

SEMI S5-0703

SAFETY GUIDELINE FOR SIZING AND IDENTIFYING FLOW LIMITING DEVICES FOR GAS CYLINDER VALVES

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NOTICE: This Document was completely rewritten in 2003.

1 Purpose

1.1 The purpose of this Safety Guideline is to provide a method to size and identify flow limiting devices that limit the rate of release of hazardous gases from the gas cylinder valve during transportation, storage, and use.

2 Scope

2.1 This Safety Guideline provides a method to identify flow limiting devices by size, and to calculate maximum and minimum flow rates so that the size required can be determined. Specific Safety Warnings are contained in § 3.

2.2 This Safety Guideline pertains to flow limiting devices for valves on cylinders containing hazardous gases. These devices are intended to limit the flow rate of uncontrolled releases of gases at or downstream of the valve outlet. This guideline does not pertain to gas releases caused by failure of the cylinder, the valve connection to the cylinder, actuation of the cylinder pressure relief device, or some failures of the valve.

2.3 This Safety Guideline pertains to flow limiting devices operating at critical flow rates that result from cylinder pressures greater than 103 kPa (15 psig). Generally, flow limiting devices are not used for cylinders pressurized less than 103 kPa (15psig) because the size required to provide adequate flow for the process is so large that flow reduction resulting from the flow limiting device would be minimal.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Safety Warnings

3.1 *Installation* — Only the gas supplier or cylinder owner should install, remove, or otherwise service the flow limiting device. Special equipment and procedures may be required to perform any installation or service operation safely. No other person should install, remove, replace, clean, adjust, or otherwise alter the flow limiting device unless authorized by the cylinder owner.

3.2 *Verification* — When a flow limiting device is required, the user should always verify that the size is identified by tag, label or marking on the cylinder or cylinder valve exterior, and that the device size indicated matches the requirement. If a required flow limiting device is missing, the cylinder should be rejected prior to use.

3.3 *Purging* — The addition of a flow limiting device in the cylinder valve may restrict gas flow during purging. The user should assure that adequate purging methods are used to prevent plugging the flow limiting device. As a minimum, the operator should purge the valve outlet after use with the same procedure used for purging the valve outlet just after installation of the cylinder. This is important to prevent contamination in the valve outlet and reduce the probability of creating a hazard at the cylinder supplier's plant.

3.4 *Blockage* — Under certain conditions, some hydrides such as Diborane can polymerize and cause obstruction or total blockage of flow limiting devices. Care should be taken with cylinders that seem to be empty, but may contain product.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

4.2 NFPA Document¹

NFPA 704 — Standard System for the Identification of Fire Hazards of Materials

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 Definitions

5.1.1 *equivalent orifice* — a passage that will allow fluid flow equivalent to a round hole at 80% efficiency. The efficiency, known as the orifice coefficient, will typically vary from 65% (0.65) for a sharp entrance to 95% (0.95) for a well-rounded entrance. A flow rate tolerance of $\pm 20\%$ is used in Table 1 to allow for variations in the entrance geometry and passage size. Figure 1 illustrates the flow rate variation resulting from this tolerance for different equivalent orifice sizes.

5.1.2 *flow limiting device* — a device installed in a gas cylinder valve that will reduce maximum flow from the valve under full flow conditions.

5.1.3 *flow rate* — flow rates in this guideline are given in standard liters per minute (slm) at the standard conditions of 0°C (32°F) and 101 kPa absolute (14.7 psia). This corresponds to the standard conditions used for calibration of mass flow controllers used in semiconductor processing systems.

5.1.4 *hazardous gases* — gases that have a degree of hazard rating in health, flammability, or reactivity of class 3 or 4 in accordance with NFPA 704, or equivalent rating by a regional standard.

5.1.5 *mixing gas* — an inert gas used to dilute another gas.

6 Flow Limiting Device Criteria

6.1 *Where Used* — Flow limiting devices should be installed or incorporated into cylinder valves that are used for gas cylinders containing the hazardous gases listed in Table 2. Table 2 lists hazardous gases for which devices are known to be feasible by reason of testing and experience. SEMI encourages testing by its members of hazardous gases not listed in Table 2 so that new information can be added.

6.2 *Materials* — The flow limiting device should be made of materials that are compatible with the gas in the cylinder.

6.3 *Installation* — The flow limiting device should be installed by the gas supplier or cylinder owner. See Safety Warnings.

6.4 *Identification* — The preferred method of identifying flow limiting devices is by equivalent orifice size as shown in Table 1. Other means of identification, requiring identification by the supplier as to the device installed, may be used if unambiguous.

6.5 *Service Life* — Removable flow limiting devices may be reused, but should be tested by the gas supplier or cylinder owner before each use to assure that the flow rate is as listed in Table 1.

6.6 *Sizing* — A flow limiting device that will not allow nitrogen flows out of the valve outlet to exceed the flow rates listed for its equivalent orifice size in Table 1. The flow limiting device should be the smallest size that satisfies the process requirements. The user should make the choice of flow rate based on safety philosophy contained in SEMI S2.

NOTE 1: Flow rates determined by the calculations in this Safety Guideline are based on critical flow where the cylinder pressure is equal or greater than 2 atmospheres and pressure at the outlet of the flow limiting device is 1 atmosphere. Consult the flow limiting device supplier to determine the minimum size that will provide the required process flow rate when cylinder absolute pressure is less than 2 times outlet absolute pressure.

7 Flow Rate Calculations

7.1 The flow rates in Table 1 are specified for critical flow of nitrogen through the flow limiting device at several cylinder pressure levels. Densities are given in Table 2 for some hazardous gases. First determine the critical flow of nitrogen through the flow limiting device from Table 1, or calculate using the method specified in ¶ 7.2. Then, using

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