Local Exhaust Ventilation

Approved by: QS/Chief, Safety and Health Division

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Chapter 7—Local Exhaust Ventilation (LEV)

NOTE: The current version of this chapter is maintained and approved by the Safety, Health and Environmental Division (SHED). The last revision date of this chapter was May 2017. The current version is located on the Glenn Research Center intranet within the BMS Library. Approved by the Chief of Safety and Health Division.

1.0 PURPOSE

This chapter establishes minimum requirements for LEV, an engineering system used for controlling occupational exposure to air contaminants at the Glenn Research Center (GRC).

2.0 APPLICABILITY

The provisions of this document are applicable to NASA Glenn Research Center personnel and contractors associated with the review of SHED program chapters.

In this chapter, all mandatory actions (i.e., requirements) are denoted by statements containing the term “shall.” The terms “may” or “can” denote discretionary privilege or permissions, “should” denotes a good practice and is recommended, but not required, “will” denotes expected outcome, and “are” or “is” denotes descriptive material.

3.0 BACKGROUND

GRC personnel use a variety of materials, ranging from inert gases to highly toxic, carcinogenic materials. An LEV is a specific engineering control used to minimize worker exposure to airborne hazardous substances. An LEV system typically consists of at least a hood to capture or contain the contaminants, ducts to transport the air containing the contaminants, and a fan to power the system. Depending on the system and the level of contaminant generation, the LEV may be equipped with an air filtration unit, such as high-efficiency particulate air (HEPA) filters, scrubber, electrostatic precipitator, or other air pollution control device.

Examples of LEV at GRC include laboratory fume hoods, exhausted gas cabinets, snorkels (e.g., welding fume control), canopies, and spray painting booths. Local exhaust ventilation for toxic materials may require an air pollution permit for operation. Please refer to the GRC Environmental Programs Manual (EPM), Chapter 4, “Air Pollution Control” for additional information.

4.0 POLICY

Construction, installation, inspection, and maintenance of all LEV systems shall comply with the Occupational Safety and Health Administration (OSHA) standards, as well as with national consensus standards, such as the American National Standards Institute (ANSI) and the American Conference of Governmental Industrial Hygienists (ACGIH). The GRC shall follow the requirements of NPR 1800.1C.

Compliance with the responsibilities and requirements of this chapter are measured and verified through the use of programmatic self-assessments, regulatory, and Agency audits and internal field inspections.
5.0 RESPONSIBILITIES

5.1 Occupational Health Branch (OHB) LEV Program Lead
- Give guidance on the requirements for conducting LEV system surveys
- Provide guidance on the requirements of Federal, State, and local ventilation regulations, as well as on standard industry practice guidelines
- Update the Industrial Hygiene Procedure: Testing LEV Systems manual (see APPENDIX B).
- Provide training on LEV systems

5.2 OHB Technician/Specialist
- Maintain database for LEV systems
- Follow the Industrial Hygiene Procedure: Testing LEV Systems manual (see APPENDIX B)

5.3 Safety Inspectors
- Shall report any LEV system not in compliance to the operations team technician, program lead or industrial hygienist

5.4 OHB Chief
- Shall provide final approval of the Testing LEV Systems manual

5.5 Waste Management
- Shall ensure that potentially contaminated ventilation equipment is disposed of properly

5.6 Area Safety Committee Industrial Hygiene Members
- Shall review new or modified LEV installations and assist with the compliance of this program
- Shall report any discrepancies to the LEV Program Lead

5.7 Facilities Division (FD), Project Engineers
- Shall obtain training either through college course work or continuing education in ventilation design for contaminant control as outlined in the Industrial Ventilation: A Manual of Recommended Practice, 27th edition, 2010 or later
- Shall obtain support from the LEV Program Lead during the design phase of projects that may require local exhaust ventilation
- Shall ensure that LEV design specifications comply with the requirements of this program and standards
- Shall review and approve all new or modified LEV systems prior to purchase and installation
- Shall inform the LEV Program Lead of all newly installed or modified LEV systems and request a ventilation survey before releasing the system for use

5.8 Support Service Contractors, Operations, and Maintenance Personnel
- Shall inform the LEV Program Lead of any modifications or repairs of LEV systems and request a ventilation survey before releasing the system for use

5.9 LEV Operators/Users/Designees/Supervisors/Safety Permit Holders
- Shall ensure that LEV is operated in accordance with the requirements of this program
- Shall stop operations, tag the LEV “out of service,” and contact F-IXIT (3–4948) if a LEV system is suspected of being deficient or if a continuous-airflow monitoring device malfunctions

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• Shall contact FD and LEV Lead for design assistance and approvals prior to the preliminary stages of tasks involving the installation or modification of LEV systems (All LEV systems must be reviewed and approved by FD before they are installed.)

• Shall inform LEV Lead of all newly installed LEV systems and all modifications or repairs of LEV systems and request a ventilation survey before releasing the system for use

5.10 LEV Users/Designees

• Shall operate LEV systems in accordance with this program

• Shall report any LEV that does not appear to adequately control exposure to air contaminants

• Shall respond to a laboratory hood that is alarming by immediately lowering the sash to a level at which the alarm ceases and resetting it (If the alarm continues, notify the LEV Lead and submit a work request to the Facility Division’s F-IXIT for repair.)

• Shall enlist area safety committee members, in their review of new or modified LEV installations, to assist with the compliance of this program and to report any discrepancies to the LEV Lead

• Shall require that employees who need to operate unfamiliar LEV systems request training for the appropriate use of the LEV system from their supervisor or from one of the OHB industrial hygienists

6.0 REQUIREMENTS

All active LEV systems are inspected, velocity flow tested and have their monitor gauges checked at least annually by the LEV technician to comply with NPR 1800.1 and 29 CFR 1910.94. If the checks are not satisfactory, a work request (WR) must be initiated by the owner/operator of the LEV system. Each LEV system shall be tagged (green, yellow, or red) with an identification number, the date of the test (month/year), and the name and telephone number of the person conducting the inspection. APPENDIX B of this document sets forth the procedure in the appendixes of the Industrial Hygiene Procedure: Testing LEV Systems.

7.0 RECORDS

• Ventilation Surveys - The database for ventilation surveys shall be maintained by the LEV technician and shall be kept in network location \smad12\QSH$

• Training Records
  – LEV training records shall be maintained in System for Administration, Training, Education Resources for NASA (SATERN).
  – LEV Supervisors/Safety Permit Holders are required to attend Laboratory and Local Exhaust Ventilation Function and Safety training (SATERN course number: GRC–4R1631).
  – LEV Users/Designees shall receive training on the specific equipment from their supervisors, and the supervisors shall be responsible for maintaining the training record information.

• Hood Repair Records - Hood repair records shall be maintained in the FD current work order database system.

• Safety Inspections - Ventilation systems shall be added to the safety inspection forms by the building inspectors under the current inspection system.

8.0 REFERENCES

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<th>Document number</th>
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<tr>
<td>29 CFR 1910.94</td>
<td>Occupational Safety &amp; Health Administration (OSHA), Ventilation in General Industry</td>
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<th>Glenn Research Center Occupational Health Programs Manual</th>
<th>Title: Local Exhaust Ventilation</th>
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<td>CDC 21-1112</td>
<td>Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th Ed. HHS Publication No. (CDC) 21-1112, 2009.</td>
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<td>NSF Int. Std. #49</td>
<td>National Science Foundation (NSF) American National Standards Institute (ANSI) International Standard Number 49.</td>
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<td>Appendix B</td>
<td>NASA Glenn Research Center, Testing Local Exhaust Ventilation (LEV) Systems guidance manual, April 2012</td>
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<tr>
<td>NPR 1800.1</td>
<td>NASA Procedural Requirements, NASA Occupational Health Program Procedures</td>
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<tr>
<td>Z33.1</td>
<td>American National Standards Institute (ANSI), Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying, 1961</td>
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APPENDIX A.—DEFINITIONS AND ACRONYMS

American Conference of Governmental Industrial Hygienists (ACGIH)

Air cleaning device.—Device that separates contaminants from the airstream before discharge to the ambient air; filters, scrubbers, electrostatic precipitators, cyclones, dropout boxes, and afterburners

Air filter.—Mechanical device that removes contaminants from the airstream

Air velocity.—Rate of air motion in a given direction, measured as distance per unit time; meters per second (m/sec), feet per minute (ft/min or fpm), miles per hour (mph)

Anemometer.—A device for measuring air velocity and commonly used to take face velocity measurements

American National Standards Institute (ANSI)

Carcinogen.—Substance or agent capable of causing or producing cancer in mammals, including humans; a chemical is considered to be a carcinogen or potential carcinogen if it has been

- Evaluated by the International Agency for Research on Cancer (IARC) and found to be a carcinogen or potential carcinogen
- Listed as a carcinogen or potential carcinogen in the annual report on carcinogens published by the National Toxicology Program (NTP)
- Regulated by OSHA as a carcinogen

Capture velocity.—At any point in front of the hood, the velocity of air necessary to overcome opposing air currents and to capture the contaminated air by causing it to flow into the exhaust hood

Duct.—Passageway made of sheet metal or other suitable material used for conveying air, gases, vapors, dust, mist, or fumes; usually exhausts contaminants from the hood outside the building

Entry loss.—Loss in pressure caused by airflow resistance in a duct or hood; usually measured in inches of water gauge

Environmental Programs Manual (EPM)

Fan.—Local exhaust ventilation system component that provides the energy required by a specific design to move air through a system

Flow monitor.—Device used on a lab fume hood to continually monitor the hood face velocity of the air entering the hood

International Agency for Research on Cancer (IARC)

HEPA filter.—Filter that removes at least 99.97 percent of airborne particles 0.3 micrometer (µm) in diameter; composed of a mat of randomly arranged fiberglass fibers having diameters between 0.5 and 2.0 µm. Key factors affecting function are fiber diameter, filter thickness, and face velocity. The air space between HEPA filter fibers is much greater than 0.3 µm. Unlike membrane filters, where particles as wide as the largest opening or distance between fibers cannot pass in between them at all, HEPA filters are designed to target much smaller particles. Diffusion predominates below the 0.1-µm-diameter particle size. Impaction and interception predominate above 0.4 µm. In between, near 0.3 µm, diffusion and interception predominate.

High-efficiency particulate air (HEPA)
Hood face velocity.—Air velocity measured at the hood face opening in feet per minute (fpm)
Inclined Manometer.—A device for measuring air pressure and routinely used in LEV systems to monitor for filter condition (service life indicator)

Industrial hygienist (IH)

Inert gas.—Gas that does not react or undergo any change of state in a system or process

Laboratory fume hood.—Device that encloses, captures, or receives emitted contaminants to effectively capture and control contaminants at the source with minimum airflow and power consumption; a shaped inlet designed to capture contaminated air and direct it into the exhaust duct system

Local exhaust ventilation (LEV).—System that captures and removes emitted contaminants before they are released into the workplace environment; components are the hood, or air capture device, duct system, air cleaning device, fan, and exhaust stack

Magnehelic guage.—A device for measuring air pressure and routinely used in LEV systems to monitor for filter condition (service life indicator)

National Fire Protection Association (NFPA)

National Science Foundation (NSF)

National Toxicology Program (NTP)

Occupational health (OH)

Occupational Safety & Health Administration (OSHA)

Plenum.—Chamber used in local exhaust ventilation systems to equalize pressure

Personal protective equipment (PPE)

Pressure, static.—Potential pressure exerted in all directions by a fluid at rest. For a fluid in motion, pressure is measured in a direction normal to the direction of flow and is usually expressed in inches water gauge when dealing with air. Static pressure is the tendency to either burst or collapse a duct.

Pressure, velocity.—Kinetic pressure in the direction of flow necessary to cause a fluid at rest to flow at a given velocity that is usually measured in inches water gauge

Stack.—Device used to discharge air away from a building

System for Administration, Training, Education Resources for NASA (SATUREN)

Toxicity.—Relative property of a chemical agent that refers to the harmful effect it exerts on some biologic mechanism and the conditions under which the effect occurs

Ventilation.—Process of supplying or removing air by natural or mechanical means to or from any space

Work request (WR)
APPENDIX B.—INDUSTRIAL HYGIENE PROCEDURE: TESTING LOCAL EXHAUST VENTILATION (LEV) SYSTEMS

1.0 PURPOSE
This procedure will establish guidelines for evaluating the function of local exhaust ventilation (LEV) systems, which are also known as process exhaust systems. The general steps in this process include determining what flow is needed to remove the contaminant of interest, deciding how best to measure this flow in a safe, efficient, and reproducible manner, documenting these flow requirements and flow measurements, and communicating relevant results to our customers.

2.0 References

2.1 Applicable Documents

<table>
<thead>
<tr>
<th>Document Number</th>
<th>Document Title</th>
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<tbody>
<tr>
<td>GRC OHPM, Chapter 7</td>
<td>Glenn Research Center, Occupational Health Programs Manual, Chapter 7, Local Exhaust Ventilation</td>
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2.2 Records and Forms

C–760a Local Exhaust Ventilation (LEV) Survey Tag—Green
C–760b Local Exhaust Ventilation (LEV) Warning Notice Tag—Yellow
C–760c Local Exhaust Ventilation (LEV) Out of Service Notice Tag—Red

The forms listed above are located at the end of Appendix B in the Testing Local Exhaust Ventilation (LEV) Systems manual.

2.3 Definitions

**Area (A).**—Surface area of a hood opening or duct; measured as round duct \( A = 3.14 \times (\text{radius})^2 \) or \( A = 0.79 \times (\text{diameter})^2 \); typically measured as rectangular duct \( A = (\text{length}) \times (\text{width}) \) in square feet (ft\(^2\))

**Duct.**—Passageway made of sheet metal or other suitable material used for conveying air, gasses, vapors, particulates, mist, or fumes

**Local exhaust ventilation (LEV).**—Industrial ventilation system that captures and removes emitted contaminants before they are released into the workplace environment

**Pitot tube probe.**—Type of probe that simultaneously measures the static pressure and total pressure within a duct, thereby allowing the velocity pressure to be calculated. ; velocity is proportional to the square root of the velocity pressure times 4004.4 for dry air at 70 °F and a barometric pressure of 29.92 inches (in.) of mercury (Hg).

**Thermal anemometer probe.**—Type of probe used to measure velocity and depends upon the known thermal capacitance of an airstream to cool the thermocouple (“hot wire”) once it has been heated

**Velocity (V).**—Time rate of movement of air in a given direction, typically measured as feet per minute (ft/min or fpm), meters per second (m/sec), or miles per hour (mph)

**Velocity, face.**—Air velocity measured at the face opening of a hood or duct
Velocity, capture.—Velocity of the air induced by a hood to capture emitted contaminants external to the hood; acceptable capture velocity depends upon the mass of the contaminant being captured, the prevailing air currents nearby, thermal properties of the contaminant (e.g., hot fumes rise), and the velocity of the contaminant relative to hood flow (e.g., belt sander throwing dust into or away from its exhaust duct).

Volumetric flow rate (Q).—Volume or quantity of air that passes a given location per unit of time and that is related to the average velocity and cross-sectional area by \( Q = VA \)

3.0 DISCUSSION

Local exhaust ventilation, or process exhaust, systems are used throughout industrial and laboratory environments to move airborne contaminants away from workers to minimize their exposures. These systems must be designed to not only handle the type and quantity of contaminant being generated but also to accommodate the employee and work activities associated with the task. LEV systems are composed of several components that include the hood, ducting, air mover, and possibly some type of contaminant removal mechanism. The design of such systems must also take into account the facility where the LEV will be located and the other ventilation systems therein. The design and layout of LEV systems is performed by Facilities Division engineering staff with input from a facility team industrial hygienist (IH).

Evaluating the performance and adequacy of process exhaust systems at the worker-LEV interface is performed by industrial hygiene staff. Many parameters must be considered when determining the flow velocity and rate necessary to adequately remove a contaminant from a work zone and successfully transport it through the ventilation system. Considerations include contaminant type (particle or gas), particle size (if not a gas), contaminant temperature, contaminant initial velocity (speed and direction), ambient air movement, hood type, hood location, and worker location. Periodic checks of the LEV system are used to compare system performance to the established flow parameters and also to determine if the system/equipment setup has changed, necessitating the establishment of new flow parameters.

4.0 Safety Precautions

Testing of local exhaust ventilation systems can involve potential safety and health hazards that must be managed appropriately. When there are questions regarding the LEV system or equipment, IH personnel should contact the individual responsible for the LEV system, experimental rig, or facility/room as needed.

Safety considerations associated with surveying LEV systems include those related to working on step ladders or step stools to make flow measurements, entering areas with industrial safety hazards (foot, hand, eye, etc.), and any potential safety hazards presented by the experiment/equipment or materials being stored or used. Managing such hazards involves following prescribed precautions and wearing appropriate personal protective equipment (PPE).

Potential occupational health (OH) hazards associated with testing LEV systems will vary and depend upon the status of the contaminant-generating activity or material/chemical storage/use and the efficacy of the ventilation system. The surrounding work environment could also present OH concerns that should be considered (e.g., high noise, lasers) Again, these hazards can be managed by using appropriate PPE and by following any specifically prescribed safety precautions in addition to observing the general work practices associated with working in a research environment.

5.0 Tools, Equipment and Materials

5.1 TSI VelociCalc® Air Velocity Meter

This meter measures velocity and temperature, calculates flow rate, performs multivalue averaging, and determines minimum and maximum readings. Prior to use, this instrument shall have a current annual calibration sticker and appear to be functioning properly.

5.2 TSI VelociCalc® Plus Multi-Parameter Ventilation Meter

This meter simultaneously measures and data logs several ventilation parameters using a single probe with multiple sensors. The ventilation meter measures temperature, humidity, and pressure. The meter also features automatic...
calculation of flow rate and automatic conversion between actual and standard velocity readings. Prior to use, this instrument shall have a current annual calibration sticker and appear to be functioning properly.

- Reserved for alternate venation meter
- Smoke tube kit that generates vapor/fume for visualizing flow of LEV systems
- Vinyl tag holders and miscellaneous administrative supplies
- Tape measure and miscellaneous tools (adjustable wrench, screwdriver)

5.3 Additional Equipment
- Smoke tube kit that generates vapor/fume for visualizing flow of LEV systems
- Vinyl tag holders and miscellaneous administrative supplies
- Tape measure and miscellaneous tools (adjustable wrench, screwdriver)

6.0 RESPONSIBILITIES
6.1 Industrial Hygiene Personnel
Personnel performing industrial hygiene functions within GRC’s Safety, Health and Environmental Division (SHED) are responsible for being familiar with and implementing this work instruction.

7.0 PERSONNEL TRAINING AND/OR CERTIFICATION
- Industrial hygiene personnel who perform local exhaust ventilation system surveys should have received the necessary training associated with entering most areas at the Center.
- Industrial hygiene personnel who perform local exhaust ventilation system surveys should have a general understanding of ventilation systems and flow parameter calculations.
- Industrial hygiene personnel who perform local exhaust ventilation system surveys should know how to operate survey equipment and be familiar with the equipment manuals.

8.0 INSTRUCTIONS
8.1 Administrative and Data Management Functions

8.1.1 Database
An Access database is used to track local exhaust ventilation systems at GRC. Information in this database includes a unique identifying number for the LEV system, point of contact, type of system, operating parameters (i.e., flow specifications), face or capture velocity (or observed reading), distance from face, and comments. In addition, images are being added to the database to aid in identifying each system and where and how the flow measurements should be secured. Standard database functions are used to sort, query, and, otherwise, manage the LEV system information. It is important that IH personnel actively maintain this data resource to reflect changes in system information or the performance of periodic surveys.

The fields “operating parameter” and “comments” should be used to provide specific instruction on how and where the flow parameter should be measured, what the requirement is, and, if needed, a description of how this flow requirement was determined.

8.1.2 Naming Convention
LEV systems are uniquely identified using the following convention:

Building No. – Room/Cell No. – Hood No.
Examples: 302 – 219 – 5
005 – CW5 – 2

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Hoods are numbered sequentially, with there being no significance or priority associated with the actual number. When a new LEV system is added to a room, it receives the next available unused number. Numbers for systems that have been removed from a room or cell are decommissioned with the system and are not reused.

8.2 Establishing Required Flow Parameters

8.2.1 General Discussion

Velocity and/or flow requirements for some LEV system types can come straight from OSHA regulations or directly out of industry guidelines, such as the ACGIH manual *Industrial Ventilation, A Manual of Recommended Practice for Design*, hereinafter identified as the “Ventilation Manual.” The manufacturer of the equipment being ventilated by the LEV system may also provide a specification for process exhaust performance. Establishing flow requirements for many other systems will depend upon assessing the LEV application along with its target activity using guidance provided in relevant ventilation references.

Although not an exhaustive list, the following guidance is intended to address most of the LEV system types found at GRC. Other LEV applications might require a bit of researching and the application of general principles to establish its flow requirements. In addition, changes to prescribed flow parameters might be allowable to address unusual LEV needs.

Once established, the flow requirements for an LEV system along with supporting information shall be recorded in the database operating parameter field and the comments field, respectively.

8.2.2 Laboratory Fume Hood

The average face velocity of nine readings (3×3) taken over the laboratory hood opening should range between 80 and 120 fpm, with a target value of 100 fpm.

If the LEV system is a continuous-flow laboratory fume hood, the hood shall provide a face velocity of 100 ft/min (fpm) ±20 percent. If the LEV system is not a continuous-flow laboratory fume hood, then the sash shall be adjusted such that the hood provides a face velocity of 100 fpm ±20 percent. The sash height shall be marked on the survey tag or on the hood itself to clearly indicate the required sash height. Hoods that are equipped with airflow monitoring gauges must indicate the tested velocity flow within ±10 percent. If not, a WR must be submitted to address the discrepancy.

Newly purchased laboratory fume hoods shall include a continuous face velocity monitor for the purpose of measuring hood performance. Each monitor shall be calibrated annually.

Laboratory hoods should not be used for general chemical storage. Keep materials stored in hoods to a minimum and do not allow them to block vents or airflow.

Refer to the Ventilation Manual pages 6-3>16, 13-47>52 and figures VS-35-01>04 for further details on laboratory fume hood design (Appendix C).

Note: Laboratory fume hoods and paint spray booths are not created equal. A paint spray booth is a specifically designed enclosure for the control of paint vapors and particulate overspray, equipped with air filtration to contain emissions and protect against combustible paint film buildup in ductwork, and includes fire suppression. Often, laboratory fume hoods do not meet this criteria. Air flow recommendations for paint booths also vary. Refer to Ventilation Manual figures VS-75-01>02 for further details (Appendix C).

8.2.3 Biological Safety Cabinets

Biological safety cabinets require annual recertification according to National Science Foundation (NSF) American National Standards Institute (ANSI) International Standard Number 49 for downflow, inflow, flowpattern, and system leakage integrity. This procedure shall be accomplished by an NSF Accredited Class II Biosafety Cabinet Certifier. Please refer to the Industrial Ventilation Manual figures VS-35-1- and VS-35-11 for further details on cabinet design considerations (Appendix C) and for complete biosafety considerations in “Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th Edition, HHS Publication No. (CDC) 21-1112, 2009.

8.2.4 Snorkel-Type Hood (Articulated Arm)

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The flow requirement for this system will depend on the characteristics of the contaminant and the distance from the point of contaminant generation to the hood opening. Typically, the hood shall be as close to this point as possible without interfering with the work task or otherwise creating another safety hazard. The flow specification can be either a capture velocity at a specified distance from the hood to reflect the work scenario or a face velocity at the hood or duct to correspond to this needed capture velocity. Note that the face velocity required to achieve a specific capture velocity at some distance \( X \) increases very rapidly as the distance \( X \) gets larger. Please refer to Ventilation Manual pages 6-18>24, 13-103>104, and 13-165>168 and figures VS-65-01 and VS-90-02 for further details (Appendix C).

**Example Welding Operation**

LEV uses a 6-in.-diameter flexible duct, and the hood expands to a diameter of 12”. The welding operation is 9 in. from the face of the hood.

Assume a required capture velocity \( Q \) of 150 fpm for welding low-toxicity materials in moderately still air (Ventilation Manual, VS–90–2, 2010).

\[
Q = 150 \ C_f \ \left(10X^2 + A\right) \quad \text{(Ventilation Manual, VS–90–2, 2010), where} \ C_f = 0.75, \ \text{for tapered duct,} \ X = \text{distance from hood to capture point,} \ A = \text{cross-sectional area of hood opening} \quad Q = 150 \ \text{fpm} \times 0.75 \times \left[10 \times (9/12)^2 \ \text{ft}^2 + 0.7854 \ \text{ft}^2\right] = 721 \text{ ft}^3/\text{min (cfm)} \quad \text{Note that the area} \ A \ \text{of an 12” circle is 0.7854 square feet.}
\]

The corresponding hood face velocity \( V = Q/A = 721 \ \text{cfm)/(0.7854 ft}^2 = 918 \ \text{fpm}
\]

The corresponding duct face velocity \( V = (721 \ \text{cfm})/(0.2 \text{ ft}^2) = 3605 \ \text{fpm}
\]

This example shows three possible velocity measurements that could be made to check the performance of such an LEV system: capture velocity = 150 fpm (minimum), hood face velocity = 918 fpm, and duct face velocity = 3605 fpm. [only pertains to a specified capture velocity of 150 fpm and a hood location 9” from the point of fume generation, with a 12” hood and 6” duct opening]

**8.2.5 Canopy Hood**

Flow requirements depend not only on the characteristic of the contaminant generated and the distance to the hood but on the type of canopy hood (open sides = 4, 3, 2, or 1). Because of this openness, their size, and the distance to the target activity, canopy hoods are not very efficient means of contaminant removal. Consequently, significant flow may be necessary to properly remove the emission from the work environment. Canopy hoods shall provide a capture velocity based on source toxicity, distance from contaminant source, temperature of process and cross drafts. Refer to Ventilation Manual pages 6-18>20, 13-35>40, and 13-110>113, and figure VS-99-03 for further details (Appendix C).

**Example Canopy Hood Operation**

The canopy hood is above an oven where hot emissions are released in an environment of relatively still air. The oven has a footprint of 2 by 2 ft. The canopy profile is 3 by 3 ft; the hood is open on all four sides, and the bottom of the canopy is 1 ft above the top of the oven. The canopy hood is attached to 8-in.-diameter ductwork.

Assume a required capture velocity \( Q \) of 75 fpm for hot effluent into quiet air (Ventilation Manual, Table 6–2). \( Q \) = 1.4 \( PHV \) (Ventilation Manual, VS–99–3, 2010), where \( P \) = emission source (oven) perimeter, \( H \) = distance from bottom of canopy to target zone

\[
Q = 1.4 \times \left(8 \text{ ft} \right) \times \left(1 \text{ ft} \right) \times \left(75 \text{ ft/min} \right) = 840 \text{ cfm}
\]

The corresponding hood face velocity \( V = (840 \ \text{cfm})/(9\text{ft2}) = 93 \ \text{fpm}
\]

The corresponding duct face velocity \( V = (840 \ \text{cfm})/(0.349) \ \text{ft}^2 = 2406 \ \text{fpm}
\]

Three choices for velocity measurements can be made to check the performance of such an LEV system: capture velocity = 75 fpm (minimum), hood face velocity of 93 fpm, and duct face velocity = 2406 fpm.

**8.2.6 Cabinet**

The flow requirements for a cabinet-style LEV system are logically somewhat lower than those for an open-type LEV hood because the target volume is enclosed on all sides. A capture velocity can be selected from Table 6-2 of Printed copies are uncontrolled and are not to be used for operational purposes.
the Ventilation Manual (See Appendix C) and the calculations made to determine the corresponding duct face velocity (cabinet outlet) or filter/slot panel velocity (cabinet inlet).

Example Cabinet Operation

A ventilated cabinet houses an activity involving a high-intensity ultraviolet xenon lamp; ozone (O₃) production is expected. The cabinet width and depth are both 2 ft. The cabinet has a 4-in.-diameter exhaust at the top on its back panel and a 6- by 12-in. filtered inlet near the bottom of the front panel.

Assume a required capture velocity of 25 fpm for the emission of a gas in a quiet, enclosed cabinet. \( Q = VA \)

\[
Q = (25 \text{ fpm}) \times (2 \text{ ft}) \times (2 \text{ ft}) = 100 \text{ cfm}
\]

The corresponding duct face velocity \( V = (100 \text{ cfm})/(0.09 \text{ ft}^2) = 1150 \text{ ft/min} \)

The corresponding filter inlet face velocity, \( V = (100 \text{ cfm})/(0.5 \text{ ft}^2) = 200 \text{ ft/min} \)

Depending upon accessibility, there may be up to three choices for making a measurement to check the performance of this system; the least intrusive would be a measurement of the inlet filter face velocity, which has a minimum specification of 200 fpm.

8.2.7 Sander/Grinder

The particles generated in these mechanical abrasion operations are relatively large and require high capture and duct velocities to grab the contaminant and keep it suspended during transport. Table 6–1 of the ventilation manual specified a minimum capture velocity of 500 to 2000 fpm for contaminants released at a high initial velocity into a zone of very rapid air motion (e.g., grinding). Other flow requirements for a sanding/grinding operation are specified based upon the type of operation and the size of the abrading media. Typical operation types include wheel, belt, and disk with pertinent dimensions being wheel width, belt width, and disk diameter. These flow requirements are specified as minimum exhaust flow rates in cubic feet per minute. Assigning a flow requirement for a particular system will depend upon how best to make a relevant and meaningful measurement.

8.2.8 Other

In general, establishing a capture velocity parameter for an LEV system based upon the operation being ventilated is the best approach for evaluating the effectiveness and performance of such a system. Ranges of capture velocities for many applications can be found in references such as the Ventilation Manual, but often a decision must be made to establish a flow requirement not covered by such a reference. In some cases, experience and professional judgment may be adequate to establish a minimum capture velocity. In other cases, personal exposure monitoring may be necessary to assess the adequacy of an LEV system.

Engineered Nanomaterials Ventilation Requirements for Engineered Nanomaterials are covered in Section 13.67 of the Industrial Ventilation manual (See Appendix C). Nanoparticles have unknown human health effects due to unique chemical and physical properties including particle size, shape, surface area, charge, chemical properties, solubility, oxidant generation potential, and degree of agglomeration.

8.3 Performing LEV System Surveys

8.3.1 General Discussion

Prior to performing LEV system assessments, the surveyor should ensure that the instrument is calibrated and appears to functioning properly. The surveyor should also verify that the subject LEV system is operating and make note of any pertinent valve/damper positions and other conditions of the mechanical ventilation system. Inspect the exhaust system and its associated ductwork and mechanical components for any obvious signs of damage or other problems. (e.g., clogged ductwork or intake, breached ductwork, broken dampers, missing or damaged seals, unusually loud motor noises or oscillations). Do not test the LEV system if it is not operable or is of questionable integrity. Raise concerns about the system with the system point of contact and/or facility personnel.

The surveyor should record as much information about the testing scenario as is necessary to properly document the LEV system’s compliance with performance specifications and to allow for reproducible measurements to be taken in the future. This information shall include distances from duct faces where capture velocity measurements were...
taken, damper positions (when applicable), the type of contaminant generated, pertinent dimensions of the system/layout, assumptions made that impacted testing, and so forth.

Although the purpose of the LEV surveys is to verify proper operation of the process exhaust system, the tools and methods being used can also be used to optimize systems or work scenarios that do not meet their flow specifications. Tracing smoke and measuring flow velocities can be used to identify the boundaries of an appropriate work zone for an LEV system or identify items that adversely impact the performance of such a system.

8.3.2 Use of Smoke Tubes

The vapor and/or fume generated by a smoke tube provides a convenient method for visualizing airflow. The value of this tool in assessing the performance of an LEV system is somewhat limited because of the subjective nature of the method and its result. Its use can be considered for a qualitative assessment of systems where flow adequacy is easily achieved and other flow parameters are difficult to measure. One example could be a toxic material storage cabinet whose exhaust is intended to remove contaminants resulting from a small leak. In this instance, the smoke can be used (1) near the door while slightly cracking the door open or (2) near an intake panel, if present. Another use would be an enclosed bead/sand blasting unit where the smoke could be used to check the integrity of enclosure seals or to determine if the exhaust system is adequately drawing or sucking on the box to keep this work volume negative in pressure relative to where the blaster operators are located.

8.3.3 Use of the Thermal Anemometer Probe [Do not use in explosive, flammable or combustible atmospheres]

The TSI VelociCalc® and VelociCalc® Plus survey instruments both include a thermal anemometer probe as their primary means of flow velocity measurement. The probes include a telescoping, articulated rod that allows the user to make measurements at a distance and with the probe’s hot wire at varying angles and orientations. The end of the probe should be placed in the two-dimensional plane of the opening being measured. In addition, the probe should be oriented to achieve the maximum flow of air over the hot wire (see figures below). The observed flow rate will decrease rapidly as the probe is rotated out of this maximum flow scenario. The probe has a direction of flow marking (a dot) on the tip that shall be oriented upstream. With exhaust systems, this means the dot will be visible to the operator when taking measurements.

In addition to facilitate making measurements out of one’s normal reach, the probe’s extendable, telescoping wand enables readings to be performed away from the instrument operator, thereby reducing the flow interference effects caused by the operator’s body.

8.3.4 Use of Pitot-Tube Probe—Reserved.

8.3.5 Laboratory Hood Surveys

Nine velocity measurements, arranged in a three-by-three (3×3) grid over the hood face, should be taken when surveying a laboratory ventilation hood. Visualize the following when performing a laboratory hood survey and make velocity measurements at the center of each of the nine rectangles.
The VelociCalc® meters will average the results for the operator. Particular attention should be paid to keeping the probe hot-wire opening perpendicular to the airflow and using the telescoping feature of the wand to stay as far away from the measurement zone as possible. The height of the vertical sash should be adjusted to get the average flow velocity to be approximately 100 fpm. The acceptable range is 80 to 120 fpm.
8.3.6 Obtaining a Face Velocity Measurement for a Duct or Hood Opening

Opening size and shape, location, orientation, obstructions, and accessibility all have bearing on how one can assess the face velocity of the opening. Many times a single centerline flow velocity measurement is adequate (e.g., small round duct face) or is all that can be readily obtained. However, this centerline flow velocity will overestimate the actual duct velocity and should be multiplied by 0.9 to estimate the average flow velocity of the duct. Larger and more accessible hood faces allow for more measurements to be made and then averaged. More measurements typically yield more accurate results; however, the above-mentioned considerations as well as the safety of the surveyor should be taken into account. Here are two examples.

For a rectangular hood, imagine it is broken up into a grid (2×2, 3×2, 3×3, or whatever seems appropriate for the size and shape of the rectangle). Then average the readings taken in each of the grids to obtain the face velocity for that hood. The hood shown was broken down into a 3×2 grid.

For a round opening, single or multiple measurements can be taken. The larger duct example identifies six measurements being taken with positions comparable to those found in references for performing a 6-point traverse. Each pair of measurement locations (1,6; 2,5 and 3,4) represent measurements within three equal-area donut-shaped disks within the duct. The average of the six readings represents the average duct face velocity. The smaller round opening has dimensions approaching that of the hot-wire probe itself, making it difficult to take multiple measurements. So a single measurement is taken and corrected with the 0.9 multiplication factor.

Again, particular attention should be paid to keeping the probe hot-wire opening perpendicular to the airflow and using the telescoping and feature of the wand to stay as far away from the measurement zone as possible.

8.3.7 Obtaining a Capture Velocity Measurement
When possible, a capture velocity reading is the best measure of the effectiveness of an LEV system because the surveyor is observing the flow effects experienced by the contaminant itself. Often, however, such measurements are difficult to make because of limited accessibility (enclosures, obstructions), requiring that some other surrogate measurement (e.g., duct face velocity) be made. When using the thermal anemometer to make these measurements, the probe’s articulating and telescoping features should be utilized to keep the hot-wire opening (1) perpendicular to the airflow and (2) away from interference created by the surveyor.

8.4 LEV System Results: Tags and Documentation

8.4.1 General Discussion

The documentation of LEV survey results involves displaying results locally at the LEV system and recording the results in the LEV database. Both modes play an important role in ensuring the health of workers relying on such engineering controls. Local postings describe whether the system is functioning properly, if there are restrictions on its use (e.g., maximum sash height of a lab hood or maximum effective range of a snorkel hood), or if there are requirements to be met prior to using the system for worker protection.

8.4.2 Recording Results Locally at LEV System

A system of multicolor tags will be used to document survey results in the field. These tags will replace the fluorescent orange “Survey” tags and red “Do Not Use” postings being used as of May 2007. In most instances, the colored tags will fit into vinyl sleeves that will be placed (using Velcro® or other adhesion method) on the LEV system to allow conspicuous viewing of the colored tags. For LEV systems where this is not possible, a brass grommet is to be added to the vinyl sleeve that will then be hung at the LEV system, again in a location to allow conspicuous viewing of the tag. In addition, sash-height labels will be placed on the side of laboratory fume hoods to identify the required position at the bottom of the sliding vertical sash.

8.4.2.1 Green LEV Survey Tag

The green “LEV Survey Tag” shown in Attachment A is to be used when survey results satisfy the system flow requirements. Tags are filled in to identify the system, document the survey results, and list any restrictions associated with the LEV system use. An example of a use restriction would be specifying a maximum effective range of 8 in. for a flexible snorkel being used for welding activities.

8.4.2.2 Yellow LEV Warning Notice Tag

The yellow “LEV Warning Notice Tag” shown in Attachment B is to be used when there is inadequate information to verify the efficacy of the system. The hood ID and any other relevant comments are to be included on the tag. For example, a canopy hood or duct drop is positioned over an area that has no source of contaminant emission. Without knowing the emission characteristics and distances involved, it would not be possible to adequately assess the adequacy of such an LEV system.

8.4.2.3 Red LEV Out of Service Notice Tag

The red “LEV Out of Service Notice Tag” shown in Attachment C is to be used when survey results do not satisfy the system flow requirements. The hood ID and any other relevant comments are to be included on the tag. After placing a red out of service (OOS) notice on a system, the surveyor shall contact the LEV system point of contact or local facility personnel to discuss the deficiency. When needed, an industrial hygienist shall be contacted to evaluate the LEV system with input from the user, facility, and maintenance personnel.

8.4.3 Updating Database

The LEV system database allows for storage of system information, testing requirements, and survey results. Typical database features such as sorting, querying, and report generating allow for convenient data manipulation and display. Following an LEV system survey, the fields within the unique record for that particular system are to be updated to reflect the survey results, date, surveyor, and if not already identified, the survey conditions and specific flow requirements and any relevant assumptions in establishing the criteria.
ATTACHMENT A.—GRC–760a LOCAL EXHAUST VENTILATION (LEV) SURVEY TAG

LEV I.D. ____________________________

IN COMPLIANCE

☐ 100 fpm (average) face velocity for lab hood
☐ ______ fpm minimum capture velocity
☐ Airflow check is OK using smoke (tracer)

______ fpm at _____ in. from fume hood/duct face

SHeD Surveyor: ____________________________
Telephone: ____________________________
Expires on: ____________________________

Please contact Safety and Health Division if this Local Exhaust Ventilation (LEV) is taken out-of-service or relocated.

fpm = feet per minute

GRC 760A 10/14 (1.0)
ATTACHMENT B.—GRC–760b LOCAL EXHAUST VENTILATION (LEV) WARNING NOTICE TAG

LEV I.D.  

CAUTION

Do not operate until contacting SHeD Surveyor regarding LEV usage or experimental setup.

SHeD Surveyor: ________________________

Telephone: ________________________

Notice Date: ________________________

Review date: ________________________

Please contact Safety and Health Division if this Local Exhaust Ventilation (LEV) is taken out-of-service or relocated.

SHeD = Safety and Health Division

GRC 760B 10/14 (10)
ATTACHMENT C.—GRC–760c LOCAL EXHAUST VENTILATION (LEV) OUT OF SERVICE NOTICE TAG

<table>
<thead>
<tr>
<th>LEV I.D.</th>
<th>OUT OF SERVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact Fix-it 3-4948 for service</td>
<td></td>
</tr>
<tr>
<td>□ Improper flow</td>
<td></td>
</tr>
<tr>
<td>□ Missing or broken parts</td>
<td></td>
</tr>
<tr>
<td>□ Flow monitor repair/calibration</td>
<td></td>
</tr>
<tr>
<td>□ Other: ____________________</td>
<td></td>
</tr>
</tbody>
</table>

Once repaired or if relocated/excessed, please contact:

SHed: ________
Telephone: ____________________

Notice Date: ____________________

LEV = Local Exhaust Ventilation  
SHed = Safety and Health Division

APPENDIX C—INDUSTRIAL VENTILATION: A MANUAL OF RECOMMENDED PRACTICE FOR DESIGN, 27TH EDITION FIGURES:

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<th>FIGURE/TABLE/SECTION</th>
</tr>
</thead>
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<tr>
<td>Biological Safety Cabinet, Type A</td>
<td>VS-35-10</td>
</tr>
<tr>
<td>Biological Safety Cabinet, Type B</td>
<td>VS-35-11</td>
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<tr>
<td>Movable Exhaust Hoods</td>
<td>VS-65-01</td>
</tr>
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<td>Large Paint Booth</td>
<td>VS-75-01</td>
</tr>
<tr>
<td>Small Paint Booth</td>
<td>VS-75-02</td>
</tr>
<tr>
<td>Capturing Hood for Low Toxicity Welding</td>
<td>VS-90-02</td>
</tr>
<tr>
<td>Glenn Research Center Occupational Health Programs Manual</td>
<td>Title: Local Exhaust Ventilation</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>--------------------------------</td>
</tr>
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<td><strong>Document No.:</strong> GLP-QS-1800.1.7</td>
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<tr>
<td>Canopy Hood</td>
<td>VS-99-03</td>
</tr>
<tr>
<td>Area and Circumferences of Circles</td>
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<tr>
<td>Recommended Capture Velocities</td>
<td>Table 6-2</td>
</tr>
<tr>
<td>Ventilation Requirements for Engineered Nanomaterials Section 13.67</td>
<td></td>
</tr>
<tr>
<td>Laboratory Hood</td>
<td>VS-35-01</td>
</tr>
</tbody>
</table>
Biological Safety Cabinet, Type A

VS-35-10
Biological Safety Cabinet, Type B
Movable Exhaust Hoods

* Recirculating Air Hoods are not recommended for use with gases or vapors.

Note: See "National Sanitation Foundation Standard 49" (13.35.4) for requirements and definitions of types and classes.

For product protection only, see VS-35-30 and VS-35-31.

All Type B cabinets require biologically contaminated ducts and plenums to be under negative pressure or surrounded by negative pressure ducts and plenums.
Large Paint Booth

VS-65-01

MOVABLE EXHAUST HOODS

CHECK CODES, REGULATIONS, AND LAWS (LOCAL, STATE, AND NATIONAL) TO ENSURE THAT DESIGN IS COMPLIANT.

Large Paint Booth

VS-75-01
Air spray paint design data.
Any combination of duct connections and baffles may be used. Large, deep booths do not require baffles. Consult manufacturers for water-curtain designs. Use explosion-proof fixtures and a non-sparking fan. Electrostatic spray booth requires automatic high-voltage disconnects forveyor failure, fan failure or grounding.

**Walk-in booth**
- W = work size + 6'
- H = work size + 3' (minimum = 7')
- C = work size + 6'
- Q = 100 acfm/ft² booth cross-section
  - May be 75 acfm/ft² for very large, deep booth. Operator may require a NIOSH certified respirator.
  - k_c = 1.78 V_B + 0.50 V_B (baffles)
  - k_c = Dirty filter resistance + 0.50 V_B (filters)
- Duct velocity = 2000 fpm

**Operator outside booth**
- W = work size + 2'
- H = work size + 2'
- C = 0.75 x larger front dimension
- Q = 100 - 150 acfm/ft² of open area, including conveyor openings.

Airless electrostatic and HVLP spray paint design
- Q = 60 acfm/ft² booth cross-section, walk-in booth
- Q = 60 - 100 acfm/ft² of total open area, operator outside of booth

Notes:
1. Baffle arrangements shown are for air distribution only.
2. Paint arresting filters usually selected for 100 - 500 fpm, consult manufacturer for specific details.
3. For construction and safety, consult NFPA 1.59.3

---

Small Paint Booth

VS-75-02
Capturing Hood for Low Toxicity Welding

Air spray design data
Any combination of branch ducts and baffles may be used.
W = work size + 12"
H = work size + 12"
C = 0.75 W or H, whichever is larger
Q = 200 acfm/R (200 WH) - for face area up to 4 ft²
   = 150 acfm/R² - for face area over 4 ft²
he = 1.78 Vf³ + 0.25 V[D (filters)
   = dirty filter resistance + 0.25 V[D (filters)
Duct velocity = 2000 fpm

Airless spray paint design data
Q = 125 acfm/R² (125 WH) - for face area up to 4 ft²
Q = 100 acfm/R - for face area over 4 ft²

Notes:
1. Baffle arrangements shown are for air distribution only.
2. Paint arresting filters usually selected for 100 - 500 fpm, consult manufacturer for specific details.
3. For construction and safety, consult NFPA 1.95-31
APPLICATION OF MOVEABLE CAPTURING HOODS

1. Not suitable for confined spaces unless coupled with appropriate use of respiratory protection and copious dilution ventilation with good mixing.

2. Not suitable for highly hazardous contaminants (use enclosing hood instead).

3. The distance of the center of the hood face to the weld (X) is critical. The welder must be diligent in keeping the hood close to the weld for these hoods to be effective.

RECOMMENDED EXHAUST RATES ($Q_L$) AND DETERMINATION OF HOOD DIMENSIONS

$$Q_L = 125 \times C_e \left( \frac{10^4}{\text{Area of hood}} \right) \left( \text{acfm} \right)$$

where

- $C_e = 0.75$ for flanged or tapered
- $C_e = 1.0$ for plain duct

<table>
<thead>
<tr>
<th>$X$, inches</th>
<th>Plain duct (acfm)</th>
<th>Flange or cone (acfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6”</td>
<td>380</td>
<td>280</td>
</tr>
<tr>
<td>9”</td>
<td>730</td>
<td>580</td>
</tr>
<tr>
<td>12”</td>
<td>1350</td>
<td>1000</td>
</tr>
</tbody>
</table>

1. $Q_L$ values above assume that the hood is elevated above the welding source to account for the mix plume. If the hood is level with the source, $Q_L$ must be much higher.

2. $Q_L$ values above are based on low toxicity welding. For moderate toxicity welding, increasing airflows by 20-40% (see also VS-90-01) may be sufficient. For still higher toxicity welding, an enclosing hood (VS-90-30) and respiratory protection may be necessary.

3. Velocities above 150 fpm at the point of the weld may disturb shield gas.

4. The greater the width of the hood the less the hood must be moved left to right, which is often awkward. The hood width should be greater than the distance, $X$, from the face of the hood to the source.

5. The velocity gradient becomes extreme for $X$-distances less than 10”. It is best to design for $X$ greater than 16”.

DUCT SIZE SELECTION AND COMPUTATION OF $SP_a$

1. Minimum design velocity for ducts should be about 2,500 - 3,000 fpm.

2. The hood static pressure is computed from the entry loss coefficient ($F_e$) and the duct velocity pressure ($VP$):

$$SP_a = (1 - F_e)VP$$

---

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https://knowledgeshare.grc.nasa.gov/bmslibrary

Page 30 of 35
Not to be used where material is toxic and worker must bend over tank or process.
Side curtains are necessary when cross-drafts are present.

\[
Q = 1.4PHV \text{ acfm} \quad \text{for open type canopy}
\]
\[
P = \text{perimeter of tank, feet}
\]
\[
V = 50-500 \text{ fpm. See Chapter 3}
\]

\[
Q = (W + L)HV \text{ acfm} \quad \text{for two sides adjacent enclosed}
\]
\[
W \text{ and } L \text{ are open sides of hood}
\]
\[
V = 50-500 \text{ fpm. See Chapter 3}
\]

\[
Q = \text{WHV acfm or LHV acfm} \quad \text{for three sides enclosed (booth)}
\]
\[
V = 50-500 \text{ fpm. See Chapter 3}
\]

\[
he = 0.25 \text{ VPd}
\]
\[
\text{Duct velocity} = 1000-3000 \text{ fpm}
\]

**Table 5-8**

Area and Circumferences of Circles
**TABLE 6-8. Area and Circumference of Circles**

<table>
<thead>
<tr>
<th>Dia. in Inches</th>
<th>AREA Square Feet</th>
<th>CIRCUMFERENCE Feet</th>
<th>Dia. in Inches</th>
<th>AREA Square Feet</th>
<th>CIRCUMFERENCE Feet</th>
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</thead>
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<td>0.0055</td>
<td>3</td>
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<tr>
<td>1.5</td>
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<td>0.9163</td>
</tr>
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</tr>
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<td>1.7017</td>
</tr>
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<td>19.4</td>
<td>23.56</td>
<td>1.9635</td>
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<tr>
<td>5</td>
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<td>0.1364</td>
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<td>26.70</td>
<td>2.2253</td>
</tr>
<tr>
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<td>0.1650</td>
<td>25.3</td>
<td>29.85</td>
<td>2.4871</td>
</tr>
<tr>
<td>6</td>
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<td>0.1963</td>
<td>28.2</td>
<td>33.0</td>
<td>2.7489</td>
</tr>
<tr>
<td>6.5</td>
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<td>0.2304</td>
<td>31.1</td>
<td>36.2</td>
<td>3.0107</td>
</tr>
<tr>
<td>7</td>
<td>38.46</td>
<td>0.2673</td>
<td>34.1</td>
<td>39.3</td>
<td>3.2732</td>
</tr>
<tr>
<td>7.5</td>
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</table>

*The usual sheet metal fabricator will have patterns for ducts in 0.5-inch steps through 5.5-inch diameter; 1-inch steps 6 inches through 20 inches and 2-inch steps 22 inches and larger diameters.*

**Recommended Capture Velocities Table 6-2**
### Table 6.2. Recommended Capture Velocities

<table>
<thead>
<tr>
<th>Energy of dispersion</th>
<th>Examples</th>
<th>V, ft/min</th>
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<tr>
<td>Little motion</td>
<td>Evaporation from tanks, degreasing</td>
<td>75–100</td>
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<tr>
<td>Average motion</td>
<td>Intermittent container filling; low speed</td>
<td>100–200</td>
</tr>
<tr>
<td></td>
<td>conveyor transfers; welding; plating; pickling</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Barrel filling; conveyor loading; crushers</td>
<td>200–500</td>
</tr>
<tr>
<td>Very high</td>
<td>Grinding; abrasive blasting; tumbling</td>
<td>500–2000</td>
</tr>
</tbody>
</table>

### Factors affecting choices within ranges

- Strength of cross-drafts due to makeup air, traffic, etc.
- Need for effectiveness in collection:
  - Toxicity of contaminants produced by the source
  - Exposures from other sources, which reduces acceptable exposure from this source quantity of air contaminants generated – production rate, volatility, time generated

*see also ANSI Z9.2-1979*

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**Figure 6-7.** Note that the source is assumed to be DIRECTLY in front of the hood opening.

4. Presence of surfaces near the hood that do not block the flow — depending on their placement, such surfaces may channel more of the airflow over the source, reducing the required airflow. For example, a flange partially blocks the flow from behind the opening, increasing the velocities in front of the hood. Likewise, resting the hood on a tabletop can reduce the exhaust airflow requirement because the airflow is channeled into the hood. Side baffles also can channel airflow to the hood face, reducing the exhaust airflow requirement.

Baffles perpendicular to the hood opening are sometimes used to block cross-drafts (Figure 6-18). They can channel air over the source and into the hood opening if cross-draft velocities are low. However, it is possible that if cross-draft velocities are high, the upstream baffle will create a strong wake zone that may reduce the effectiveness of the hood rather than enhance it.

5. Objects and surfaces that impede flow across the source and into the hood face — an object placed between the source and the hood can channel the airflow so that it misses the contaminant.

6. Competing air currents — a high velocity cross-draft (e.g., greater than 25% of the capture velocity) may substantially distort the effective zone unless it is blocked by other surfaces or objects. Likewise, competing air currents near the hood due to blowing air, mechanical or operator movements, etc. also can distort and shrink the effective zone.

7. Motion of the contaminant — if the contaminant is released at high velocity, it may fly away from the hood despite the flow of air into the hood. The real problem is generally not the velocity imparted to the particle, but that a competing air current has been simultaneously created.

8. Buoyancy of the contaminated air — if the contaminated air is rising rapidly because it is much warmer than room air, its path becomes a complex function of the velocity components in each direction induced by the air drawn into the hood face and the upward velocity of the buoyant air. If the hood is drawing air solely in the horizontal plane, the buoyant air may escape capture (Figure 6-19). In those cases, the hood generally should be placed above the source with its face angled approximately 45 degrees with the vertical plane, as is shown in Figure 6-20.

### 6.7.4 Capturing Hood Shape and Placement.

The hood should be located so that the preponderance of the emissions is in the effective zone of the hood. Considering the effects of cross-drafts and other disturbances on the effective zone, the hood should be placed so that contaminants are well within the effective zone.

In general, the capturing hood should be at least 50% wider...
13.67.1 Precautionary Measures. Given the limited amount of information about health risks that may be associated with nanomaterials, taking measures to minimize worker exposures is prudent. For most processes and job tasks, the control of airborne exposure to nanomaterials can be accomplished using a variety of engineering control techniques similar to those used in reducing exposure to general aerosols (see Chapters 4, 5, 6, and 6). The implementation of a risk management program in workplaces where exposure to nanomaterials exists can help to minimize the potential for exposure to nanoparticles. Elements of such a program should include the following:

- Evaluating the hazard posed by the nanomaterial based on available physical and chemical property data, toxicology, or health-effects data
- Assessing the worker’s job tasks to determine the potential for exposure (see Chapter 1)
- Educating and training workers in the proper handling of nanomaterials (e.g., good work practices)
- Establishing criteria and procedures for installing and evaluating engineering controls (e.g., exhaust ventilation) at locations where exposure to nanomaterials might occur (see Chapters 5 and 6)
- Systematically evaluating exposures to ensure that control measures are working properly and that workers are being provided the appropriate personal protective equipment
- Developing procedures for determining the need for and selecting proper personal protective equipment (e.g., clothing, gloves, respirators)

13.67.2 Controlling Potential Worker Exposures. When controlling potential exposures within a workplace, it is recommended to use the hierarchy of controls to reduce worker exposures (see Chapter 1). The philosophy of the hierarchy of controls is to eliminate the hazard when possible (i.e., substitute with a less hazardous material) or, if not feasible, control the hazard at or as close to the source as possible.

13.67.2.1 Applicable Engineering Controls. If the potential hazard cannot be eliminated or substituted with a less hazardous or non-hazardous substance, then engineering controls should be installed and tailored to the process (see Chapters 5 and 6). Engineering control techniques such as source enclosure (i.e., isolating the generation source from the worker) and local exhaust ventilation systems should be effective for capturing airborne nanoparticles. However, the type of engineering control used should take into account information on the potential hazardous properties of the precursor materials and intermediates as well as those of the resulting nanomaterial. In light of current scientific knowledge about the generation, transport, and capture of aerosols, current knowledge indicates that a well-designed exhaust ventilation system with a high-efficiency particulate air (HEPA) filter should effectively remove nanomaterials.

Other factors that influence selection of controls include the physical form of the nanomaterial as well as task duration and frequency. For instance, working with nanomaterial in the...
Local Exhaust Ventilation

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