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**Gas analysis — Preparation of calibration  
gas mixtures using dynamic volumetric  
methods —**

**Part 6:  
Critical orifices**

**iTeh STANDARD PREVIEW**  
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*Analyse des gaz — Préparation des mélanges de gaz pour étalonnage à  
l'aide de méthodes volumétriques dynamiques —  
Partie 6: Orifices critiques*

ISO 6145-6:2003

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 6145-6 was prepared by Technical Committee ISO/TC 158, *Analysis of gases*.

This second edition cancels and replaces the first edition (ISO 6145-6:1986), which has been technically revised.

ISO 6145 consists of the following parts, under the general title *Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods*:

— *Part 1: Methods of calibration*

— *Part 2: Volumetric pumps*

— *Part 4: Continuous injection method*

— *Part 5: Capillary calibration devices*

— *Part 6: Critical orifices*

— *Part 7: Thermal mass-flow controllers*

— *Part 9: Saturation method*

— *Part 10: Permeation method*

Diffusion will be the subject of a future Part 8 to ISO 6145. Part 3 to ISO 6145, entitled *Periodic injections into a flowing gas*, has been withdrawn.

## Introduction

This part of ISO 6145 is one of a series of standards that present various dynamic volumetric methods used for the preparation of calibration gas mixtures.

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# Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods —

## Part 6: Critical orifices

### 1 Scope

This part of ISO 6145 specifies a method for the continuous production of calibration gas mixtures, containing two or more components, from pure gases or other gas mixtures by use of critical orifice systems. By selection of appropriate combinations of orifices and with the use of pure gases, the volume fraction of the calibration component in the calibration gas mixture can be varied by a factor of  $10^4$ . Additionally, it can be changed by a factor of  $10^2$  by changing the initial pressures in the orifice systems. The uncertainty of the method depends mainly upon the flow calibration method and the variations in temperature and outlet pressure. The relative expanded uncertainty in the volume fraction obtainable for a binary mixture (at a coverage factor of 2) is 3 %.

If pre-mixed gases are used instead of pure gases, much lower volume fractions can be obtained (see Annex A). The mass flow rates or volume flow rates, from which the mass or volume fractions are determined, can be calculated and can be independently measured by a suitable method given in ISO 6145-1.

The merits of the method are that multi-component mixtures can be prepared as readily as binary mixtures if the appropriate number of orifices is utilized, and that a large quantity of calibration gas mixture can be prepared on a continuous basis. The range of flow rates can be from several millilitres per minute to approximately 10 l/min.

Although particularly applicable to preparation of gas mixtures at barometric pressure, the method also provides a means of preparation of calibration gas mixtures at pressures above barometric pressure.

Annex B gives practical hints on the use of the method.

### 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6143, *Gas analysis — Comparison methods for determining and checking the composition of calibration gas mixtures*

ISO 6145-1, *Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods — Part 1: Methods of calibration*

### 3 Principle

When passed through a critical orifice at increasing upstream pressure  $p_1$ , the volume flow rate of gas passing through the orifice will increase. When the ratio of the gas pressure upstream  $p_1$  and the gas pressure downstream of the orifice  $p_2$  has reached a critical value, on further increase of  $p_1$  the volume flow rate of the gas becomes independent with respect to  $p_2$ .

For a given gas, and at constant temperature the critical pressure ratio is:

$$\left(\frac{p_2}{p_1}\right)_{\text{crit}} = \left(\frac{2}{\gamma + 1}\right)^{\frac{\gamma}{\gamma - 1}} \quad (1)$$

where  $\gamma$  is the ratio of the molar heat capacities of the gas at constant pressure and at constant volume.

For monatomic, diatomic and triatomic gases, this critical pressure ratio is approximately 0,5.

Orifice systems which are operated at pressure ratios  $p_2/p_1$  less than  $(p_2/p_1)_{\text{crit}}$  are termed "critical orifices". Use of such systems provides a means of maintaining constant flow rates of gases. In actual practice it is convenient to arrange the system so that  $p_2$  is equal to the prevailing barometric pressure.

To prepare calibration gas mixtures, the complementary gas is supplied at known flow rate, from a critical orifice, to meet the calibration component emerging from another critical orifice. The mixture is then allowed to pass along a mixing tube, at the end of which the flow rate is measured by a suitable method as given in ISO 6145-1. Since the volume flow rate of the calibration component remains the same whether or not the complementary gas is flowing, it can be measured after the flow of complementary gas has been stopped. The concentration of the calibration gas mixture is calculated from the two measured critical flow rates.

## 4 Application to preparation of gas mixtures

### 4.1 Description of the orifice system and the experimental procedure

A schematic diagram of the arrangement for preparation of binary mixtures is shown in Figure 1.

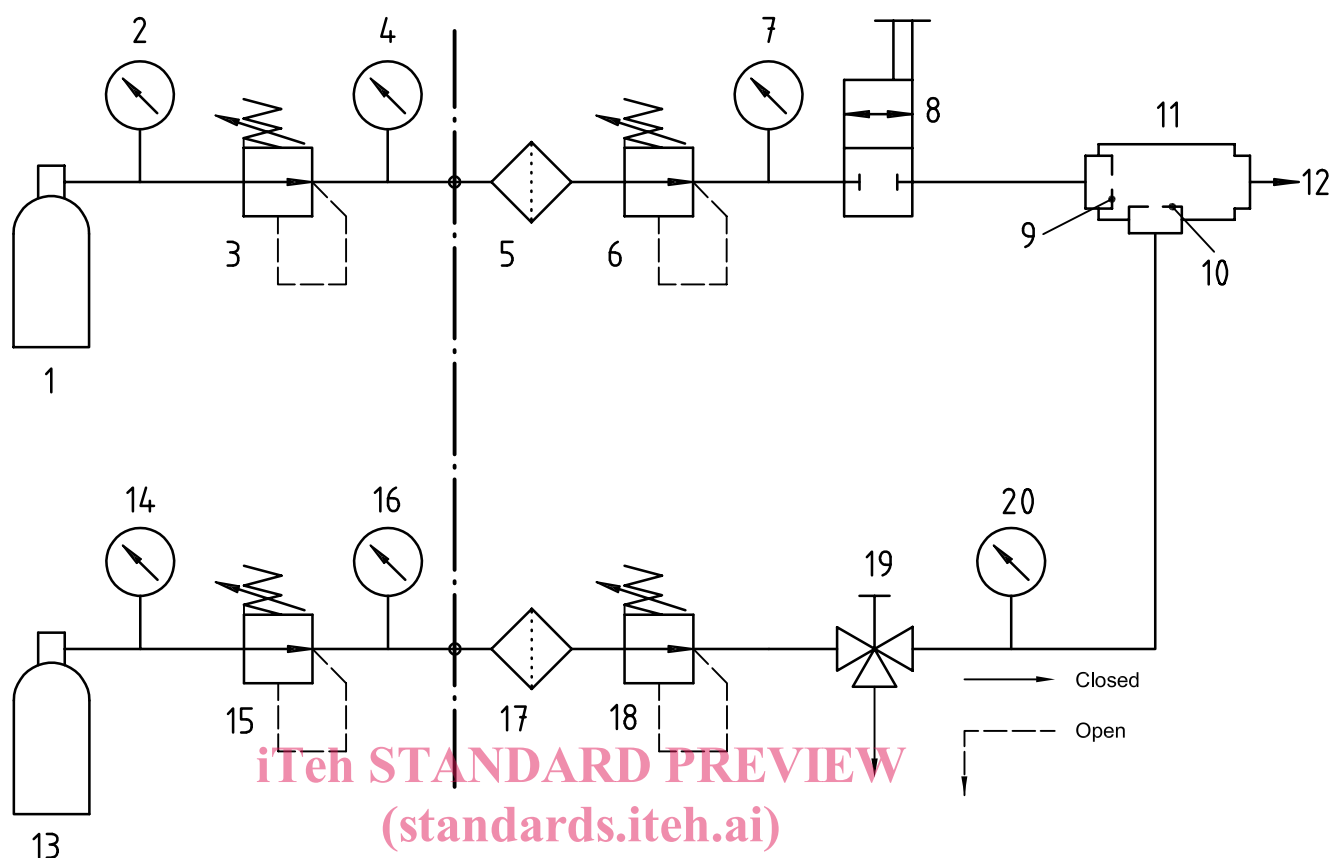
In Figure 1, the orifices 9 and 10, respectively, for the complementary gas and the calibration component to be added are mounted in the orifice system (11). Cylinders 1 and 13, respectively, contain the complementary gas and the other gaseous component, and are connected to the mixing system via pressure-reducing valves (3 and 15) and metallic filters (5 and 17), which provide protection against contamination. In each of the lines, and upstream of the filters, are a pressure-reducing valve and a pressure gauge. A shut-off valve (8) is provided in the complementary gas line and a venting valve is included in the other line.

To operate the gas-mixing system, the valves of the gas cylinders are opened and the readings on the pressure gauges 4 and 16 are adjusted, each to a value approximately 200 kPa (2 bar) above the values anticipated at pressure gauges 7 and 20 respectively.

The pressure regulators (6 and 18) are opened so that the complementary gas and the calibration component flow through the respective orifices. The flow of complementary gas is then stopped by closing the shut-off valve 8. The other line is then flushed with the calibration component by repeated opening and closure of the venting valve 19. Valve 19 is then closed and pressure regulator 18 is adjusted so as to set the pressure at gauge 20 to the value necessary to produce the required flow rate (see below). The flow rate is then measured, by one of the methods given in ISO 6145-1, at outlet 12 of the orifice system (11).

The shut-off valve 8 is then opened and pressure regulator 6 is adjusted to set the pressure indicated on pressure gauge 7 to the value necessary to produce the required flow rate. The combined flow rates of the complementary gas and the calibration component are then measured by a suitable method according to ISO 6145-1.





ISO 6145-6:2003

**Key**

- 1 pressure cylinder (complementary gas)  
 2 pressure gauge (inlet pressure)  
 3 pressure-reducing valve  
 4 pressure gauge (delivery pressure)  
 5 filter  
 6 pressure regulator  
 7 pressure gauge  
 8 shut-off valve  
 9 orifice (complementary gas)  
 10 orifice (calibration component)  
 11 orifice system  
 12 exit for calibration gas mixture  
 13 pressure cylinder (calibration component)  
 14 pressure gauge (inlet pressure)  
 15 pressure-reducing valve  
 16 pressure gauge (delivery pressure)  
 17 filter  
 18 pressure regulator  
 19 vent valve  
 20 pressure gauge

**Figure 1 — Preparation of calibration gas mixtures with a critical orifice system**