

ANSI/ASSP Z9.10-2017

Fundamentals Governing the Design and Operation of Dilution Ventilation Systems in Industrial Occupancies

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ANSI®
ANSI/ASSE Z9.10 – 2017

American National Standard

**Fundamentals Governing the Design and Operation of
Dilution Ventilation Systems in Industrial Occupancies**

Secretariat

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

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American National Standards Institute, Inc.

American National Standard

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Foreword (This Foreword is not a part of American National Standard Z9.10-2017.)

This standard describes fundamental good practices related to the commissioning, design, selection, installation, operation, maintenance and testing of dilution ventilation (DV) or general exhaust ventilation (GEV) systems used for the control of employee exposure to airborne contaminants.

It is intended for use by individuals who have involvement in the design, installation, operation and maintenance of DV/GEV system; such individuals may include owners, employers, industrial hygienists, safety professionals, facility engineers, maintenance personnel, testing and balancing personnel, ventilation system designers and others with responsibility for such systems.

It is thought to be compatible with related and recognized standards of good practice. Where incompatibilities are found, use the more stringent or more correct version.

General Coverage. The standard describes recommended practices for the management, operation, testing and maintenance of dilution ventilation systems used for control of employee exposures to airborne contaminants, alone or in conjunction with local exhaust ventilation systems.

The standard covers industrial employee occupancies such as foundry operations, semiconductor manufacturing facilities, welding operations and any other industrial process where employees are present.

Format. The standard is presented in a two-column format. The left column presents the requirements of the standard; the right column provides clarification and explanation of the requirements plus "how to comply" information. The Appendix provides supplementary information by standard section number. The letter "(A)" at the end of a section or paragraph designates an Appendix entry for that section or paragraph.

Standard 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 the OH&S sciences as well as in design, operation and maintenance of industrial ventilation systems. An audit form is provided in the Appendix.

Overlap. For sections to be mutually exclusive and to stand alone, similar requirements may be stated in more than one section of the standard.

Flexibility. Requirements are minimum criteria and can be adapted to the needs of the user. Demonstrably equal or better approaches are acceptable.

Where standard provisions are in conflict with other standards and codes, the more stringent or correct should be applied. Where the user deviates from the standard's requirements, the user should document justification for the deviation.

Response and Update. Suggestions for improvement of this standard are welcome. The Committee will carefully consider all comments and suggestions. Comments should be sent to the Z9 Secretariat, American Society of Safety Engineers, 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:

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AMERICAN NATIONAL STANDARD Z9.10 FUNDAMENTALS GOVERNING THE DESIGN AND OPERATION OF DILUTION VENTILATION SYSTEMS IN INDUSTRIAL OCCUPANCIES

STANDARD REQUIREMENTS

EXPLANATORY INFORMATION

*(Not part of American National
Standard Z9.10)*

1. SCOPE AND EXCLUSIONS

1.1 Scope. This standard establishes minimum requirements for the commissioning, design, specification, construction, installation, management, operation, maintenance and testing of dilution ventilation systems (including demand dilution ventilation) used for the reduction, prevention and control of employee exposure to harmful concentrations of airborne substances in the industrial environment. The standard establishes minimum DV requirements to provide safe and healthful working conditions in industrial employee occupancies.

1.2 Exclusions. This standard does not cover:

- ventilation used exclusively for commercial buildings and/or comfort ventilation
- HVAC and dilution ventilation systems used in non-industrial employee occupancies
- Laboratory ventilation
- LEV systems
- displacement ventilation systems
- natural dilution ventilation systems (A)
- dilution used exclusively for fire protection (A)
- systems used exclusively for heat removal and heat stress control

1.3 Conflicts with Other Standards and Codes. Where standard provisions may be in conflict with building codes or other

E1.1 Properly operating dilution ventilation systems are used to maintain acceptable air quality in the industrial occupational work environment through dilution and removal of air contaminants.

The standard also applies to supply and LEV makeup air systems where the makeup air is used for dilution.

The standard also applies to supplied-air islands and similar ventilation systems where the supply air is also used for dilution.

Employee comfort is a secondary factor in the standard.

E1.2 LEV systems are covered in ANSI/ASSE Z9.2. Laboratory ventilation systems are covered in ANSI/ASSE Z9.5. See Appendix A2 for addresses.

HVAC and dilution ventilation systems for comfort and non-industrial employee occupancies are covered in current versions of other standards and guidelines, e.g., ASHRAE 62 and AIHA's guideline, *Recommendations for the Management, Operation, Testing and Maintenance of HVAC Systems*. See Appendix A1.2 for information on natural ventilation systems and dilution ventilation used to protect against fire hazards.

Information on heat stress can be found at:
<http://www.cdc.gov/niosh/topics/heatstress/>

recognized standards, the more stringent should be applied.

2. REFERENCED STANDARDS AND GUIDELINES

Existing standards, guidelines and other sources of information contain provisions that complement the recommendations of this ANSI standard. Please see Appendix A2 for a list of such documents.

E2 The items listed in Appendix A2 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 editions of the regulations, standards and guidelines listed.

3. DEFINITIONS

Definitions explain terms as they are used in this standard.

3.1 Acceptable Concentration. The concentration in air of a gas, vapor or aerosol that the user determines is acceptable for the employee-occupied space. User-defined acceptable concentrations might include, for example, 5% of the OSHA PEL, 10% of the ACGIH TLV®, and so forth

3.2 Air Cleaning Equipment. A device or combination of devices for separating contaminants from the air handled by a dilution ventilation system. Particle filters are most common, but filtration may also include chemical and activated charcoal beds for removing gases and vapors.

3.3 Air Handling Unit, AHU, Air Handling Equipment. The equipment used to collect, clean, temper and control dilution air. Could include fan, motor, intakes, connecting ductwork, dampers and any equipment used to clean and/or temper the air.

3.4 AMCA. The Air Moving and Control Association. AMCA establishes certification criteria for fans, air intake louvers and other air moving equipment.

3.5 Balancing; Air Balancing. The

proportioning of airflows within a duct or air distribution system according to specified design criteria. Normally associated with testing and adjustment of duct airflow controls (e.g., dampers) to assure proper distribution of dilution air.

3.6 Code of Jurisdiction. Codes, standards and rules that apply to the DV equipment in the locale employed.

3.7 Commissioning. A process or plan in which a dilution ventilation system's performance is identified, verified and documented before, during and after design, construction or remodeling. This helps assure proper operation and compliance with codes, standards and user intentions. Commissioning begins during the design process. System acceptance tests end when tests and demonstrations verify that the system operates as intended. A commissioning agent is often used to administer the commissioning process which, in turn, is tailored to the needs of the system. It is a process that typically continues throughout the life of the system.

3.8 Commissioning Plan. Documentation that defines the commissioning process.

3.9 Contaminant; Air Contaminant. A substance (dust, fume, fiber, ultrafine particle, nanoparticle, mist, vapor, gas) whose presence in air is harmful, hazardous, toxic, irritating or creates a nuisance.

3.10 Demand Dilution Ventilation (DDV). Industrial dilution ventilation systems equipped with a control system that continuously monitors an airborne contaminant and modulates fans, dampers, etc., to adjust dilution air volumes (or exhaust air volumes), based on measured contaminant concentrations. For example, carbon monoxide sensors used to turn on dilution ventilation fans in an automobile repair facility when CO concentrations exceed some user set point. The abbreviated term "DDV" is unique to this standard and does

not relate to the use of similar terms elsewhere.

3.11 Design. The process that includes characterizing the interactions between emissions, workers and the air; determining appropriate air flowrates, static pressures and other operational parameters; and specifying equipment and system components. Design also recognizes the interaction of proposed equipment with installed or future environmental systems.

3.12 Designer. Person charged with designing a DV system; typical designers include mechanical and industrial hygiene engineers.

3.13 Dilution, Dilution Ventilation, DV, Dilution and Removal Ventilation, Ventilation, General Exhaust Ventilation, GEV. Use of uncontaminated (generally considered to be outdoor) air to thoroughly mix with actual or potentially contaminated air to reduce airborne concentrations of contaminants to an acceptable concentration. Air contaminants thus leave the work environment in exhausted dilution air. All supply air systems provide dilution ventilation when they contain a component of fresh, outdoor air of acceptable quality. A dilution ventilation system typically consists of air supply and exhaust systems with appropriate control equipment. Dilution air should normally be exhausted to the outside of the building in a manner that does not result in significant re-entrainment or exposure to those in the exhaust vicinity.

3.14 Dilution Air, Outdoor Air; OA. Acceptably clean air ultimately responsible for dilution purposes which originates normally from outside the building; air that has a lower concentration of the contaminant to be diluted and removed. Similar terms include: Intake air, fresh air, makeup air, outside air, outdoor air and OSA. Outdoor air is used (1) to replace air that is exhausted to outside the building or occupied space, and/or (2) to dilute indoor contaminated air. Dilution air may also

include acceptably clean indoor air sources, such as air taken from a warehouse or hallway that has access to an outdoor air source. It might also include return air that has been cleaned to outdoor air quality, but this is rarely a cost-effective approach. Sometimes outdoor air is mixed with recirculated or return air, and the mix is used to enhance mixing in the space to be diluted.

3.15 Dilution Ventilation Intake, Outdoor Air Intake. The equipment and location of the air inlet to the dilution ventilation system.

3.16 Dilution Ventilation System, Ventilation System, the System, DV System. The dilution ventilation system, its equipment and components. A dilution ventilation system typically consists of the air supply equipment and the general exhaust equipment. (A3.16)

3.17 Displacement Ventilation; Plug-Flow. Air contaminant control where air is induced to move as a body in one direction. For example, cold air introduced at the floor level that rises to exhaust grilles in the ceiling. In displacement ventilation, mixing of contaminants in the air is discouraged.

3.18 Document; To Document; Documentation. The formal process of planning and recording decisions made by the user or other relevant individuals. Also may include the written procedures developed for operating, testing and maintaining a dilution ventilation system.

3.19 Ducts; Ductwork. Normally, elongated rigid or flexible enclosures, pipes or tubes used to convey air, pressure and entrained contaminants from one location to another. In this standard, it can also mean plenums, mixing boxes and any enclosed path taken by the air in the dilution ventilation system, not to include the occupied space.

3.20 Environmental Systems. Environmental systems are dilution ventilation systems designed and installed to comply with EPA environmental regulations that generally pertain to control of emissions from a process or building.

3.21 Fan. Mechanical device used to provide static pressure and move air.

3.22 General Exhaust Ventilation, GEV. See **Dilution**.

3.23 Health Maintenance. Maintaining homeostasis of employees thus promoting health and well-being; maintaining normally healthy conditions. Comfort is considered a component of good mental and physical health and is also desirable because it influences productivity and performance.

3.24 HVAC System. Heating, ventilating and air conditioning system. Generic term for ventilation systems providing both thermal comfort and minimal dilution ventilation for dilution and removal of air contaminants, especially bio-effluents, in non-industrial applications.

3.25 IH; Industrial Hygiene. The profession devoted to the anticipation, recognition, evaluation and control of employee exposures to airborne contaminants. More broadly, the science and art devoted to forestalling, anticipating, recognizing, evaluating and controlling hazards and stressors in the workplace which may cause illness, injury or discomfort.

3.26 Industrial Occupancy. An employee-occupied location where industrial operations and production processes are carried out. Examples include a foundry floor, wood shop, welding operations and factory production floor. It is an employee-occupied location where primary air contaminants are generated by industrial processes. Alternately, it is defined by cognizant government agencies (e.g., OSHA) as an industrial operation and

regulated by industrial regulations and standards (see also **Non-Industrial Occupancy**).

3.27 LEV; Local Exhaust Ventilation.

Ventilation approach used to capture, control, contain, receive and/or remove air contaminants at the source of generation.

3.28 Makeup Air, Replacement Air.

Outdoor or acceptably clean air supplied to replace dilution air and then exhausted from the space or building. (See also **Supply Air** and **Tramp Air** for more information.) 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.

3.29 MERV. Minimum efficiency rating value for filters as established originally by ASHRAE 52.2. Testing protocol for air filters.

3.30 Non-Industrial Occupancy. An employee-occupied location or space where industrial operations and production processes are not carried out. Examples include offices, conference rooms, cafeterias, break rooms, multipurpose rooms and any location where primary air contaminants are generated by non-industrial sources (e.g., humans, building materials such as carpets, outdoor sources such as smoke or herbicides, natural sources such as mold spores and pollen, tobacco smoking).

3.31 Occupational Exposure Limit (OEL). A (typically time-weighted average) concentration of a contaminant in air not to be exceeded in the breathing zone of employees and based on recognized standards, regulations or chemical manufacturer's guidelines. Typical OELs include: Permissible Exposure Limit (PEL, OSHA), Workplace Environmental Exposure Level (WEEL®, AIHA), Recommended Exposure Limit (REL, NIOSH), Threshold Limit Value (TLV®, ACGIH) and published Derived No-

Effect Level (DNEL, REACH).

3.32 Occupied Space, Occupied Industrial Space. Indoor industrial space where employees are located and designed for normal occupancy.

3.33 Periodic. Performing a task at a time interval suitable for maintaining the dilution ventilation system or equipment in acceptable working condition to assure proper employee exposure control.

3.34 Pressurization. Technique using pressure differentials to induce airflow in an intended direction. May be achieved by differential pressure control or volumetric offset control. Pressurization is used to prevent air infiltration, smoke control, water intrusion and for isolation strategies. Pressurization helps avoid, for example, infiltration of unwanted air into a protected location.

3.35 Recirculated Air. Air that meets the requirements of ANSI/ASSE Z9.7.

3.36 Replacement Air. See **Makeup Air**.

3.37 SMACNA. Sheet Metal and Air Conditioning Contractors' National Association. SMACNA is an association that provides publications, standards and guidelines related to sheet metal and ductwork.

3.38 Standard. Refers to this American National Standard: ANSI/ASSE Z9.10.

3.39 Standard Conditions, Standard Dry Air. Air at 70°F (21°C) and 29.92 inches Hg (101,325 Pa) absolute pressure, with little or no moisture content, weighing 0.075 lbs/ft³ (1.2 kg/m³). The definition of STP varies between standards.

3.40 Supply Air. The total amount of air delivered to a space used for dilution ventilation, heating, cooling, humidification and dehumidification. See also **Makeup Air**. Supply air is the contribution of

recirculated air and outdoor air.

3.41 System. See **Ventilation System**.

3.42 Tramp Air; also Infiltration. Tramp air is an older term, but both terms refer to outdoor or exterior makeup or replacement air that enters the building or occupied spaces through openings due to an indoor or interior negative pressures relative to the outside, caused by temperature differences and wind forces. These terms also refer to air that does not come into the facility or space through a dedicated path identified by design intent, e.g., through doors, cracks, eaves, etc. and is not tempered, filtered or routed correctly.

3.43 User. Refers to the person or entity using the standard, i.e., those responsible for the design, management, operation, testing and/or maintenance of the dilution ventilation system. The user of the standard could be defined as (but is not limited to) the employer (usually the ultimate user), the work supervisor, the building maintenance supervisor, the dilution ventilation system operator, an industrial hygienist and so forth. The definition of user varies between standard paragraphs and may involve individuals with different assigned responsibilities, local environmental factors, building and dilution ventilation types and so forth. Examples of typical users are provided in some sections. The intent of employing the general term user in the standard is to encourage and require the assignment of responsibility to the appropriate person, but in a way that allows flexibility for users of the standard.

4. GENERAL REQUIREMENTS

4.1 Traditional industrial hygiene air contaminant control strategies (other than dilution ventilation) shall also be considered when applying the standard.

E4.1 Cost-effective source control and other emission/exposure reduction IH strategies are normally applied before relying on dilution ventilation. Traditional source emission control approaches include local exhaust ventilation (LEV which in some cases is required by codes and standards),

isolation, space pressurization, barriers and so forth. This standard primarily covers the use of dilution ventilation systems as a control strategy. When there are specific and point emission sources, source controls used in conjunction with dilution ventilation are usually cost effective. Dilution ventilation alone should not be used for the control of highly toxic materials or to control emission sources near the breathing zone. Dilution ventilation is generally more effective for gases, vapors and respirable particles and has limited use for larger aerosols and/or when contaminants are released at a high or variable rate of emission.

4.2 Design and operation of dilution ventilation (DV) 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
- Interaction with environmental systems

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 estimate for each.

Emission source behavior:

- Location and number of emission sources, or potential emission sources, that contribute to exposure.
- The (potential) contribution of each source to exposure.
- Characterization of individual contributing emissions, including (but not limited to): source, location, emission rate, chemical composition, temperature, condition of dispersion (e.g., passive or active generation into steady or rapid air motion) and operational variability (continuous, intermittent or peak with the respective intervals of emission).
- Potential synergistic effects of air contaminants in ambient air.
- Review of information related to safety data sheets (SDS), occupational exposure levels (OEL), lower explosive levels (LEL), and so forth.
- Potential source emission changes during transfer route between source and detection location, e.g., liquid mist emissions which vaporize; wet particulates (liquid and solid) which vaporize and separate to dry particulate and vapors/

gases; chemical reactions.

- For gas or vapor emissions, the user should consider the molecular weight and/or the density of the contaminant and the environmental air conditions. When the MW and concentrations are high, the contaminant may collect near the floor (if heavier than air) and near the ceiling (if lighter than air) before adequate mixing occurs.

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 turnover rates, effects of wind speed and direction, effects of weather and season).
- Airflow patterns as determined by locations of the inlet and supply ports of the ventilation system and the physical configuration of the control area. Open windows and doors in a space can also affect the overall air movement.
- Temperature variations; temperature induced stratification, for example, may effect airflow patterns.
- Potential adverse effect on LEV systems.
- Stack or chimney effect in taller industrial buildings.

Worker behavior and interaction:

- Worker behavior and interaction with emission sources and contaminated air.
- Characterization of work practices, worker education and training, consistency in performing standard operating procedures, location of work station with respect to emission sources, and location of workstation with respect to supply and intake ports of the ventilation system, and so forth.
- Use of video technology, coupled with data logging exposure monitoring, may help in assessing the two tasks listed above.