

SECTION 10: VENTILATION PROGRAM / REPORTS

The Louisiana Division Ventilation Program complies with the Corporate Industrial Hygiene: Guidelines and Resource Document For the Selection, Use, and Maintenance of Chemical Laboratory Fume Hoods.

Ventilation systems are designed to protect the health of individuals by removing physical and chemical stresses from the workplace. To ensure that these ventilation systems are operating effectively, the Louisiana Division Ventilation Program consists of a detailed inventory of the local exhaust equipment at the plant/department level. This equipment is placed on a plant/department-specific performance evaluation and maintenance schedule to ensure effective operation of the equipment. Manufacturer's specifications and applicable guidelines for all equipment and applications are utilized to ensure the proper operation of local exhaust ventilation.

Operating Criteria: Periodic performance evaluations are performed by the Industrial Hygiene Department. The Industrial Hygiene Department shall be consulted on the purchase and installation of all local exhaust and lab hood systems.

Local Exhaust Ventilation Performance Criteria: Capture velocities may range from 100-2000 feet per minute (fpm) depending on contaminant size, generation rate, air currents and other variables. Each local exhaust ventilation system must be independently evaluated to determine adequate operating parameters.

Laboratory Fume Hood Performance Criteria: Face velocity is measured according to operating conditions which can be with sash fully open, with the sash at 18" from the bottom of the hood, and with the sash at a marked restricted sash opening (if necessary). Average face velocity should be greater than or equal to 100 feet per minute (fpm) and not exceeding 150 (fpm). {NOTE: certain OSHA regulated carcinogens require 150 (fpm).} A smoke stream is introduced into the hood for measuring internal turbulence. If the air capture is well defined with minimal internal turbulence and no smoke swirls back to the hood face with a person standing in front of it, the hood air flow is judged as **good**. If the air capture is positive but has some internal turbulence observed at the hood face with no smoke escaping the hood, the hood air flow is judged as **moderate**. If the air capture is weak and/or not well defined and smoke escapes the hood face, the hood air flow is judged as **poor**.

Fume hoods with a locally-mounted pressure or flowing sensing device readings must be obtained quarterly. The readings should be recorded on Appendix "C" and retained in this section.

Evaluation Schedule: All fume hoods must have an Industrial Hygiene Hood Evaluation. Lab hoods *without* a locally-mounted pressure or flowing sensing device must have 6 month evaluation conducted by the I.H. Department. Lab hoods *with* a locally-mounted pressure or flowing sensing device must have an evaluation every three years. After the hood evaluation is completed, an I.H. Hood Evaluation sticker is placed on the hood (Appendix E).

Training: Training on laboratory fume hoods shall be conducted periodically for all employees. The training consists of: 1) appropriate uses of laboratory fume hoods; 2) problems associated with hood location; and 3) criteria and methods of evaluation for performance of laboratory fume hoods.

Documentation: Documentation must be maintained by the Plant I.H. Contact as part of the plant/department Industrial Hygiene program (**Appendix A-D**). Each plant/department should prepare a Ventilation System Inventory of all lab hood and local exhaust systems located in their facility.

This section contains the following documents:

1. **Plant/department-Specific Ventilation Program**
The following documents make up the plant/department ventilation program:
 - Ventilation System Inventory (**Appendix A**)
 - Industrial Hygiene Hood Evaluation (**Appendix B**)
 - Quarterly Checklist For Fume Hood (**Appendix C**)
 - Fume Hood Troubleshooting Guide (**Appendix D**)
2. **Lab Hood/Local Exhaust Ventilation Inventory**
This provides a list of the type and location of the ventilation systems used in your plant/department.
3. **Current Industrial Hygiene Hood Evaluation for Plant/department Area**
The most recent Industrial Hygiene Hood Evaluation documentation should be kept in the manual.
4. **Corporate Industrial Hygiene: Guidelines and Resource Document For the Selection, Use, and Maintenance of Chemical Laboratory Fume Hoods**
5. **Quarterly Check of Flow Sensing Device for Fume Hood & Housekeeping**
This provides the necessary documentation to assure the hood is checked regularly for proper operation.
6. **Fume Hood Troubleshooting Guide**
This provides a guide for troubleshooting a fume hood system.
7. **MSMS Welding Sign Illustration**
8. **Calculation Sheet for Number of Fans for Confined Space Entry**

Instructions for Dwyer Mark II Molded Plastic Manometers

Filling:

Back out (turn counter clockwise) the zero adjust knob: then turn in approximately three full turns so that there is room for adjustment in either direction. Remove the fill plug, add fluid until it is visible in the vicinity of the zero on scale, then replace fill plug. Use Dwyer red oil only -- other fluids may damage the gauge.

Caution: Use 0.826 specific gravity red gauge oil for Gauge #'s 25 and 27.

If the unit is overfilled to the extent that there is insufficient zero adjustment to accommodate it, the excess oil can be removed by inserting a pipe cleaner through the fill port and blotting up the excess.

Fluid Level Check, Zero Check, and Preventive Maintenance:

Check oil level occasionally and adjust for exact zero setting with zero knob. There are two methods used to adjust the zero. Whichever method was used initially, should be used each time the zero is adjusted.

Method 1: Be sure all pressure is removed by disconnecting tubing at top of gauge before adjusting zero knob.

Method 2: If the tubing can not be disconnected from the gauge for adjusting the zero, then turn hood off, close sash, and adjust zero. Slight fluctuation of the zero usually occurs with this method.

Add oil only when necessary. Clean with a soft cloth using a little pure soap and water. Use of a small brush will aid in cleaning the knobs. Avoid cleaning fluids and liquid soaps that may have chlorinated solvents in them as they may damage the gauge.

Setpoint Check:

The static pressure reading (setpoint) was established at the time of the Industrial Hygiene Evaluation and indicated by a red line on the device.

Deviation Check:

When a continuous monitor device measuring velocity deviates (+/-) 25% from the initial value (setpoint), perform a fluid level check, zero check and preventive maintenance. Once the device is checked, and the static pressure is still out of (+/-) 25% range, please call Industrial Hygiene as soon as possible.

1/31/95
dsc

DO A 039050
CONFIDENTIAL

Section 10 - Ventilation Program/Reports
Table of Contents

<u>Section Name</u>	<u>See</u>
Lab Hood and Local Exhaust Ventilation Inventory_____	Appendix A
Current Industrial Hygiene Hood Evaluation for Plant/department Area_____	Appendix B
Quarterly Check of Flow Sensing Device and General Housekeeping_____	Appendix C
Fume Hood Troubleshooting Guide_____	Appendix D
Industrial Hygiene Sticker for Hood Evaluation_____	Appendix E
Corporate Industrial Hygiene: Guidelines and Resource Document for the Selection, Use, and Maintenance of Chemical Laboratory Fume Hoods_____	Appendix F
MSMS Welding Sign Illustration_____	Appendix G
Calculation Sheet for Number of Fans for Confined Space Entry_____	Appendix H

Appendix "A"

Lab Hood
and
Local Exhaust
Ventilation Inventory

Appendix A

Lab Hood / Local Exhaust Ventilation Inventory

Plant/Department: _____

Year: _____

<u>Hood Identification</u>	<u>Location</u>	<u>Use*</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

*Give the intended use for the ventilation source for example: for volatile liquids/vapors, dusty operation, welding, etc.

DO A 039053
CONFIDENTIAL

Appendix "B"

**Current
Industrial Hygiene
Hood Evaluation
for
Plant/department
Area**

Appendix "C"

**Quarterly Check of
Flow Sensing Device
and
General Housekeeping**

APPENDIX C

Quarterly Check Of Flow Measuring Device For Fume Hood And General Housekeeping Of Fume Hood

This document is for the required check on the permanent, locally-mounted pressure or flow sensing device (manometer or equivalent). The static pressure reading (setpoint check) was established at the time of the Industrial Hygiene Evaluation and is indicated by a red line on the device. When the manometer deviates (deviation check) (+/-) 25% from the initial value (setpoint check), refer to Appendix D - Troubleshooting Guide. If the device is zeroed and static pressure is still out of the (+/-) 25% range, please call Industrial Hygiene as soon as possible.

Quarterly housekeeping should include the following inspection and cleaning of:

- a. unnecessary items (sample bottles, tools, paper, etc.)
- b. slots and rear baffles inside hood (wipe off dust, dirt, grime, etc.)
- c. operation and condition of glass door (cracked)

Plant / Department : _____ Hood ID: _____

Year 199_	Setpoint Check	Zero Check	Fluid level Check	Deviation Check	General Housekeeping
(1Q) January					
(2Q) April					
(3Q) July					
(4Q) October					

Listed below are the Dow MSMS code numbers for the Dwyer II, Model #25 and the red gauge oil. The manometer is used on chemical fume hoods to determine static pressure.

Dwyer II, Model #25 -- measures -0.5 to 3.0.
(comes with a small bottle of oil)

Dow Code #6451006

Red Gauge oil, .826 Specific Gravity, 4 oz bottle
1 pint bottle

Dow Code #6451012

Dow Code #6451010

RETURN TO PLANT INDUSTRIAL HYGIENE CONTACT

rev. IHD
1-31-95

DO A 039056
CONFIDENTIAL

Instructions for Dwyer Mark II Molded Plastic Manometers

Filling:

Back out (turn counter clockwise) the zero adjust knob: then turn in approximately three full turns so that there is room for adjustment in either direction. Remove the fill plug, add fluid until it is visible in the vicinity of the zero on scale, then replace fill plug. Use Dwyer red oil only -- other fluids may damage the gauge.

Caution: Use 0.826 specific gravity red gauge oil for Gauge #'s 25 and 27.

If the unit is overfilled to the extent that there is insufficient zero adjustment to accommodate it, the excess oil can be removed by inserting a pipe cleaner through the fill port and blotting up the excess.

Fluid Level Check, Zero Check, and Preventive Maintenance:

Check oil level occasionally and adjust for exact zero setting with zero knob. There are two methods used to adjust the zero. Whichever method was used initially, should be used each time the zero is adjusted.

Method 1: Be sure all pressure is removed by disconnecting tubing at top of gauge before adjusting zero knob.

Method 2: If the tubing can not be disconnected from the gauge for adjusting the zero, then turn hood off, close sash, and adjust zero. Slight fluctuation of the zero usually occurs with this method.

Add oil only when necessary. Clean with a soft cloth using a little pure soap and water. Use of a small brush will aid in cleaning the knobs. Avoid cleaning fluids and liquid soaps that may have chlorinated solvents in them as they may damage the gauge.

Setpoint Check:

The static pressure reading (setpoint) was established at the time of the Industrial Hygiene Evaluation and indicated by a red line on the device.

Deviation Check:

When a continuous monitor device measuring velocity deviates (+/-) 10% from the initial value (setpoint), perform a fluid level check, zero check and preventive maintenance. Once the device is checked, and the static pressure is still out of (+/-) 10% range, please call Industrial Hygiene as soon as possible.

09/22/92
dsc

Dyer Instruments Inc.
Material Safety Data Sheet
Date Prepared 5-12-87

received
10-06-92
D. Creel

Section I (Material Identification)

Name: Red Sage Oil
Manufacturer: Dyer Instruments Inc.
P.O. Box 373
Michigan City, Indiana 46340

Telephone: (219) 872-9141

Product Number: 71-440133-00

Hazards: Health (2) Flammability (2) Reactivity (0) PP (B)

Section II (Hazardous Ingredients)

Components	CAS Number	Notes
Dyer Red Sage Oil	Mixture	
1 Aliphatic Petroleum Distillates	N/A	(2)
2 Solvent Refined, Hydrotreated, Middle Distillate	64742-46-7	(3)
3 Solvent Refined, Hydrotreated, Heavy Naphthenic Distillate	64742-52-5	(3)
4 Polymeric Additive in Oil	Mixture	(1)
5 Minor Additives	Mixture	(1)
6 Red Dye	N/A	(1)

Notes:

- (1) Based on data available to Dyer, these components in this product are not hazardous under OSHA Hazard Communication (29 CFR 1910.1200)
- (2) PEL 500 PPM - NIOSH recommends a limit of 100 mg/m³ 8 hour time weighted average.
- (3) Toxicity data not available for these components.

The components of this product are not listed with NTP, IARC, or OSHA.

Section III (Physical Data)

Boiling Point: Not Available
Vapor Pressure: Not Available
Vapor Density (Air=1): Not Available
Solubility in Water: Negligible
Specific Gravity (H₂O=1): .826
% Volatile By Volume: Not Available
Evaporation Rate (1): Not Available
Appearance and Odor: Red liquid with slight odor.

Red Sage Oil Page 1 of 3

Section IV (Fire and Explosion Data)

Flash Point: 147°F Method: ICC LEL: N/A % UEL: N/A %
Extinguishing Media: Dry Chemical, Foam, CO₂
Hazardous Decomposition Products: CO, CO₂, HF, CL₂
Special Fire Fighting Procedures: None Known
Unusual Fire and Explosion Hazard: None Known

Section V (Health Hazard Information)

Permissible Exposure Level (PEL) 500 PPM

Primary Routes Of Entry And Effects Of Acute Overexposure:

Eyes - Can cause severe irritation, redness, tearing, blurred vision.

Skin - Prolonged or repeated contact can cause moderate irritation, defatting, and dermatitis.

Breathing - Excessive inhalation of vapors can cause nasal and respiratory irritation, dizziness, weakness, fatigue, nausea, headache, possible unconsciousness and even asphyxiation.

Swallowing - Can cause gastrointestinal irritation, nausea, vomiting and diarrhea. Aspiration of material into the lungs can cause chemical pneumonitis which can be fatal.

First Aid:

If On Skin: Wash exposed area with soap and water. Launder contaminated clothing before re-use.

If In Eyes: Flush with large amounts of water, lifting upper and lower lids. Get Medical Attention.

If Swallowed: Do not induce vomiting, keep person warm, quiet and get medical attention. Aspiration of materials into lungs due to vomiting can cause chemical pneumonitis which can be fatal.

If Breathed: If affected, remove individual to fresh air. If breathing is difficult, administer oxygen. If breathing has stopped give artificial respiration. Keep person warm, quiet, and get medical attention.

Section VI (Reactivity Data)

Stability: Unstable ___ Stable X
Hazardous Polymerization: May Occur ___ Will Not Occur X
Conditions To Avoid: None Known
Incompatibility (Materials to Avoid): Strong Oxidizing Agents

Section VII (Spill Or Leak Procedure)

Steps To Be Taken In Case Material Is Released Or Spilled:

- (1) Eliminate all possible ignition sources.
- (2) Soak up spill with absorbent material. (Sawdust, Vermiculite, etc.)

Waste Disposal Method: Dispose of in accordance with local, state and federal regulations.

Red Sage Oil Page 2 of 3

DO A 039058
CONFIDENTIAL

Appendix "D"

Fume Hood Troubleshooting Guide

APPENDIX D

Fume Hood Troubleshooting Guide

The following items are to be inspected and/or repaired on the fume hood ventilation system listed below. Inspection of the fume hood can be performed by the block Electrician or Instrument personnel for Item #1. If Item #2 applies, the block Maintenance or Lab personnel can perform the inspection.

Date: _____

Fume Hood I.D./Location: _____

Inspected By: _____

Repaired By: _____

1. Perform motor inspections as needed:

- a. Check motor temperature, amperage, rpm, vibration _____
- b. Lubricate motor bearings _____
- c. Inspect/check belts and sheaves for wear and alignment
and condition of electrical connections and insulation _____

Please add comments below concerning any problems, defects, or repair performed to the motor.

Perform fan assembly and fan suction/discharge inspections:

- a. Inspect, check, clean fan assembly and check suction/discharge for dirt,
or corrosion, etc., condition of electrical connections and insulation,
wheel and blades for wear or buildup, belts and sheaves for wear
and alignment (Replace and/or adjust belts and sheaves as required) _____
- b. Check fan operation, rotation, vibration, noise, and/or air pulsation _____
- c. Lubricate fan bearings _____

Please add comments below concerning any problems, defects, or repair performed to the fan.

2. If an oily or dusty operation is being performed in the hood on a continuous basis, the following should be performed:

Examples of oily or dusty operations: an oil bath is located inside the hood, drying or grinding slag, sifting powder substances for quality control, etc.,

- a. Removal of baffle system to inspect for buildup
(Powder, dirt, dust, oil, etc.) _____
- b. If excessive buildup has occurred behind baffle system, the
discharge duct work must be inspected for possible buildup. _____

Comments: _____

Return To Plant Industrial Hygiene Contact

rev. IHD
2-4-94

DO A 039060
CONFIDENTIAL



Managers
Superintendents
Department Heads
Safety Coords./Reps.
Bulletin Boards

INCIDENTS TO LEARN FROM

Louisiana Division



Lab Hood Incident

On Saturday, February 19, 1994, the Poly B plant experienced an incident involving a laboratory fume hood. The cables that connect the hood sash to the counterweight broke, due to rubbing on the pulley brackets, and the sash suddenly came crashing down.

There was no injury associated with this incident, but there was an opportunity for serious injury. As a result of findings during the investigation, we have reason to believe that the potential for similar failures exist in other fume hoods of this brand name. The brand name is HAMILTON and we are presently working with our local supplier, a fume hood service company, and the manufacturer to determine the final solution to the problem.

During this interim, each department should check their fume hood(s) to see if they are HAMILTON; and if so, the entire cable network should be inspected for wear. The cables should be inspected with the sash in the fully open position and then inspected again with the sash in the fully closed position. The problem is likely to be found in the vicinity of the last pulley before the counterweight. These pulleys will be located on the top exterior of the hood completely to the rear and in the center.

If any problems are found or you have questions, contact Eddie Supple at ext. 5722 or Darlene Creel at ext. 6181 IMMEDIATELY.

LAD Safety Communications Committee
03/11/94
ILF94-01
Remove Date: 04/12/94

*Trademark of The Dow Chemical Company



CSHA
VPP
STAR
WORK
SITE

AN OPERATING UNIT OF THE DOW CHEMICAL COMPANY

DO A 039061
CONFIDENTIAL

Appendix "E"

Industrial Hygiene Sticker
for
Hood Evaluation

DO A 039062
CONFIDENTIAL

Appendix E

Industrial Hygiene Sticker For Hood Evaluation

INDUSTRIAL HYGIENE HOOD EVALUATION			
Hood Identification: _____			
Date Of Evaluation: _____			
Evaluator/Phone: _____			
Static Pressure: _____ *			
Face Velocity	@	Sash Opening	Classification
_____	@	_____	_____
_____	@	_____	_____
_____	@	_____	_____
Chemicals Used Under Hood: _____			

Smoke Observation:	Good	Moderate	Poor
Classification:			
A Carcinogenic or Highly Toxic	B General Lab Use		Inadequate
Restrictions: _____			

* If static pressure readings vary 10% from setpoint, calibrate, zero and check device and/or exhaust system.			
If modifications are made in hood operations or conditions, this hood should be rechecked. Please contact Industrial Hygiene at ext. 1883 or 2301.			
Dow Chemical Company Louisiana Division Plaquemine, Louisiana			
VP-127			

Arrow Sticker Indicating Operating Sash Opening

THIS HOOD MUST NOT BE OPERATED UNLESS
THE SASH IS CLOSED TO THIS POINT

**THIS HOOD SASH MUST BE CLOSED
TO HERE BEFORE OPERATING**

VP-126

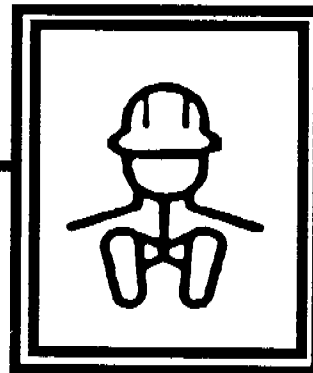
DO A 039063
CONFIDENTIAL

Appendix "F"

Corporate Industrial Hygiene: Guidelines and Resource Document for the Selection, Use, and Maintenance of Chemical Laboratory Fume Hoods

DO A 039065
CONFIDENTIAL

INDUSTRIAL HYGIENE



GUIDELINES AND RESOURCE DOCUMENT FOR THE SELECTION, USE AND MAINTENANCE OF CHEMICAL LABORATORY FUME HOODS

April 1992

The Dow Chemical Company
Corporate Industrial Hygiene
Midland, Michigan

GUIDELINES AND RESOURCE DOCUMENT FOR THE SELECTION, USE AND MAINTENANCE OF CHEMICAL LABORATORY FUME HOODS

**J. P. Jurgiel, Corporate Industrial Hygiene, Midland, MI
R. M. A. Hahne, Corporate Industrial Hygiene, Midland, MI
D. T. Hitchings, Michigan Division R&D Operations, Midland, MI**

**THE DOW CHEMICAL COMPANY
CORPORATE INDUSTRIAL HYGIENE
1803 BUILDING
MIDLAND, MICHIGAN 48674**

CONTENTS

	PAGE
I. Industrial Hygiene Guidelines for the Selection, Use, and Maintenance of Chemical Laboratory Fume Hoods.....	1
II. Resource Document for Chemical Laboratory Fume Hoods.....	4
Purpose of Fume Hoods and Conditions of Use.....	5
Location, Installation and Operation.....	7
Types and Designs of Fume Hoods.....	10
Fume Hood Exhaust System	15
Variable Air Volume (VAV) Control Systems.....	22
Performance Criteria for Fume Hoods.....	23
Evaluation of Fume Hoods	26
Maintenance of Chemical Fume Hood Systems.....	33
Appendix A: Criteria for the Determination of Recommended Fume Hood Face Velocities.....	35
Appendix B: Regulatory Requirements, Voluntary Standards, and Other References.....	38
Appendix C: Definitions.....	41
Appendix D: Model Hood Survey Data Form.....	45
Appendix E: Model Fume Hood Survey Tag.....	46

DO A 039068
CONFIDENTIAL

SECTION I:

GUIDELINES FOR THE SELECTION, USE AND MAINTENANCE OF CHEMICAL LABORATORY FUME HOODS

GUIDELINES FOR THE SELECTION, USE AND MAINTENANCE OF CHEMICAL LABORATORY FUME HOODS

- A. An inventory and identification scheme should be prepared for all the fume hoods located in a given facility.
- B. A standard procedure to review the industrial hygiene considerations of the design, purchase, installation, relocation, or modification of fume hoods should be established. The procedure should involve the industrial hygienist or industrial hygiene contact and include for review items such as location with respect to doors, traffic, makeup air availability, location of general ventilation inlets and outlets, type of hood, and nature of the materials to be handled in the hood.
- C. A performance standard should be established for fume hoods, based on accepted criteria arising from peer-reviewed empirical data. The standard shall not conflict with any existing Dow safety standards or regulatory standards.
- D. Each new or existing fume hood should have a pressure drop or flow-measuring device to monitor hood performance. The device should be visible to the hood user and clearly marked to indicate the value observed at the time of the last survey. A procedure should be established for verifying and documenting that the hood performance has not degraded significantly since the last survey. Degradation of performance should lead to identification and correction of the problem and subsequent re-evaluation of the hood.
- E. Each fume hood should have a tag or label which indicates the performance characteristics of the hood and the materials and equipment used in the hood at the time of the last survey. The hood face should be clearly marked and labeled if there is a maximum opening which the sash(es) should not exceed.
- F. The face velocity of every fume hood should be periodically measured and evaluated for acceptability against the specified performance standards. Measurement should be at the time of installation, modification, or relocation, and subsequently

SECTION II.

RESOURCE DOCUMENT FOR FOR THE SELECTION, USE AND MAINTENANCE OF CHEMICAL LABORATORY FUME HOODS

SELECTION, USE AND MAINTENANCE OF CHEMICAL LABORATORY FUME HOODS

PREFACE

This document is meant for use by industrial hygienists, safety engineers, and laboratory environmental control or design engineers as a guide and tool for effective chemical fume hood system design and use.

Section I consists of Guidelines for the Selection, Use and Maintenance of Chemical Laboratory Fume Hoods. These guidelines include the basic criteria for establishing a program to help ensure the proper use and performance of chemical fume hoods.

Section II is a Resource Document which reviews and summarizes information and describes additional resources related to specific parameters of chemical fume hood design, use and evaluation. It provides a practical guide for meeting the conditions spelled out in the "Guidelines".

DO A 039071
CONFIDENTIAL

**GUIDELINES AND RESOURCE DOCUMENT
FOR THE
SELECTION, USE AND MAINTENANCE OF
CHEMICAL LABORATORY FUME HOODS**

**J. P. Jurgiel, Corporate Industrial Hygiene, Midland, MI
R. M. A. Hahne, Corporate Industrial Hygiene, Midland, MI
D. T. Hitchings, Michigan Division R&D Operations, Midland, MI**

**THE DOW CHEMICAL COMPANY
CORPORATE INDUSTRIAL HYGIENE
1803 BUILDING
MIDLAND, MICHIGAN 48674**

DO A 039072
CONFIDENTIAL

CONTENTS

	PAGE
I. Industrial Hygiene Guidelines for the Selection, Use, and Maintenance of Chemical Laboratory Fume Hoods.....	1
II. Resource Document for Chemical Laboratory Fume Hoods.....	4
Purpose of Fume Hoods and Conditions of Use.....	5
Location, Installation and Operation.....	7
Types and Designs of Fume Hoods.....	10
Fume Hood Exhaust System.....	15
Variable Air Volume (VAV) Control Systems.....	22
Performance Criteria for Fume Hoods.....	23
Evaluation of Fume Hoods.....	26
Maintenance of Chemical Fume Hood Systems.....	33
Appendix A: Criteria for the Determination of Recommended Fume Hood Face Velocities.....	35
Appendix B: Regulatory Requirements, Voluntary Standards, and Other References.....	38
Appendix C: Definitions.....	41
Appendix D: Model Hood Survey Data Form.....	45
Appendix E: Model Fume Hood Survey Tag.....	46

SECTION I:

**GUIDELINES FOR THE SELECTION, USE
AND MAINTENANCE OF CHEMICAL
LABORATORY FUME HOODS**

GUIDELINES FOR THE SELECTION, USE AND MAINTENANCE OF CHEMICAL LABORATORY FUME HOODS

- A. An inventory and identification scheme should be prepared for all the fume hoods located in a given facility.
- B. A standard procedure to review the industrial hygiene considerations of the design, purchase, installation, relocation, or modification of fume hoods should be established. The procedure should involve the industrial hygienist or industrial hygiene contact and include for review items such as location with respect to doors, traffic, makeup air availability, location of general ventilation inlets and outlets, type of hood, and nature of the materials to be handled in the hood.
- C. A performance standard should be established for fume hoods, based on accepted criteria arising from peer-reviewed empirical data. The standard shall not conflict with any existing Dow safety standards or regulatory standards.
- D. Each new or existing fume hood should have a pressure drop or flow-measuring device to monitor hood performance. The device should be visible to the hood user and clearly marked to indicate the value observed at the time of the last survey. A procedure should be established for verifying and documenting that the hood performance has not degraded significantly since the last survey. Degradation of performance should lead to identification and correction of the problem and subsequent re-evaluation of the hood.
- E. Each fume hood should have a tag or label which indicates the performance characteristics of the hood and the materials and equipment used in the hood at the time of the last survey. The hood face should be clearly marked and labeled if there is a maximum opening which the sash(es) should not exceed.
- F. The face velocity of every fume hood should be periodically measured and evaluated for acceptability against the specified performance standards. Measurement should be at the time of installation, modification, or relocation, and subsequently

RESOURCE DOCUMENT FOR THE SELECTION, USE AND MAINTENANCE OF CHEMICAL LABORATORY FUME HOODS

A. Purpose of Fume Hoods and Conditions of Use

1. Introduction

This document is intended to review the critical issues which need to be considered in the installation, use, modification, and maintenance of various types of laboratory fume hoods and is of primary value to the industrial hygienist or industrial hygiene contact who needs to deal with such problems in detail. Although the installation or modification of fume hoods, exhaust systems, or other types of laboratory environmental systems should be under the supervision of an experienced laboratory environmental control engineer or consultant, this document may also be of value to building or design engineers involved in such activities. Purchase specifications of fume hoods are not dealt with in this document, since in most locations the manufacturers already use some standardized performance test to evaluate a particular hood design. The (U.S.) ASHRAE Standard 110-1985 (Appendix B, Reference 9a) is one possible standard against which the performance of the hood could be compared. Other possible standards are given in Appendix B, References 3 through 7.

2. Purpose of Fume Hoods

Chemical fume hoods (or *fume cupboards*, as they are more commonly identified in Europe) fall into the broad category of engineering controls. Their use in controlling exposures of employees to chemicals is preferable to the use of personal protective equipment.

Fume hoods are especially important for use in research laboratories in which the toxic properties of many of the materials being handled may not be well known. Fume hoods should be considered a second line of defense in the reduction of exposures to the materials being handled.

Adequate experimental design, knowledge of the chemical, physical, and toxicological properties and appropriate training in material handling procedures should all be considered prior to running a new experiment or procedure.

A chemical fume hood should not be considered an appropriate means of disposing of unwanted volatile compounds by simply allowing them to evaporate in the hood and be carried away by the exhaust system.

3. Installation and Use

Fume hoods, like any other piece of equipment, should be installed and used with due consideration for their limitations. Industrial Hygiene review must be a part of any project which may involve the purchase, installation or modification of fume hoods and air handling systems, or other local ventilation. Fume hoods can be subject to improper installation or modification, as well as to malfunction. A critical element in any fume hood installation is the balancing of the air handling system with consideration for adequate makeup air and the overall heating, ventilation and air conditioning (HVAC) system's effects on hood performance. Thus, in order to ensure proper hood performance, a program of routine maintenance and evaluation must be established. Section G addresses these points in detail.

4. Changing Uses or Changing Conditions

Fume hood users must recognize that changing uses or changing conditions can significantly affect the performance of the hood. The introduction of additional equipment in the hood, use of different materials, modifications to the HVAC system in the laboratory or specifically to the fume hood blower or ductwork will all impact the performance of the fume hood. Thus, although a hood has been found to perform adequately for one set of conditions, it cannot be assumed that it will perform satisfactorily for all conditions. Sections B and G present specific details regarding these considerations.

B. Location, Installation and Operation

1. Location Considerations

The proper location of a fume hood is essential to maintaining the proper capture efficiency. The following points should be observed:

- a) Keep fume hoods at least 3-6 feet (1-2 meters) away from sources of outside air disturbances, such as windows, doors, frequently used passageways, supply air outlets, *etc.* Any air currents exceeding 30-50% of the fume hood face velocity and impinging on the fume hood opening will cause loss of containment.
- b) Do not place a fume hood adjacent to the only exit of a laboratory. In case of a fire or explosion in the fume hood, access to the exit may not be possible.
- c) Ensure that the local Industrial Hygiene Contact or Industrial Hygienist reviews all proposed laboratory construction or renovation plans involving the installation, renovation, location and sizing of fume hoods and exhaust systems.

2. Installation and Operational Considerations

In addition to location, a number of other considerations should be considered during the design, installation, and operation phases. The following parameters should be reviewed during the planning stage:

- a) Design the exhaust system (fan and motor) so that the face velocity will be 10 to 15% above the recommended face velocities derived from the formula in Appendix A. This additional face velocity should compensate for unexpected flow losses in the ductwork or fume hood.
- b) Never plan to connect another fume hood to an existing exhaust system, unless the new system design parameters for entire system have been reviewed, ensuring that all fume hoods connected to the system can be operated with adequate face velocity.

- c) Mount exhaust fans outside the building to keep ductwork inside the building under negative pressure, thereby minimizing the potential for contaminants to leak from the ducts into the work area. This will also help reduce fan noise in the work area. Fans should be mounted in such a way to allow ease of inspection and maintenance.
- d) Prepare a written maintenance and cleaning schedule for ductwork exhausting dusts and/or condensable vapors. Ductwork carrying condensable vapors should be sloped towards a suitable sump or drain with a downward slope of at least 1 inch/10 feet (0.8 cm/m) in the direction of the airflow.
- e) Avoid the use of manually adjustable dampers and blast gates to prevent changing the air flow distribution.
- f) Avoid placing exhaust duct outlets near building fresh air intakes. See Section D, 3.
- g) Rain 'caps' (weather protection) can be used on exhaust duct outlets, but must not deflect or allow for the entrainment of the exhaust plume into the building intake air. Since rain caps can also increase the static pressure the exhaust system fans must overcome, they also decrease the exhaust volume. The preferred rain 'cap' configuration is a larger diameter annulus which is coaxial with the exhaust duct, as specified in Appendix B, Reference 18.
- h) In order to achieve the desired performance, an adequate supply of makeup air must be provided to replace the volume exhausted through the fume hoods. Consultation with the engineers responsible for the laboratory or plant HVAC systems is advised on this matter.
- i) Design sink drains in fume hoods to include traps which prevent gases and vapors from entering the work area through adjoining fume hood drains. Fume hood sink drains should have standing tubes in them or a "dam" in place around them to prevent unintentional spillage of liquids into the drain.

- j) Specify chemically-resistant materials for the construction of fume hoods, ductwork, drains and exhaust systems.
- k) Use fume hoods equipped with side and lower edge airfoils to minimize turbulence at the hood face. The lower air foil should generally be raised about 1.2 inches (3 cm) above the hood floor to allow for external cords, hoses, *etc.*, to be passed into the hood, under the airfoil, without blocking the sash.
- l) Equip all fume hoods with a continuous flow- or pressure-measuring device such as an inclined manometer or Magnehelic gauge in order to detect any change in hood performance. In some cases, an audible alarm may be desirable to alert lab personnel of significant changes in duct static pressure.
- m) Specify a "dished" work surface with a 0.25 inch (6 mm) minimum lip around the entire hood floor. Make sure that the hood floor is level, since a sloped surface will severely reduce the liquid containment volume in case of a spill. Seal the counter top to the hood lining with silicone (or other chemically-resistant) caulk to prevent spilled materials from leaking into inaccessible areas.
- n) Mark a line 5 to 6 inches (12 to 15 cm) back from the front edge of the fume hood to remind users that all work should be performed behind this line.
- o) Before any work is done in a newly-installed or modified hood, the local industrial hygienist or industrial hygiene contact should conduct a performance evaluation of the fume hood.
- p) Maintain a fume hood inventory for each laboratory.
- q) Schedule periodic performance evaluations for all fume hoods.
- r) Schedule periodic maintenance inspections of the entire fume hood exhaust system. (See Section H)

C. Types and Designs of Fume Hoods

1. General Purpose Hoods

- a) Conventional Bench-Type Hoods -- This is a box-type enclosure with a moveable sash on the front side for adjusting the size of the opening. It is typically mounted on a laboratory bench or work table. Interior baffles at the rear and top of the hood, which usually can be adjusted, are designed to provide a uniform air flow across the hood face. The hood's performance depends largely on the position of the sash since the face velocity is inversely proportional to the sash opening area.
- b) Variable Air Volume Hoods -- This is a conventional (or non-bypass) hood fitted with a face velocity control. As the sash is closed, the air volume drawn through the hood decreases to maintain a constant face velocity. This type of fume hood system is recommended from a safety and energy conservation standpoint. Refer to Section E for more information and cautions regarding this technology.
- c) Bypass Hoods -- This hood is similar to the conventional hood except it is designed so that as the sash is closed, a proportional fraction of the air volume is drawn through an opening in the hood structure (above the sash) instead of through the open face. The purpose of the bypass is to reduce large velocity fluctuations at the hood face by maintaining an open area when the sash is lowered. The bypass opening's area should be dependent only on the position of the sash. This type of hood is recommended for many applications.
- d) Auxiliary Air Hoods -- This hood is similar to the conventional hood except that it supplies untempered air at the hood face as an energy saving feature. However, this auxiliary air may create uncomfortable conditions for the user, carry excessive humidity which might affect experiments, and cause excessive turbulence in the

hood. *The auxiliary air hood should be avoided in all new laboratory installations.*

- e) Portable Hoods -- As the name implies, portable hoods are readily moveable to different locations. There are two types of portable fume hoods: ductless and ducted. *Ductless hoods may be appropriate for control of certain dusts or aerosols, but should not be used for control of vapors and gases as the small-scale filtration systems are typically inadequate for effectively trapping the contaminants.* Consult with your industrial hygienist for specific applications.

Portable, ducted hoods which connect to existing exhaust systems are suitable for use if they meet appropriate design and performance criteria discussed later in this document. Never connect such hoods to the HVAC return air ductwork--only to a dedicated chemical exhaust system.

2. Special Purpose Hoods

- a) Distillation and Walk-In Hoods -- Walk-in hoods are similar to the conventional hood except that they are usually larger and are floor-mounted rather than bench-mounted to accommodate larger equipment. A distillation hood is usually mounted on a low bench, *ca.* 18 inches (45 cm) high, under which equipment such as vacuum pumps, *etc.*, can be kept. Walk-in hoods are mounted directly to the floor. Face velocity controls are recommended for these hoods because of the large air volumes required to operate them and because most have horizontal sashes which prevent the use of a bypass.
- b) Perchloric Acid Hoods -- These hoods are similar to a conventional bench top hood except that materials of construction must be able to withstand a highly corrosive and oxidizing environment. All interior surfaces (including ductwork) should be made of inert materials such as stainless steel, ceramic coated steel, glass, or polyvinyl chloride (PVC). The bottom and sides should have continuous welded seams, and all right angles

should be coved to facilitate cleaning and eliminate deposition of perchlorates. The entire exhaust system including the stack, fan, ductwork and hood should have a wash-down feature, with a gutter and drain to capture and remove the wash water. (See Appendix B, Reference 18, Chapter 10, for additional design parameters.)

- c) Radioisotope Hoods -- These hoods are similar to conventional hoods except that the bottom and sides should be coved. The interior surfaces should be made of a material which allows for easy cleaning and decontamination. The bottom should be constructed to support a number of lead bricks for shielding purposes. All air from radioisotope hoods should be filtered using a high efficiency particulate air (HEPA) filter.
- d) Glove Boxes -- The glove box is a special case application required when dealing with highly toxic materials. Glove box requirements are beyond the scope of this document.
- e) Biological Safety Cabinets (BSC) -- The BSC is a special case application required when dealing with biohazards. BSC requirements are beyond the scope of this document.

3. Hood Design and Construction

The following specifications apply to all types of hoods unless otherwise noted:

a) Perimeter of Opening

An airfoil should be provided at the base of the hood to reduce turbulence. The airfoil should have a 90° arc with a minimum radius of 1.5 inches (3.8 cm) and a 1.2 inch (3 cm) air gap between the airfoil and the hood base.

The side posts of the front face should also incorporate a similar airfoil, or at least have a 45° taper at the forward, inside edge of the post. Squared edges around the perimeter create

unwanted turbulence that can allow contaminants to escape from the hood.

b) Sash

The open face of the hood should be provided with a transparent, moveable sash that allows for closing of the entire face of the hood. The sash should be constructed of approved safety glass.

There are three standard types of sashes: vertical sliding, horizontal sliding, and a combination which includes horizontal sliding sashes within a vertical sliding sash. Face velocities of hoods with vertical sashes are easier to evaluate because the sash height is the only variable. Hoods with horizontal sashes afford the advantage of a smaller area opening for manipulating inside the hood, thus requiring a lower air flow rate.

The bottom edge of the vertical-sliding sash should be designed with an airfoil or a 45° tapered edge to reduce excessive eddy currents. No more than 5 pounds of force should be required to raise or lower the sash. The sash should be able to remain in place at any position. A sash enclosure may be provided at the top of the hood to receive the vertical sliding sash as it moves upward.

c) Work Surface and Walls

The work surface or floor of the hood should be seamless, level, and be recessed at least 0.25 inch (0.6 cm) to aid in containing spills.

All materials of construction for interior surfaces should comply with standards on combustibility. For example, in the United States, the construction materials must have a Flame Spread Index of 25 or less when tested using (U.S.) National Fire Protection Association (NFPA) #255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*. The bypass opening on a bypass hood should be shielded by a slotted panel to impede flying debris and/or liquids in the event of a runaway reaction or explosion.

d) Baffles

The rear and top interior of the hood should incorporate baffles with at least three adjustable slots across the entire width of the hood for achieving a uniform flow of air into the hood under a variety of use conditions. Optimum performance can be achieved through trial and error adjustments of the slots under normal use conditions. A good rule of thumb is to have one slot at the base of the back of the hood, one slot at the middle of the back, and one slot at the top of the back. Slot widths generally range from 1 to 2 inches (2.5 to 5 cm). At least two slots should remain open at all times.

e) Utilities

Controls for utilities serving the hood should be readily accessible, directly outside the hood. Each control should be clearly identified with a tamper-proof label. If there is a water spigot inside the hood, the water should be directed to flow directly into a cup drain.

All valves and switches should meet relevant national standards, such as the (U.S.) American Society of Mechanical Engineers (ASME) standards, and (U.S.) National Electrical Code (NEC) requirements. Under no circumstances should permanent electrical switches or outlets be located inside the hood. All outlets should be of the ground fault circuit interrupter type. Panels which permit access to the utilities for maintenance purposes should be on the outside wall of the hood.

Light fixtures mounted outside the hood liner should be protected by a sealed, transparent, impact resistant vapor shield (Flame Spread Index of 25 or less). Access should be from the exterior of the hood. Light fixtures mounted inside the hood liner should be explosion proof and corrosion resistant. Access may be from the hood interior. Fluorescent lighting is preferred.

DO A 039085
CONFIDENTIAL

f) Noise

Moving the large quantities of air which are required in laboratories can cause excessive noise if proper noise attenuation techniques are not employed. Excessive noise or a significant increase in noise level in an existing system may indicate a problem and should be investigated. Dow corporate Program Requirements for Hearing Conservation and any relevant governmental noise regulations must be observed (Appendix B, Reference 10).

D. Fume Hood Exhaust System

1. Ductwork Systems

There are two major fume hood exhaust system designs to choose from: (a) individual systems consisting of one fan per fume hood and (b) manifolded systems with many fume hoods connected to a common exhaust system which may consist of more than one fan for redundancy and reliability. Each of these systems has advantages and disadvantages. Manifolded systems consisting of more than four hoods in the same general location generally cost less to install, operate, and maintain. However, the chemicals used in the fume hoods connected to this type of system must be carefully evaluated to minimize the risk of cross-reactions occurring in the exhaust system. For the most part, this is not a problem due to the low concentrations involved, coupled with the high dilution factors inside the manifolded systems. In large buildings with many hoods, the ideal exhaust system will probably be a combination of manifolded systems serving most of the fume hoods along with a few individual systems serving perchloric acid hoods, biological safety cabinets, and radioisotope hoods.

a) System Design

Duct systems should take the shortest and most direct route possible. The number of bends, elbows and offsets should be minimized to reduce the static pressure losses in the system. Where needed, bends

and elbows should have a centerline radius of least twice the duct diameter (see Appendix B, Reference 18). Round ducts are preferred to rectangular ducts because of the lower static pressure loss and higher strength. Avoid the use of dampers, blast gates and baffles in the ductwork whenever possible. In order to assure a negative pressure in the portion of the exhaust system located inside the building, the exhaust fan should be located outside the building. This will insure that if there are any leaks in the system contamination cannot escape into the building.

Static pressure losses in the duct system are proportional to the square of the duct velocity. Therefore, duct velocities should be kept as near to the minimum velocity of 1000 ft/min (5.1 m/sec) as possible to minimize the static pressure losses of the system. Certain circumstances may exist which require higher minimum duct velocities, such as when it is necessary to maintain dusts or aerosols in suspension to prevent their deposition in the ductwork. In order to minimize condensation in the ductwork during cold weather, a backdraft damper should be installed when the system is shut down. Insulation of the ductwork should be considered in unheated ceiling spaces. Velocities above 2000 ft/min (10.2 m/sec) should be avoided due to the resulting high noise levels.

In situations where the duct velocity is insufficient to remove dusts or where condensation may form, the duct system should be designed to carry the additional load of the duct partially filled with the deposited material. Built-in spray down capabilities with wet collection systems may be needed in some instances to allow for routine cleaning during normal operation. Sloping ductwork which lead to drains in the direction of the airflow should be considered if condensation is expected to be a problem. All systems should be designed so that routine maintenance and cleaning can be accomplished quickly and thoroughly.

b) Duct Material

The ductwork is usually round in shape and can be fabricated from a number of materials. Flexible ductwork should not be used because of the high static pressure losses and leakage associated with this type of ductwork. The interior of the duct should be smooth and obstruction-free. The duct should be constructed of material which is non-combustible and chemically resistant to the materials in the airstream of the duct. Combustible ducts, exhibiting a Flame Spread Index of 25 or less when tested in accordance with ASTM E162-87, *Standard Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, may be used if installed in accordance with approved standards and regulations. Protective coatings on the interior surface of the ductwork should be used with caution. Some common ductwork materials include galvanized carbon steel, stainless steel, glass fiber-reinforced plastic, and polyvinyl chloride (PVC).

c) Special Considerations

- 1) Perchloric Acid Hoods: Exhaust systems for perchloric acid fume hoods must not be connected into non-perchloric acid fume hood exhausts. The entire hood, duct, fan and stack surfaces must be equipped with water washdown capabilities. The ductwork shall be stainless steel with smooth-welded seams and shall provide a positive drainage back into the hood. The hood and exhaust system must meet the requirements of the (U.S.) NFPA Standard 45, *Fire Protection for Laboratories Using Chemicals* (Appendix B, Reference 11a).
- 2) Radionuclide Hoods (hoods for use with radioactive materials): In the United States, fume hoods used with radioactive materials must be in accordance with regulations established by the (U.S.) Nuclear Regulatory Commission (NRC) (Appendix B, Reference 1). Similar regulatory agencies exist in many other countries, as well. Any maintenance activity or

decommissioning of a fume hood must be in accordance with these guidelines or license requirements and should be reviewed by the Radiation Safety Officer (RSO). All hoods handling radioactive materials must be equipped with HEPA filters to capture radioactive particulates before exhausting to the atmosphere.

2. Fans

The driving force behind any fume hood and fume hood exhaust system is the exhaust fan. All fans in the United States should be certified by the Air Movement and Control Association (AMCA). In other locations, they should comply with local minimum requirements. Fans should be selected so that their performance is as near as possible to the point of optimum efficiency on the fan curve. The two main factors in matching a fan to a system are the flow rate and the static pressure. The fan should be selected to allow a 10 to 15% increase in flow rate. The calculated static pressure should account for all static pressure losses in the system, including the fume hood losses, duct entry losses, ductwork losses, fan entry losses, effluent cleaning device losses and stack losses.

There are two basic types of fans: axial fans and centrifugal fans. Axial fans should be avoided for contaminated airstreams because the belts, bearings, and in many cases, the motors, are located in the airstream. Axial fans are also very sensitive to changes in pressure which may lead to degradation in system performance. Types of centrifugal fans include airfoil, backward-inclined, radial, and forward-curved. The ideal fan for most fume hood exhaust applications is the backward-inclined centrifugal fan or the forward-curved centrifugal fan. In clean-air environments (little dust, aerosols or other particulates which could clog a fan), the forward-curved operates at a lower RPM than the backward-inclined fan for the same flow rate. The backward-inclined centrifugal fan is more rugged than the forward-curved centrifugal fan. The forward-curved fan has a greater tendency to become loaded with dust, thus decreasing fan performance. Other factors to consider for fan selection include the

composition of the fan itself. The fan should be constructed of material which is corrosion-resistant to the expected contaminants. Although belt-driven fans allow for more flexibility in the operating speed of the fan, they do require additional maintenance. Fan selection should be made by someone knowledgeable about fan characteristics such as a mechanical engineer.

The exhaust fan should be mounted so that it is isolated from the building structure to prevent transmission of the fan vibration back to the building.

The fan should be equipped with a drain at the lowest point to allow for condensation removal, if condensation is expected. There should be ready access to the fan for easy cleaning.

All fume hood fans should have spark-resistant construction. In the United States, AMCA Type "C" construction is the minimum requirement. Under certain conditions, more protective specifications such as AMCA Type "B" or AMCA Type "A" construction may be necessary.

Fans for use with perchloric acid hoods must be equipped with water washdown capabilities and must also be acid-resistant. The motor for the fan and any belts, which must be conductive, must be outside the ductwork.

Exhaust fans with mushroom-type caps are prohibited for use with laboratory fume hoods. They cannot be vibration isolated, are frequently excessively loud, and their exhaust outlet is too near the roof.

3. Discharge Stacks

Care should be taken to ensure that contaminated air discharged from fume hoods or other sources is not drawn back into the building through building air intakes or other openings. The turbulence around a building caused by the wind is complicated by the wind direction, local topography, and the presence of nearby structures. Appropriate location of exhaust stacks and air intakes may require dispersion modeling or other aerodynamic methods.

Empirical research has determined the minimum exhaust stack heights that are required to prevent recirculation of contaminated air back into a building or into a nearby building. The following general recommendations are taken from a Dow Chemical USA, Michigan Division Engineering Practice and are applicable for the majority of cases where nearby structures do not exceed the height of the building in question, where the terrain is essentially flat, and where no unusual meteorological phenomena are common: 1) all laboratory fume hood exhaust systems require a stack at the outlet of each fan which should extend a minimum of 10 ft (3.3 m) above the tallest roof or air intake within a 1000 foot (328 m) radius, in order to avoid contamination of building air supply systems; 2) the stack is to be sized for 3000 feet per minute (10.2 m/sec) discharge velocity at nominal flow. For VAV systems, a minimum discharge velocity of 2000 feet per minute should be observed. Above 4000 feet per minute (20.3 m/sec), static pressure in the system becomes excessive. See Chapter 14 of the *American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Guide and Data Book* for more information regarding exhaust stack design criteria (Appendix B, Reference 17).

A discharge stack should be supported 10 feet below the top with four guy wires attached to building structural steel or other rigid structure or else supported with a steel frame attached to the building structure. If the stack is short and wide enough, guy wires may not be needed. An engineer must be involved in stack design to ensure that the stack can withstand design wind loading in accord with applicable building codes.

Stack configuration should be the *no-loss* design, as outlined in the *ACGIH Industrial Ventilation Manual*. The exhaust stream should be directed straight up and all types of caps, e.g. rain caps, triangular caps, elbows, etc., should be avoided.

4. Effluent Cleaning

On occasion it may be necessary to remove a contaminant from the exhaust air before discharge to

the atmosphere. If possible, the effluent from small processes should be scrubbed within the hood. For example, if a potential byproduct of a reaction was hydrogen cyanide (HCN), the discharge port from the reaction flask/vessel should have an alkaline scrubber to trap any HCN released from the vessel. If cleaning of the entire air stream from the hood is necessary, the following questions need to be answered:

- a) What is the maximum allowable concentration (or maximum emission per unit time) of the contaminant in the exhausted air?
- b) Will the introduction of an air cleaning system affect the flow characteristics of the hood system?
- c) How will any waste material collected from the air stream be disposed of and what handling procedures will be required?
- d) What routine maintenance will be necessary to assure that the system is working properly?

Effluent cleaning could entail either the removal of particulate matter, a gas or vapor. For particulate matter, filtration would be the method of choice, if the dust loading averages a few milligrams per cubic meter or less. Heavier loadings would require a dust collection device. Extremely small particles require a HEPA filter which removes particles with a diameter of $0.3\ \mu\text{m}$ with at least 99.97% efficiency. The efficacy of a filter is often judged by noting the initial pressure drop across the filter and monitoring the change in pressure drop during the filter's lifetime. When the pressure drop increases by a predetermined fraction, the filter is replaced.

Certain radioactive effluents may require particulate removal with a HEPA filter before venting.

For removal of a gaseous contaminant from a fume hood exhaust, absorption, adsorption, combustion, condensation, or digestion are all possible options. *Absorption* involves passing the effluent through a scrubbing solution, spray device, or bed containing the absorbing material. *Adsorption* involves trapping the

material on a solid sorbent such as activated charcoal, silica gel, or a molecular sieve. *Combustion* involves passing the effluent through an oxygen-rich flame that could oxidize, and render harmless, the material of interest. *Condensation* entails passing the effluent through a cold trap which condenses out the material of interest. This can be done using a refrigerant, dry ice, or liquid nitrogen, depending on the nature of the material being trapped. *Digestion* or biofiltration is a relatively new technology which uses the catalytic and microbiological properties of soil to clean the airstream.

Details concerning the various measures needed for effluent cleaning can be found in the ACGIH *Ventilation Manual* (Appendix B, Reference 18).

E. Variable Air Volume (VAV) Control Systems

Fume hood face velocity controls are used to maintain a constant face velocity by varying the volume of air exhausted from a fume hood in relation to the sash position. Laboratories having fume hoods with face velocity controls are referred to as VAV laboratories.

Variable air volume (VAV) designs are being used with increasing frequency for many of the newest laboratory environmental control systems. Return on investment in a VAV system, due to energy savings, is possible within a year's time. Existing facilities retrofitted with variable air volume systems have shown net cost savings after three years or less.

The following considerations are critical in successful VAV designs:

- VAV laboratory designs must meet the criteria of providing a comfortable working environment for researchers and other users.
- The total environmental control system design must be well coordinated and integrated with the function of the existing building systems.
- Effective maintenance training and monitoring procedures must be implemented.

In searching for energy savings, the environmental control system engineer and user should not forget all of the safety considerations that need to be implemented in laboratory design.

Maintaining a negative differential static pressure between the laboratory and adjoining spaces is required, for example, by the NFPA Standard Code No. 45 in order to prevent the migration of a fire or spill. In a constant volume laboratory this is difficult to do. In a VAV laboratory it is even more difficult to do unless the appropriate equipment, instruments and controls are employed correctly. These techniques may require HVAC engineers to seek the assistance of a consultant or mechanical engineer experienced in VAV laboratory technology.

The actual control methods and technologies necessary for various types of VAV control systems are beyond the scope of this document.

F. Performance Criteria for Fume Hoods

It is necessary to have a readily measurable, objective means of determining if a chemical fume hood is performing acceptably.

There are several approaches for determining the acceptability of fume hood performance. In some cases, one approach or technique can be used to supplement another more complicated one for purposes of more frequent verification.

1. Quantitative Performance Assessment

a) Face Velocity Determination

The most widely accepted criterion for determining the acceptability of laboratory fume hoods' performance relates to the air velocity at the face of the fume hood (face velocity).

In the absence of any specific regulatory requirements, an acceptable average face velocity

for a fume hood can be determined using the Dow-developed formula and guidelines provided in Appendix A, Criteria for the Determination of Recommended Fume Hood Face Velocities. Using the formula found in these criteria, one can estimate an acceptable face velocity based upon four factors: the toxicity of the materials used in the fume hood, the potential for the generation of airborne material, the external air disturbances at the face of the hood, and the sources of turbulence within the hood.

Using this formula, optimal capture is attained with face velocities between 70 and 120 linear feet per minute and values below or above this range reduce the capture efficiency. Face velocities under 100 ft/min should only be used under nearly ideal conditions or when the materials being used are of low toxicity.

b) Tracer Gas Analysis

A performance evaluation of a fume hood may also be conducted using a tracer gas and measuring the capture efficiency, rather than using face velocity as a measure of adequate hood performance. Performance evaluation entails measuring the concentration of the actual material to be used in the hood or introducing a known concentration of a tracer representing that material (the tracer is a material that can be readily detected at low concentrations) at the face of the hood and then determining the concentration of the actual material or tracer at certain locations outside the hood.

Quantitative performance evaluations are normally done in a formalized, reproducible manner, so that measurements from different investigators are comparable. The hood capture efficiency is the parameter of interest in such an evaluation, and it is defined as the ratio of the concentration of the test material at the release point to the concentration of the test material at a point outside the fume hood, in what would be the normal breathing zone of the hood user.

However, performance criteria based on capture efficiency are rarely used. In most cases this procedure is impractical because of its complexity and cost.

c) Uranine Dye Method

The U.S. Environmental Protection Agency (EPA) has developed a method to evaluate the ability of an auxiliary air fume hood to capture contaminants released inside the hood. This test is only required for evaluating the hood under conditions where exhaust and supply air volumes are equal, and not for evaluating a hood under normal operating conditions in which the volumes are different. The use of such hoods is strongly discouraged. For any locations that have such hoods and wish to do a quantitative evaluation of this aspect of the auxiliary air fume hood's performance, refer to Appendix B, Reference 16.

2. Continuous Flow Monitoring

Continuous flow monitoring constitutes measuring on a continuous basis some parameter directly related to hood performance. A continuous flow monitoring device is used to determine, on a real-time basis, if the hood is performing properly, or if its performance has changed. The lack of such a device necessitates more frequent checks of the face velocity. Several types of devices are available for such monitoring. One directly measures the air velocity at some location in the hood. This device is quite expensive in comparison to other devices, which measure the static pressure difference between the outside of the hood (essentially at the hood face and inside the exhaust duct.

Significant changes in pressure drop from that noted at the time the hood was evaluated are taken as an indication of malfunction.

A velocity or static pressure measuring device can also be connected to an alarm system, so that when the air velocity or pressure drop falls below some preset level, an audible alarm sounds. This eliminates the necessity

of checking the monitoring device visually. However, if the device gives false alarms, people are sometimes known to shut it off, leaving the hood with no operational monitoring device.

3. Qualitative Performance Assessment

A qualitative method to observe the capture efficiency of a fume hood is to generate visible smoke and watch the air flow pattern. Smoke can be generated using smoke bombs, candles or smoke tubes. Smoke can also be used to observe dispersion patterns from the fume hood exhaust outlet, if there are concerns regarding the recapture of effluent by fresh air intakes.

G. Evaluation of Fume Hoods

This section describes the different ways of testing and evaluating the performance of fume hoods.

1. Face Velocity Measurements

The measurement of the air velocity at the face of the fume hood is the method of choice and most common means for quantitatively evaluating chemical fume hoods.

a) Air Velocity Measurement Devices

The most commonly used device for measuring the velocity of air at the face of a fume hood is a hot-wire (thermal) anemometer. There are several types of hot-wire anemometers, including: (a) direct reading analog instruments such as the TSI 1650 Air Velocity Meter, (b) the miniature Kurz Series 490 Minianemometer, (c) the digital readout Alnor Model 8565 CompuFlow® Thermoanemometer with averaging and printout capabilities, and (d) the digital readout Solomat MPM 500e with the Model 127 MS hotwire probe (which can perform time-averaging of air velocities over a time period of the user's choosing). Such devices, when appropriately calibrated, should give reliable velocity readings over a range of 10 to 3000 linear feet per minute. Calibration of the velocity-measuring device should be done in a calibrated

wind tunnel once a year, or in accordance with the manufacturer's recommendations.

Other devices for measuring face velocity include a pitot tube, rotating vane anemometer, swinging vane anemometer, and heated thermocouple. These devices are described in some detail in Appendix B, Reference 18.

b) Survey Procedures and Documentation

A Hood Survey Data Form (similar to that shown in Appendix D), can be used for reporting the key information about the hood characteristics and performance during a survey. Information similar to the following should be documented:

- study file number
- building number
- date
- type of hood
- hood location
- sketch of hood sash configuration to be tested, including dimensions of the opening
- presence of internal dampers
- presence of external baffles
- chemicals handled in the hood
- number of other hoods connected to this system
- sources of external air disturbances to this hood
- instrument used for the survey
- surveyor's name and signature

c) Face Velocity Measurement Procedures

- 1) With the hood blower off, measure the velocity of the air impinging at the face of the hood from external sources. If it exceeds 30 ft/min (0.015 m/sec), the situation must be corrected before making face velocity measurements. This step is very important and must not be overlooked. If flow disturbances caused by doors, windows, pedestrians, traffic, air supply diffusers or other sources are present, the hood face velocity measured may indicate adequate performance when the actual performance is unacceptable.

- 2) A series of velocity measurements should be made across the face of the hood, at the center of a series of imaginary, equal-sized rectangles with dimensions in the range of 12 to 24 inches (30 to 60 cm) on a side. Air velocity measurements should be made in the plane defined by the sash in the closed position. The face velocity should be measured at a minimum of six points, regardless of the open area of the hood face. The greater the variation in velocity readings across the hood face, the greater the number of measurements that should be made.
- 3) Allow the air velocity meter to stabilize for at least 10 seconds at each measuring location. Record average values for each location.
- 4) Repeat these steps for each fan speed and sash opening to be tested.
- 5) If the face velocity does not meet the Dow performance criteria, then the sash height (or width), baffle position, damper in the exhaust duct (if present), or fan speed should be adjusted in order to meet the specifications.
- 6) If the ratio of the range of face velocity measurements to the mean face velocity exceeds 0.7, the hood performance must be improved, and then remeasured, prior to completing the survey.

d) Recording and Evaluation of Data

1) HOODLUM

Corporate Industrial Hygiene has prepared a computerized hood evaluation program under the name "Hoodlum", which simplifies and standardizes the evaluation of laboratory fume hoods. This program is written in an IBM-compatible BASIC language. The menu-driven program allows the surveyor to enter in data on the materials being used in the hood, the physical configuration of the hood and the air velocities measured for each sash height and fan

speed tested. The program will calculate the average velocity, the maximum and minimum velocities, the variability of the velocity, and the recommended face velocity for the use(s) described. The use of HOODLUM encourages a standardization of fume hood reports and generates an output which can constitute the major portion of a fume hood evaluation report. Copies of the software for HOODLUM are available from Corporate Industrial Hygiene, 1803 Building, Midland, Michigan, U.S.A. HOODLUM may not be applicable if there are local Dow or regulatory requirements which differ from the Dow performance criteria.

2) Manual Calculations

If HOODLUM is not available, using the formula and guidelines in Appendix A, calculate the recommended face velocity for the chemicals being used. If the hood is to be used for a variety of compounds, make the calculations using the worst case scenario, i.e. assuming the most toxic and volatile compound that might be used in the hood. The standard Hood Survey Data Form (Appendix D) can be used for sketching a layout of the fume hood and reporting key information.

3) Recording Performance Data

- A) Prepare and affix a fume hood survey tag (see Appendix E), to the hood for quick reference, indicating the correct hood fan speed and sash height for safe operation of the fume hood and the date of the survey.
- B) Mark maximum sash heights on hood and/or install sash stops which allow for the safe operation of the fume hood.

2. Tracer Gas Analysis

Although rarely utilized, a performance evaluation of a fume hood may be conducted by using a tracer gas and measuring the capture efficiency. Typically a

human mannequin is placed in front of the hood and the concentration measurements are taken in the "breathing zone" of the mannequin. Some of the reasons for doing this include: 1) to determine the adequacy of the hood design and the resulting capture efficiency; 2) to determine if the configuration (i.e. the particular arrangement of equipment or apparatus in the hood) of the hood is such that it must be empirically determined if the hood can capture escaping vapors, dusts, or fumes; 3) to evaluate hood design or operational parameters, e.g. air foil design, face velocity, or relative positions of upper and lower hood baffles.

The contaminant historically used in tracer gas analysis is dichlorodifluoroethane (chlorofluorocarbon-12). A portable nondispersive infrared spectrophotometer is used to detect the gas. Concerns about atmospheric ozone depletion and recent cost increases in this compound have precipitated the use of another test material, sulfur hexafluoride (SF_6). This material can be measured with a detector based on the electron capture principle used in many gas chromatographs. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) 110-1985 Performance Test (Appendix B, Reference 9a) specifies in detail how the quantitative evaluation using a tracer gas is to be performed.

A paper in the American Industrial Hygiene Association Journal gives an alternative method for determining hood capture efficiency while normal work activities are ongoing (Appendix B, Reference 19).

3. Continuous Flow Monitoring

a) Hot-Wire Anemometer

Continuous flow monitoring devices may be used to determine if the hood is performing properly, or if its performance has changed. A hot-wire anemometer can be used to directly measure the air velocity at some location in the hood. This device needs to be placed at a location where no particulate

matter could interfere with the operation or damage the hot wire probe. One possible location is between the inner and outer walls of the hood which, in most fume hoods made in the United States, is open to the room air.

b) Static Pressure Gauges

Both Magnehelic® gauges and inclined manometers are used to measure the static pressure differences between the outside of the hood (essentially at the hood face) and inside the exhaust duct. The Magnehelic® gauges are slightly more expensive, but do not require the periodic maintenance needed for a manometer. With either device, significant changes in pressure drop from that noted at the time the hood was evaluated are taken as an indication of malfunction.

Any flow monitoring device must be checked periodically to ensure that the hood is working properly. For example, the low pressure side of a differential static pressure measuring device should be disconnected to check that the pressure reads zero and whether manometer fluid needs to be added.

c) Correlation of Data to Static Pressure Device

Measure the static pressure of the fume hood (when using an inclined manometer or Magnehelic® gauge to indicate changes in performance) once the performance criteria have been met.

- 1) The static pressure gauge must be set to zero by disconnecting the low pressure tube and adjusting the zero knob.
- 2) Reconnect the low pressure tube to the static pressure gauge and determine the static pressure from the static pressure gauge at the different fan speeds with the sash fully open.

3) Record the static pressure readings on the Hood Survey Data Form (Appendix D) for the different fan speeds.

4) Mark the static pressure for the normal hood parameters (if there are such) on the inclined manometer using a small adhesive arrow or line, for easy determination of pressure variability. Also include the fume hood static pressure on the Fume Hood Survey Tag.

4. Qualitative Performance Testing

The capture efficiency of a fume hood can be observed by watching the smoke pattern generated by the use of smoke bombs, candles, or smoke tubes. Smoke can be generated using either titanium tetrachloride (TiCl_4) or stannic tetrachloride (SnCl_4), both of which are volatile and hydrolyze in the presence of atmospheric moisture to form titanium dioxide or stannic oxychloride smoke and hydrogen chloride. TiCl_4 or SnCl_4 on a cotton swab, or in a smoke tube, are ways of generating smoke for this purpose. Smoke tubes (e.g. Draeger and MSA) with other chemical formulations are also commercially available for such purposes. Smoke candles or bombs with varying burn times and smoke volumes are also commercially available. Typically, a thirty second smoke candle placed inside a hood should be adequate to evaluate the hood performance.

5. Frequency of Testing

a) Routine fume hood performance testing for each fume hood equipped with a manometer or other performance indicator should be at least once every two years if there is no drastic change in the chemicals or equipment being used in the hood. Hoods not equipped with such a device must be tested every six months. In some locations, regulatory requirements may necessitate more frequent testing.

Chapter 6 of (U.S.) NFPA 45, Fire Protection for Laboratories Using Chemicals, indicates that fume hoods should be checked in such a manner once a year, but makes an exception for programs that

provide an equivalent level of performance. It is felt that a well-run program such as that described above meets the NFPA 45 criteria and should suffice to assure the user that the hood is functioning adequately.

The (U.S.) Scientific Apparatus Makers Association (SAMA) also specifies in the (non-mandatory) Appendix C of their SAMA Standard LF10-1980 (Appendix B, Reference 15), that face velocity measurements be made at least annually, as part of the inspection and maintenance activities.

- b) Fume hood performance testing should be performed before additional work is done in a fume hood when the static pressure deviates from the listed static pressure by more than 25%, when the fume hood is altered or damaged, or when the materials and/or equipment used in the fume hood are changed.

(Since the air flow through the hood is proportional to the square root of the static pressure, a 25% deviation in the static pressure entails a flow change of only about 12%.) If the continuous monitor measures velocity directly, then a deviation of 10% from the initial value should be cause for investigation and remediation.

H. Maintenance of Chemical Fume Hood Systems

In addition to doing routine evaluation of the fume hood's performance, the entire system should also be subject to a program of routine maintenance. The following list indicates those items which should be included in a routine maintenance program for fume hood systems (Appendix B, Reference 10c):

1. check and clean fan assembly
2. lubricate fan bearings per requirements
3. lubricate motor bearings per requirements
4. check belts and sheaves for wear and alignment
5. replace and adjust belts and sheaves as required
6. tighten all nuts and bolts
7. check motor mounts
8. check vibration isolators, pads, and springs

9. check motor temperature, amperage, and revolutions per minute
10. inspect electrical connections and insulation
11. lubricate and adjust dampers and linkages
12. check fan rotation and operation
13. check fan wheel/blades for wear or buildup
14. check and clean strainers, traps, valves, and drains
15. inspect filter and shaft coolers
16. check fan and motor housings for wear or holes
17. check cutoff for proper spacing
18. check for undue fan vibration and/or air pulsation
19. check flex connections at fan suction and discharge for holes or excessive wear
20. inspect horizontal ductwork for dust deposition or condensation.

APPENDIX A: CRITERIA FOR THE DETERMINATION OF RECOMMENDED FUME HOOD FACE VELOCITIES

$$V_{\text{rec}} = 70 + A + B + C + D \text{ (ft/min)}$$

or

$$V'_{\text{rec}} = 0.35 + A' + B' + C' + D' \text{ (m/sec)}$$

where V_{rec} and V'_{rec} are the mean air velocities measured at the hood face.

A, A' = terms to compensate for materials requiring additional exposure control.

A = 0 ft/min (A' = 0 m/sec) for materials with an exposure guideline greater than 100 ppm.

A = 10 ft/min (A' = 0.05 m/sec) for materials with an exposure guideline of 10 to 100 ppm.

A = 20 ft/min (A' = 0.10 m/sec) for materials with an exposure guideline of 0.1 to 10 ppm.

Materials with an exposure guideline of less than 0.1 ppm should be evaluated on a case by case basis for the appropriateness of special handling procedures.

B, B' = terms to compensate for increased contaminant generation.

In general, materials with a boiling point greater than 100°C are considered to be of low volatility, while those with boiling points of 100°C or less are considered to be highly volatile.

B = 0 ft/min (B' = 0 m/sec) for materials of low volatility which are handled in closed systems.

B = 5 ft/min (B' = 0.025 m/sec) for materials of low volatility in an open system (significant evaporative surface); or highly volatile materials in a closed system that may be occasionally opened.

B = 10 ft/min (B' = 0.05 m/sec) for highly volatile materials handled in an open system which require frequent direct handling.

Special consideration must be given to high pressure or heated systems where significant volumes may be released.

C, C' = terms to compensate for external conditions that can cause turbulence at the hood face.

C = 0 ft/min (C' = 0 m/sec) for minimal outside disturbances expected to create less than 10 ft/min (0.05 m/sec) of external air flow at the hood face.

C = 5 ft/min (C' = 0.025 m/sec) for frequent outside disturbances expected to create 10 to 20 ft/min (0.05 to 0.10 m/sec) of external air flow at the hood face.

C = 10 ft/min (C' = 0.05 m/sec) for frequent outside disturbances expected to create 20 to 30 ft/min (0.10 to 0.15 m/sec) of external air flow at the hood face.

External disturbances greater than 30 ft/min (0.015 m/sec) require corrective action prior to hood use.

D, D' = velocity terms to compensate for turbulence caused by internal conditions which result in poor air distribution.

This term takes into account the variability in hood face velocity as a result of internal conditions in the hood. The variability, calculated as the face velocity range divided by the mean face velocity, is used as a measure of balanced air distribution.

D = 0 ft/min (D' = 0 m/sec) for good air distribution: the ratio of face velocity range to the mean face velocity is less than 0.3

D = 5 ft/min (D' = 0.025 m/sec) for moderate air distribution: the ratio of face velocity range to the mean face velocity is 0.3 to 0.5

$D = 10 \text{ ft/min}$ ($D' = 0.05 \text{ m/sec}$) for marginal air distribution:
the ratio of face velocity to the mean face velocity is 0.5
to 0.7

For variability greater than 0.7, hood modifications and/or
equipment rearrangements should be implemented.

APPENDIX B: REGULATORY REQUIREMENTS, VOLUNTARY STANDARDS, AND OTHER REFERENCES

REGULATORY REQUIREMENTS

1. U.S. Nuclear Regulatory Commission (NRC): Nuclear Regulatory Commission (NRC) Regulation Guide 8.21, 1979. Section 1.14.
2. U.S. Occupational Safety and Health Administration (OSHA): Safety and Health Standards:
 - (a) 29 CFR 1910.252 {¶ (c) (2), (3) & (4)}
 - (b) 29 CFR 1910.1003 - 1016 {¶ (b) (11); (c) (1), (c) (4) (ii) & (d) (4) (i)}
 - (c) 29 CFR 1910.1017 {¶ (f) (1) & (2)}
 - (d) 29 CFR 1910.1018 {¶ (g) (1) (i) & (ii)}
 - (e) 29 CFR 1910.1025 {¶ (e) (1) (i), (ii) & (e) (5) (i), (ii)}
 - (f) 29 CFR 1910.1028 {¶ (f) (1) (i) & (ii)}
 - (g) 29 CFR 1910.1450 {¶ (b); (e) (3); (I) (App. A) (C) (4), (E) (1) (n), (E) (3) (c) & (E) (4) (c), (k)}
3. Australian Standard 2243.8 (1986); "Fume Cupboard" AS 3/86.
4. British Standard BS 7258, Laboratory Fume Cupboards, Parts 1, 2, 3 and BSI 1990.
5. Dansk (Danish) Standard DS 457 "Stinkskabe: (October 1986).
6. German Standard: DIN 12923 and 12924; "Laborabzuege: (1991).
7. Norme Francaise NPX 15-203 and 206 "Sorbonnes"; (NF) (December 1987).

VOLUNTARY STANDARDS

8. American National Standards Institute (ANSI):
 - (a) ANSI Standard Z9.2-1979, "Fundamentals Governing the Design and Operation of Local Exhaust Systems," American National Standards Institute (ANSI), Inc., New York, NY, 1979.
 - (b) ANSI Standard Z9.5-1989, "Laboratory Ventilation," American National Standards Institute (ANSI), Inc., New York, NY, 1989.

9. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE):
 - (a) ASHRAE Standard 110-1985, *Method of Testing Laboratory Fume Hoods*, American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), Atlanta, GA, 1985.
 - (b) F. H. Fuller and A. W. Etchells, "The Rating of Laboratory Hood Performance," *ASHRAE J.*, pp. 49-53 (1979).
 - (c) K. J. Caplan and G. W. Knutson, "Laboratory Fume Hoods, A Performance Test," *RP 70 ASHRAE Trans.*, 84, (I) (1978).
10. Dow Chemical Standards
 - (a) Dow Chemical U.S.A., HEH2.16-1-1(1): Development of Improved Laboratory Fume Hood Performance Criteria, R. W. Bohl, *et al.*, 1984
 - (b) The Dow Chemical Company Loss Prevention Principles, Section 12.5.4, "Laboratory Hoods or Fume Hoods" (1991).
 - (c) Dow Chemical U.S.A., Texas Operations; Safety Reference No. 7, "Laboratory Exhaust Hoods".
 - (d) Dow Europe; Guidance Note for Industrial Hygiene Functions: "Assessment of Local Exhaust Capture Hoods".
 - (e) Dow Chemical U.S.A., Eastern Division; Safety Reference No. 9.
 - (f) Dow Chemical U.S.A., Michigan Division, Engineering Standards and Practices: Design Aid M5B-5072-00 (1990).
11. National Fire Protection Association (NFPA):
 - (a) NFPA Standard Code No. 45, *Fire Protection for Laboratories Using Chemicals*, National Fire Protection Association (NFPA), Quincy, MA, 1986. Chapter 6; "Laboratory Ventilating Systems and Hood Requirements.
12. National Institute of Health (NIH): *NIH Guidelines for the Laboratory Use of Chemical Carcinogens*, National Institute of Health (NIH) Publication 81-2385, May, 1981.
13. National Institute of Occupational Safety and Health (NIOSH): *Recommended Industrial Ventilation Guidelines*, U.S. Dept. of Health, Education and Welfare, HEW Pub. No. 76-162, NIOSH Contract No. CDC-99-74-33, prepared by Arthur D. Little, Inc., Cambridge, MA, GPO 1976-657/5543, January, 1976.
14. National Sanitation Foundation (NSF): NSF Standard No. 49, *National Sanitation Foundation Standard for Class II (Laminar Flow) Biohazard Cabinetry*, NSF No. 49, National Sanitation Foundation (NSF), Ann Arbor, MI, 1987.

15. Scientific Apparatus Makers Association (SAMA): SAMA Standard LF 10-1980, "Laboratory Fume Hoods," Scientific Apparatus Makers Association, Washington, D.C., 1980.
16. U.S. Environmental Protection Agency (EPA): Laboratory Fume Hood Standards as recommended for the U.S. EPA dated January 15, 1978, Contract No. 68-01-4661.
17. ASHRAE Guide and Data Book, American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1989.

OTHER REFERENCE MATERIAL

18. American Conference of Governmental Industrial Hygienists (ACGIH):
 - (a) *Industrial Ventilation - A Manual of Recommended Practice*, 21st Ed., Committee on Industrial Ventilation, American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH, 1992. Chapter 3: Local Exhaust Hoods; Chapter 4: Air Cleaning Devices; Chapter 5: Exhaust System Design Procedure; Chapter 6: Fans; Chapter 8: Construction Guidelines for Local Exhaust Systems; Chapter 9: Testing of Ventilation Systems; Chapter 10: Specific Operations
19. A New Method for Quantitative, In-Use Testing of Laboratory Fume Hoods, R. E. Ivany, M. W. First, and L. J. Deberardinis, *A.I.H.A. Journal*, 50 (5), 275-280 (1989).
20. National Research Council, Prudent Practices for Handling Hazardous Chemicals in Laboratories. National Academy Press, Washington, D.C., 1981. Chapter I, Section H: Laboratory Ventilation.
21. Safe Laboratories: Principles and Practices for Design and Remodeling. P. C. Ashbrook and M. M. Renfrew, Eds., Lewis Publishers, Inc., Chelsea, Michigan, 1991. Chapter 6: Basic Principles of Ventilation in Chemical Laboratories; Chapter 9: Ventilation, A Consultant's Perspective; Chapter 10: Basic Principles of Fume Hood Design and Operation; Chapter 11: Common Ventilation and Fume Hood Problems; Chapter 12: Basic Concepts for Improving Ventilation During Major Remodeling Projects.
22. CRC Handbook of Laboratory Safety, Third Edition, A. K. Furr, Ed., CRC Press, Inc., Boca Raton, Florida, 1991.

APPENDIX C: DEFINITIONS

ACGIH: American Conference of Governmental Industrial Hygienists.

AIHA: American Industrial Hygiene Association.

Air Foil: A curved or angular member at the fume hood face.

Air Intake: An air inlet which draws fresh air in from the outside of the building and circulates it through a ventilation system.

AMCA: Air Movement and Control Association.

Anemometer: Any device used to measure the velocity of air. Common types include the rotating vane, swinging vane and thermo: anemometer (hot: wire anemometer).

ANSI: American National Standards Institute.

ASHRAE: American Society of Heating, Refrigerating, and Air: conditioning Engineers.

ASME: American Society of Mechanical Engineers.

Balanced Branch Ventilation System: A local exhaust ventilation system designed by selecting duct size for generating adequate static pressure to distribute air flow without the use of dampers (blast gates). The balanced branch system is less prone to tampering and plugging than the blast gate system.

Blast Gate Ventilation System: A local exhaust ventilation system designed with blast gates (dampers) for controlling air flow through the system. This system is prone to tampering by workers and to plugging. It is not recommended for use.

By pass Hood: An enclosed fume hood designed so that as the sash is closed, air flow is maintained through the air foil.

California Style Hood: A benchtop fume hood with horizontal sliding sashes on both sides of the hood.

Capture Velocity: The velocity of air necessary to capture the contaminant(s) of interest, typically by use of local ventilation; the higher the release velocity of the contaminant, the higher the required capture velocity.

Conventional Hood: A basic enclosed fume hood which has interior baffles at the rear and top of the hood which are used to evenly distribute air flow.

Damper: A gate or valve within a duct which controls air flow.

EPA: U.S. Environmental Protection Agency.

Face Velocity: The air velocity in the theoretical plane defined by the front of the hood, usually in the same plane as the sash (see below).

Flow Rate: The rate at which a blower is exhausting air through the hood or local ventilation system, expressed in volume/time (cfm or m³/sec).

Glove Box Hood: An enclosed fume hood with protective gloves built into one side of the hood for access.

HEPA Filter: High Efficiency Particulate Air filter. A HEPA filter collects 99.7% of all particles of 0.3 microns in diameter or greater.

Hood Configuration: A particular combination of sash height, fan speed, equipment or other items in the hood, materials (and amounts) being used, and static pressure drop across the hood which define a specific set of performance characteristics

HVAC: Heating, Ventilation and Air Conditioning system. The HVAC system is designed to temper fresh and recirculated air within a building for comfort, safety and health.

Magnehelic® Gauge: A device which measures the static pressure differential across a barrier (i.e., the difference between the static pressure inside the fume hood and the outside atmosphere).

Makeup Air: That air which must replenish the air being removed by a fume hood or local ventilation system; lack of adequate makeup air will reduce the effectiveness of a fume hood or local ventilation

Manometer: A device which measures the pressure differential across an enclosure and the open atmosphere.

Minimum Duct Velocity: The minimum velocity in the duct which will adequately transport contaminants (i.e., particles, vapors, mists, etc.) in order to prevent plugging or damage to the duct (i.e., corrosion).

Negative Pressure: Pressure differential such that the pressure inside an enclosure is less than the atmospheric pressure. Air moves inside the enclosure.

NFPA: National Fire Protection Association.

NRC: U.S. Nuclear Regulatory Commission.

OSHA: U.S. Occupational Safety and Health Administration.

Performance: In reference to a fume hood, the extent to which the hood accomplishes its task of quantitatively removing the vapor or particulate matter released by a source located within it.

Permissible Exposure Limit (PEL): The employee exposure limit to chemicals established by OSHA.

Positive Pressure: Pressure differential such that the pressure inside an enclosure is greater than the atmospheric pressure. Air moves out of the enclosure.

Sash: A movable (but occasionally fixed) transparent panel, which can move vertically or horizontally, or sometimes in both directions, which is used to open or close the one open side of a fume hood.

Sash Height: The position of a vertically: movable fume hood sash.

Static Pressure: The pressure attributed to air confined within an enclosure which exerts pressure perpendicularly to the walls of the enclosure. The sum of static pressure and velocity pressure is equal to the total pressure.

Thermoanemometer: An anemometer which utilizes the change in resistance in electrically: conductive probe as a function of the air passing over the probe to determine air velocity.

Threshold Limit Value (TLV): The recommended employee exposure limit to chemicals established by ACGIH.

Total Pressure: The pressure exerted in a duct as the sum of the static pressure and the velocity pressure.

Turbulent Flow: Air movement which is not uniform; turbulence reduces hood capture efficiency.

Velocity Meter (velometer): A device which measures air velocity.

Velocity Pressure: The pressure attributed to the velocity of air.

HOOD SURVEY DATA

RECOMMENDED EXHAUST RATE FOR THIS HOOD _____ C. F. M.[illegible]

	MAXIMUM	MINIMUM	MEAN	VARIANCE (s^2)
ACTUAL FACE VELOCITIES	_____ F.P.M.	_____ F.P.M.	_____ F.P.M.	_____
HOOD FACE AREA DURING SURVEY	_____ SQ. FT.			
EXHAUST RATE DURING SURVEY	_____ C.F.M.			
MAXIMUM OPENING: HEIGHT	_____ IN.	WIDTH	_____ IN.	MAXIMUM HOOD FACE AREA _____ SQ. FT.

FORM C-1250 PRINTED IN U.S.A. 8-10-65

Appendix "G"

MSMS Welding Sign Illustration

Physical Hazards



PART NO.: DOW027

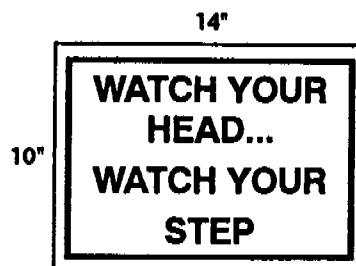
SIZE: 10" x 14"

MATERIAL: Accu-Shield

RECOMMENDED PRODUCT USAGE

Use at all unlevel floor areas where tripping hazards exist.

Dow Code: #2790825



PART NO.: DOW015

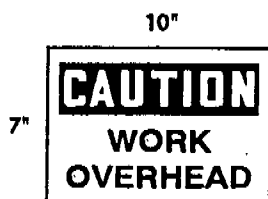
SIZE: 10" x 14"

MATERIAL: Accu-Shield

RECOMMENDED PRODUCT USAGE

General information sign used to warn of low pipes, racks or overhead beams. Place wherever tripping hazards exist.

Dow Code: #2790826



PART NO.: DOW022

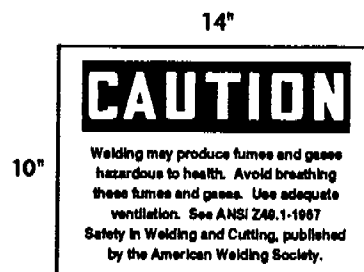
SIZE: 7" x 10"

MATERIAL: Accu-Shield

RECOMMENDED PRODUCT USAGE

Use to temporarily identify overhead work areas where falling objects may be a hazard.

Dow Code: #2790827



PART NO.: DOW4003

SIZE: 10" x 14"

MATERIAL: Accu-Shield

RECOMMENDED PRODUCT USAGE

All areas which contain gas cylinders, calcium carbide, and materials which may release toxic fumes and gases during use must be posted with adequate warnings.

(Refer to OSHA standard 29CFR1910.252)

Dow Code: #2790862

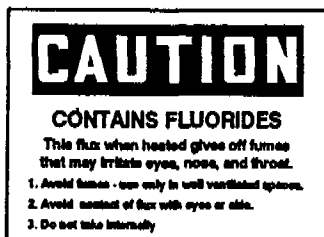
H-8

DO A 039118
CONFIDENTIAL

Physical Hazards

14"

10"



PART NO.: DOW4004

SIZE: 10" x 14"

MATERIAL: Accu-Shield

RECOMMENDED PRODUCT USAGE

All areas which contain gas cylinders, calcium carbide, and materials which may release toxic fumes and gases during use must be posted with adequate warnings.

(Refer to OSHA standard 29CFR1910.252)

Dow Code: #2790863

14"

10"



PART NO.: DOW4005

SIZE: 10" x 14"

MATERIAL: Accu-Shield

RECOMMENDED PRODUCT USAGE

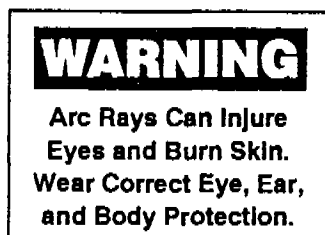
All areas in which Welding is present shall be posted with adequate warnings against related hazards.

(Refer to OSHA standard 29CFR1910.252)

Dow Code: #2790864

14"

10"



PART NO.: DOW4006

SIZE: 10" x 14"

MATERIAL: Accu-Shield

RECOMMENDED PRODUCT USAGE

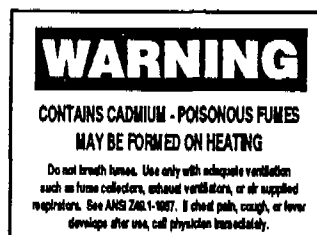
All areas in which Welding is present shall be posted with adequate warnings against related hazards.

(Refer to OSHA standard 29CFR1910.252)

Dow Code: #2790865

14"

10"



PART NO.: DOW4007

SIZE: 10" x 14"

MATERIAL: Accu-Shield

RECOMMENDED PRODUCT USAGE

All areas which contain gas cylinders, calcium carbide, and materials which may release toxic fumes and gases during use must be posted with adequate warnings.

(Refer to OSHA standard 29CFR1910.252)

Dow Code: #2790866

DO A 039119
CONFIDENTIAL

H-9

Appendix "H"

Calculation Sheet

for

Number of Fans

for

Confined Space Entry

DO A 039120
CONFIDENTIAL

Calculation For Adequate Ventilation For Welding In A Confined Space

According to the welding standard 29 CFR 1910.252-257, welding in a confined space requires a minimum of 2,000 ft³/minute/welder.

Fans from Tool Room	Air Pressure (psig)	Air Flow (CFM)
6" Air Mover	70	3150
10" Air Mover	81	5560
36" Box Fan	High setting	10,300
36" Box Fan	Low setting	6810
20" Copus Blower	80	11,000

10 volume changes / hour required according S&LP:

Volume of vessel = 132,935 ft³

10 X 132,935 ft³ = 1,329,350 ft³/hr

How many Copus type blowers needed for 10 changes/hour?

$$\frac{1,329,350 \text{ ft}^3/\text{hr}}{11,000 \text{ CFM/blower} \times 60 \text{ min/hour}} = 2 \text{ coppus blowers}$$

The minimum rate/minute/welder = 2,000 CFM

How many welders can be working with 2 Copus Blowers?

$$Q = \frac{2 \times 11,000 \text{ CFM}}{2,000 \text{ CFM/welder}} = 11 \text{ welders}$$

To handle 17 welders:

$$\# \text{ Copus Blowers} = \frac{17 \times 2,000 \text{ CFM}}{11,000 \text{ CFM}} = \frac{34,000}{11,000} = 3.09$$

To handle 19 welders:

$$\# \text{ Copus Blowers} = \frac{19 \times 2,000 \text{ CFM}}{11,000 \text{ CFM}} = \frac{38,000}{11,000} = 3.45$$

You would need 4 Copus blowers for 20 or more welders.

BH/MRM 9/22/92

DO A 039121
CONFIDENTIAL