

ANSI/ASSP Z9.9-2010

Portable Ventilation Systems

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American National Standard — Portable Ventilation Systems

Secretariat

American Industrial Hygiene Association®

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Contents

Page

Foreword	iii
Committee and Subcommittee Members	iv
1. Associated Standards and Publications	1
2. Definitions	4
3. Scope	10
4. General Requirements	11
5. Specific Requirements	43

Appendices

Appendix A. Labeling System for Portable Ventilation Equipment	59
Appendix B. Portable Ventilation Equipment and Ignition Hazards	63

FOREWORD

This Standard describes fundamental good practices related to the design, manufacture, labeling, use and application, as well as maintenance and testing of portable ventilation systems used for the control of airborne contaminants or environmental conditions. Intended users of this Standard include owners of facilities, designers and manufacturers of portable ventilation equipment, employers, industrial hygienists and safety professionals, maintenance personnel, and end users. This Standard is compatible with other recognized standards of good practice.

This Standard is new. It intends to address a long-standing need in the ventilation arena. Portable ventilation is a broad and complex subject. Much of what applies to portable ventilation systems does not apply to fixed (in-place) systems and vice versa. Use of portable ventilation equipment occurs in many applications: confined space (sewer) entries; collection of welding plumes; maintaining negative pressure in structures during asbestos, lead, and mold remediation; and controlling emissions from spray painting and abrasive blasting, to name just a few.

This equipment is usually unobtrusive, often just another piece of clutter in surroundings crowded with other portable and mobile equipment and tools.

The environment in which much of this equipment is used is rough and tumble. These units can be used in any kind of condition and unpleasant weather. They can be thrown or kicked in frustration, dropped off trucks, and accidentally run over. These types of units require solid construction. Thus, design and fabrication may require incorporation of subtle features such as abuse-tolerant bonding from the electrical box to the frame to the ground connection through the electrical cord. Safety features must provide reliable protection in situations of high abuse.

Portable equipment comes in all shapes and sizes, ranging from the home built to the shop built to the factory built, and the utilitarian to the elegant. Very little, if anything, exists in standard textbooks on ventilation about this subject. Yet, the subject is far more complicated than meets the eye of the casual observer.

The Standard is presented in a two-column format. The left column presents requirements of the Standard; the right column clarifies and explains the requirements and provides information on how to comply with them.

Appendices supplement information provided in the Standard.

This Standard presents minimum requirements adaptable to the needs of the user establishment. Demonstrably equal or better approaches are acceptable. When deviating from the Standard, the responsible agent should provide documentation.

Suggestions for improvement of this Standard are welcome. The Committee will carefully consider all comments and suggestions. Please send comments to: Scientific and Technical Initiatives, AIHA®, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031.

Trademark OK here?

The Z9 Accredited Standards Committee on Health and Safety Standards for Ventilation Systems prepared, processed, and approved this Standard for submittal to ANSI. Committee approval of the Standard does not necessarily imply unanimity among all members of the Committee. At the time of approval, the Z9 Committee had the following members:

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American National Standard — Portable Ventilation Systems

1. Associated Standards and Publications

1.1. Standards and Regulatory Requirements

The following codes, regulations, standards, and guidelines contain provisions that have potential impact on provisions of this Standard. Where published requirements conflict, the more stringent shall apply. All regulations, standards, and guidelines are subject to revision. Users of the Standard are encouraged to consult the most recent edition to determine continued applicability.

1.1.1. Air Movement and Control Association (Arlington Heights, IL)

Classifications for Spark Resistant Construction (AMCA Standard 99-0401-86).
Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (ANSI/AMCA 210-99; ANSI/ASHRAE 51-99).
Laboratory Methods of Testing Air Circulator Fans for Rating (AMCA Standard 230-99).
Laboratory Method of Testing Positive Pressure Ventilators for Rating (ANSI/AMCA Standard 240-96).
Laboratory Methods of Testing Jet Tunnel Fans for Performance (ANSI/AMCA 250-05).

1.1.2. American Gas Association/Canadian Gas Association (Arlington, VA)

Gas Fired Appliances for Outdoor Installation (CAN/CGA-1-2.21-M85 (R1996)).
Gas-Fired Central Furnaces (CAN/CGA-2.3-M93/ANSI Z21.47-1993).
Automatic Safety Shut-Off Gas Valves (CAN/CGA-3.9-M87).
Gas Appliance Pressure Regulators (CAN/CGA-6.3-M95/ANSI Z21.18-1995).
Automatic Valves for Gas Appliances (CAN/CGA-6.5-M89/ANSI Z21.21-1995).
Gas Hose Connectors for Portable Outdoor Gas-Fired Appliances (CAN/CGA-8.4-M96/ANSI Z21.54-1996).
Electrical Features of Fuel-Burning Equipment (CSA C22.2 No. 3-M1988 (R1993)).

1.1.3. American Industrial Hygiene Association (Fairfax, VA)

Open-Surfaced Tanks (ANSI/AIHA Z9.1).
Fundamentals Governing the Design and Operation of Local Exhaust Systems (ANSI/AIHA Z9.2).
Spray Finishing Operations (ANSI/AIHA Z9.3).
Abrasive Blasting Operations (ANSI/AIHA Z9.4).
Laboratory Ventilation (ANSI/AIHA Z9.5).
Grinding, Buffing and Polishing (ANSI/AIHA Z9.6).
Recirculation of Exhaust Air (ANSI/AIHA Z9.7).
Fundamentals Governing the Management, Operation, Maintenance, and Testing of Existing HVAC Systems for Maintaining Acceptable Indoor Air Quality in Employee Occupancies through Dilution Ventilation (ANSI/AIHA Z9.8).
Fundamentals Governing the Design and Operation of Dilution Ventilation Systems in Industrial Occupancies (ANSI/AIHA Z9.10) (in preparation).

1.1.4. American Petroleum Institute (Washington, DC)

Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks (ANSI/API Standard 2015 – 2001) (Sixth Ed.).
Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks (ANSI/API Recommended Practice 2016) (First Ed.).
Protection Against Ignitions Arising out of Static, Lightning and Stray Currents, 6th Ed. (RP 2003).

1.1.5. American Society of Mechanical Engineers (New York)

Nuclear Power Plant Air Cleaning Units and Components (ASME N509-2002).
Testing of Nuclear Air-Treatment Systems (ASME N510-1989).

1.1.6. California Air Resources Board

Small Off-Road Engines and Equipment
(<http://www.arb.ca.gov/msprog/offroad/sore/sore.htm>). Information concerning emission standards referred to in promotional material from some manufacturers.

1.1.7. Canadian Standards Association (Rexdale, ON)

Bonding and Grounding of Electrical Equipment (Protective Grounding) (CSA C22.2 No. 0.4-M1982 (R1993)).
Compressed Breathing Air and Systems (CSA Z180.1-00).
Enclosures for Use in Class II, Groups E, F, and G Hazardous Locations (CSA C22.2 No. 25-1966 (R1992)).
Explosion-Proof Enclosures for Use in Class I Hazardous Locations (CSA C22.2 No. 30-M1986 (R1992)).
Special Purpose Enclosures (CAN/CSA C22.2 No. 94-M91).
Fans and Ventilators (CSA C22.2 No. 113-M1984 (R1993)).
Motors and Generators for Use in Hazardous Locations. (CSA C22.2 No. 145-M1986 (R1992)).

1.1.8. Compressed Gas Association (Arlington VA)

Commodity Specification for Air (ANSI/CGA G-7.1).

1.1.9. Electrostatic Discharge Association (Rome NY)

EOS/ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Grounding - Recommended Practice (ANSI EOS/ESD S 6.1).
ESD Association Standard for the Development of an ESD Control Program for the Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (ANSI/ESD S20.20).
ESD Association Standard for Evaluating the Performance of Electrostatic Discharge Shielding Materials — Bags (ANSI/ESD STM 11.31).
ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items — Packaging Materials for ESD Sensitive Items (ANSI/ESD S541).
ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items — Surface Resistance Measurement of Static Dissipative Planar Materials (ANSI/ESD STM 11.11).
ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items — Two-Point Resistance Measurement of Static Dissipative Materials (ESD STM 11.13 (Pending)).

ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items — Volume Resistance Measurement of Static Dissipative Planar Materials (ESD STM 11.12).

ESD Association Standard Test Method for the Protection of Electrostatic Discharge Susceptible Items — Garments. (ESD STM 2.1).

1.1.10. International Electrotechnical Commission (Geneva)

Classification of Hazardous Areas (IEC 79-10).

1.1.11. Mine Safety and Health Administration (Arlington, VA)

Code of Federal Regulations: Title 30, Part 7, Subpart B (Technical requirements and performance tests required on fabrics manufactured for use in mining applications).

1.1.12. National Electrical Manufacturers Association (Rosslyn, VA)

ANSI Z535.1-2006. Safety Color Code.

ANSI Z535.2-2006. Environmental and Facility Safety Signs.

ANSI Z535.3-2006. Criteria for Safety Symbols.

ANSI Z535.4-2006. Product Safety Signs and Labels.

ANSI Z535.5-2006. Safety Tags and Barricade Tapes (For Temporary Hazards).

ANSI Z535.6-2006. Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials.

1.1.13. National Fire Protection Association (Quincy, MA)

Basic Classification of Flammable and Combustible Liquids (NFPA 321).

Classification of Flammable Liquids, Gases, or Vapours and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas (NFPA 497).

Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas (NFPA 499).

Explosion Prevention Systems (NFPA 69).

Fire Hazards in Oxygen-Enriched Atmospheres (NFPA 53).

Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids (NFPA 325M).

National Electrical Code (NFPA 70).

Spray Application Using Flammable or Combustible Materials (NFPA 33).

Recommended Practice on Static Electricity (NFPA 77).

1.1.14. Occupational Safety and Health Administration.

Code of Federal Regulations, Title 29, Part 1910, Section 94, Ventilation.

Office of the Federal Register: Code of Federal Regulations — Title 29, Part 1926 Construction (OSHA). National Archives and Records Administration/Office of the Federal Register, 1996.

1.1.15. Underwriters Laboratories (Northbrook, IL)

Electric Fans. UL Standard 507.

Electric Motors and Generators for Use in Hazardous (Classified) Locations, Class I, Groups C and D, Class II, Groups E, F, and G (UL Standard 674).

Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations (UL Standard 1203).

Standard for Safety of Ground-Fault Circuit Interrupters (UL 943), 3rd Ed.

Standard for Safety for Tests for Flammability of Plastic Materials (UL 94), 5th Ed.

1.2. Additional Resources

AGA: *Purging Principles and Practice*, 2nd. Ed. Arlington, VA: American Gas Association, 1975.

AMCA: *Fans and Systems* (AMCA Publication 201-02). Arlington Heights, IL: Air Movement and Control Association, 2002.

AMCA: *Air Systems* (AMCA Publication 200-95). Arlington Heights, IL: Air Movement and Control Association, 1995.

Bossert, J.A.: *Hazardous Locations, Guide for the Design, Testing, Construction, and Installation of Equipment in Explosive Atmospheres*, 2nd. Ed. Rexdale, ON: Canadian Standards Association, 1994.

ESD: *ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items – Handbook* (ADV 2.0). Rome, NY: Electrostatic Discharge Association.

ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items - Triboelectric Charge Accumulation Testing (ESD ADV 11.2).

McManus, N.: *Safety and Health in Confined Spaces*. Boca Raton, FL: Lewis Publishers, 1999.

McManus, N.: *Portable Ventilation Systems Handbook*. New York: Taylor & Francis.

OSHA: *Ground-Fault Protection on Construction Sites* (OSHA 3007 Revised). Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration (U.S. DOL/OSHA), 1998.

Paschal, J.: *Understanding NE Code Rules on Grounding & Bonding Based on the 1999 NE Code*, 2nd Ed. Overland Park, KS: EC&M Books, 1998.

Paschal, J.: *Understanding NE Code Rules on Hazardous Locations Based on the 1999 NE Code*. Overland Park, KS: EC&M Books, 1998.

Roberts, E.W.: *Overcurrents and Undercurrents, All About GFCIs*. Mystic, CT: Reptec, 1996.

UL: *Practical Application Guideline for Leakage Current Protection Devices* (UL943A). Northbrook, IL: Underwriters Laboratories, 1998.

2. Definitions

The following definitions explain terms used in this Standard.

- 2.1. **Air changes per hour (ACH).** A common means for expressing a volumetric airflow through a room. Each ACH for a room is intended to represent an amount of air equal to the gross volume of the air passing through the room each hour. An ACH rate for a room can be converted to volumetric airflow by multiplying the ACH number times the gross volume of the room. For instance, for an ACH of 10, a room with a gross volume of 2400 cubic feet has a volumetric airflow of 400 cfm ($10 \times 2400 \div 60$). The air change rate depends on exhaust flow for a negatively pressurized room and on supply flow for a positively pressurized room. This term does not reflect actual mixing factors and therefore does not indicate the effective air exchange rate in the room. See the ACGIH® *Industrial Ventilation Manual* for further information on mixing factors.
- 2.2. **Air-cleaning equipment.** A device or combination of devices designed for separating contaminants from the air transported by a portable ventilation system.
- 2.3. **Air mover.** A powered device used to induce airflow in a portable ventilation system. Air movers include fans, venturis, and compressed air, that is, anything capable of inducing movement of air in a manner suitable for ventilation.
- 2.4. **Air mover performance curve.** The x-y plot of static pressure achieved in an air mover vs. volumetric flow. The air mover performance curve is unique to each air mover. The air mover performance curve in combination with the system resistance curve predicts exact volumetric flow delivered by a particular configuration of portable ventilation system.

- 2.5. **Axial fan.** A fan that propels air along a linear path from entry to discharge.
- 2.6. **Capture.** Also **Capture velocity.** The air velocity at a point in space of sufficient magnitude to overcome room air currents and draw the air and any contaminants at that point into the hood entry of a portable ventilation system. The process of entraining air and accompanying contaminants from free space into the internal space of a portable ventilation system.
- 2.7. **Centrifugal fan.** A fan in which the inlet to discharge angle is 90°.
- 2.8. **Clean air.** Ambient air that lacks contamination.
- 2.9. **Components.** Filters, baghouses, settling chambers, and sorbent beds that enhance the capability of the portable ventilation system.
- 2.10. **Contaminant.** Also, **Airborne contaminant.** A substance (vapor or gas, or dust, fume, or mist) whose presence in air is harmful, hazardous, or a nuisance to humans.
- 2.11. **Contamination.** The chemical and physical processes by which contaminants adhere to surfaces of portable ventilation equipment
- 2.12. **Corrosive behavior.** A chemical process of reduction of one substance and oxidation of another that leads to destruction of materials of construction of the portable ventilation system.
- 2.13. **Damp location.** See **Wet location.**
- 2.14. **Decontamination.** The chemical and physical processes used to remove contaminants from surfaces.
- 2.15. **Degradation.** A physical process through which a material loses properties for which it is valued. Degradation often occurs through dissolving of a liquid into the material of interest.
- 2.16. **Design.** The process of specifying equipment and system components to satisfy particular needs or objectives. As applied to the design of a portable ventilation system, the process includes characterizing the interactions between emissions and workers; determining appropriate volumetric flow rates, static pressures, and other operational parameters.
- 2.17. **Designer.** The person charged with designing components for a manufacturer or the portable ventilation system. Designers can include mechanical engineers, industrial hygienists, and others who possess design education, training, and experience.
- 2.18. **Dilution.** Also **Dilution ventilation.** Ventilation airflow that dilutes contaminant concentrations by mixing with contaminated air, as distinguished from capturing the contaminated air. The ventilation technique involving blending clean air into contaminated air to reduce the concentration of contaminants. Efficiency of the process depends on the rapidity and thoroughness of mixing of the incoming clean air with the contaminated air. This process is efficient only in highly turbulent conditions.
- 2.19. **Displacement.** The ventilation technique involving the transport of contaminated air from one location to another with the minimum of mixing. This process occurs in the space external to the ventilation system. The portable ventilation system enables displacement to occur. Efficiency of the process depends on minimizing mixing between clean air and contaminated air. The process is most efficient in still conditions where the interface between clean air and contaminated air is maintained for the longest possible time. Displacement is widely used with portable systems.

- 2.20. Document; to Document; Documentation.** The formal process of planning and recording the rationale for decisions made by the User, the Designer, or others. Also, the written procedures developed for operating, testing, and maintaining a portable ventilation system.
- 2.21. Duct.** Elongated rigid or flexible enclosures used to convey air and entrained contaminants from one location to another.
- 2.22. Duct velocity.** See **Transport velocity**.
- 2.23. Dust.** Solid form of matter containing pieces small enough to become and to be maintained airborne.
- 2.24. Electrocution hazard.** A situation where a source of current and a receiver of current are close enough in proximity and the potential difference between them is sufficient that flow will occur through an imperfect conductive material, such as the human body, in such a quantity as to cause the heart to undergo fibrillation. Fibrillation can occur at currents of 50 to 70 milliAmperes at 50 Volts.
- 2.25. Electrostatic discharge.** The process of removal of accumulated electrical charge from an object. The rate of discharge governs the potential for development of an electrostatic spark. Electrostatic sparks of sufficient energy and geometry are capable of igniting mixtures of gas and vapor in air.
- 2.26. Erosive behavior.** Removal of material from a surface due to frictional collisions between airborne particulates and structures.
- 2.27. ERPG.** Emergency Response Planning Guideline developed by the Emergency Response Planning Committee of AIHA® to assist emergency response personnel planning for catastrophic chemical releases in the community.
- 2.28. Exhaust.** Also **Exhaust mode**. The air that is removed from an enclosed space and discharged to atmosphere. Ventilation strategy involving removal of air from a space through a portable ventilation system.
- 2.29. External surroundings.** The environment outside the portable ventilation system and the space it is ventilating.
- 2.30. Exposure limits.** See **Occupational exposure limits**.
- 2.31. Fan.** A fan is a mechanical air mover powered by various means: electric, compressed air and hydraulic motors; gasoline, propane, and diesel engines; and water and steam turbines. A fan induces air movement through rotational motion of internal components.
- 2.32. Fittings.** A general term used to describe hoods, constricted duct used to assist entry of personnel into small openings, transitions between larger and smaller diameters, entries for feeder duct into the main duct, short sections of duct used to join together sections of fabric duct, fastenings used to clamp together sections of fabric duct, and attachments used to establish electrical bonds between components and fittings.
- 2.33. Fixed system.** A ventilation system that by design and construction is intended to remain in a particular location for a prolonged period, extending the life of the equipment or structure that it services.
- 2.34. Flow rate.** See **Volumetric flow rate**.

- 2.35. Gas.** The gaseous state of matter in which molecules or atoms experience no lasting interaction with each other. Gases possess sufficient vapor pressure as to exist only in the gaseous state under ambient conditions. Another definition is the physical state of a material that exists as a formless fluid above its critical temperature. A material above its critical temperature cannot be condensed at any pressure.
- 2.36. Hazardous location equipment.** Equipment containing electrical components designed or selected to perform without posing a hazard in atmospheres that are or can become ignitable.
- 2.37. IDLH.** Immediately Dangerous to Life or Health. The term was originally coined by NIOSH (National Institute for Occupational Safety and Health) and referred to specific detrimental conditions that could occur within a specific time limit. The term has taken on different meanings according to its use by other agencies.
- 2.38. Ignitable atmosphere.** A mixture in air containing some or all of gas and/or vapor, and/or dust and/or mist in sufficient concentration to be ignited by an energetic source of ignition. A mixture containing gas or vapor is most susceptible to ignition.
- 2.39. Ignitable mixture.** See **Ignitable atmosphere.**
- 2.40. Ignition hazard.** Source of energy capable of release in such a manner through appropriate geometry to be able to ignite a mixture containing some or all of gas and/or vapor, and/or dust and/or mist.
- 2.41. Incompatibility of materials.** Chemical reactivity between materials of construction of the portable ventilation system and the substance(s) being transported. Reactivity between the materials of construction and substance(s) being transported can lead to premature aging or outright destruction of the component or system.
- 2.42. Internal environment.** Space formed by the internal surfaces of the portable ventilation system and the space being ventilated.
- 2.43. LEL.** Lower Explosive Limit, a measure of the concentration of gas or vapor mixture in air capable of being exploded by an energetic source of ignition.
- 2.44. LFL.** Lower Flammable Limit, a measure of the concentration of gas or vapor mixture in air capable of being ignited by an energetic source of ignition.
- 2.45. Mist.** A suspension of droplets (liquid aerosols) in air. Mists form by condensation from gas or vapor in air or turbulence involving agitation of bulk liquid.
- 2.46. Mixing potential.** A measure of the ability of airstreams to mix together. This depends on distribution, turbulence, temperature difference, and velocity. Mixing potential is reflected in the “k” factor found in ventilation textbooks and used in calculations as an inefficiency factor to justify provision of additional volume or volumetric flow as a precautionary measure.
- 2.47. Mode of power.** The means used to provide motive power to an air mover. Mode of power can include direct means, such as motors and turbines, and indirect means, such as compressed gases that entrain airflow during the expansion to ambient conditions.
- 2.48. MSDS.** Material Safety Data Sheet. The MSDS is the source of hazard information and protective measures for chemicals and chemical products.

- 2.49. **Negative air mover.** A unit containing a fan and often filtration and/or a sorption component used to remove air from a space, thereby inducing inward flow from openings in boundary surfaces. Sufficiently restricted inward flow creates a negative static pressure on surfaces relative to the external surroundings.
- 2.50. **Non-rated equipment.** Equipment containing electrical components or wiring not subjected to a formal evaluation about suitability for use in hazardous locations.
- 2.51. **Occupational exposure limit (OEL).** A concentration of contaminant in air not to be exceeded in the breathing zone of workers. Published OELs include permissible exposure limits (PELs), established by the Occupational Safety and Health Administration (OSHA); Workplace Environmental Exposure Levels (WEELs™), sponsored by ACGIH®; recommended exposure limits (RELs), sponsored by the National Institute for Occupational Safety and Health; and threshold limit values (TLVs®), sponsored by ACGIH®. In some cases, chemical manufacturers have developed in-house OELs when published OELs are not available.
- 2.52. **OH&S professional.** An individual by training or experience qualified to work in the field of occupational health and safety.
- 2.53. **Operation-critical applications.** Applications of portable ventilation systems for which assurance of reliability and performance are critically important parameters. Examples include permit-required confined spaces in which there is a serious risk of loss of life due to inability to self-rescue in the event of failure of the ventilation system.
- 2.54. **PEL.** See **Occupational exposure limit.**
- 2.55. **Permeation.** Physical process leading to passage of molecules through materials. The process involves contact with the outer surface, followed simultaneously by diffusion through the material, followed by contact with the inner surface and vapor formation.
- 2.56. **Portable ventilation equipment.** See **Portable ventilation system.**
- 2.57. **Portable ventilation system.** The entity created by assembling air mover(s), duct, components, and fittings in a coherent and functional manner.
- 2.58. **Quiescence.** The period of quiet needed for development of an oxygen deficiency or accumulation of a hazardous atmosphere in a space. These phenomena are not instantaneous and require a finite period of time for their occurrence.
- 2.59. **Recirculated air.** Work area air captured and treated by the portable air cleaning device and then not discharged outdoors to the atmosphere but returned to the work area or adjacent work areas.
- 2.60. **Static electricity.** An electrical phenomenon expressed through the accumulation, storage, and discharge of electrons from the surface of objects and materials. Static electricity is generated through the contact and separation of dissimilar materials, that is, because of differing levels of attraction for electrons between dissimilar materials.
- 2.61. **Static pressure.** Pressure exerted by a fluid (gas or liquid) against the walls of the containment. The pressure exerted depends on whether the fluid is being pushed or pulled through the containment. Fluid being pushed exerts a positive pressure against the walls of the containment, while fluid being pulled exerts a negative pressure. Typically expressed as inches of water gage (wg).

- 2.62. Supply mode.** Ventilation strategy involving provision of clean air to a space by a portable ventilation system.
- 2.63. System effect loss.** A loss of fan performance (both pressure and volume flow rate) created when inlet and outlet conditions at the fan are not ideal, e.g., an elbow is mounted directly on the inlet to the fan.
- 2.64. System performance.** Volumetric flow of air under specific conditions of configuration of air mover, duct, air cleaning components, and fittings.
- 2.65. System resistance curve.** The x-y plot of static pressure versus volumetric flow for a particular configuration of a portable ventilation system.
- 2.66. TLV®.** See **Occupational exposure limit.**
- 2.67. Transport velocity.** The air velocity generated in a specific configuration of a portable ventilation system. Transport of particulate air contaminants through a portable ventilation system requires a minimum velocity to prevent settling out in the duct by dry air contaminants.
- 2.68. User.** User refers to the person assuming immediate and ultimate responsibility for the design, operation, and/or maintenance of a portable ventilation system or a component of the system. The user could include the employer, owner, foreman, architect, engineer, or other responsible person.
- 2.69. Vapor.** The gaseous state of matter that exists as solid or liquid under ambient conditions of temperature and pressure. Another definition is the physical state of a material that exists as a formless fluid at a temperature below its critical temperature but above its boiling point. A vapor can be condensed back to a liquid by cooling or compressing.
- 2.70. Velocity pressure.** Pressure required to accelerate air from zero velocity to a desired velocity and is proportional to the kinetic energy of the airstream. VP is exerted by an airstream in the forward direction. Velocity pressure is always a positive quantity. Typically expressed as inches of water gage (wg).
- 2.71. Ventilation principles.** Truisms discovered by application of the scientific method to the study of the movement of gases through ventilation systems and the supply and removal from spaces.
- 2.72. Ventilation strategy.** Coordinated decision making regarding the choice of supplying air to a space or removing air from it.
- 2.73. Venturi air mover.** Air mover that uses the expansion of compressed gas in the constrained geometry of an open-ended cone to entrain flow in a coordinated manner. Efficient venturi air movers produce a 40-fold amplification of flow.
- 2.74. Volatile material.** Liquid or solid on whose surface vapor forms under ambient conditions.
- 2.75. Volumetric flow rate (also Volumetric flow).** The rate of airflow expressed in terms of volume (cubic feet, cubic meters, or liters) per unit of time. These are commonly expressed as cubic feet per minute (ft³/min or cfm) in USCS units; cubic meters per second (m³/s); or liters per second (l/s) in SI units.
- 2.76. Wet location.** A location containing rain, mist, or snow or wet surfaces in which a portable ventilation system is intended to operate.

Requirements of the Standard**3. Scope**

3.1. This Standard discusses portable ventilation equipment and systems used for the reduction, control, or prevention of exposure to hazardous atmospheres or airborne substances in the occupational environment, and for provision of comfort to employees.

3.2. This Standard establishes minimum requirements for the design, construction, and labeling of portable ventilation equipment and systems.

3.3. This Standard also establishes fundamental requirements for the application, management, operation, maintenance, performance validation, and testing of portable ventilation equipment and systems to ensure satisfactory performance over their lifetime.

3.4. This Standard covers components of portable ventilation systems, including:

- air movers and their modes of power
- other components of portable ventilation systems including entry hoods; duct, hose, and

Clarification and Explanation of the Requirements

3.1.1. Portable ventilation systems are an important engineering control for establishing and maintaining acceptable air quality and supplementing the effectiveness of fixed systems in the work environment. The major approaches employed in the use and application of portable ventilation systems include provision of tempered air to provide and maintain comfort, displacement of airborne contaminants from the workspace, dilution of airborne contaminants in the workspace, supplying breathable air to eliminate or prevent oxygen deficiency in an environment, and the capture or containment of airborne contaminants at or as close as possible to the point of generation. Properly designed, installed, and operated portable ventilation systems can provide excellent control of airborne contaminants.

3.1.2. Some sections of this Standard are written to stand alone. As a result, they may duplicate requirements of other sections.

other conveying structures;
air-cleaning equipment including
filters and sorbent air-purifying
devices; and air coolers and
heaters.

- 3.5. This Standard does not intend to address every application and technical problem that arises during the use of portable ventilation systems in industry. The manner in which portable ventilating equipment is used requires judgement and discretion by the end-user.

- 3.6. The Standard does not cover:

- air recirculation systems, such as recirculating fume hoods, intended for use in laboratory applications
- air moving systems that are part of an industrial process

- 3.7. Where provisions of this Standard conflict with other Standards, the more stringent shall apply.

4. General Requirements

Personnel Qualifications

- 4.1. Only persons qualified through education, training, and/or relevant experience shall specify, design, operate, maintain, or test a portable ventilation system or its components.

- 3.5. There is no simple formula governing decisions concerning use of this equipment. The end user should refer to appropriate technical references and publications, such as included here, for further guidance on uses and applications and strengths and limitations of portable ventilation systems in specific applications.

- 4.1.1. Currently there are few prerequisites for designing, operating, maintaining, or testing portable ventilation systems or their components. Literally anyone can perform these functions.

- 4.1.2. Component designers require, at the least, knowledge about the basics of ventilation principles and ventilation system design, fluid mechanics, machine design and construction, electrical safety, electrical design requirements for non-rated and hazardous location equipment, control of electrostatic accumulation and discharge, product safety, fire resistance of materials, contamination and decontamination issues, and incompatibility of materials. The sources of much of this

information are principles of air pollution and industrial hygiene control, consensus and regulatory standards, and codes of practice. The sources of the remainder are resource texts. (See references.)

- 4.1.3. System designers require, at the least, knowledge about the nature of the source; nature of the work to be performed; interaction between the source and the worker during performance of work; ventilation principles and strategies; legal requirements for ventilation provision in work areas; ventilation system design, function, and capability and strengths and limitations of ventilation system components; electrical safety; non-rated and hazardous location equipment; control of static electricity; contamination and decontamination issues; strategies and procedures, and incompatibility of materials. The sources of much of this information are principles of air pollution and industrial hygiene control, consensus and regulatory standards, and codes of practice. The sources of the remainder are resource texts. (See references.)

- 4.1.4. Prudent design for product safety must reflect foreseeable use and misuse of the units and hardware. Examples of this include:

- Design of electrical systems and selection of electrical components to resist reasonably anticipated abuse. This can occur due to exposure to water or other wet materials from inclement weather or to chemical products, running over of electrical power cords by vehicles or contact with sharp objects dropped on them, pulling electrical plugs from the receptacle straight out or at angles that bend the blades, pulling forces on the cord jacket rather than the plug or at the main connection to the unit, ground leads that are not substantial to withstand frequent connection and disconnection, and low strength plastics

- used for electrical control switch handles or receptacle plates.
- Design of mechanical components to consider mishandling of the unit, such as throwing onto a truck bed, transporting on a truck while covered by heavy materials, or dropping a considerable distance into a hole.
- Selection of non-metallic materials (plastic components and fabrics) with inherent ruggedness to withstand misuse listed previously.

- 4.1.5. Selection of these materials must also consider the potential effects of chemical exposure and electrostatic generation and discharge described elsewhere in this document.
- 4.1.6. End users (owner/operators) require, at the least, knowledge about the nature of the source of air contaminants for which control is required; nature of the work to be performed; interaction between the source and the worker during performance of work; ventilation principles and strategies; legal requirements for ventilation provision in work areas; function and capability and strengths and limitations of ventilation system components; safety issues; and training in equipment operation, optimizing performance, and operational performance testing of the ventilation system. The sources of some of this information are principles of air pollution and industrial hygiene control, consensus and regulatory standards and codes of practice. The sources of the remainder are manufacturer's data and resource texts. (See references.)
- 4.1.7. Maintenance personnel require, at the least, knowledge about function and performance and design features of ventilation system components, electrical safety, electrical design requirements and features for non-rated and hazardous locations, control of electrostatic accumulation and discharge, contamination issues and decontamination strategies, and incompatibility of materials, and

Best Design Practices

- 4.2. Design of portable ventilation equipment shall conform to provisions of this Standard.

Operational Design Factors

- 4.3. Design, configuration, deployment, and operation of a portable ventilation system shall reflect, at minimum, consideration of the following factors:
- source characteristics and behavior
 - potential incompatibility between airborne and surfacial contaminants and materials of construction of components of the portable ventilation system (corrosive and erosive effects)
 - geometry of the space to be ventilated
 - geometry of the external surroundings
 - worker interaction with emission sources
 - level of control to be achieved in the space
 - source of clean air for the portable ventilation system
 - means of conveyance of clean or contaminated air by the portable ventilation system
 - need for air cleaning
 - means of assurance of quality of air provided by the portable ventilation system

training in procedures for disassembly and repair and maintenance, decontamination, and bench testing of ventilation system components. The sources of some of this information are consensus and regulatory standards and codes of practice. The sources of the remainder are manufacturer's data and resource texts. (See references.)

- 4.2. The list of references provides recognized sources of good practice. Note that there is little in print concerning specific issues involved in the design of portable ventilation equipment.

- 4.3.1. There is no simple formula, that is, no single setup governing design of a portable ventilation system. The design incorporates not only the selection and physical connection of system components, but also consideration for the point of intake of clean air provided to the space to be ventilated and the point of discharge of air from the space or the duct. Air provided to the space must be clean and remain or be maintained in this condition. Air discharged or expelled from the space must not create exposure issues for personnel working in the immediate area or in the vicinity. Creating the best or most appropriate design requires consideration of a number of factors, including and possibly exceeding those listed here.

- 4.3.2. The source of contamination is the critical issue to consider. Sources can be intermittent or continuous, and single or multiple point or distributed. The source of contamination can change, depending on the point in the work cycle. Volatile materials vary in evaporation rate.

- detrimental effects of the external surroundings on the portable ventilation system
- detrimental effects of emissions from the portable ventilation system or the space to be ventilated on persons working external to the space
- detrimental effects of the portable ventilation system on the external surroundings
- contamination of internal surfaces of the portable ventilation system by contaminants in the airflow
- contamination of external surfaces of the portable ventilation system by the external surroundings

4.3.3. The purpose for the ventilation can vary from controlling emissions to preventing overexposure or preventing fire to providing tempered air for comfort. Often there is little information on which to make an estimate of exposure potential; hence, the assessment may at best be a guess.

4.3.4. Source characteristics include:

- chemical composition
- temperature
- rate of emission
- direction of emission
- initial emission velocity
- continuousness or intermittency
- duration of emission
- exposure limits (TLV, PEL, REL, internal corporate limit, ERPG, IDLH). Refer to the MSDS and other resources for further information.
- fire behavior (LFL, LEL). Refer to the MSDS and other resources for further information.
- corrosive behavior. Refer to the MSDS and other resources for further information.
- erosive behavior. Refer to product specifications information.
- chemical incompatibility. Refer to the MSDS and other resources for further information.

4.3.5. Source behavior includes:

- location of sources, or potential sources of emission, to identify sources that contribute to exposure.
- potential or actual contribution from each source to exposure

4.3.6. Aerodynamic behavior includes:

- air movement in the space (direction, velocity)
- characterization of the air (temperature, mixing potential, other nearby operations (forklift turbulence, CO emissions and conveyor turbulence, supply and

return flow conditions, air changes per hour, effects of wind speed and direction, effects of weather and season)

4.3.7. Worker interaction includes:

- worker behavior and interaction with emission sources and contaminated air
- worker involvement (placement, left or right handedness, worker position with respect to source(s) of clean and contaminated air, work practices, education, and training, cooperation)

4.3.8. To illustrate the complexity intrinsic in the decision, the contamination in many confined spaces results from a long period of quiescence. Purging with outside air removes the contamination. Applying a coating in the same space or welding in the space can create additional hazardous conditions requiring different ventilation strategies and possibly even equipment. Requirements for containment during abatement of asbestos or lead paint or mold in the same space can considerably modify the ventilation strategy from what at first would seem to be apparent.

4.3.9. Operation of the portable ventilation equipment creates a possible risk to the operator and the surroundings. This can result from discharge of hazardous substances contained in the space to be ventilated. Similarly, the surroundings create a possible risk to operators of the equipment and ventilation air provided by it. This can result in safety and health hazards, as well as airborne hazardous substances.

4.3.10. Materials contained in the space and drawn through the equipment can destroy components through chemical attack or corrosion, or erosion, or damage to bearings through contamination of lubricants, or a combination of these. These materials can cause lasting problems through contamination of internal surfaces of the

- 4.4. Designers and manufacturers of portable ventilation systems shall apply principles and practices in the design of these systems based on a thorough understanding of foreseeable use and misuse. Design of the portable ventilation system shall apply best practice reflecting its end purpose. Refer to ANSI/AIHA® Z9.2–2006 or other recognized sources for further information.

Foreseeable Use Factors

- 4.5. The design of the portable ventilation system shall acknowledge and respect the presence of existing structures and the potentially hazardous nature of existing equipment and processes.

portable ventilation equipment and contamination of the external surroundings following discharge. Similarly, contamination of external surfaces of the portable ventilation equipment can occur following contact with contaminated surfaces. Lead-containing dust, asbestos-containing material, and radioactive materials are prime examples of such materials.

- 4.4.1. System design must reflect end purpose. To illustrate, transport of dusty (particulate) materials requires duct velocity exceeding 4000 feet per minute. This is a well-known design parameter found in recognized sources. A lesser velocity could lead to failure of capture or dust settling in duct or other component.
- 4.4.2. Flow rates, filter efficiencies, and system performance are directly related to static pressure. No system can be properly designed or operated without first estimating (calculating or determining) static pressure demands throughout the system.
- 4.5.1. Some applications of portable ventilation systems occur in buildings containing installed ventilation systems. Familiar examples include ventilation of temporary enclosures used during asbestos, lead, and mold remediation.
- 4.5.2. These systems operate on the premise of maintaining a differential negative pressure inside the enclosed work area, so that air flows from the immediate surroundings into the enclosure. Differential pressurization can occur in two ways: exhaust of the enclosed area and partial pressurization of the immediate surroundings coupled with exhaust of the enclosed area.
- 4.5.3. Operational buildings usually contain supply and general exhaust systems and sometimes local exhaust systems. In laboratories, fume hoods

are part of a once-through, and in some cases recirculating, exhaust system. Maintaining performance of these systems according to design specifications requires operation within design parameters.

- 4.5.4. Operation of a portable ventilation system in an operational building can confound balance relationships in a supply system, as well as performance of fume hoods and other exhaust systems. To illustrate, fans in a fixed system receive air from known sources with known parameters of flow and pressure. A negative air mover introduced into a temporary enclosure that exhausts outside a building receives supply from the enclosed work area and then from the immediate surroundings. Similarly, a fan used to pressurize the immediate surroundings relative to the enclosed work area receives supply possibly from the outdoors and possibly beyond the immediate surroundings. Fans in the portable ventilation system compete for air with fans in the installed system.
- 4.5.5. This situation can lead to partial starvation and performance decrement in both systems. It also can lead to modification of normal paths of airflow. Examples of this include backdrafting down furnace, boiler and hot water heater; fireplace and clothes drier flues in houses and institutional buildings; the result being unexpected exposure to combustion gases. A similar problem results following drying out of P-traps leading to the sanitary sewer, and inflow of sewer gases.
- 4.5.6. In office, institutional, and residential settings the user must configure the portable ventilation system so as not to:
- compete in a detrimental manner with the installed system
 - create a hazardous situation through backdrafting down chimneys and flues

- create a trip hazard in hallways, walkways, and stairways
- overload electrical circuits in the building
- introduce exhaust gases from mobile and portable equipment into the work area

4.5.7. Similar problems and different problems occur in industrial settings where the portable ventilation system can interfere with normal operation of equipment. In these settings the user must arrange the components of the portable ventilation system to:

- permit the free operation of cranes, elevators, forklifts, etc.
- allow unobstructed accessibility to existing equipment for inspection, cleaning, and repairs
- provide maximum protection of existing equipment from damage
- avoid damage to the portable ventilation system and its components
- prevent entry of hazardous substances from adjacent processes into the portable ventilation system when used in supply mode

4.5.8. The discharge from portable ventilation systems is also a consideration. Portable ventilation systems that discharge into a workplace, in essence, are air recirculation systems. These systems range in size from self-contained, vacuum-cleaner-sized units used in welding fume collection, to vacuum cleaners attached to portable tools, to mobile welding fume extractor units. Air recirculation is the subject of ANSI BSR 9.7 and a topic in *Industrial Ventilation Manual*, published by ACGIH®. The latter publications address recirculation of large quantities of air by fixed ventilation systems.

4.6. The design, configuration, and implementation of the portable ventilation system shall not create an obvious safety hazard beyond what existed prior to its installation and shall not magnify the hazard posed by existing equipment or processes.

4.7. Where uncertainty exists about the design or implementation (installation, maintenance, or use) of a portable ventilation system, the designer shall seek assistance from relevant professional disciplines.

4.6. Consideration of existing equipment and processes in the design of the portable ventilation system is essential to ensure that it does not impose additional and possibly unforeseen hazards. The portable ventilation system shall not:

- obstruct walkways, hallways, or stairways
- block open fire doors
- pose an electrical safety hazard
- pose an ignition hazard to process emissions

4.7. This provision will help to ensure that the right actions are taken for the right reasons. Each professional discipline should review the proposal for its own purposes. Industrial hygienists may review to ensure the adequacy of emission control; fire experts: explosion and smoke control; safety engineers: safe operating conditions; and so forth. The review should include such matters as:

- nature of emissions
- hood or collector placement and enclosure
- location and impact of discharge on people and surroundings
- compatibility of work practices with ventilation capacity
- volumetric flow rates
- predicted static pressures throughout the system
- transport velocity
- discharge stack height and location
- fire protection
- electrical hazards
- potential for explosions in duct and air cleaners
- ease of maintenance
- air emissions

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| <p>4.8. The designer, in consultation with members of other disciplines and users of such equipment, as necessary or appropriate, shall estimate concentration of contaminants in contact with internal and external surfaces of system components during the proposed usage of the portable ventilation system.</p> | <p>4.8.1. This is essential to establish the likely environment in which the portable ventilation system will operate. Environments that are potentially hostile to unprotected equipment include:</p> <ul style="list-style-type: none"> — damp or wet conditions — environments containing substances incompatible with materials of construction of the equipment — environments containing ignitable mixtures of gas, vapor, dust, or mist <p>4.8.2. This process should result in the setting and documenting of limits of concentration of airborne contaminants to which internal and external surfaces will be exposed. This process should also consider potential for exposure of the portable ventilation system to sprays, splashes, and immersion by mists and flowable bulk liquids and solids. These limits could include, for example, dilution to below one-half the IDLH in the system under the worst credible accident, or to below 10% of the LFL or LEL during normal operation at the exhaust discharge.</p> |
| <p>4.9. The designer, in consultation with other disciplines, as necessary or appropriate, shall specify components and materials of construction that are compatible with conditions expected in the internal environment of the portable ventilation system and the external environment.</p> | <p>4.9.1. Concerns exist for compatibility of materials of construction with those to be transported, and contamination of internal components by materials to be transported.</p> <p>4.9.2. Choice of material should reflect that at maximum concentration of substances carried in the airstream and compatibility with each other and materials of construction of the portable ventilation system.</p> <p>4.9.3. Some circumstances may require the system simultaneously to transport rusty steel slag and an ignitable mixture of gas, mist, or vapor. This situation would be incompatible with use of a fan containing aluminum internals. Metallic aluminum reacts with</p> |