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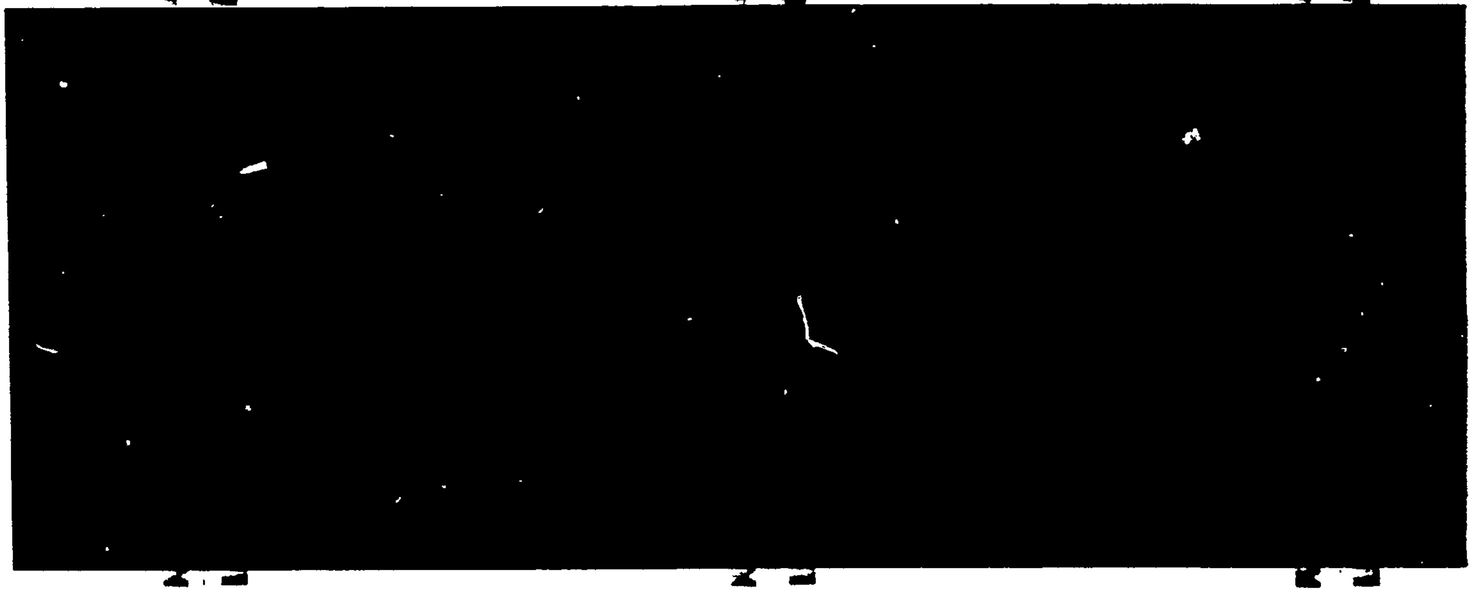
ABSTRACT

Guidelines for controlling indoor air quality problems associated with kilns, copiers, and welding in schools are provided in this document. Individual sections on kilns, duplicating equipment, and welding operations contain information on the following: sources of contaminants; health effects; methods of control; ventilation strategies; and environmental standards and guidelines. Four figures are included. (LMI)



GUIDELINES FOR CONTROLLING INDOOR AIR QUALITY PROBLEMS ASSOCIATED WITH KILNS, COPIERS, AND WELDING IN SCHOOLS

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General Overview

In order to protect school employees, as well as students, this document provides practical guidance to control the emissions from ceramic kilns, copiers, and welding operations. Although this document references Maryland, the guidance presented is valuable nationwide.

Kilns

Sources of Contaminants

Clays and glazes are composed of minerals and metal compounds. When these materials are handled in dry form their dusts can become airbome and can be inhaled easily. Some of the dusts in standard ceramic work are hazardous, particularly crystalline free silica. When greenware is fired in a kiln, the high temperature (over 2000F) causes emissions that can include sulfur dioxide, metals, nitrogen dioxide, carbon monoxide, organic compounds, and ozone.

Some of these emissions, such as the oxides of sulfur and nitrogen, are irritating to the upper respiratory system. The metal colorants such as cobalt, cadmium, and lead can be quite toxic and should be banned from school supplies.

The use of a kiln also tends to heat up the space where it is used, causing thermal discomfort to occupants.

Description of Facilities

Kilns are either electric or gas-fired. Most schools try to physically isolate the units by placing them in a separate room or an isolated section of the art classroom. Kilns have been moved to boiler rooms in some schools.

STANDARDS AND GUIDELINES

Occupational Standards

Most of the contaminants found in the emissions of kilns have an occupational standard set by the federal Occupational Safety and Health Administration (OSHA), and enforced in Maryland by Maryland Occupational Safety and Health (MOSH).

Air tests conducted by industrial hygienists rarely show airborne concentrations of these contaminants in excess of the OSHA standards. This is particularly true if the raw materials to be used - the clays and glazes - are chosen carefully to avoid those with ingredients known to be toxic. Teachers are covered by the OSHA standards and have the right to file a complaint with the agency and to know the hazards of the materials they work with. It is the responsibility of the school system to maintain a Material Safety Data Sheet (MSDS) for all materials used that have a hazardous component.

Occupational standards do not apply to children. The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) recommends that occupational standards be divided by a factor of ten for schools and other non-industrial settings.

Certification Program of the Art and Craft Materials Institute

Choosing safe art materials for school systems is made easier by the Approved Products (AP) Program of the Art and Craft Materials Institute. The Institute is a non-profit association of manufacturers of children's quality art materials. The AP Seal, a registered U.S. Certification Mark, appears on certain packages and containers of children's art materials, indicating that they are approved as non-toxic.

AP Nontoxic means that the product has been evaluated by medical experts and found to be non-toxic if inhaled, ingested or absorbed.

The Center for Safety in the Arts worked with the California Department of Education to develop a list of products that are safe for children from kindergarten to the sixth grade. The Center recommends using this list and provides it for a nominal charge. It is available from: **Center for Safety in the Arts, 5 Beekman Street, New York 10038, phone 212/227-6220.**

Asbestos Bans

The Environmental Protection Agency (EPA), under the Toxic Substances Control Act has banned the manufacture and distribution of all products containing asbestos by 1996. This ban includes all art materials.

METHODS OF CONTROL

Material Selection

Only products that are included on the California Department of Education list or are certified under the AP Program should be considered for purchase. An MSDS should be obtained for each, as a condition of purchase.

Operational Considerations

Even with adequate ventilation, school systems should try to fire the kiln at times of lower occupancy.

Given the variety of emissions from gas-fired kilns, preference should always be given to electric kilns in future purchases.

Many school systems allow the use of facilities by outside groups after school. These groups should be provided with guidelines that prevent the use of glazes that are banned for classroom use.

Kilns should be isolated as much as practical. School construction plans should incorporate a separate kiln room. For older schools, options are much more limited but a separate location for the kilns should still be given serious consideration.

VENTILATION

General Dilution vs. Local Exhaust

Ventilation is controlling the environment by controlling the movement of air, which is no simple matter. A common approach is to dilute the concentration of any contaminant in the air by constantly introducing uncontaminated air into the space. This is called **general dilution ventilation and is not recommended for ceramic kilns.**

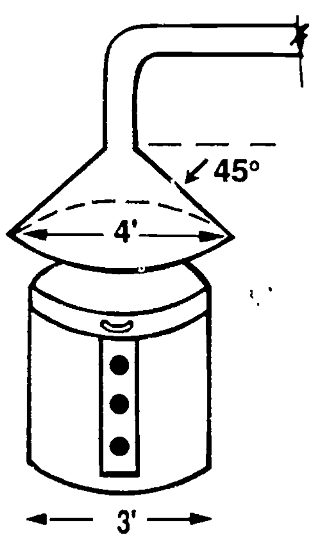


Figure 1. Canopy Hood for Kiln, Good example of Local Exhaust.
Source: Ventilation, A Practical Guide for Artists, Nancy Clark

Much more preferable is the use of **local exhaust ventilation** which attempts to catch a contaminant at the point of generation and exhaust it outside the building. For kilns, this system is usually a canopy hood, although a unit is available for retrofitting older kilns that requires cutting into the bottom and attaching a duct.

General Rules for Hood Design

For efficient kiln hood design:

1. Eliminate air currents around the work area before installing a hood.
2. Design a system that minimizes the resistance to air flow.
3. Enclose the hood as much as possible.
4. Position the hood as close as possible to the source of the contaminants.
5. Provide a capture velocity which draws the agents completely into the hood.
6. Take advantage of natural movement of contaminants into the hood. For a kiln this should be above the unit, as shown in Figure 1.
7. Consider where the make-up air will come from to replace what is being exhausted.

Considerations for Canopy Hoods

Most canopy hoods are installed permanently above a specific spot. They can be equipped with a swinging joint or a counter-weight to allow easy access for a top loading kiln. If the hood is in a fixed position, a small kiln can be put on rollers and moved. An optimum distance for a canopy is not more than two feet above the kiln.

To remove most contaminants adequately with a canopy hood, the American Conference of Governmental Industrial Hygienists (ACGIH) recommends providing an air capacity of roughly 100 cubic feet per minute for every square foot of hood face. The air should be exhausted outside the building being careful not to exhaust it in the vicinity of outdoor air intakes.

Often local environmental protection codes specify suitable termination points for exhaust ducting. Many codes require that ducts end a few feet above a building's roof to guarantee dispersion of contaminated air. It is important to find out what regulations apply in each situation.

The ACGIH's "Industrial Ventilation: A Manual of Recommended Practice" provides guidance for canopy hood design and can be ordered by calling 513/661-7881.

DUPLICATING EQUIPMENT

INTRODUCTION

Duplicating equipment has been identified as a source of indoor air contaminants which pose potential health hazards for equipment operators and building occupants. Five types of duplicating equipment are in common use in Maryland public schools: photocopiers, spirit duplicating machines, mimeograph machines, and diazo dyeline (blue print) machines and electronic stencil makers.

PHOTOCOPIERS

Source of Contaminants

Photocopiers employ an electrostatic copying process in which a photoconductive material is charged and discharged. In the process, ozone is produced as the major contaminant.

The photoconductive material in photocopiers is selenium, but cadmium sulfide, zinc oxide, and organic polymers are also used. Very small quantities of these materials can be released into the air exhausted from the photocopier.

The toner powder contains carbon black and a resin to make the carbon black adhere to the paper. Toner powder, if exhausted from the copier, can create dust in the ambient air. If the toner is fixed to the paper with heat-rolls, vapors from the powder can be produced. The odor normally associated with photocopiers is caused not only by ozone but by these emitted vapors.

Health Effects

Ozone can cause irritation to mucous membranes, headaches, and impairment of vision. Under normal copying conditions, however, an air concentration of the photoconductive material is not expected to cause health hazards.

Ventilation

Most manufacturers recommend that the area in the vicinity of photocopiers should be mechanically ventilated at the rate of at least four air changes per hour (0.5 cubic feet per minute per square foot of floor space, assuming an 8 foot ceiling).

Ventilation by a central air conditioning system with total air circulation through the space at this rate should be satisfactory.

In most cases, no direct exhaust to the outdoors is needed. Unnecessary exhaust to the outdoors will entail additional heating and cooling energy use.

Copiers, especially if heavily used, will generate considerable heat. Even when cooled, the supply air flow needed to offset this heat gain could exceed the ventilation rate stated above by several times. This rate should be calculated considering equipment power, frequency of use, and system cooling characteristics.

SPIRIT DUPLICATING MACHINES

Source of Contaminants

Spirit duplicating machines use methyl alcohol as a duplicating fluid. During the duplicating process, methyl alcohol vapors are released to the ambient air. The methyl alcohol duplicating fluid is available in several concentrations. High content duplicating fluid may contain greater than 95% methyl alcohol while low content duplicating fluid may contain less than 5% methyl alcohol. The lower content duplicating fluids may contain other hazardous materials such as ethyl alcohol, and ethylene glycol monoethyl ether.

Methyl alcohol is also a flammable liquid and must be stored according to the National Fire Protection Association (NFPA) Standard 30 - *Storage and Handling of Flammable and Combustible Liquids.* Storage shall be limited to that required for operation of office equipment in offices and educational facilities. Local fire officials should be contacted for additional information.

Health Effects

Overexposure to methyl alcohol vapors may cause drowsiness, dizziness, nausea, vomiting, irritation and burning of the eyes, and blurred or temporary loss of vision. **The use of the low methyl alcohol content duplicating fluid greatly reduces the inhalation and fire hazard.**

Ventilation

Spirit duplicators are best located in a separate room dedicated to copying and duplicating. The room should be well ventilated with the duplicating equipment area exhausted to the outdoors at a rate of eight air changes per hour (approximately 1 cubic foot per minute per square foot of floor area).

The exhaust air outlet should be located on a wall on the side of the duplicator opposite the normal position of the operator at the height of the duplicating process. Figure 2 shows the preferred method for duplicating machine exhaust.

The source of make-up air can be the air conditioning or ventilation

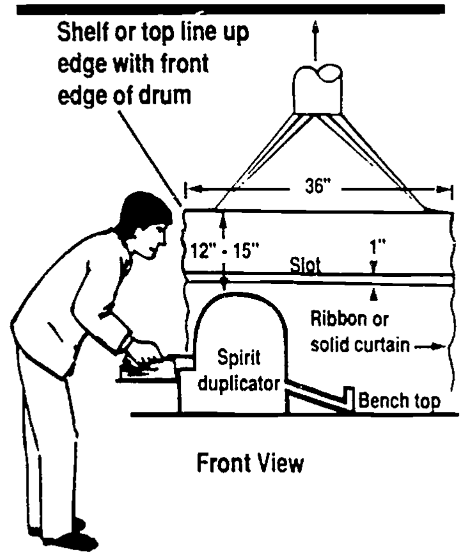


Figure 2. Preferred method for duplicating machine exhaust.
Source: Center for Disease Control.

supply to the room or by transfer through a door grille from adjacent space. The exhaust should exceed the supply air to maintain slightly negative pressure to limit odor permeation into other areas.

The use of low methyl alcohol content duplicating fluid will reduce the concentration of vapors released. These lower concentrations will reduce or eliminate the need for forced ventilation.

MIMEOGRAPH MACHINES

Source of Contaminants

Mimeograph machines use black mimeograph ink. the major constituent of which is an untreated naphthenic oil.

Health Effects

The ink, because of its relatively insignificant vapor pressure, does not normally present an inhalation hazard. therefore no special ventilation is necessary.

DIAZO DYELINE COPIERS

Source of Contaminants

Diazo dyeline copiers use ammonia in an aqueous solution. Ammonia vapors may be released from the solution to the ambient environment. Developers used in dyeline copiers contain hydroquinone and resorcinol.

Health Effects

Ammonia in concentrations likely to be associated with the use of diazo copiers is a strong irritant affecting the eyes and mucous membranes. Both hydroquinone and resorcinol are powerful irritants and the latter is readily absorbed through the skin.

Ventilation

Diazo dyeline copiers are commonly equipped by the manufacturer with an internal exhaust fan and duct connection for site installation of duct work to a point of discharge outdoors. The capabilities of these fans for overcoming the air flow resistance is limited.

Accordingly, the external resistance of the pathway must be determined and compared with the manufacturer's allowance. If the resistance exceeds the allowance, either redesign of the duct work or the addition of a booster fan will be required.

Such reproduction equipment is normally located in a separate room. In addition to the exhaust from the machine, the room itself should be exhausted independently of the machine. While it may be appropriate to cool the reproduction area with conditioned supply air, this air should not be recirculated. The exhaust rate should exceed the supply to create a slightly negative pressure to limit permeation of odors to other spaces.

Other Considerations

Some diazo dyeline copiers use anhydrous ammonia supplied as a compressed gas. The gas cylinders require special storage and handling as specified in NFPA Code 49, Hazardous Chemical Data, the Compressed Gas Association Pamphlet G-1-1966 and Code of Federal Regulations 29 CFR 1910.111, Storage and Handling of Anhydrous Ammonia.

The cylinders should be stored outside or in detached buildings. If stored inside, keep in a cool, well-ventilated, non-combustible location, away from all possible sources of emission.

ELECTRONIC STENCIL MAKERS

Source of Contaminants

Electronic stencil makers use high intensity sparks to burn characters in plastic stencils. In the process, hydrogen chloride, particulate matter, organic vapors, ozone, and carbon monoxide may be produced. Under normal operating conditions, only trace amounts of these contaminants are released.

Health Effects

At the concentrations normally encountered, the contaminants represent a nuisance more than a health hazard. They often create an annoying odor. Hydrogen chloride. ozone, and particulate matter cause irritation to the eyes and to the mucous membranes of the nose and throat.

Ventilation

No special ventilation is necessary. The contaminants released during stencil making are generally confined to the immediate vicinity of the equipment. An exhaust or return air register located near the point of contaminant release should sufficiently control the odor.

The quantity of contaminants is limited and intermittent so that the dilution occurring in a central air conditioning system permits recirculation.

WELDING

INTRODUCTION

Welding, as defined by the National Institute for Occupational Safety and Health (NIOSH) includes *"those processes that join or cut pieces of metal by heat, pressure, or both."* They include welding, brazing, and thermal cutting. The most commonly used welding processes are: arc welding, oxy-acetylene gas welding, and resistance welding. Electric arc welding has numerous variations, depending on the type of electrodes, fluxes, shielding gases, and other associated equipment.

The types of welding most frequently taught in public schools are electric arc, "stick welding", metal inert gas (MIG) welding, and tungsten inert gas (TIG) welding. In addition to these, school maintenance personnel may also use resistance welding.

The principle base metals used in the public schools in welding and art classes is ferrous metal, more specifically, carbon steel. Aluminum alloy is used to a lesser extent. Maintenance personnel may also weld stainless steel.

Sources of Contaminants

Welding, brazing, and thermal cutting processes generate many types of metal fumes and gases which present potential health hazards.

The single largest source of metal fumes is the filler metal. Fumes may also originate from the base metal, from coatings applied to the base metal, and from the flux or electrode coatings. If the metal has a primer coat which contains lead, the fume may be released during welding.

Gases may come from the arc, the burning process, or from changes in the surrounding air. Some of these hazardous gases include acetylene, arsine, carbon monoxide, nitrogen dioxide, ozone, phosgene, and phosphine.

Various photochemical and decomposition products of halogenated hydrocarbons from cleaning and degreasing activities are also present or produced during welding.

Health Effects

The most common acute respiratory diseases associated with welding are metal fume fever and pneumonitis. The most common cause of metal fume fever is zinc from welding galvanized or cutting galvanized metal. Welding on brass, magnesium, copper, and iron can also result in this condition. Some metal fumes may only be irritants, but others can cause long-term damage to the exposed welder.

Materials found in fluxes can also be harmful. Fluorides, for example, when inhaled can burn the lungs and cause fluid formation in the lung. Some chlorinated solvents such as trichloroethylene can be broken down by ultra-violet radiation from the welding arc to form phosgene - a potent nerve agent. The various components of the welding process may also interact to produce adverse health effects.

Other materials of concern include, but are not limited to: cadmium, lead, beryllium, and mercury.

METHODS OF CONTROL

Rather than being concerned about limiting chemical exposure to specific levels, exposures should be controlled to the lowest level possible through the use of good work practices and properly designed engineering controls.

Work Practices

The use of well-designed work practices is required to prevent illness and injury from welding activities. Such work practices include:

- wearing personal protective clothing
- practicing good housekeeping, sanitation, and personal hygiene
- handling compressed gases safely
- knowing how to handle emergency situations
- not using donated materials
- using High Efficiency Particulate Air (HEPA) vacuums

Persons welding and cutting should take particular precautions to avoid breathing the fumes directly. Positioning the work and the ventilation can directs the fumes away from the person's face.

Ventilation

Adequate ventilation (natural or mechanical) must be provided for all welding, brazing, and thermal cutting. American National Standards Institute (ANSI) Standard Z49.1-88 defines adequate ventilation as *"enough ventilation such that personnel exposures to hazardous concentrations of airborne contaminants are maintained below the allowable levels specified by the U.S. Occupational Safety and Health Administration, the American Conference of Governmental Industrial Hygienists or other applicable authorities."*

Of utmost importance is the need to prevent the volume of contaminants generated during welding from passing through the welder's breathing zone. There are a number of factors which influence the adequacy of ventilation. ANSI Standard Z49.1-88 describes these to be:

- Volume and configuration of the space in which operations occur.
- Number and type of operations generating contaminants.
- Allowable levels of specific toxic or flammable contaminants being generated.
- Natural air flow (rate and general atmospheric conditions where the work is being done).
- Location of the welder's and other person's breathing zones in relation to the contaminants or sources.

Natural ventilation may, under certain conditions, provide adequate ventilation for welding operations. These conditions pertain to space requirements per welder, ceiling height, and composition of materials used in the welding process.

Specific requirements for the use of natural ventilation can be found in MOSH Standard 1910.252 and ANSI Standard Z49.1-88.

When the use of natural ventilation is not sufficient nor recommended, mechanical ventilation should be provided. Mechanical ventilation includes local exhaust, local supply, and dilution ventilation.

Local exhaust ventilation is preferred to dilution ventilation for the control of health hazards from fumes or gases. Nonetheless, dilution ventilation may be used in some cases where personal exposures are well characterized and local exhaust ventilation cannot be placed close to the source of emissions.

The ACGIH's *"Industrial Ventilation: A Manual of Recommended Practice"* provides design guidelines for local exhaust ventilation for welding operations.

Such ventilation may be provided by either fixed enclosures or freely moveable hoods intended to be placed as close to the work being welded as practicable. Figures 3 and 4 illustrate effective local exhaust systems.

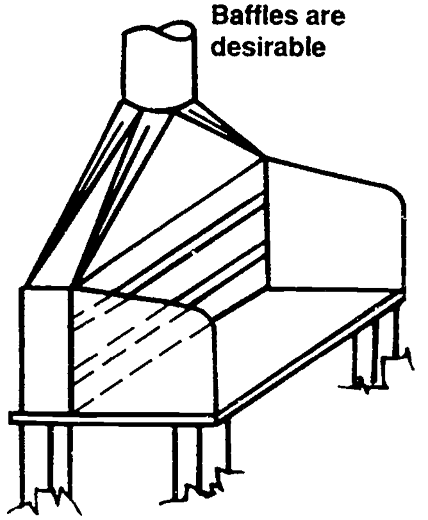


Figure 3. Welding Bench
Source:ACGIH Industrial Ventilation Manual

The air velocity at the face of the hood should be sufficient to capture emissions from the welding process. Hood design should be such that captured emissions are carried away from the breathing zone of the welder. Air flow in the direction of the hood should be 100 linear feet per minute in the zone of welding when the hood is at the most remote position from the point of welding.

In general, local exhaust ventilation works well for welding processes that are conducted at a fixed location such as a workbench, or that are performed on parts of the same size and shape. The degree of effectiveness depends on the distance between the face of the duct inlet and the work, the design of the system, and the flow rate and volume of air exhausted.

A distance of about 9 to 14 inches is adequate for capturing fumes and gases. After optimizing the design of the duct hood so that it can be placed as close as possible to the work, the flow rate can be adjusted to ensure effective capture velocity. The use of side baffles or flanges at the duct inlet can increase the capture velocity.

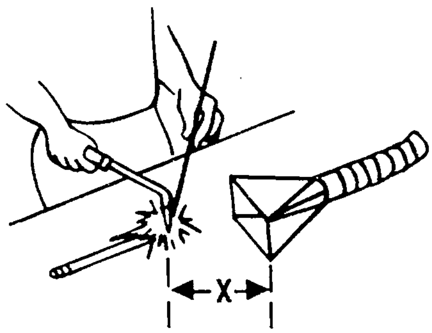
Canopy hoods are not recommended for the removal of welding fumes and gases since air flow into the hood is likely to draw contaminants through the welder's breathing zone.

When fixed enclosures are used to provide local exhaust ventilation, they should enclose the welding operations as much as possible and should be provided with not less than two sides which surround the welding or cutting operations. The air flow should be sufficient to maintain an air velocity away from the welder of not less than 100 linear feet per minute. Provisions should also be made for clean make-up air to replace that which is exhausted.

When welding is performed at remote sites or with long parts, a flanged hood with a flexible duct may be appropriate. See Figure 4. In-line duct velocities for local exhaust systems that are used to control welding emissions should exceed 3,000 feet per minute (fpm) to prevent particulates from settling in horizontal duct runs.

The recirculation of air from systems exhausting welding operations is not recommended. Local exhaust systems should be equipped with flow or vacuum meters or other devices to monitor air flow.

Place hood as close to the source as possible



If 1000 cfm is needed at x distance, 2x requires 4000 cfm.

Figure 4. Portable welding hood

An alternative to using an exhaust hood for gas-shielded arc welding processes is to exhaust the emissions by means of an extracting gun. Such extraction systems can reduce the concentration of contaminants in the welder's breathing zone by 70% or more. Good exhaust flow can be provided while still maintaining weld quality.

Dilution ventilation can be used to supplement local exhaust ventilation and may be necessary when local exhausts cannot be placed close enough to the work to be completely effective. The ACGIH recommends that where local exhaust cannot be used, 800 cubic feet per minute (cfm) of air be exhausted for every pound of welding rod used per hour.

When properly placed at the side of the worker and operated at a relatively low velocity, cooling fans can be used in some environments to provide local forced ventilation to remove welding fumes from the breathing zone. Cooling fans have limited use and should be considered when local exhaust is not possible.

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