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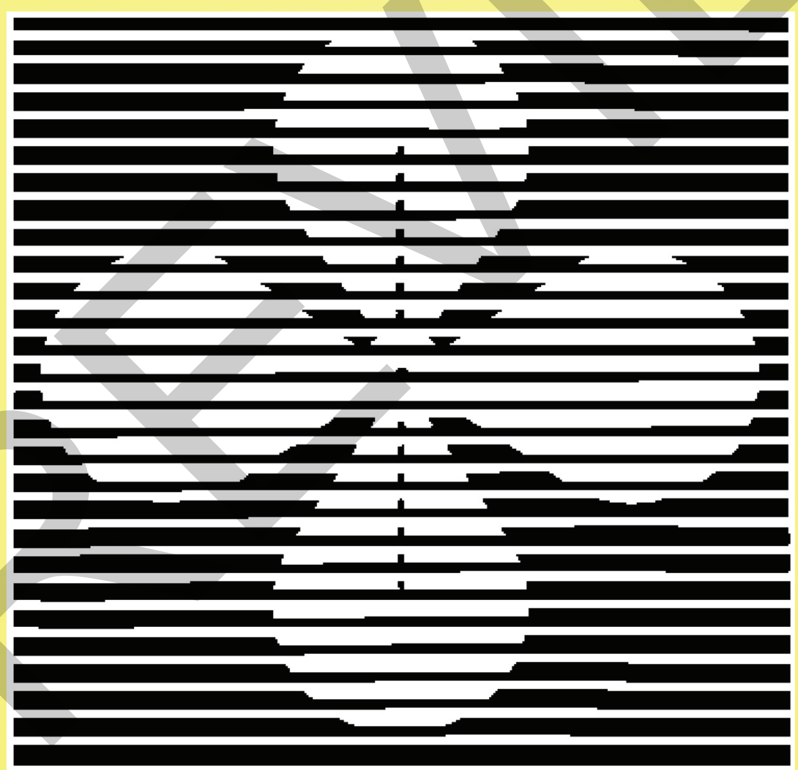

by D. Jeff Burton

AIHA™
HEALTHIER WORKPLACES | A HEALTHIER WORLD

Laboratory Ventilation Guidebook

2nd Edition

Harmonized with ANSI Z9.5 and
traditional
Standards of Good Practice

D. Jeff Burton

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Industrial Ventilation

“A Workbook of Practical Applications.”   “References.”

“Study text.”

Includes Table of Contents with Index, Glossary, Bibliography, Reference Charts, Checklists, Text, Exercises, Figures, Tables

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Table of Contents

Chapter 1

Introduction

People

The *Guidebook* summarizes lab ventilation, but I hope you'll sense that it's more than about ventilation. I hope you'll sense that it is about people who work in labs; it's really about their health. well-being and comfort.

I haven't seen any real statistics, but over the years, thousands of laboratory workers have likely suffered illness, injury, or discomfort from inadequate laboratory ventilation.

Here's a number you can call if an emergency occurs (e.g., a chemical spill, the most common lab emergency). A 24-hour hotline is available from **Chemtrec,** which is sponsored by the chemical industry: (75)

Emergency? CALL: 1-800-424-9300 www.chemtrec.com

The Appendix provides a checklist for other information and emergency phone numbers. (See Checklist No. 18)

Users

I expect a wide range of readers—HVAC engineers, nurses, building managers, lab safety engineers, industrial hygienists, lab chemists, and so forth. So please don't be too critical if some parts seem too simple, or some too complex, or some irrelevant. Just take what you need.

This book will be used by two types of readers: those looking to learn about the entire subject and those interested in solving a single problem.

For the single-problem reader

You might be tempted to read only those paragraphs related to a specific problem. I suggest you review the whole *Guidebook* first. (It will take only an hour.) Then, study those chapters of most use to you.

You may be part of a design team and will need to review plans and specifications. This book has a chapter devoted to this topic. You may be evaluating an existing facility, or troubleshooting a deficiency. Perhaps an existing lab is to be remodeled and you are expected to make suggestions. Maybe you are supposed to come up with a management plan for ventilating a lab. There are chapters on these topics, as well.

The *Guidebook* covers today's common labs—the general chemistry lab and its equipment. But we'll also touch on specialty areas: glovebox hoods, perchloric acid fume hoods, bio-safety cabinets, hazardous materials labs, and so forth. Detailed information concerning these special topics can be found in references shown in the Appendix.

Sources

You won't see a lot of footnotes, but I give credit to people where I use something they said or wrote. I use a number in parenthesis, e.g., "(75)", to indicate the source, which is described in the Appendix.

Wealth of information

Check out the Appendix. It contains forms, charts, and checklists you can use.

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Case studies

Case studies are *composites* of real situations. Names and places have been changed. They're simply written but they contain many details you can use to solve similar problems.

Sample Calculations

Sample calculations and exercises (usually at the end of a chapter) often contain new information. For that reason, it is important you work (or at least read) every example and exercise. Answers to exercises are also found at the end of each chapter.

Objectives

If you study the entire *Guidebook,* you will be able to:

- Talk confidently with others about the subject.
- Recognize laboratory ventilation problems and identify their potential causes.
- Relate specific complaints to potential sources.
- Use questionnaires and other paper instruments to evaluate laboratory ventilation problems.
- Understand the basics of air behavior.
- Recognize and evaluate different types of laboratory HVAC systems.
- Recognize, choose, and evaluate lab fume hoods.
- Understand and use existing consensus standards.
- Understand government codes and activities.
- Assist in the control of lab ventilation problems.
- Develop your own in-house lab ventilation program.
- Develop your own in-house standards.
- Deal with employees and the public on lab ventilation issues.
- Develop and provide training to laboratory workers.
- Test laboratory ventilation systems.
- Set up real-time monitoring systems.
- Take certification exams with confidence.

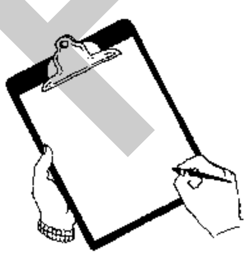
Case Study

Multiple Causes

Your Notes:

During the past several years, regular requests from university labs had kept the university's industrial hygiene (IH) staff busy. Everyone was trying to upgrade their Chemical Hygiene Plan and comply with the ANSI Z9.5 standard on lab ventilation.

A request had come from the chemistry department. A small lab in the basement doing government contract work had been shut down for several days after employees complained of "bad" conditions in the lab. An IH had been sent to investigate.



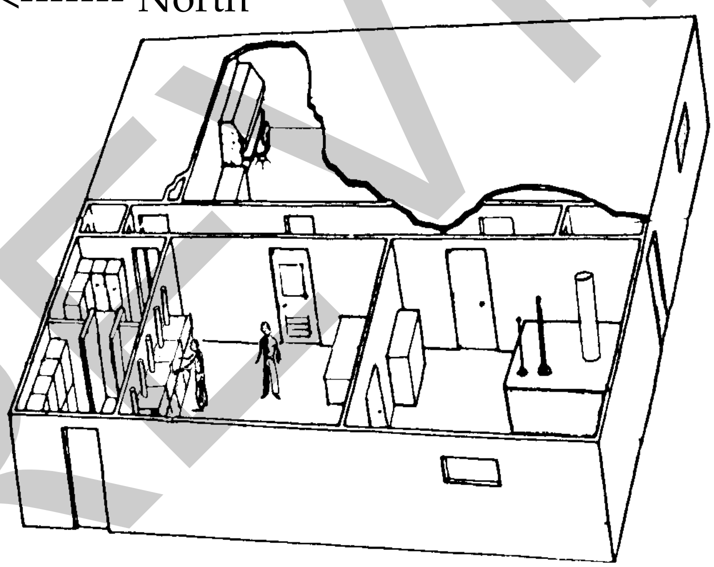
The IH's report noted:

"There are two lab technicians and one student working at hoods in the lab module. They run tests on water samples; no hazardous chemicals are used. All three people had severe headaches on Friday. There have been sporadic complaints of headaches and other maladies all winter.

"I suspected carbon monoxide so I searched for CO sources. The lab is in the basement, near store rooms, and other small labs. It is near the building's north wall. South of it is the Mechanical Room...water heaters, small boiler, incinerator, and so forth. A small make-up air unit on the roof brings some replacement air to the labroom. The rest of the make-up air comes from the hallway through the door, or through a louver in the door when it is shut. I don't think it meets our fire code, but that wouldn't solve the problem we have—headaches and other complaints.

"There are two doors, one at the hall and one on the south wall that enters the Mechanical Room. See Sketch."

<------- North



Exercise 1-1. From the data given so far, what comes to mind as a potential source of the trouble? (Note: Answers to exercises are provided at the end of each chapter.)

IH Report, continued.

"I checked the makeup or replacement air system. It was on, but was supplying only about one-tenth of the exhaust air. The hoods were exhausting about 3,000 cubic feet per minute (cfm), and the makeup air system was supplying about 300 cfm of outdoor air. The rest was coming from the hallway.

"As for other things, the hoods were working fine—no observable emissions using smoke. No obvious sources of carbon monoxide or solvents that could have caused headache. The employees complained of smoke.

"There is a heavy negative pressure in the room. The door opens into the lab. It is very difficult to close. The louver in the door was mostly blocked with a football poster."

Exercise 1-2. From the data given above, what *now* comes to mind as a potential source of the trouble?

IH Report, continued.

"Replacement air must come from somewhere. If it is not coming from the make-up air system or the hallway, then it might be coming from the Mechanical Room through the door connecting the two rooms. If the Mechanical Room is also under negative pressure, it could be drawing flue gases back down the chimneys and stacks. The smell of smoke obviously suggests a combustion source. And where there's smoke, there is likely to be carbon monoxide. This theory needed to be checked out."

Exercise 1-3. How could it be "checked out?"

IH Report, continued.

"With the hall door closed, air was definitely coming from the Mechanical Room. Unfortunately, sometime during the Fall, the outside air inlet to the Mechanical Room was blocked to avoid freezing the pipes.

"As a result, both rooms were starved for air. So makeup air was entering the mechanical room through the water heater vent pipe and the incinerator stack. Thus the smoke and the carbon monoxide. I measured carbon monoxide concentrations as high as 200 ppm."

Exercise 1-4. What could be done to fix the problem?

The IH's Report concluded with these paragraphs:

"The short-term fix involved taking the poster off the front door. It made a big difference. The building mechanic also opened the Mechanical Room outside air inlet. All airflow through the vent stacks is now out of the building.

"The long-term fix will require an appropriation of next year's funds. They're going to provide a new make-up air system to supply ninety percent outdoor air to the labroom. We are also having the combustion equipment checked for proper burning. "

Exercise 1-5. Suggest a probable chain of events which led to the complaints. How could they have been avoided?

Answers

Exercise 1-1. From the data given so far, what comes to mind as a potential source of the trouble?

Carbon Monoxide often suggests incomplete combustion. The mechanical room (next door to the lab!) contains equipment which burns fuel. It may only be a coincidence, but it would be worth looking into.

Exercise 1-2. From the data given, what comes to mind as a potential source of the trouble?

The smell of smoke and the tightness of the room now strongly suggests a combustion source coming from an adjacent space to the lab. Again, the Mechanical Room seems a likely culprit.

Exercise 1-3. How should it be "checked out?"

Depending on your expertise, you might want to call in an industrial hygienist or safety professional to monitor for carbon monoxide. To check out the Mechanical Room, you'd want to involve the building mechanic, and get him/her to explain the equipment, and check it out for you. At this point in our *Guidebook,* we can't be too specific. But when you have finished, you'll be much more knowledgeable about what to do, what to look for, and how to solve the problem. (However, we can never hope to do it all by ourselves.)

Exercise 1-4. What could be done to fix the problem?

See text of case study.

Exercise 1-5. Suggest a probable chain of events which led to the complaints. How could they have been avoided?

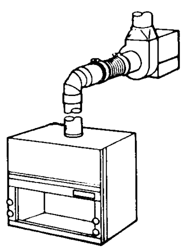
Your list is as good as any. Here is one: 1. The replacement air system was originally undersized; perhaps fire codes were not met. 2. A poster was hung over the inlet louvers on the front door, drawing air into the lab through the mechanical room from the outside air louvre. 3. Cold air coming into the Mechanical Room froze some pipes during the winter. 4. The outside louver was blocked to stop infiltration of cold air to the Mechanical Room, thus starving the hoods, and creating a negative pressure in both rooms. 5. Air was drawn down exhaust stacks, introducing flue gases into the space.

A good approach to avoiding a negative chain-of-events is to train people to understand how the system operates. A lab technician or student is likely to be oblivious to the workings of the various ventilation systems in the lab. It is a good idea to show employees and students exactly how the system is designed to operate. Then, when changes occur, the user may be better prepared to recognize and avoid problems, or identify their causes after they have occurred.

Chapter 4

Management of Lab Ventilation Systems

Objectives



Ventilation is provided in a lab to control chemical emissions and exposures, and to provide a comfortable, safe, and healthful environment. None of this can be accomplished or maintained without management participation.

Regardless of your position, you are part of that management effort. You may be called upon, for example, to determine whether or not ventilation is required to control emissions and exposures, or whether existing ventilation is adequate.

ANSI Z9.5*

ANSI Z9.5 on lab ventilation—which is discussed in more detail in Chapter 12—includes multiple pages of management requirements. Chapter 4 of the *Guidebook* is compatible with those requirements, some of which are shown in the box. Item 2.4 is probably the most important management provision.

Box 1. Selected Management Requirements Summary of ANSI Z9.5*

2.1.1 Adequate ventilation is used when employee exposures could exceed exposure limits.
2.2 The laboratory should develop a Chemical Hygiene Plan according to the OSHA Laboratory Standard (29 CFR 1910.1450). The plan shall address the laboratory operations and procedures that might generate air contamination in excess of the requirements of Section 2.1.1.
2.3 In each operation using laboratory ventilation systems, the user should designate a "responsible person."
2.4 Employers should ensure an ongoing system for assessing the potential for hazardous chemical exposure (i.e., conduct hazard assessments).
2.5 Complete and permanent records should be maintained for each laboratory ventilation system.

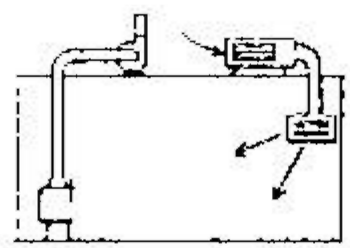
See Form No. 1

Form No. 1, *Laboratory Chemical Hazard-Potential Determination Worksheet* (**Charts** section in the Appendix) provides a roadmap for you to organize your evaluation of the hazard potential. You may need to bring in outside expertise to assist you (e.g., an industrial hygienist, toxicologist, and so forth.)

*Always use the latest and current verions of standards.

To control a chemical hazard with ventilation, specific amounts of air are supplied to and exhausted from the lab. In order to provide comfort for lab occupants, odors, air temperature, and humidity are also controlled.

Exhaust systems are provided to capture, contain, and control chemical emissions, and to transport them out of the laboratory. Laboratory fume hoods are attached to fans by exhaust ductwork. Air cleaners and stacks may be provided to avoid reentry of exhausted chemicals to the building.



Air supply systems replace exhausted air and maintain appropriate pressures within the laboratory space. They also provide a measured amount of outdoor air and appropriate amounts of air exchange. Fugitive emissions from exhaust ventilation systems or other non-exhausted bench activities are also controlled by the supply system, which acts as a dilution ventilation system.

An HVAC (heating, ventilating, and air conditioning) *system* provides temperature and humidity control, and may be integrated into the supply/replacement air system. This is often called the *comfort ventilation system.*

Review Chapter 3 — Have you read **Chapter 3** which introduced you to the basics of air physics? If you haven't read that chapter, you should do so before proceeding.

This chapter introduces fundamental approaches to the design and operation of laboratory ventilation systems. Later chapters provide more detailed information.

Hoods — For example, Chapter 5 provides information on chemical laboratory fume hoods. Chapters 6, 7, and 8 discuss glove box hoods, perchloric acid fume hoods, and bio-safety cabinets.

High toxicity — Chapter 9 covers special requirements for the ventilation of labs handling highly hazardous materials.

Testing — Chapter 10 discusses ventilation testing and monitoring.

Hood SP — Chapter 11 expands on the use of hood static pressure monitoring.

HVAC — Chapter 13 introduces supply and HVAC systems.

Duct systems — Chapters 15, 17, and 18 discuss stacks, duct design, and fan selection.

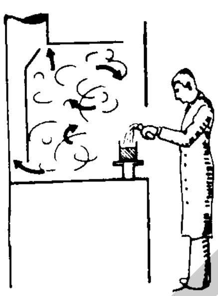
Dilution — Chapter 16 discusses vapor generation and dilution exhaust air volumes. (A very valuable chapter.)

Chapter 5

Laboratory Chemical Hoods

General Considerations

Objectives



The primary objective of any hood is to control emissions and employee exposures by capturing, receiving, or containing contaminated air generated at or near the hood.

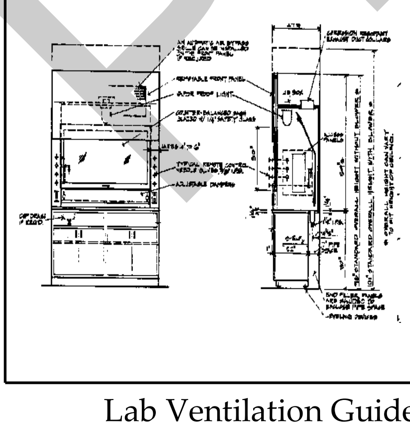
A laboratory chemical hood (traditionally called the "lab fume hood" in the USA) effectively controls an emission by *enclosing and containing* the emission within the hood.

Laboratory operations involving toxic, hazardous, or odoriferous chemicals should be conducted within an enclosure-type hood. Air flow into the hood mixes with emitted contaminants and the air carries them into the exhaust duct.

Containment and removal

Successful containment minimizes fugitive emissions from the hood. This protects the lab worker standing in front of the hood and keeps background levels of contaminants in the lab at acceptable concentrations.

The American Chemical Society (among others) has suggested that where workers spend much of their time working with chemicals, at least one hood should be provided for each two workers. Each worker should have at least 2.5 linear feet of working space at the hood face. (33)



This chapter presents good practices in the selection and operation of lab fume hoods.

Standards of Practice for Lab Chemical Hoods

There are many published codes, guidelines, and standards of practice for the design, construction, operation and maintenance of laboratory hoods that handle chemicals (traditionally known as the "lab fume hood" or the "lab chemical hood").

References 1, 2, 3, 4, 15, 19, 20, 22-33, 37-42 and 47 (Appendix) all include suggested guidelines, standards and codes for "lab fume hoods." Some are still current; others have been superseded by more current standards of practice (at least in some minds).

This chapter reflects current good practice as published in these standards. (See Disclaimer on page iv of the Front Materials.)

ANSI Z9.5

This widely-used standard, ANSI Z9.5-2012* *Laboratory Ventilation,* contains multiple pages of requirements for chemical lab hoods in its Section 3. (See Chapter 12 for a general overview of the entire standard.)

*The standard was being revised in 2017.

Box 1 shows selected *highlights* of Section 3 of the ANSI Z9.5 standard. (Obtain a full copy of the latest standard from ASSE see References.)

Box 1. Selected Requirements for Laboratory Chemical Hoods found in ANSI Z9.5-2012 Section 3

3.1 The design and construction of laboratory chemical hoods shall conform to the applicable guidelines presented in the latest edition of ACGIH *Industrial Ventilation: A Manual of Recommended Practice,* and the most current codes, guidelines and standards, and any other applicable regulations and recommendations.

3.1.1 The laboratory chemical hood should be equipped with a safety viewing sash at the face opening.

- Sashes should be not removed when the hood is in use.
- Sash-limiting devices (stops) should not be removed if the design opening is less than full opening.

3.1.1.1 Where the design sash opening area is less than the maximum sash opening area, the hood should be equipped with a mechanical sash stop or alarm to indicate openings in excess of the design opening area.

3.2.3 Conventional hoods should meet the requirements in Section 3.3.

3.2.4 Floor-mounted hoods (formerly called walk-in hoods) should meet the requirements of Section 3.3.

3.2.6 A variable air volume hood should meet all mandatory requirements of Section 3.3

3.3.3 All hoods shall be equipped with a flow-measuring device or a face velocity alarm indicator.

- The flow measuring device should be capable of indicating airflows at the design flow and ±20% of the design flow.
- The device should be calibrated at least annually and whenever damaged.

Why standards?

Why obtain and follow standards of good practice when designing, constructing, operating and maintaining chemical lab hoods? Three major reasons come to mind:

- There is a reasonably good chance that the hoods and connecting systems will work effectively and will be cost effective.
- Protection of employees, the environment, and any products or materials in the hood is likely to enhanced.
- It can help avoid legal problems and even liability if something goes wrong. ("We were following the currently recommended standards of practice.")

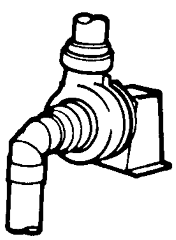
.

The Physics of Air Movement at the Hood

Read first

Have you read Chapters 3 and 4? It would be best to do so before proceeding.

Static Pressure

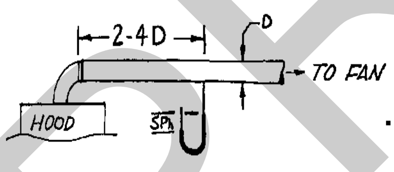


In a lab fume hood exhaust system, the fan creates negative static pressure in the duct serving the hood. Atmospheric pressure pushes air into the hood (and then into the duct) in an effort to equalize the pressure. But the fan continues to turn. Within a few seconds of turning on the fan, a steady state condition of flow is established.

At the lab hood, all of the static pressure in the duct is converted to *velocity pressure* or to *hood entry loss*. In other words, the static pressure in the duct near the hood, called the "hood static pressure," SPh, is converted either to VP, or to the entry losses, He. This is described algebraically by

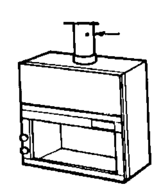
$SP_h = -(VP + He)$ where

SP_h = static pressure in the duct at the lab hood, inches w.g.
VP = duct velocity pressure, inch wg   [mm w.g.]
He = hood entry loss, inch wg   [mm w.g.]



Hood static pressure should be measured in the duct serving the hood, usually about 4-5 duct diameters downstream from the hood. If an elbow occurs before a straight section is obtained, take the measurement downstream. (The elbow loss becomes part of the hood loss.) Mark your hole for future use.

Example 5-1. What is the hood static pressure, SP_h, if the duct velocity pressure is VP = 0.33 inches w.g., and the hood entry loss is He = 0.43 inches w.g.?



$SP_h = -(VP + He) = -(0.33 + 0.44) = -0.77$ inch w.g.

Chapter 14

Reading Plans and Specifications

If you are involved with lab ventilation systems, you'll be expected to read *mechanical plans and specifications* from time to time.

New construction is usually based on plans developed by an "A&E" (Architect and/or Engineer) in accordance with the user's desires. Plans and specifications are prepared prior to construction.

Construction documents are the legal drawings, plans, and specifications from which a building is built or remodeled.

Documents may include: working drawings (also, bid drawings) which outline the design intentions of the A&E, addenda and change orders, as-built drawings which show how the building was actually constructed, and O&M manuals for all mechanical equipment.

Looks deceiving

They all look extremely complicated. Actually, just the opposite is true. Yes, they are very detailed and busy, but they are also very simple when broken down to individual components.

Drawings and specifications are written so the contractor or installer will know exactly what is expected. They are legal documents. "No detail overlooked" is the aim.

Unfortunately, details are often overlooked and you may be asked to find them.

Standards

Almost all ventilation systems are built to recognized codes and standards. There are many recommended standards and some required regulations and codes.

Chapter 12 describes many of the more important standards and standards-setting organizations. Chart 2 summarizes some of the more important standards for exhaust ventilation work.

Plans and specifications usually follow standard forms and symbols described, for example, in the such sources as the *Construction 2×ÌÊÐÍÐÊÈÛÐÖÕÚndex* (CSI), but they do differ from job to job.

Plans and specifications usually go from the general to the specific. They are broken into sections: Electrical, Plumbing, Structural, *Mechanical,* and so forth. CSI Divisaion 15 is the section dealing with mechanical plans and specs. Paragraph 15A covers general information; Paragraph D covers HVAC and often includes specs for exhaust ventilation as well.

Typical Specifications for a Lab Fume Hood

1. The fume hood shall be of the "bypass" type. The air bypass shall be located above the hood face opening.
2. Bypass air shall pass through the work chamber of the hood.
3. The bypass shall provide a barrier when the sash is open.
4. The bypass mechanism shall provide a constant air flow rate through the hood at all times. Face velocities shall not increase more than three times the average with the sash at any position.
5. The hood shall have a vertical sliding sash.
6. The sash shall move freely throughout its range of motion and be capable of stopping at any point in its run.
7. When in the full-open position, the sash shall be at least 30 inches above the airfoil.
8. The fume hood shall be of the airfoil design type with a foil at the bottom and a taper along both vertical sides of the face opening.
9. The sash shall rest on the airfoil when in the down portion.
10. The bottom airfoil shall be raised approximately 1 inch above the bench surface.
11. The superstructure of the hood shall be counter-mounted.
12. Interior clear working height shall not be less than 36 inches above the work surface for the full depth.
13. The hood shall have a removable baffle with three slots, one near the bench surface, one in the middle, and one at the top.
14. Hood baffles shall provide a plenum. The plenum shall be provided with a round duct take-off flange of at least 10 inches, centered over the plenum.
15. Slots shall be fixed in place, but shall also be adjustable with common tools (e.g., screwdrivers, pliers, wrenches.)
16. All walls shall be of double construction and shall fully enclose structural supports, sash balance mechanisms, and mechanical connections for utilities and service outlets and controls.
17. Access shall be provided for the inspection and maintenance of the sliding sash mechanism and other mechanical services.
18. Materials of construction shall be non-flammable and acid resistant. Exterior surfaces shall be coated with baked enamel.
19. The hood shall be exhausted so as to provide an average velocity of 100 fpm through the face of the hood when the sash is in the wide open position. The velocity across the face shall be uniform, and shall not exceed plus or minus 10 percent of the average at any one position when tested at the manufacturer's plant, and plus or minus 20% at the installed location.
20. The hood shall be capable of meeting an ASHRAE 110 test rating of AM 0.01.
21. The manufacturer shall provide written and documented results of all tests at the time of delivery.
22. Non-flammable chemical storage shall be provided in a base cabinet constructed so as to be compatible with the hood.

Plans

Drawings amplify specifications. See the next box. Drawings are usually drafted to scale. For example, 1/8″ on the sheet may represent one foot on the ground. With a ruler, or a scale, you can check dimensions and lengths.

The following paragraphs show sample stack specifications for the initial stages of a project. More detailed requirements may be added before the project is commenced.

Stacks

Part 1 - General

1.01 Scope: This section covers the requirements for furnishing and installing a stack to service a lab fume hood.

1.02 Reference Standards: All materials, equipment, and fabrication components shall be in accordance with the latest applicable requirements of AIHA/ANSI, NFPA, NEC, NEMA, ASTM, AWS, OSHA, the State of Utah, and the SMACNA standard for steel stacks.

Part 2 - Products

2.01 General: The stack shall be fabricated and constructed in accordance with the applicable section of the listed specification, codes, and standards.

2.02 Specific Requirements

A. The stack shall be a free standing steel stack with a minimal discharge height of 10' above the roof line, and 20' above the adjacent grade level. The stack shall be structurally designed to withstand forces resulting from Seismic Zone 1 and wind loading of 90 mph.

B. The stack shall be constructed of galvanized steel, Ga 16 or heavier.

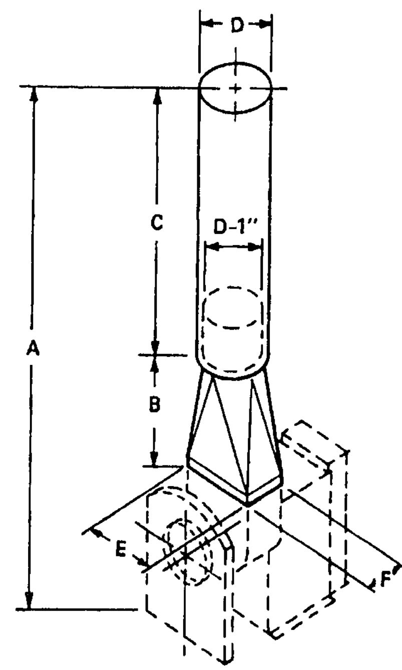
C. The stack shall be of the stack-head type, with rain drainage.

D. The stack shall be securely attached to the roof with steel guy wires attached to four sides of the stack.

E. See Drawing for more details.

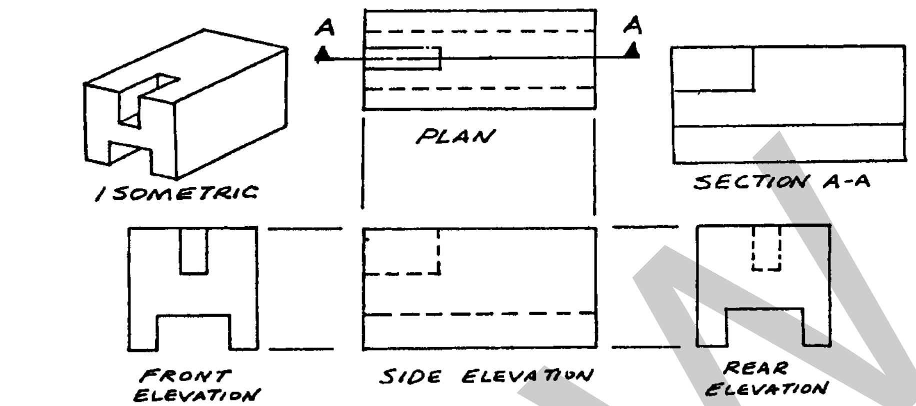
A	B	C	D	E	F	G
76⅞"	14"	42"	9"	7⅞"	5⅜"	8"
83⅛"	16"	46"	10"	9⁵⁄₁₆"	6½"	9"
88¹⁄₁₆"	16"	50"	11"	10¾"	8"	10"
105½"	16"	62"	14"	13⅛"	9⅝"	13"
112⅜"	18"	66"	15"	14⅜"	10¾"	14"
121¾"	18"	74"	17"	16¼"	11¾"	16"

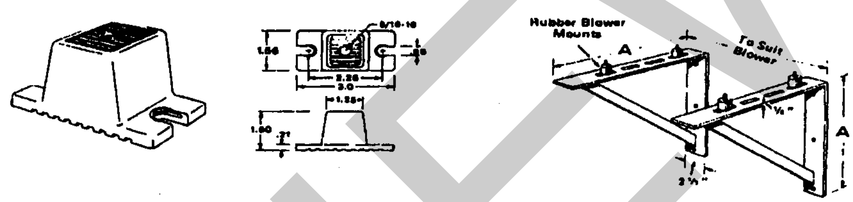
E & F are exhaust outlet of blower.



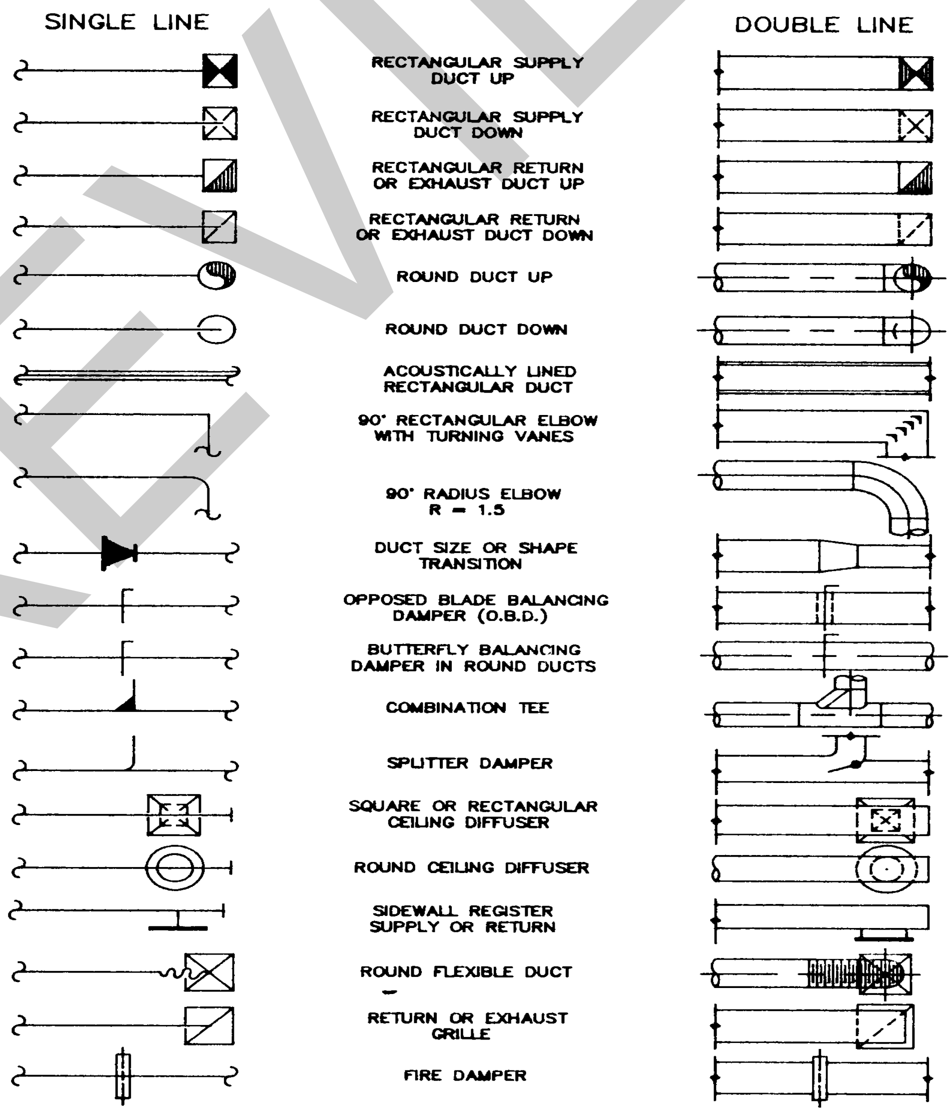
Drawing

Drawings come in many types and views: *plan* (top), *elevation* (side and front), *isometric, and section.*





Most drawings follow standard symbols.



Form No. 5
Lab Ventilation Deficiency Report Worksheet

Bldg_________ Room _________ Hood Number _____________ Fan Number _____________

Date__________ Investigator/Reporter ________

Notes:

Management
( ) No local cognizant person
( ) Lack of records
( ) Lack of up-to-date plans and specifications
( ) Lack of emergency plan
( ) Insufficient employee training
( ) No hood testing mechanism
( ) No hood-use approval mechanism

Lab Fume Hood
( ) Improper type for operation/chemicals used
( ) Air leaking from hood (smoke noncontainment)
( ) Surfaces corroded
( ) Surfaces dirty
( ) Hood mechanisms inoperable
( ) Sash broken
( ) Electrical service in hood
( ) Chemical storage in hood
( ) Other storage in hood
( ) Equipment within 6" of face
( ) Lack of real-time airflow monitor
( ) Flammable construction materials
( ) Slots not open to appropriate size
( ) Slots blocked by equipment, chemicals
( ) Open containers in hood during non-use
( ) Use of auxiliary supply at hood face

Hood Operation
( ) Sash not at proper height
( ) Use of hood when hood exhaust off
( ) Hood not being used
( ) Inappropriate chemicals in hood
( ) Noisy

Work practices
( ) Untrained personnel
( ) Rapid movements at hood face
( ) Placing upper body in hood
( ) Use of chemicals outside hood
( ) Use of perchloric acid in unapproved hood

Ductwork
( ) Holes, air leaking
( ) Dents
( ) Poor construction
( ) Plugged
( ) Corroded
( ) Leaking
( ) Dampers improperly set
( ) Fire dampers in exhaust system
( ) Doesn't meet SMACNA qualifications

Fan/Motor
( ) Worn out or corroded
( ) Insufficient rpm
( ) Insufficient horsepower
( ) Belts slipping or broken
( ) Motor burned out
( ) Undersized fan

Stack
( ) Not attached
( ) Inappropriate location
( ) Inadequate height
( ) Stack exist velocity insufficient
( ) Aesthetic enclosure hinders dispersion

Exhaust air
( ) Inadequate exhaust volume
( ) Inadequate face velocity
( ) Inadequate face velocity range
( ) Turbulence in hood face

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Supply air
( ) No supply air
( ) Insufficient air for dilution of fugitive emissions
( ) Contaminated by exhaust air
( ) Supply diffuser blows on hood face
( ) Supply diffuser blocked
( ) Temperature inadequate
( ) Employee complaints (noise, draft)
( ) Does not meet ASHRAE 62 provisions
( ) Supply not balanced with exhaust

Hood Maintenance
( ) Inadequate maintenance (equipment broken)
( ) Lack of ongoing PM program

Chemical storage cabinets
( ) Cabinet missing doors, panels
( ) Constructed of flammable materials
( ) Mixed acid/solvent/bases
( ) Electrical outlets in cabinet
( ) Lack of approved fire-rated cabinet
( ) Corroded
( ) Dirty
( ) Open containers
( ) Unlabeled containers
( ) No fire extinguisher, or out-of-date

Laboratory
( ) Cluttered, housekeeping poor, dirty
( ) Hood positioned near door, window, walkway
( ) Fire escape routes blocked
( ) Aisles blocked

Manifolded exhaust systems
( ) Likelihood of fire/explosion; mixed chemicals
( ) Corrosion in manifold
( ) Condensation in manifold
( ) One hood goes positive
( ) Part of system under positive pressure

Form No. 5
Lab Ventilation Deficiency Report Worksheet, page 2

Notes

For more information see Chapters 19, 10, and 5. (c) 2017 D. Jeff Burton

Form No. 6 Duct Design Worksheet

Name:		Project:						
Row	**Item**	**Source**	**Units (US/SI)**					
1	Duct ID	Plans	**FROM-->TO**					
2	Design Q		cfm or cms					
3	Transport vel.		fpm or mps					
4	Slotted hood?	[Yes--> row 5; no--> row 12]						
5	Slot velocity		fpm or mps					
6	Slot area	[row 2 / row 5]	sq ft or sq meter					
7	Slot VP		inch or mm w.g.					
8	Slot entry loss factor		(1.78)					
9	Acceleration factor		(1.0)					
10	Plenum loss factor		(2.78)					
11	Plenum SP	[row 7 x row 10]	inch or mm w.g.					
12	Duct diameter		inch or cm					
13	Duct area		sq ft or sq meter					
14	Duct velocity	[row 2 / row 13]	fpm or mps					
15	Duct VP		inch or mm w.g.					
16	Duct length	From plans	feet or meters					
17	Friction R		--					
18	Friction K		--					
19	Friction K, duct	[row 16 x row 17 x row 18]						
20	Hood entry		--					
21	Acceleration	[1.0 at hoods]	--					
22	Elbows		--					
23	Branch entry		--					
24	System effect		--					
25	Other K loss	( )	--					
26	Total K	[sum rows 19-25]	--					
27	Duct SP	[row 26 x row 15]	inch or mm w.g.					
28	SP at FROM location	(row 33)	inch or mm w.g.					
29	Junction VP change at **FROM**		inch or mm w.g.					
30	Other SP loss	( )	inch or mm w.g.					
31	Total SP at TO	[sum rows 11 + 27-30]	inch or mm w.g.					
32	In this Governing SP?		(yes or no)					
33	Governing SP	[at **TO** location]	inch or mm w.g.					
34	Actual Q	[row 2 x (row 33/row 31)$^{0.5}$]	cfm or cm					
35	SPh	[row 11 + row 15 x (rows 20+21)]	inch or mm w.g.					
36	Total slot length	plans	feet or meters					
37	Slot width	y(row 6 / row 36)	inch or cm					
		US: y = 12; SI: y = 100						

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