New Materials

In this book I try to provide information on the hazards of art materials whenever the information is available, and if I know that a particular chemical is being used. However, artists often experiment with new materials and found materials, or use old materials in new and possibly dangerous ways. In these cases you should always specifically ask the manufacturer for information in writing on the hazards of the material and what precautions to take. In some instances, the way in which you are using it might not be covered in the Material Safety Data Sheet.

NEED FOR RESEARCH

Finding less toxic substitutes for many of the art materials presently being used is one area in which much work needs to be done. Art students interested in the properties of art materials could do research in this area, possibly even for dissertations. A more important source of research, of course, should be the art material manufacturers, which should be developing the safest art materials possible. This area of developing safer substitutes is one of the more crucial research needs.

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7

Ventilation of Your Studio

Ventilation, which can be defined as the use of airflow to control the environment, has three basic purposes: (1) to control heat and humidity for comfort; (2) to prevent fire and explosions; and (3) to remove toxic vapors, gases, dusts, and fumes. The first reason is the most familiar, for example, using air conditioners to cool rooms on hot days. However, for artists and craftspeople, the second and third reasons for ventilation can be critical to their health.

Many solvents and their mixtures contain the warning "Use with adequate ventilation" on their labels. The question is, what is "adequate ventilation"? To many people, this simply means opening a window or door. Except when working with very small amounts of solvents, however, this is not adequate ventilation, since you have no control over the direction or the amount of the airflow. The wind might blow the contaminants in your face. Nor is an air conditioner adequate ventilation. Air conditioners recirculate the air, including whatever is contaminating the air. Even on vent, most of the air is recirculated.

Many people also think that working outdoors is sufficient protection. With highly toxic materials, this is not sufficient if there is no wind or if the

wind happens to change direction and blow the toxic vapors or gases back in your face. This can also happen if you depend only on an open window.

In the discussion that follows, I discuss what constitutes adequate ventilation in different situations.

There are two basic types of ventilation: general or dilution ventilation, and local exhaust ventilation. General ventilation operates on the principle of diluting or lowering the concentration of toxic materials in the air you breathe by mixing in uncontaminated air, and then exhausting the air. Local exhaust ventilation, on the other hand, works on the principle of capturing the toxic materials at their source before they have a chance to contaminate the air in the room that you breathe.

Obviously, local exhaust ventilation is preferred in cases in which the contaminants are highly toxic, or in which large amounts of toxic materials are being produced. Examples are the use of aerosol sprays, solvent washing of printing screens, etching with nitric acid, resin casting and molding, drying of screen prints, and kiln firing. Dusts and fumes from processes such as welding, mixing dry clay, and grinding operations are also usually best controlled by local exhaust ventilation. In addition, since local exhaust ventilation requires the exhaust of less air than dilution ventilation, it is a cheaper method in situations in which you have to heat or cool the incoming makeup air to make it comfortable.

DILUTION VENTILATION

A dilution ventilation system can consist of a supply of clean air, air heaters or coolers to make the air comfortable, blowers, and exhaust fans. In some cases, ducting may be necessary to transport the clean air to where it is needed. The minimum needed is a supply of clean air and an exhaust fan.

The sources just listed do not include air-conditioning. Although air-conditioning is useful in providing comfort, it can be hazardous in art studios and workshops, since these systems will recirculate any toxic vapors or gases in the air. In addition, when the ventilation system is tied into the rest of the building, as in central air-conditioning systems, other people may needlessly be exposed to toxic substances. The use of filters and other types of air cleaners to remove toxic contaminants from recirculating air-conditioning systems is not advisable because of the constant need for ensuring that the air cleaner is working properly. Studios using toxic substances should have their own ventilation systems, and they should not be the recirculating type.

In using a general ventilation system to dilute toxic solvent vapors, the important question is how much air is required to dilute the vapors to a safer level. The ventilation rate depends on the toxicity of the material, the amount of material being evaporated, the time period over which this occurs, and the

degree to which the contaminated and uncontaminated air mixes. If these factors are known, the required ventilation rate can be calculated. For solvents, the amount of dilution ventilation required (Q) can be calculated by the following formula:

Q = total amt evaporated (pints) x dilution volume/pint x K/number of minutes

Where

- The dilution volume is the number of cubic feet of exhaust air required to dilute the vapor concentration from the evaporation of one pint of a solvent to the Threshold Limit Value (the TLV is the 8-hour average concentration that is supposed to be safe). See Table 7-1 for dilution volumes for common solvents.
- K is a safety factor to allow for uneven mixing of air, being close to the point of solvent vapor production, solvent toxicity, and rate of evaporation. I normally recommend a safety factor of 10, especially since there is controversy about the safety of many TLVs.
- number of minutes is the time over which solvent evaporation occurs.

Table 7-1. *Dilution Volumes for Common Solvents*

Solvent (TLV in ppm)	Dilution Volume (cu. ft./pint)
Acetone (500)	11,025
Ethyl alcohol (1000)	6,900
n-Heptane (100)	6,900
n-Hexane (50)	Not Recommended
d-Limonene (100*)	89,300
Methyl ethyl ketone (200)	22,500
Methylene chloride (50)	63,400
Mineral spirits** (100)	30,000–35,000
Toluene (50)	76,000
1,1,1-Trichloroethane (350)	11,400
Turpentine (20)	Not Recommended
Xylene (100)	33,000

* American Industrial Hygiene Association recommendation

** Use 30,000 for odorless mineral spirits.

For example, if a pint of odorless mineral spirits is used and evaporates over a four-hour period, then the amount of dilution ventilation needed would be about 1,250 cubic feet per minute (using a safety factor of 10). If you increased the amount evaporated, the amount of dilution ventilation needed would be correspondingly increased. If the solvent evaporates over a longer period of time, then the amount of dilution ventilation needed would decrease, since the solvent concentration would be less at any given time.

Sometimes ventilation rates are expressed in room air changes per hour (AC/Hr). To calculate the ventilation rate in cfm from air changes/hour, you need to know the volume of the room. For example, if you need 10 air changes/hour and have a room 12 x 10 x 8 feet, then you calculate the ventilation rate in cfm as follows:

Room volume = 12 x 10 x 8 cu. ft. = 960 cu. ft.
cfm = room volume x #AC/Hr/60 minutes
= 960 cu. ft. x 10 AC/Hr/60 min.
= 160 cfm.

The following are some simple rules to observe for dilution ventilation:

1. Do not use dilution ventilation with highly toxic materials or with large volumes of toxic materials. The amount of makeup air needed for large amounts of gases or vapors, or highly toxic ones, is very large. Dilution ventilation should also not be used with dusts, since you will be stirring up the dust.
2. Make sure that enough clean or makeup air is entering the studio to replace or make up for the air being exhausted. Otherwise your ventilation system will not be working as designed. A simple way to check this is to open the door to your studio. If the door opens outward and is difficult to open, or if it opens inward and opens too easily, then you are not providing sufficient makeup air.
3. When large quantities of makeup air are required, a fan should be used as a blower to supply the air to prevent a negative air pressure in the studio.
4. Make sure that the air intake and exhaust are sufficiently far apart so that the contaminated air leaving the studio does not reenter through the air intake.
5. The ventilation system should be designed so that the fresh air passes through your breathing zones before being contaminated and exhausted (see Figure 7-1). For this reason, overhead exhaust fans are usually not recommended.
6. Make sure that the clean makeup air reaches all parts of the studio and that there are no uncomfortable drafts.

7. If necessary, cool or heat the makeup air to a comfortable temperature.
8. Check the components of the ventilation system regularly to see that they are working properly.
9. Make sure that the exhaust fan has sufficient capacity to meet the required ventilation rate (see the section on fans in this chapter). Note that just opening a window will not provide ventilation, since the direction of airflow will depend on the wind direction.
10. A simple way to test the effectiveness of your dilution ventilation is to use a child's soap bubble kit. The movement of the soap bubbles will show you the air patterns in the room. If the bubbles just fall, then your system is not effective.

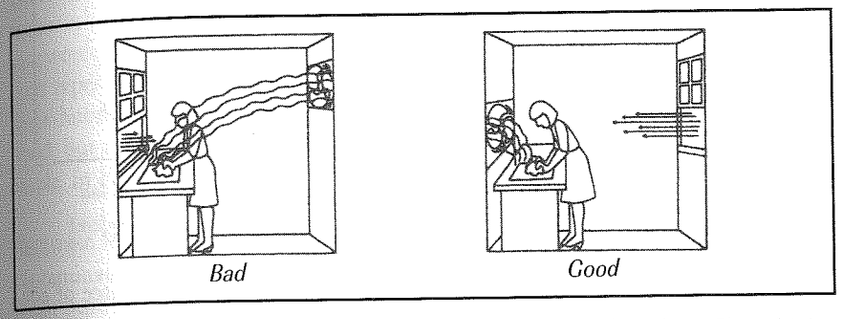


Figure 7-1. Good and bad dilution ventilation (Illustration by Sedonia Champlain)

LOCAL EXHAUST VENTILATION

Local exhaust ventilation is usually preferred over dilution ventilation. Not only does it involve the movement of less air (requiring a smaller fan and less heating or cooling), but, more importantly, it prevents any exposure to the toxic materials. Furthermore, local exhaust systems can be used to control dust, which is impossible to achieve with dilution ventilation.

Local exhaust systems consist of one or more hoods to capture contaminants, ducts to carry the contaminants to the outside, an exhaust fan, and sometimes air cleaners such as dust collectors to remove the contaminants from the exhaust air before releasing it to the outside. (See Figure 7-2).

An exhaust system pulling air away from your face is more effective than a fan blowing the contaminants away, since blowing can just spread the contaminants around. An exhaust hood, on the other hand, pulls the air into the hood from all directions. Since you want just the contaminated air to enter the hood, blocking off clean air from entering the hood by enclosing the hood with shields or baffles is effective. The velocity of the air entering the hood drops off rapidly as you get further away from the hood opening. For this

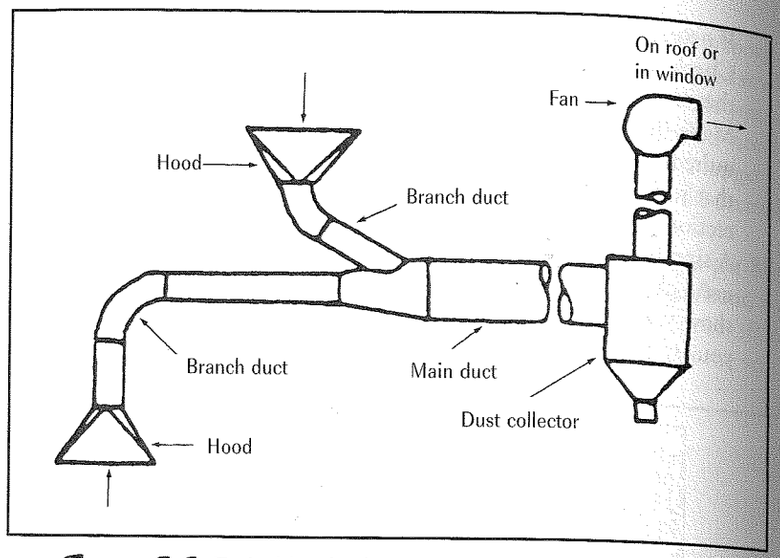


Figure 7-2. Typical local exhaust system: hood, collector, and fan (Adapted from a PHILAPOSH fact sheet) (Illustration by Sedonia Champlain)

reason, local exhaust hoods should be located as close to the source of contamination as possible.

In certain types of processes, the Occupational Safety and Health Act of 1970 requires local exhaust ventilation (for those workplaces covered by OSHA). These include abrasive blasting, grinding, polishing and buffing, spray finishing and painting, welding, open surface tanks of solvents and other toxic liquids, cutting, and brazing. Also, local exhaust ventilation is required with flammable and combustible liquids in storage rooms and enclosures. If OSHA applies to you, you should check its regulations for these processes. Of course individual artists should also use local exhaust ventilation in these instances. The following are simple rules for local exhaust ventilation:

1. Enclose the process as much as possible. The more the process is enclosed, the lower the chance of contaminating the studio and the less airflow required.
2. Make sure that the airflow at the source of the contamination is great enough to capture the contaminant so that it does not escape into the studio. The velocity required is called the capture velocity. Dusts require a much higher capture velocity than do vapors and gases.
3. Make sure that the flow of contaminated air is away from your face so that you do not inhale airborne toxic materials.
4. Make sure that the exhausted air cannot reenter the studio.

5. Make sure that you supply enough makeup air to replace the air exhausted.
6. Regularly check the local exhaust system to make sure it is working. Use soap bubbles as a test. The bubbles should be steadily drawn into the exhaust hood.

Local Exhaust Hoods

Basically there are three types of local exhaust hoods: enclosures, receiving hoods, and exterior hoods.

Enclosures. Complete enclosures are not common in art processes because of the artist's need to work with the materials. One example of a complete enclosure would be a venting system attached directly to a gas-fired kiln. More common types of modified enclosure hoods found in art processes are laboratory fume hoods and spray booths in which the process is carried on inside the hood, but the hood is partially open on one side. See the spray booth, for example, in Figure 7-3.

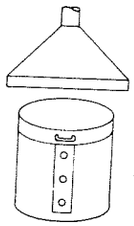
Receiving Hoods. With receiving hoods, the exhaust hood receives a stream of contaminated air and then exhausts it. The source of the gases, vapors, or dusts is not inside the hood. Receiving hoods take advantage of the natural patterns of airflow induced by the art process. For example, receiving hoods are often attached to grinding wheels, sanders, and woodworking machines so that the hood is located in the pathway of the dust as it is thrown off by the machine (see the dust-collecting hood in Figure 7-3).

Another type of receiving hood is a canopy hood (see Figure 7-3). A common example is an overhead stove hood that captures the rising steam and grease from cooking. Canopy hoods are useful for venting kilns because the hot fumes and air rise. The major problem with canopy hoods is that your head can be in the pathway of the contaminated air if you lean over the process. Therefore they are not recommended in situations in which you are working over the contaminant source. In addition, canopy hoods require a lot of exhaust air and are not very effective at a distance from the source of the contaminants.

Exterior Hoods. Exterior hoods are similar to receiving hoods except that exterior hoods do not depend on a natural flow of contaminated air into the hood. Instead, the contaminants have to be pulled into the hood by the exhaust air alone. The exhaust air has to have an adequate capture velocity. The slot hood and plain-opening hood in Figure 7-3 are examples of exterior hoods. Slot hoods, for example, are often used for soldering operations, solvent cleaning

Local Exhaust Ventilation for Art and Craft Processes

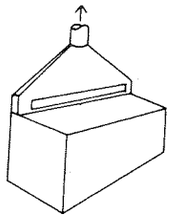
CANOPY HOOD



Process: ceramic kiln, metal foundry, forging.
Form: vapor, gas, fume, steam
Not ready-made.*

Advantages
Captures upward-moving contaminants.
Good for heat-producing operations.
Handles surges of hot air.
Easy to construct.
Designed in various sizes.
Disadvantages
Exposes worker to contaminants if he works under hood.
Often used improperly.
Should not be used for dust.

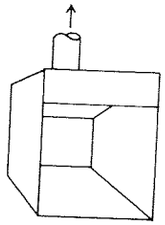
SLOT HOOD



Process: silk-screening, acid etching, bench welding, soldering.
Form: vapor, gas, fume.
Not ready-made.*

Advantages
Has universal applications.
Does not interfere with most processes.
Can cover a long work area: four-foot maximum selections are used side by side.
Good for processes performed on a work bench.
Disadvantages
Work must be kept in close proximity of slot opening.
Work-table depth has a 36" maximum.
Can be difficult and costly to construct.

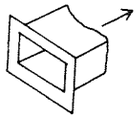
SPRAY BOOTH
and other enclosed hoods



Process: spraying lacquer, paint, ceramic glazes, flammable materials, highly toxic materials.
Form: vapor, gas, fume, dust.
Ready-made.*

Advantages
Completely encloses contaminant.
Safest hood for flammables and highly toxic materials.
Conserves materials.
Reduces housekeeping.
Designed in various sizes.
Disadvantages
Cost of operation high.
Requires more space than other hoods.
Requires constant cleaning.

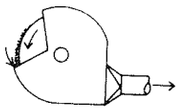
PLAIN-OPENING HOOD



Process: welding, soldering, art conservation.
Form: vapor, gas, fume.
Ready-made.*

Advantages
Can be used in areas where conventional hood will not fit.
Can be connected to flexible ducting for repositioning to fit work and for several alternating locations.
Easy and inexpensive to construct.
Disadvantages
Must be in a range of four to six inches from opening for effective capture.

DUST-COLLECTING HOOD



Process: grinding, woodworking, polishing.
Form: dust.
Sometimes ready-made.*

Advantages
Reduces housekeeping.
Reduces fire hazards.
Disadvantages
Ready-made hoods often ineffective.
Requires constant cleaning.

* Ready-made hoods are available in set sizes and are complete with all equipment from manufacturer and dealers. Others must be fabricated by a sheet-metal shop.

Figure 7-3. *Hoods for local exhaust systems (First appeared in* Ventilation: A Practical Guide, *Center for Occupational Hazards, 1984) (Illustration by Sedonia Champlain)*

operations, and screen printing. Plain-opening hoods with flexible ducts are often used for welding. Another example of an exterior hood is an exhaust hose hooked up to an electric drill or similar hand tool (see Figure 7-4).

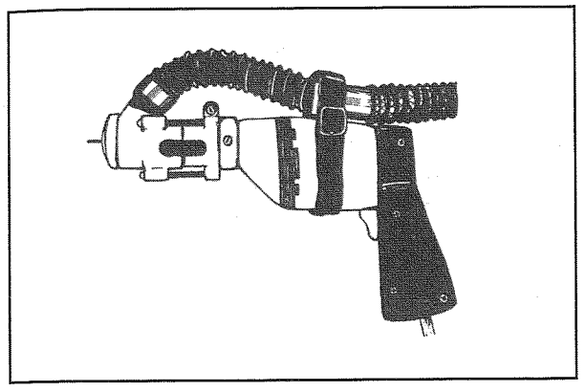


Figure 7-4. *Local exhaust of an electric drill (Illustration by Carlene Joyce Meeker)*

With exterior hoods, the limiting factor in efficiency is how far the source of contamination is from the hood inlet. For most effective use, try to place the exhaust hood as close as possible. Another way to improve the efficiency is to put flanges or side shields on the hood inlet to control the flow of air so that all the air entering the inlet comes from the contamination source.

In cases in which a local exhaust system is too expensive or impractical for an individual artist, a modified local exhaust can often be obtained by use of a window exhaust fan and screens or walls to control the direction of the airflow. Note that the fan should be at or slightly above table level, since solvent vapors do not normally fall (except in still-air situations). The work table should be placed right against the window to have the art process as close as possible to the window fan. This is shown clearly in the example of good ventilation in Figure 7-1.

This type of system in combination with a respirator might be used in cases such as polyester resin casting, in which the respirator will protect you while working and the exhaust fan will remove the vapors so that your respirator can be removed after work. Of course this should be a last resort, not a first choice.

EXHAUST DUCTS

Ducts in local exhaust systems transport the contaminated air from the hood to the point of discharge. In the case of dust contaminants, the air velocity in the duct must be high enough to prevent the dust from settling in the ducts (at least 3,500 feet per minute).

If the ducts are just transporting solvent vapors, fumes, or gases, then the duct velocity is a compromise between the various costs of duct size, fan size, motor size, and power consumption. For example, larger ducts—which are more expensive—permit lower transport velocities and therefore smaller fans. Often duct velocities between 1,200 and 2,500 feet per minute are used.

Normally in local exhaust ducts, circular ducts are used rather than the rectangular ducts common in air-conditioning. Ducts should be made of fire-resistant materials. If the material being exhausted is corrosive, the ducts should be corrosion resistant. Ducts should have as few bends as possible and should not have sharp changes of direction, since these can cause a loss of air velocity, which would have to be overcome by a more powerful fan. Industrial ventilation manufacturers can supply the ducting needed. Details on designing hood and duct systems can be found in the references for this chapter.

FANS

Fan selection is one of the most important parts of ventilation system design. There are two basic types of fans: axial flow fans and centrifugal fans (see Figure 7-5). In axial flow fans, the direction of airflow is parallel to the axis of rotation of the fan. The standard propeller fan is one of the most common examples. This type of fan is normally used for dilution ventilation of solvent vapors and gases and sometimes for spray booths if there are only a few feet of ducting. Axial fans are not effective in exhausting air against resistance (e.g., from filters, long stretches of ducts, hoods).

With centrifugal fans (e.g., squirrel cage fans), on the other hand, the airflow is perpendicular to the fan axis of rotation. Centrifugal fans—especially the radial blade type—are commonly used for dusts, for example, from grinding, mixing clay, and sanding.

Choosing a Fan

In choosing a fan, the following factors should be considered:

1. *Required airflow.* The size and type of fan you choose will depend to a great extent on the ventilation rate needed. For example, propeller fans are used for removing large volumes of air at low velocity, whereas centrifugal fans are used when less air movement is needed, but at a higher velocity (e.g., for dusts).
2. *The nature of the contaminant.* As discussed above, the contaminant determines whether you will choose an axial flow or centrifugal fan. In general, centrifugal fans are used for dusts.
3. *Flammability and explosive hazards.* If the contaminant is flammable or explosive, special types of fans will be needed (see the next section).

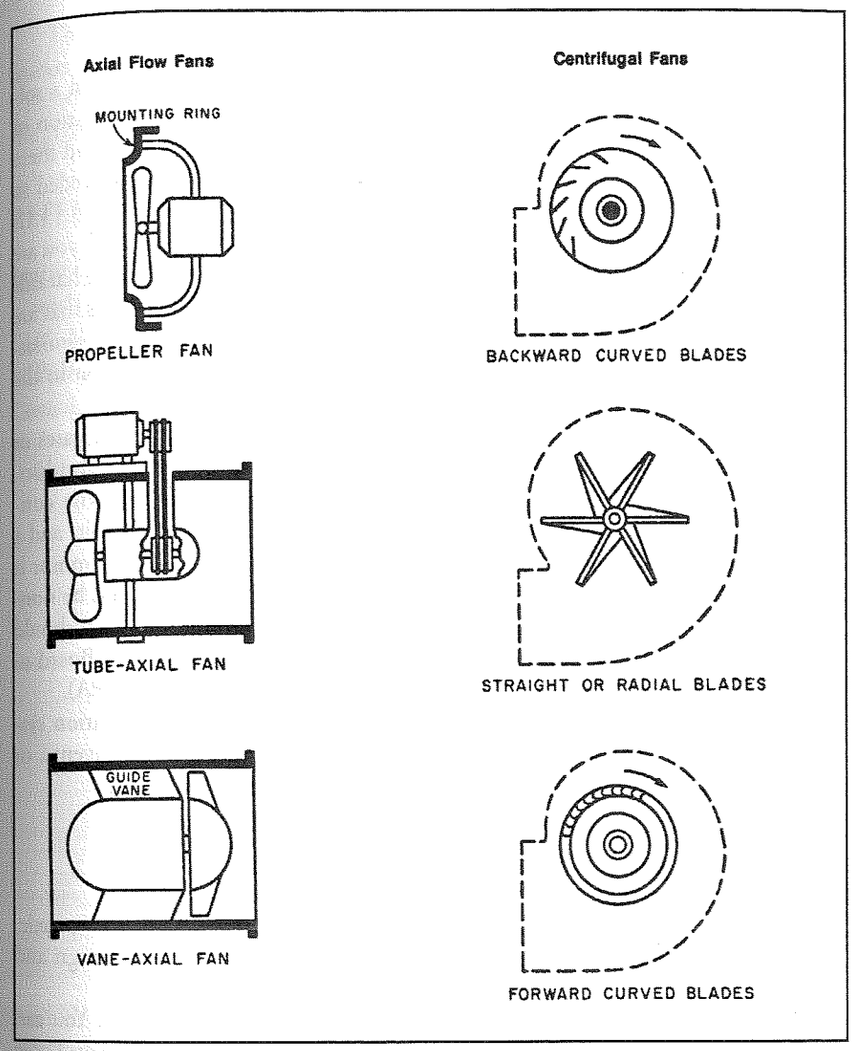


Figure 7-5. Basic fan types

4. *Noise level.* The higher the speed of the fan blade tip, the noisier the fan. This can be an important factor limiting the speed of the fan. With propeller fans, you can often cut the noise level and achieve the same airflow rate by using a larger fan blade with a slower fan speed. Some fans can be equipped with silencers. In addition, vibration is often a major source of noise. This can be prevented by mounting the fan on rubber shock absorbers.

FIRE AND EXPLOSION HAZARDS

If flammable solvents evaporate in an enclosed space—for example, in a solvent storage room—there is a chance of an explosion if the concentration of solvent vapors builds up to the lower explosive limit for that solvent and there is a source of ignition present. In such cases, exhaust ventilation is needed to ensure that the lower explosive limit is not reached.

Reaching the lower explosive limits of a solvent is not a problem if you are properly ventilating your studio to protect yourself against the health hazards of the solvent. The reason for this is that the concentrations of solvents that are unhealthy are much lower than the lower explosive limits; therefore, ventilating for health reasons will automatically keep the vapor concentration in the studio below the lower explosive limit.

Local exhaust systems that are exhausting flammable solvents or gases or combustible dusts require special consideration. If the fan motor is in the duct, then an explosion-proof fan motor is necessary because the airborne contaminants inside the duct might build up to the lower explosive limit, and a spark from a normal fan motor could set off an explosion. If the fan motor is outside the duct and a belt-driven fan is used, then the blades should be nonsparking (e.g., aluminum) and the belt should be enclosed. All fan parts should be electrically grounded and conform to standards of the National Board of Fire Underwriters and the National Fire Protection Association (NFPA).

Explosion-proof fans might also be necessary in dilution ventilation systems when there is a risk of spilling large amounts of flammable solvents, or when solvent-containing materials are sprayed outside a spray booth.

HELP WITH YOUR VENTILATION SYSTEM

This chapter has described the principles of ventilation for exhausting toxic, airborne chemicals. But how do you actually go about the actual design and installation of a ventilation system?

If all you need is a window exhaust fan, then it is fairly simple. You can calculate the capacity of the exhaust fan in cubic feet per minute if you know how much solvent you are evaporating, as discussed earlier. Spray booths and movable exhaust hoods for welding can be purchased directly. If you are not sure what type of system you need, you should consult an industrial hygienist. However, often you need experts to design your exhaust system, build it, and install it. For this, you need a registered professional engineer with expertise in industrial ventilation. Most heating, ventilating, and air-conditioning engineers do not have this expertise, although with the help of the books in the chapter references, they should be able to do the job. Ask whoever you get to design the system for references from similar types of jobs and check them.

The actual manufacture and installation are often done by sheet-metal workers. Make sure that any electrical work is done by licensed electricians. The installation and testing of the ventilation system should be supervised by the engineer.

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