infinitely adjustable from zero to the maximum setting) with built-in RFI and noise filters is superior to conventional "step" controllers. Chemical and abrasion resistant stainless steel work surface will never chip. Lip at front edge of the work surface contains spills in the work zone. Curved front edge minimizes airflow turbulence and improves user comfort.

D. NANOCARB™ Filter Features

Nanocarb™ activated carbon filter(s) are factory installed and tested for efficiency according to British Standard BS 7989. Small filter ID window behind the front panel allows the user to easily identify the type of filter they are using. Unique diffusion technology (US patent pending) with white epoxy powder-coated filter diffuser constructed of electro-galvanized steel is installed in the work zone ceiling below the filter. The diffuser ensures a uniform adsorption of the fumes across the filter surface, preventing filter degradation at concentrated points and prolonging the filter life span. Pre-filter is built-in with the main carbon filter, which means there are no separate pre-filters to replace. Improved filter clamping design (no bolts are used) allows easier filter removal while maintaining uniform clamping over the entire filter surface to prevent leaks. Optional secondary exhaust back-up filter may be installed to ensure a higher level of filtration. When installed, the hood complies with the requirements of ANSI/AIHA Z9.5- 2003.

E. Operational Features

True airflow velocity (for inflow velocity) sensing technology, with temperature compensation for improved sensor accuracy. (Air-velocity can be displayed in either fpm or m/s). Continuous digital display of inflow velocity on the front LCD for constant monitoring. Configurable post-purge cycle ensures all residue contaminants are purged out of the cabinet work zone before the hood is deactivated. Intelligent diagnostics of hardware problems with error message reports is included. All hood operating parameters can be customized and configured based on the requirements of the user. A built-in 24hr clock and experiment timer display for monitoring the duration of experiments and processes are standard. Ambient temperature display both in Celsius and Fahrenheit.

F. Security Features

Fail-safe control system equipped with a watchdog timer ensures the user's safety is not compromised even if the electronics hardware fails. In case of failure, the control will automatically reset the system and restore the hood to safe settings. An Admin PIN can be set by the laboratory supervisor to restrict access to all menu functions. A Fan PIN feature allows the supervisor to restrict access to fan control, thereby preventing usage of the hood by unauthorized personnel.

G. Safety Features

Audible and visual alarms for low and /or high airflow, unsafe sash positions - Sash alarm is activated and the light is automatically cut off when the sash is lower or higher than standard operation height in order to restrict the user's operation and thus enhancing safety. Some models incorporate a high temperature alarm for monitoring emergency conditions like a fire in the cabinet.

H. Maintenance Features

Blower hour meter to help the user monitor total cabinet usage, and thus gauge the life span of the carbon filter / pre-filter. Every 60 hours, the control system reminds the user to test the exhaust concentration with the gas detection tube to see whether the filter is saturated. Airflow calibration can be done easily using the microprocessor control on the front panel of the hood. The special maintenance mode for servicing purposes allows for by-pass of the hood presets and complete control over the hood's functions. All system interlocks are disabled, and all raw inputs and outputs can be viewed for troubleshooting purposes.

I. Green Features

Unlike conventional fume hoods, ductless fume hoods filter out chemical fumes using activated carbon filters and recycle the air directly back to the working environment. Even if the hood's exhaust is externally vented, the carbon filter adsorbs vapors, odors and other contaminants ensuring no pollution in the exhausted air.

Without external venting, ductless fume hoods use less energy. Since the air is safely recycled through the carbon filter, there is no need for exhaust blower, makeup air system and environment conditioning unit (AC or heater) which usually consume a lot of energy.

J. FILTRACHECK™ Chemical Advisory Service

Ductless fume hoods offer many advantages over conventional ducted enclosures such as mobility, no installation costs and energy savings. However, they are only suitable primarily for lighter or fixed chemical applications. The complex nature of any chemical laboratory today means that thousands of chemicals in almost infinite permutations can be used in a chemical hood or enclosure. How can you be sure that a ductless hood will offer the right level of protection and determine how often your filters need to be changed?

Esco's FiltraCheck™ Chemical Advisory Service is a free chemical assessment service dedicated to advising current and potential users of Esco ductless fume hoods on the proper hood and filter for their application. FiltraCheck™ is conveniently available online and can be completed by means of a simple online form. Just tell us how you plan to use your ductless fume hood (including information on chemicals, quantities and types of experiments) and we will do the rest!

At Esco, your safety means the world to us. Esco FiltraCheck™ is supported by our dedicated in-house test laboratory, trained experts on carbon adsorption technology, and external consultants from independent organizations and the world's leading carbon suppliers. Our in-house computer simulations can be used to estimate carbon adsorption capacity, efficiency and simulate competitive adsorption scenarios where multiple types of chemicals may be used.

In our Invent-UK recognized laboratory, we can run almost any type of chemical application using combinations or single compounds to validate your application to actual, empirical test data. Our laboratory performs tests primarily in accordance with the chemical adsorption test methods specified in world standards such as the French Standard AFNOR NF X 15-211 and British Standard BS 7989:2001. Our test capabilities have also been independently validated and recognized by Invent-UK, an independent organization specializing in the field of chemical containment technology. An optional follow-up reminder service is also available from FiltraCheck™ to remind you when your filters need to be changed.

Online Filtracheck form now available at:
http://www.escoglobal.com/ductless/filtracheck.php

Since 1978, Esco has emerged as a leader in the development of controlled environment, laboratory and cleanroom equipment solutions. Products sold in more than 100 countries include biological safety cabinets, fume hoods, ductless fume hoods, laminar flow clean benches, animal containment workstations, cytotoxic cabinets, hospital pharmacy isolators, and PCR cabinets and instrumentation. With the most extensive product line in the industry, Esco has passed more tests, in more languages, for more certifications, throughout more countries than any biosafety cabinet manufacturer in the world. Esco remains dedicated to delivering innovative solutions for the clinical, life science, research and industrial laboratory community. www.escoglobal.com.

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