

ANSI/ASSP Z9.2-2018

Fundamentals Governing the Design and
Operation of Local Exhaust Ventilation Systems



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ANSI/ASSP Z9.2 – 2018

American National Standard

**Fundamentals Governing
the Design and Operation of
Local Exhaust Ventilation Systems**

Secretariat

American Society of Safety Professionals
520 N. Northwest Highway
Park Ridge, Illinois 60068

Approved July 2, 2018

American National Standards Institute

American National Standard

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Foreword (This Foreword is not a part of American National Standard Z9.2 – 2018.)

This standard describes fundamental good practices related to the commissioning, design, selection, installation, operation, maintenance and testing of local exhaust ventilation (LEV) systems used for the control of employee exposure to airborne contaminants. It is intended for use by LEV system owners, employers, industrial hygienists, facility engineers, maintenance personnel, testing and balancing personnel, ventilation system designers and others with responsibility for LEV systems. It is compatible with the ACGIH *Industrial Ventilation Manual* and other recognized standards of good practice.

A document describing fundamentals of exhaust system design was originally published in 1936. This was formalized by the Z9 Committee under the direction of Knowlton Caplan, and published in 1960, with updates in 1971 and 1979. The 2001 edition, under the direction of D. Jeff Burton, constituted a major revision of that earlier document and was a more performance-based document with a systems orientation that appealed to a wider audience. Much of the previously included technical design detail had been left to other, more thorough and comprehensive sources. This 2018 version is an update of the most recent version published in 2012.

How to Read This Standard

The standard is presented in two-column format. The left column presents the requirements of the standard; the right column provides clarifications, exceptions and explanations of the requirements plus “how to comply” information. Appendix A provides supplementary information by standard section number. The designation “(See Appendix)”, at the end of a section designates an appendix entry for that section and paragraph.

Requirements should be considered minimum criteria and can be adapted to the needs of the user establishment. Demonstrably equal or better approaches are acceptable. When deviating from the standard, documentation should be provided. The standard is auditable by those trained in local exhaust ventilation. An audit form is provided in Appendix B.

Suggestions for improvement of this standard are welcome. They should be sent to the American Society of Safety Professionals, 520 N. Northwest Highway, Park Ridge, Illinois 60068.

This standard was processed and approved for submittal to ANSI by the Z9 Accredited Standards Committee on Health and Safety Standards for Ventilation Systems. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the Z9 Committee had the following members:

Theodore Knutson, MS, P.E., Chair
Geoffrey Raifsnider, P.E., Vice Chair
Ovidiu Munteanu, Secretary
Timothy R. Fisher, CSP, CHMM, ARM, CPEA, CAE, STS Assistant Secretary
Jennie Dalesandro, Administrative Technical Support

Organization Represented

AES Corporation
American Foundry Society
American Industrial Hygiene Association
American Society of Safety Professionals

ASHRAE
AstraZeneca

Name of Representative

Dan Flinta, CIH, CSP
Robert Scholz
Lou DiBerardinis, CIH, CSP
Paul Osley, P.E., CSP, CIH, CHMM
Jeffrey Nesbitt, CIH, CSP
Thomas Smith
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D. Jeff Burton, P.E.
Terry Ketchum
Crescente Figueroa, Ph.D., CIH
Geoffrey Raifsnider, P.E.
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Peter Engelbert, CIH, CSP, CHST, CET
Theodore Knutson, MS, P.E.
Gerhard Knutson, Ph.D., CIH
Kyle Hankinson
Kenneth Hankinson
Michael Elliott, Ph.D., P.E., CIH
Farhad Memarzadeh, Ph.D., P.E.
Neil McManus, DSc, CIH, ROH, CSP
Steven Crooks
John (Jack) Price
Ronald Schaible, CSP, CIH
Alejandro Ruiz, CIH, CSP, CHMM, CET, SMS
Holly Colt
John Sheehy, Ph.D.
Brian Haynack
Jay Dick
Daniel Kallin

Lindsay Cook
James Nelson, P.E.

Subgroup Z9.2 had the following members:

D. Jeff Burton, P.E., Chair
Crescente Figueroa, Ph.D., CIH, Vice Chair
Lou DiBerardinis, CIH, CSP
Rodney Handy, Ph.D., CIH
Clint Holm
George Hrbek
Jim Rock
Scott Swanson
Jeff Throckmorton

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AMERICAN NATIONAL STANDARD Z9.2 FUNDAMENTALS GOVERNING THE DESIGN AND OPERATION OF LOCAL EXHAUST VENTILATION SYSTEMS

STANDARD REQUIREMENTS

EXPLANATORY INFORMATION

*(Not part of American National
Standard Z9.2)*

1. SCOPE AND PURPOSE

1.1 This standard establishes minimum requirements for the commissioning, design, specification, construction and installation of fixed industrial local exhaust ventilation (LEV) systems used for the reduction and prevention of employee exposure to harmful airborne substances in the industrial environment.

E1.1 Local exhaust ventilation is an important engineering control technique for maintaining acceptable air quality in the industrial work environment. Its major approaches are the capture, control or containment of airborne contaminants at or as close as possible to the point of contaminant generation. LEV is often used with other control methods, e.g., isolation, dilution ventilation or personal protective equipment. Properly designed, installed and operated, LEV systems can provide excellent control of airborne contaminants.

1.2 This standard also establishes fundamental requirements for the management, operation, maintenance and testing of LEV systems to assure satisfactory performance over the life of the system.

1.3 This standard also describes basic requirements for replacing air exhausted from the space.

E1.3 Replacement air systems that are improperly designed, installed or operated can impair otherwise acceptable LEV systems.

1.4 This standard does not cover:

- ventilation for comfort;
- air moving systems which are part of an industrial process;
- paint booths not used primarily for employee protection; or
- energy conservation

E1.4 No ventilation standard can provide complete and comprehensive coverage of every application and technical problem encountered when applying LEV systems to the wide range of processes and equipment found in industry. The user should refer to appropriate technical references and publications for further guidance on uses and applications of local exhaust in specific applications (see Appendix).

except when they also impact or apply to airborne contaminant control for employee protection.

1.5 Where standard provisions are in conflict, the more stringent shall apply.

E1.5 Because some sections are written to stand alone, they may duplicate require-

ments of other sections. Efforts to avoid conflicts within the standard have been taken, but every consensus and committee-generated standard has the possibility of conflicts.

2. REFERENCED STANDARDS AND PUBLICATIONS

The following codes, regulations, standards and guidelines contain provisions that, through reference in this standard, constitute provisions of this standard. Where published requirements are in conflict, the more stringent shall apply.

E2 The items listed in Sections 2.1 to 2.3 are not all-inclusive, but are considered current and recognized standards of good practice. All regulations, standards and guidelines are subject to revision. Users of the standard are encouraged to consult the most recent versions or editions of the listed regulations, standards and guidelines to determine continued applicability.

- Citations are listed in alphabetical order.
- Standards and dates may change over time. Refer to latest versions of standards to determine current applicability.
- Additional technical resources are provided in Appendix A. These explain and demonstrate the application of the standards of good practice found in Section 2.

2.1 American National Standards.

E2.1 At the time of publication, the editions indicated were current. All standards and guidelines are subject to revision, and users of this American National Standard are encouraged to consult the most recent editions of the standards and guidelines listed below and apply them when feasible.

ANSI/ASSP Z9.1 thru ANSI/ASSP Z9.14 standards on industrial ventilation, as follows:

ANSI/ASSP Z9.1, *Open-Surfaced Tanks Ventilation and Operation*

ANSI/ASSP Z9.3, *Spray Finishing Operations - Safety Code for Design, Construction and Ventilation*

ANSI/ASSP Z9.4, *Abrasive Blasting Operations - Ventilation and Safe Practices for Fixed Location Enclosures*

ANSI/ASSP Z9.5, *Laboratory Ventilation*

ANSI/ASSP Z9.6, *Exhaust Systems for Grinding, Buffing and Polishing*

ANSI/ASSP Z9.7, *Recirculation of Air from Industrial Process Exhaust Systems*

ANSI/ASSP Z9.10, *Fundamentals Governing the Design and Operation of Dilution Ventilation Systems in Industrial Occupancies*

ANSI/ASSP Z9.11, *Laboratory Decommissioning*

ANSI/ASSP Z9.14, *Testing and Performance - Verification Methodologies for Ventilation Systems for Biosafety Level 3 (BSL-3) and Animal Biosafety Level 3 (ABSL-3) Facilities*

ANSI/ASHRAE 62.1, *Ventilation for Acceptable Indoor Air Quality*

ANSI/ASHRAE 55, *Thermal Environmental Conditions for Human Occupancy*

ANSI/ASHRAE 52.2, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*

ANSI/ASHRAE 110, *Method of Testing Performance of Laboratory Fume Hoods*

ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes*

2.2 NFPA Standards.

NFPA 91, *Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*

NFPA 45, *Fire Protection for Laboratories Using Chemicals*

NFPA 33, *Standard for Spray Operation Using Flammable or Combustible Materials*

2.3 Occupational Safety and Health Administration Standards.

E2.3 Federal standard 29 CFR 1910.94 lists four standards adopted from earlier versions of ANSI Z9 standards on ventilation of open

surface tanks, spray finishing operations, abrasive blasting and grinding, buffing and polishing (use latest versions and watch for changes).

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

Code of Federal Regulations, Title 29, Part 1910, Subpart Z, *Toxic and Hazardous Substances*

Code of Federal Regulations, Title 29, Part 1910, Section 1450, *Occupational Exposures to Hazardous Chemicals in Laboratories*

2.4 Other Recognized Standards and Guidelines of Good Practice.

ASHRAE Handbook *Fundamentals*. Atlanta, GA: American Society of Heating, Refrigerating and Air Conditioning Engineers

ASHRAE Handbook *HVAC Applications*. Atlanta, GA: American Society of Heating, Refrigerating and Air Conditioning Engineers

ASHRAE Guideline 1. *The HVAC Commissioning Process*; Guideline 4, *Preparation of O&M Documentation for Building Systems*

Although not intended for LEV systems, ASHRAE Guideline 1 provides a model of how commissioning can be performed.

Heating and Cooling for Man in Industry, American Industrial Hygiene Association

Industrial Ventilation: A Manual of Recommended Practice for Design and Industrial Ventilation: A Manual of Recommended Practice for Operation and Maintenance (two volumes), Latest Editions. Cincinnati, OH: Committee on Industrial Ventilation of the American Conference of Governmental Industrial Hygienists

The 29th Edition of the ACGIH *Industrial Ventilation Manual* was issued in 2016.

SMACNA publications: *Accepted Industry Practice for Industrial Duct Construction; Rectangular Industrial Duct Construction Standards; Round Industrial Duct Construction Standards; Guide for Steel Stack Construction; Testing, Adjusting, and Balancing HVAC Systems*

SEMI S2-1016b, *Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment*

SEMI S6-0707E, *EHS Guideline for Exhaust Ventilation of Semiconductor Manufacturing Equipment*

3. DEFINITIONS

The following definitions explain terms used in this standard.

3.1 Air Cleaning Equipment. A device or combination of devices for separating contaminants from the air handled by an LEV system.

3.2 Aspect Ratio. In rectangular exhaust openings, usually the ratio of the width to length of the hood opening, e.g., in slot or face openings; in ductwork, the ratio of the height to width of the duct cross-sectional dimensions.

3.3 Baffle, also Flange. Partial enclosures in and around emission sources that improve or enhance airflow patterns at the emission source and at the hood.

3.4 Balanced. In LEV, a balanced system is one in which the desired air flowrate is achieved simultaneously in all branches of the system.

3.5 Branch. A duct connecting an exhaust hood to a main or submain.

3.6 Coefficient of Entry, also known as Hood Flow Coefficient. A unitless factor, designated in the literature as C_e , which relates static pressure at a hood to the velocity pressure in the duct serving the hood. The coefficient of entry is usually calculated as $(VP_{ave}/SP_{hood})^{0.5}$.

3.7 Commissioning, Commissioning Plan. A process or plan in which a local exhaust ventilation systems performance is identified,

E3.3 Baffles and flanges can minimize cross drafts; increase hood efficiencies; reduce airflow requirements; increase control or hood face velocities; reduce costs; and improve hood containment performance.

E3.4 Balance can be achieved through good design, proper fitting and duct selection and, when necessary, by the use of balancing dampers, which include systems built with direct digital control (DDC) equipment.

E3.6 Used in design; coefficients of entry are published in the LEV literature for many hoods; see also **Loss Factor**.

E3.7 Commissioning ends when tests and demonstrations have verified that the system operates as intended. A commissioning

verified and documented before, during and after design, construction or remodeling to assure proper operation and compliance with codes, standards and user intentions.

3.8 Contaminant. Also, **Air Contaminant, Stressor.** A substance (smoke, dust, fume, mist, vapor or gas) whose presence in air is harmful, hazardous or a nuisance to humans.

3.9 Control Velocity. Also, **Capture Velocity.** The velocity of air at a point in space sufficient to prevent contaminants from escaping from an enclosing hood and/or to draw contaminants and contaminated air into an exhaust hood.

3.10 Design. The process that includes characterizing the interactions between emissions, workers and the air; determining appropriate air flowrates, static pressures and other operational parameters; specifying equipment and system components.

3.11 Designer. Persons charged with designing an LEV system; may include mechanical engineers, industrial hygienists and others with design education and experience. See 3.10 for a definition of “design”.

3.12 Document; to Document; Documentation. The formal process of planning and recording of the rationale for decisions made by the user, the designer or others. Also, the written procedures developed for operating, testing and maintaining an LEV system.

3.13 Ductwork. Elongated rigid or flexible enclosures used to convey air and entrained contaminants from one location to another.

3.14 Entry. The point at which a segment of ductwork (i.e., branch or submain) enters another segment of ductwork (i.e., submain or main); entry from a hood to a duct; and entry from a plenum to a duct.

3.15 Exhaust Hood. A shaped opening designed to capture or control chemical

agent is often used to administer the commissioning process, tailored to the needs of the system.

E3.15 The major exhaust hood types include the enclosing hood, the capture hood and the

emissions and other air contaminants. An exhaust hood typically encloses, captures, receives and/or removes emissions or contaminated air from process equipment enclosures or directly from an emission source.

receiving hood. The enclosing hood essentially surrounds the emission source; the capture hood is external to the emission source and relies on capturing the emission by removing the air into which the chemical contaminant is emitted; the receiving hood is a passive hood that relies on the emission and contaminated air moving into the hood by natural means. e.g., by gravity or momentum. The basic term “exhaust hood” also applies to exhaust ventilated enclosures, exhaust ventilated tools and exhaust apparatus or devices attached or integral with the process equipment when it is used, in part, for employee exposure protection. The exhaust hood normally encloses as much as possible the locations where the contaminant is released or creates air flow through the zone or zones of contaminant release of such magnitude and direction as to capture and carry the contaminated air into the exhaust system. Exhaust hoods and exhausted enclosures may also serve to keep materials within the process by preventing their dispersion.

3.16 Exhaust Rate. Also, **Exhaust Volume Flowrate, Air Flowrate.** Air volume flowrate through an exhaust hood.

3.17 Exhaust System, LEV System. A mechanical system for removing contaminated air from a potentially occupied space, comprised of one or more of the following elements: exhaust hood, ductwork, air cleaning equipment, exhauster or fan and stack.

E3.17 An LEV system operates as a functional entity and the performance of all parts is affected by the design and performance of all other parts. Although overlap may exist, an LEV system may not include some exhaust systems that directly remove process exhausts materials such as a chimney, a furnace exhaust system or other highly concentrated exhaust coming directly from a process.

3.18 Face Velocity. Average velocity of the air in the plane of a hood opening with a directional vector perpendicular to that plane.

3.19 Fan. Also, **Exhauster, Ejector.** Mechanical device used to provide pressure and move air through an LEV system.

3.20 Flowrate. Also, **Volumetric Air Flowrate.** In U.S. units, flowrate can be specified

E3.20 In the Metric units, flowrate is usually specified in terms of actual cubic meters per

as actual cubic feet per minute (acfm) or standard cubic feet per minute (scfm).

second (acms) or standard cubic meters per second (scms).

3.21 Hood. See **Exhaust Hood**.

3.22 Immediately Dangerous to Life or Health (IDLH). As defined by appropriate authorities.

3.23 Industrial Hygiene, Industrial Hygienist (IH), Certified Industrial Hygienist (CIH). The profession and the professional devoted to the anticipation, recognition, evaluation and control of employee exposures to airborne contaminants.

E3.23 A CIH is an IH certified by the American Board of Industrial Hygiene.

3.24 Local Exhaust Ventilation (LEV). See Exhaust System.

3.25 Loss Factor. A unitless factor (designated variously in the literature as F, K or k) that relates static pressure loss to velocity pressure in system hood, fittings and equipment. The loss factor at standard conditions is usually calculated as SP_{loss}/VP_{ave} .

E3.25 Necessary for design, many loss factors are published in the LEV literature. The hood loss factor is related to the coefficient of entry.

3.26 Main. A duct or pipe connecting two or more branches or submains to the fan, exhauster or air cleaner.

3.27 Makeup Air. Also, **Replacement Air** or **Supply Air.** Outside or acceptably clean air supplied to replace air that is exhausted through an LEV system.

E3.27 Makeup air commonly refers to building ventilation while replacement air refers to air replaced as part of the industrial process, but overlap occurs in usage. It may or may not include air provided for comfort.

3.28 Occupational Exposure Limit (OEL). A concentration of contaminant in air not to be exceeded in the breathing zone of employees.

E3.28 Published OELs include:

- Permissible Exposure Limits (PELs); established by OSHA;
- Workplace Environmental Exposure Levels (WEELs); developed by Occupational Alliance for Risk Science/ Toxicology Excellence for Risk Assessment (OARS/TERA) and published by AIHA;
- Recommended Exposure Limits (RELs); sponsored by NIOSH; and

- Threshold Limit Values (TLVs); sponsored by ACGIH).

In some cases, the user may develop in-house OELs (i.e., when published OELs are not available).

3.29 OH&S Professional. Someone who by training, experience and/or appropriate certification is qualified to work in the field of occupational health and safety.

3.30 Periodic. Performing a task at a time interval suitable for maintaining the system or equipment in acceptable working condition and that will not cause deterioration of emission or employee exposure control.

3.31 Recirculated Air. Air that meets the requirements of ANSI/ASSP Z9.7, latest version.

3.32 Replacement Air. See **Makeup Air**.

3.33 Slot or Slotted Entry. Hood or plenum opening(s) with a width-to-length ratio less than 0.2.

E3.33 Slots and plenum hoods are commonly used to achieve uniform static pressure, air flow distribution and capture velocity over long hood lengths, such as would be required for plating tanks or large plenums where air flow must be uniformly distributed over a large area.

3.34 Slot Velocity. The average velocity of the air in the plane of the slot with a directional vector perpendicular to that plane.

3.35 System Operating Point (SOP). A combination of the desired or actual air flow and static or total pressure in an LEV system; usually used in fan selection. Also, the point where the system curve and the fan curve intersect on a graph of pressure vs. flow.

3.36 Standard, the Standard. Refers to this American National Standard: ANSI/ASSP Z9.2–2018.

3.37 Standard Conditions, Standard Dry Air. Air at 70°F (20°C) and 29.92 inches Hg (101,325 Pa; 14.696 psia) absolute pressure,

with little or no moisture content, weighing 0.075 lbs/cu foot (1.2 kg/cu meter).

3.38 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.

3.39 Transport Velocity. The air velocity in ductwork required to prevent dry air contaminants from settling out in the ductwork; also, **Scouring Velocity.**

3.40 User. In this standard, “user” refers to the person assuming immediate and ultimate responsibility for the design, operation and/or maintenance of an LEV system or a component of the system; could include the employer, owner, foreman, architect, engineer and/or other responsible persons.

4. GENERAL REQUIREMENTS

4.1 Persons designing, operating, maintaining or testing an LEV system shall be qualified by training or experience to perform the job.

4.2 Design and operation of LEV systems shall be based on the following minimum baseline data:

- emission source behavior and characteristics
- air behavior in the space
- worker interaction with emission sources

E4.1 Designers, for example, should be trained in the basics of fluid mechanics, local exhaust ventilation and industrial duct system design; operators of the equipment should be trained in system function and how to determine proper performance; testing personnel should be trained in testing and balancing procedures; maintenance personnel should be trained in safe maintenance functions (see Appendix).

E4.2 The information items listed below should be developed by the user. Some items often cannot be answered with much accuracy, but there should be an estimation for each (see Appendix):

- emission source behavior
- location of emission sources, or potential emission sources
- determination of emission sources that contribute to exposure
- the (potential) contribution of each source to exposure
- characterization of each contributor, e.g., chemical composition, temperature, rate

of emission, direction of emission, initial emission velocity, continuous or intermittent, time intervals of emission, Safety Data Sheet (SDS), TLV, IDLH, LEL, lower flammability limit (LFL) and so forth.

Air behavior:

- air movement in the space (e.g., direction, velocity)
- characterization of the air (e.g., air temperature, mixing potential, supply and return flow conditions, air changes per hour, effects of wind speed and direction, effects of weather and season)

Worker behavior and interaction:

- worker behavior and interaction with emission sources and contaminated air
- characterization of employee involvement (e.g., worker placement, work practices, worker education and training, cooperation)

4.3 LEV system design and specifications shall be reviewed by those knowledgeable in LEV applications before construction or installation begins.

E4.3 This provision will help to assure successful and reliable service. Each professional discipline should review for its own purposes: industrial hygienists may review to assure that adequate emission control will be achieved; seismic engineers, earthquake protection; fire experts, explosion and smoke controls; safety engineers, safe operating conditions; and so forth.

The review should include such matters as: hood placement and enclosure, compatibility with work practices, air volume flowrates, static pressures throughout the system, transport velocities, fan pressures, stack height and locations, fire protection, potential for explosions in ductwork and air cleaners, ease of maintenance, air emissions, etc.

4.4 LEV system designs and specifications shall conform to provisions of this standard, or to other published standards of good practice if demonstrably equal to or more stringent than this standard.

E4.4 Sources of standards of good practice are summarized in Section 2 of Appendix A. See also Section 12 on commissioning.

4.5 The LEV system shall be designed, installed and accepted in accordance with a commissioning plan approved by the user.

4.6 Exhaust volume flowrates and equipment sizes shall be selected to dilute air contaminants to an acceptable concentration in the LEV system, and at the exhaust air outlet or stack.

4.7 Static pressure losses throughout the LEV system shall be estimated before fans are chosen and before construction or installation begins.

4.8 The LEV system shall be constructed throughout with structurally appropriate and chemically compatible materials

4.9 LEV systems shall be provided with performance monitoring capabilities.

E4.5 See Section 12 for details on commissioning.

E4.6 The designer, working with the user, should determine proposed LEV system usage and, using appropriate dilution/concentration prediction equations, determine likely airborne contaminant concentrations in the LEV system during various operations. Limits should be established and documented where appropriate. For example: “dilution to below one-half of the IDLH in the ductwork,” or “to below 25% of the lower explosive limit (LEL) during normal operation or worst credible accident,” etc. Such limits should be chosen by the user at the exhaust stack, in consultation with a qualified industrial hygienist or other occupational health and safety (OH&S) professional.

E4.7 Flow rates, power consumption, filter efficiencies, costs and system performance are related to static pressure. No system can be properly designed or operated without first estimating (calculating or determining) static pressure demands throughout the system.

E4.8 This may include, for example, fire-rated fiberglass for acidic air streams and galvanized steel for solvent vapor air streams with sufficient thickness for the intended life of the system. LEV systems should be constructed such that at maximum concentrations, chemicals carried in the air stream are also compatible with each other and hood, duct and fan materials. See also Sections 7 and 8.

E4.9 Performance monitoring systems or equipment selected by the user could include analog or digital flow monitors, smoke detectors, gas detectors or other equipment or procedures depending on need and feasibility. LEV systems are often provided with static pressure taps located in the duct serving the hood (before any dampers and close to the hood) because the air flowrate at the hood is often the most cost-effective performance measure of an LEV system and

the hood static pressure can be related mathematically to the air flowrate at the hood. See References for more information

4.10 LEV systems shall be provided with equipment redundancy as appropriate to assure continuous protection of employees.

E4.10 Redundancy is necessary when LEV equipment failure could result in substantial hazards to employees, e.g., overexposure to airborne contaminants. Redundancy could include such backup devices as auxiliary fans, emergency and standby power supplies, multiple sampling taps, and so forth, depending on need. The designer should work with the user to determine appropriate redundancy and testing protocols for such redundant systems. See Sections 7.4 and 14 for related information.

4.11 The LEV system shall be kept clean and free of fire, smoke and explosion-producing materials, and maintained in good working order throughout its working lifetime.

E4.11 This requirement does not prohibit the use of fire, smoke or explosion-producing chemicals in an LEV hood when required for the process being safely conducted in the hood.

The commissioning process and periodic inspections can help assure the LEV system is maintained free of such materials. See Section 14.7.

Many fire safety guidance groups, e.g., the U.S. Chemical Safety Board, recommend that LEV system users evaluate potential incompatibilities if and when dusts, fume or vapors are intermixed in the LEV system to ensure that such mixtures do not result in fire or explosion hazards or destructive corrosion. Consult with such standards as ASTM 2012-00 (2003-08-IR1-R6) and others provided in Section 2.

4.12 LEV equipment suppliers shall not claim compliance with this standard.

E4.12 Claims of compliance with the standard (for a manufactured hood, for example) may be misleading because improper installation or operation could invalidate compliance and create a false sense of security.

4.13 Users of this standard shall not claim compliance with this standard unless every applicable element is complied with.

5. PLANT LAYOUT AND CONSTRUCTION

5.1 LEV design shall consider plant layout and construction. At a minimum, design shall consider items listed in Sections 5.1.1 to 5.1.5.

5.1.1 Location of Processes.

E5.1 Consideration of plant layout and construction in the design helps assure an optimum combination of employee protection, capital investment and operating economy for all factors within the control of the designer. Layout based only on production or materials handling considerations may prove uneconomical when necessary exhaust or ventilation requirements are superimposed upon a layout not originally including such considerations.

E5.1.1 Processes to be exhaust ventilated by a single LEV system should be located close together and arranged, if conditions permit, in order that:

- 1) The shortest lengths of duct and minimum number of elbows are used.
- 2) Proper proportioning of air flow from the various hoods is facilitated.

Scattered processes, or equipment operated infrequently, should normally be provided with separate exhaust systems.

5.1.2 Location of Equipment.

E5.1.2 Process equipment to be provided with a local exhaust system and the components of an exhaust system (e.g., hoods) should be arranged to permit the location of exhaust ductwork so as to:

- 1) Permit the free operation of cranes, elevators, trucks, etc.
- 2) Allow unobstructed accessibility to the ductwork for inspection, cleaning and repairs.
- 3) Provide maximum protection of ductwork from damage from the outside.

5.1.3 Placement of exhaust stacks and makeup air intakes, louvers and grills.

E5.1.3 See Section 6 on Makeup Air Systems and Section 8 on Stacks.

5.1.4 Segregation of hazardous and non-hazardous operations.

E5.1.4 Hazardous operations should be segregated from non-hazardous work so far as practicable. In plants where most of the processes produce potentially harmful concentrations of air contaminants, it is preferable to isolate non-hazardous

processes, e.g., place them in a separate building or room.

5.1.5 Location of air cleaning equipment.

E5.1.5 Building design should make possible the location of air cleaning equipment so as to:

- 1) Permit safe and unobstructed access for maintenance (e.g., filter or collection media removal, cleaning or electrostatic precipitator servicing) and repair of air-cleaning equipment.
- 2) Permit easy removal of dust or other collected material without creating a nuisance, health hazard or a materials handling problem.
- 3) Allow for cleaning and repairing the apparatus without contaminating general plant air.
- 4) Protect wet collection systems and associated piping from freezing.

If the air cleaning equipment handles potentially explosive or highly flammable gases or contaminants, it should be located outside or otherwise isolated; provided with pressure relief panels and safety barriers; adequately protected from lightning; and electrically grounded. Such precautions may be minimized for systems in which sufficient dilution air is handled to keep contaminant concentrations below 10% of the lower explosive limit for gases and vapors and 20% of the minimum explosible concentration for dusts, provided that adequate safety controls are installed to prevent mis-operation (see Appendix).

Designers and users of LEV systems should also be cognizant of long-term plans for the site, adjacent buildings and their usages and nearby geographical features.

Air cleaning equipment should normally be located between the hood(s) and the air moving device (fan) unless the manufacturer of such equipment specifies otherwise, or for other documentable reasons.

5.2 Buildings shall be suitably adapted for hazardous operations and shall meet local

E5.2 Generators, tanks and other equipment in which toxic or explosive gases and volatile

building and fire codes related to LEV systems.

(either at normal or operating temperature) liquids are handled should not be housed in cellars or pits, for example. Explosion vents should be provided as required by codes of the National Fire Protection Association (NFPA) and/or the local fire authority having jurisdiction.

Fire curtains should be provided as required by codes of the NFPA and the local authority having jurisdiction.

Roof vents for automatically venting smoke and products of combustion in event of fire should be provided as required by codes of the NFPA and by local or state building and fire codes.

5.3 LEV system components shall be designed and constructed to provide easy cleaning and draining.

E5.3 See references in Appendix A for more information on minimizing the effects of condensation of materials in the ductwork.

5.4 Where tools, processes or equipment generate different dusts, fumes or vapors that will, when intermixed, result in a health or explosion hazard, or destructive corrosion, such air contaminants shall be exhausted by separate exhaust ventilation systems.

E5.4 It is the common practice in the semiconductor industry, for example, to provide separate LEV systems for air containing acids/corrosives and solvent vapors; labs routinely separate acids and cyanides.

- 1) Permit safe and unobstructed access for maintenance (e.g., filter or collection media removal, cleaning or electrostatic precipitator servicing) and repair of air-cleaning equipment.
- 2) Permit easy removal of dust or other collected material without creating a nuisance, health hazard or a materials handling problem.
- 3) Allow for cleaning and repairing the apparatus without contaminating general plant air.
- 4) Protect wet collection systems and associated piping from freezing.

This requirement assumes dusts, fumes and vapors will be at sufficient concentrations in the exhaust air to create a health, fire, explosion or corrosive hazard. Destructive corrosion implies failure of duct, fitting, fan or air cleaners.

5.5 LEV systems handling radioactive materials shall refer to Nuclear Regulatory Commission (NRC) requirements, or to other appropriate agencies for guidance.

E5.5 Other appropriate agencies include, for example, the U.S. Department of Energy, or “Agreement State” provisions where a state agency has authority to regulate certain uses of radioactive materials within the state (see Appendix).