

SEMI S6-93

SAFETY GUIDELINE FOR VENTILATION

NOTICE: This guideline does not purport to address all of the safety issues associated with its use. It is the responsibility of the user of this guideline to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

NOTE: As listed or revised, all documents cited shall be the latest publications of adopted standards.

1 Introduction

The equipment supplier should design an internal equipment exhaust system that is efficient when connected to potential users' exhaust systems. Seldom, if ever, are users' systems designed for a specific piece of process equipment or set of process equipment. Most users' exhaust systems are designed and installed to industry-accepted exhaust principles.

2 Purpose

This document is intended to help the semiconductor equipment supplier design equipment exhaust systems to a common set of performance criteria as well as to provide assistance to both users and suppliers in the understanding of exhaust requirements for equipment systems. It is not intended to establish design specifications. The supplier will still own, and be responsible for, the information it specifies. This guideline has six concurrent performance-related objectives.

2.1 Ensure hazardous gases, fumes, and vapors are controlled (during normal operations of equipment and facilities services) such that concentrations present in the work room air should be less than 1.0% of the Threshold Limit Value (TLV), as established by the American Conference of Governmental Industrial Hygienists (ACGIH) or Permissible Exposure Limit (PEL) as published by the appropriate regulatory agency, whichever is lower.

2.2 Ensure exhaust is provided within specifications to support the proper operation of equipment.

2.3 Optimize the user's exhaust system(s).

2.4 Use the most cost effective methods to interface with user's exhaust systems.

2.5 Provide a platform for communicating "special case" exhaust requirements.

2.6 Establish guidelines for measurement and communication of equipment exhaust requirements.

3 Scope

This guideline applies to all semiconductor equipment that incorporates exhausted enclosures that are intended to be connected to user facilities' exhaust system(s). This document is written with the assumption that the users' exhaust distribution systems will be designed with central fans, ducting, and, where applicable, abatement equipment. Where users use other types of exhaust systems, equipment suppliers should acquire exhaust specifications from the users. Whether equipment is connected to a central exhaust system or to one which serves only that piece of equipment, this guideline should be applied.

4 Referenced Documents (see Appendix 2)

5 Terminology

5.1 *balancing* — Adjustments made after the ventilated equipment and the ventilation system are installed to assure that airflow to each piece of ventilated equipment is within design specifications.

5.2 *capture* — To entrain undesirable elements (gases, fumes, vapor, and particles) in the exhaust stream for removal.

5.3 *dilute* — To reduce the concentration of undesirable elements to acceptable levels. Dilution is a function of flow volume.

5.4 *flow velocity (V)* — The average speed at which the effluent stream travels through the exhaust duct. It is measured in meters per second (m/s) or feet per minute (fpm).

5.5 *flow volume (Q)* — The volumetric flow rate of the effluent stream passing a given location in the exhaust system per unit of time. It is measured in cubic meters per second (m³/s) or cubic feet per minute (cfm).

5.6 *initiate motion* — To use an exhaust stream to start contaminants (or machine parts) moving from a rest position.

5.7 *long radius elbow* — An exhaust duct elbow that has a center line radius 1.5 or more times the duct diameter.

5.8 *set point tolerance* — The range (+/-) of static pressure within which an exhaust enclosure will perform efficiently and effectively.

5.9 *static pressure (SP)* — The measure of differential pressure across the duct wall to the ambient pressure

(inside the duct). The unit of measure is pascals (Pa, Newtons per square meter (N/m^2)) or inches of water.

5.10 *traverse measurements* — Multiple air flow measurements taken at points of equal separation, in a matrix pattern, along the face plane of an exhaust duct or opening in an exhaust enclosure.

5.11 *vena contracta* — A point in a duct where the diameter of the air stream is smaller than the diameter of the duct.

6 Attributes of Typical Semiconductor Facilities' Exhaust Systems

6.1 A typical semiconductor facility's exhaust system has three measurable working elements: (1) flow velocity, (2) flow volume, and (3) pressure.

6.1.1 Flow Volume is related to the Flow Velocity by the equation $Q = VA$. In this equation, Q = volumetric flow rate, V = average velocity, and A = duct cross sectional area (m^2 or ft^2).

6.2 There are three duct pressure measurements possible: (1) static pressure, (2) velocity pressure, and (3) total pressure.

6.2.1 In exhaust distribution systems with central fans and abatement equipment (typical of semiconductor facilities), exhaust duct pressure (static) upstream of the fan is less than the ambient pressure outside of the duct.

6.2.2 While Velocity Pressure (VP) and Total Pressure (TP) provide a more reliable measure of Flow than Static Pressure, VP and TP are normally not specified for semiconductor facilities' exhaust systems; therefore, they will not be discussed in these guidelines. If more information is desired on VP or TP, it can be found in "Industrial Ventilation" (Appendix 2, Reference 1).

7 Exhaust Usage Typical of Semiconductor Operations

Semiconductor equipment typically uses exhaust to perform one or more of the following tasks:

7.1 *Capture* — Capture should occur as close to the source as practical to prevent exposure of personnel or products to the undesirable elements.

7.1.1 Capture is a function of Flow Velocity. Chapter 3 of "Industrial Ventilation," A Manual of Recommended Practice, 20th Edition, (Appendix 2, Reference 1) outlines the design principles and required velocity calculations for proper capture of process emissions.

7.2 *Moving* is also a function of Flow Velocity. The exhaust requirements specified by the equipment supplier should be adequate to maintain motion of

undesirable elements once they are captured in the exhaust stream.

7.3 *Dilution* is a function of Flow Volume. Dilution may also provide reactive elements to undesirable elements entrained in the exhaust stream (for example, air and silane).

7.4 *Holding* — The movement of the exhaust stream is often used to activate and hold safety control devices, such as vane switches or differential pressure gauges in the active state. Such safety control devices should be used to sense adequate exhaust pressure or flow to ensure safe operation of the process equipment.

7.5 *Initiation of Motion* — The use of exhaust to initiate motion in the semiconductor industry is a special case application and should be resolved at the time of purchase. Most semiconductor-related gases, vapors, fumes, and fine particles (less than 20 microns in diameter) move with the air in which they are mixed.

8 Key Elements of Exhaust Specifications

8.1 SEMI S2 establishes specific requirements for exhaust enclosures of equipment that use hazardous materials. Access to enclosures serving hazardous materials requires special design. If there is a potential for exposure of personnel to hazardous materials when the access hatch is open, an average face velocity (measured at the hatch opening) sufficient to capture the hazardous materials should be maintained in the hatch opening. (SEMI S2 also has recommendations for exhaust monitoring and alarms. S2 should be fully understood before designing exhaust systems for hazardous materials.)

8.2 Properties of chemicals (density, vapor pressure, boiling point, flammability, etc.), the state of the materials within the exhausted enclosure (solid, liquid, or gas), and conditions such as temperature and concentration will determine the final design and exhaust specifications of the equipment enclosure. Equipment suppliers should use available reference books and Material Safety Data Sheets (MSDS) to obtain information on chemical properties. The equipment's process requirements will dictate the state and condition of the material.

8.3 When developing specifications for equipment exhaust systems to be given to the equipment user, equipment suppliers should incorporate all of the key elements that will provide clear and accurate information. These key elements are:

1. Point of measurement.
2. Duct size at the point of measurement.
3. Flow through the duct.

4. Air density.
5. Temperature of the exhaust stream when it enters the exhaust system.
6. Static pressure at the point of measurement.
7. Physical condition of the process equipment at the time of measurement.
8. Peak, normal, and special exhaust requirements.
9. Equipment environmental conditions anticipated (installed).
10. Stability and tolerance requirements of the specifications.
11. Priority of exhaust attributes when the system is balanced. (What is the primary intent of the exhaust, secondary, etc.?)
12. Instruments and practices used (and recommended) for taking measurements.
13. Design information on the complete equipment exhaust system (including materials of construction).
14. Constituents of the exhaust stream.

Each of these key elements is discussed in detail in Sections 8.3.1 through 8.3.14.

8.3.1 The point of measurement for the equipment exhaust duct should be clearly defined. Information given to locate the point of measurement should include a diagram of the exhaust connection with locations of the traverse points used.

8.3.1.1 Turbulence in the duct at the point of measurement should be minimized. The measurement point should be in a straight section of duct. It should be downstream in the connecting duct past the vena contracta from the last transition made in the equipment. It should be far enough from fittings, dampers, or sprinkler heads to minimize their interference with the measurements. Normal recommended practice is 7.5 duct diameters from any point of connection or fitting. See “HVAC Systems Testing, Adjusting, and Balancing,” (Appendix 2, Reference 3).

8.3.1.2 Equipment users typically use a throttling damper for exhaust balancing where the equipment drop connects to the rest of the exhaust system. Balancing measurements should be taken on the equipment side of these balancing dampers. The supplier may elect to provide a damper, at or near the equipment connection point, to be used only as a

trimming device over a narrow performance band around the equipment flow and pressure specifications. Features of this damper should be designed to prevent complete blockage of exhaust flow.

8.3.2 Duct size is the inside diameter of the exhaust connection from the equipment. The supplier should provide any other dimensions needed to design the connection of the exhaust system to the equipment.

8.3.2.1 The duct size of the equipment connection should fall in the low flow velocity range of the duct friction table. See “HVAC Systems Duct Design” (Appendix 2, Reference 2). Low flow velocity ducts will promote flexibility and ease of interface to exhaust systems serving multiple equipment. When particles are to be captured and removed, design the system for the minimum flow velocity that will ensure capture.

NOTE: Exhaust system designers should always keep in mind the difficulty that can be experienced in flow velocity measurements in unduly large ducts. Tool connections should be sized for accurate flow measurements.

8.3.2.2 The design of the equipment exhaust connection should allow for long radius connecting elbows at the point of connection. This will reduce friction losses. Additionally, the equipment supplier should avoid configurations that would require an angle of entrance into the user’s branch ducts of greater than 30 degrees.

8.3.2.3 Duct connection configuration should be such that liquid spills or releases within the equipment enclosures will not enter the facility’s exhaust system.

8.3.3 Flow through the equipment enclosure, and the duct at the point of connection, can be specified in velocity or volume. Normally, the balancing engineer will measure Flow Velocity and convert velocity to Flow Volume using the equation $Q = VA$. (See Section 6.1.1.)

8.3.3.1 Section 8.3.6 of this document shows the pressure guidelines for semiconductor exhaust systems. The equipment supplier should establish, through testing, the Flow Velocity and Volume required for efficient operation of its equipment’s exhaust system. The user and the supplier should agree, before the purchase of the equipment, on the safety control devices to be used. Any safety control device requiring flows or pressures outside these ranges is a special case and should be resolved at the time of purchase.

8.3.4 Exhaust specifications should be stated in Standard Air Density (kg/m^3 or lb/ft^3), as defined in “Industrial Ventilation,” (Appendix 2, Reference 1). If the measurements are of non-standard air, state the correction factor for density. Users should correct field balancing measurements taken above 600 meters (2000