INTERNATIONAL STANDARD

**ISO 10156-2**

First edition
2005-08-01

# Gas cylinders — Gases and gas mixtures —

## Part 2: Determination of oxidizing ability of toxic and corrosive gases and gas mixtures



*Bouteilles à gaz — Gaz et mélanges de gaz —*

*Partie 2: Détermination du pouvoir oxydant des gaz et mélanges de gaz toxiques et corrosifs*



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# Foreword

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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 10156-2 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 2, *Cylinder fittings*.



This first edition of ISO 10156-2, together with the future ISO 10156-1 (under preparation), will cancel and replace ISO 10156:1996, which has been technically revised.



ISO 10156 consists of the following parts, under the general title *Gas cylinders — Gases and gas mixtures*:



— *Part 2: Determination of oxidizing ability of toxic and corrosive gases and gas mixtures*

# Gas cylinders — Gases and gas mixtures —

# Part 2: Determination of oxidizing ability of toxic and corrosive gases and gas mixtures

**WARNING 1 — There may be a risk of explosion when carrying out the test specified in this part of ISO 10156. Special care is to be taken when dealing with toxic and corrosive gases. Personnel shall be made aware of the potential hazards and shall take the necessary precautions. The test apparatus should be installed in a laboratory fume cupboard.**

**WARNING 2 — Fuel gas and oxidants to be tested shall not be mixed together under pressure in gas cylinders, except by competent persons to a well proven procedure. This part of ISO 10156 does not attempt to clarify which oxidizing gas mixtures can be manufactured safely and successfully; this is the responsibility of the mixture manufacturer using established practices and procedures to ensure the safety of personnel, equipment, and surroundings.**



## 1 Scope

This part of ISO 10156 specifies a test and a calculation method to be used for determining whether or not a gas (or a gas mixture) is more oxidizing than air. This part of ISO 10156 only applies to toxic and corrosive gases and gas mixtures.



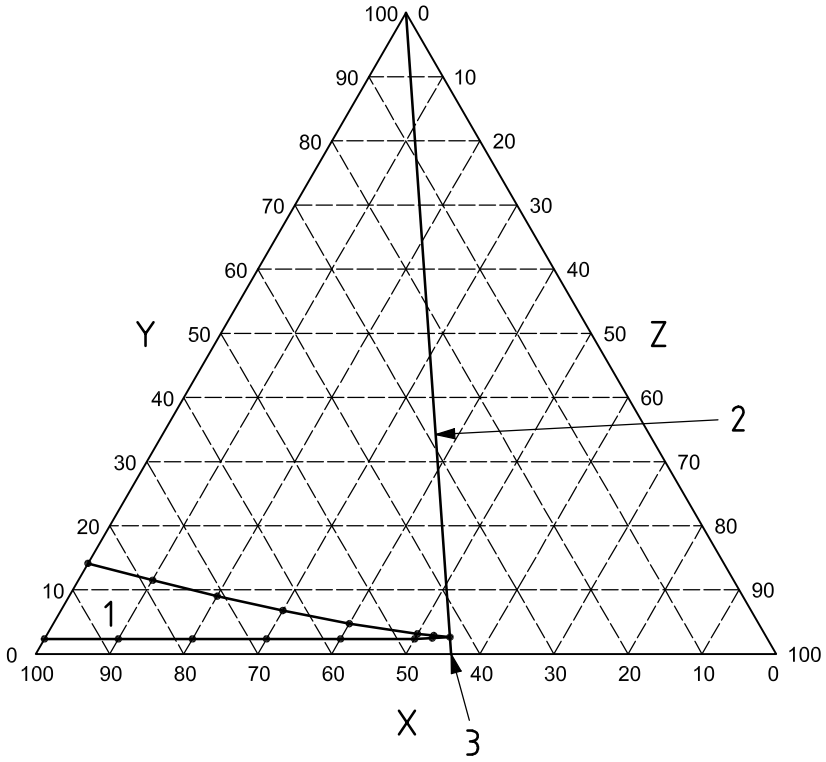
## 2 Test method

### 2.1 Principle

The gas or gas mixture to be evaluated (X) is mixed at a fixed ratio with nitrogen (N) to form a mixture (XN). That fixed ratio shall be the same as in the limiting mixture (NA) of nitrogen and air (A), which just does not support combustion of the reference combustible “ethane” (C) (see Figure 1).

By using the apparatus described in 2.2, the mixture XN is then mixed with increasing amounts of the reference combustible (C) to form test mixtures (XNC). By applying the procedure and criterion to determine flammability, it is observed if these test mixtures are flammable.

If any mixture of XN and C is flammable, the gas to be evaluated (X) is considered to be more oxidizing than air. If flammability is not observed in a range of combustible contents up to a maximum value ($c_{max}$), the gas to be evaluated is considered to be no more oxidizing than air.




**Key**

X air in mol %
Y ethane in mol %
Z nitrogen in mol %
1 explosion range
2 line of constant ratio oxidizer/nitrogen
3 limiting oxidizer fraction, LOF = 43,4 mol % air



**Figure 1 — Determination of limiting oxidizer fraction of air in nitrogen, which does not support the combustion of ethane**

## 2.2 Apparatus and materials

### 2.2.1 Description

The apparatus (see Figure 2) includes

— a closed test vessel with stirrer;

— an ignition system;

— two pressure measuring systems;

— a system for checking the test gas composition.

### 2.2.2 Test vessel

The test vessel shall be made of stainless steel and designed to withstand a maximum overpressure of at least 30 bar (3 MPa). The volume shall be at least 0,005 $m^3$. It can be either cylindrical or spherical. If a cylindrical vessel is used, the length-to-diameter ratio shall be 1. The vessel shall incorporate a stirrer and sufficient ports to enable filling, evacuation and purging.

The vessel shall be equipped with a suitable temperature measuring device.

### 2.2.3 Ignition system

A fusing wire igniter shall be used. This ignition device generates an electric arc by passing an electric current along a straight length of a NiCr-wire connecting two metal rods. The rods (diameter at least 3 mm) shall be parallel to one another at a separation distance of (5 ± 1) mm. The diameter of wire shall be between 0,05 mm and 0,2 mm. The electrical power for melting this wire and generating the arc is supplied by an a.c. isolating transformer (power 0,7 kVA to 3,5 kVA; secondary voltage 230 V). The secondary winding of the transformer shall be switched to the rods by an electronic device allowing adjustment of the ignition energy between 10 J and 20 J. This can be achieved by phase-angle control of secondary voltage by thyristor switching elements.

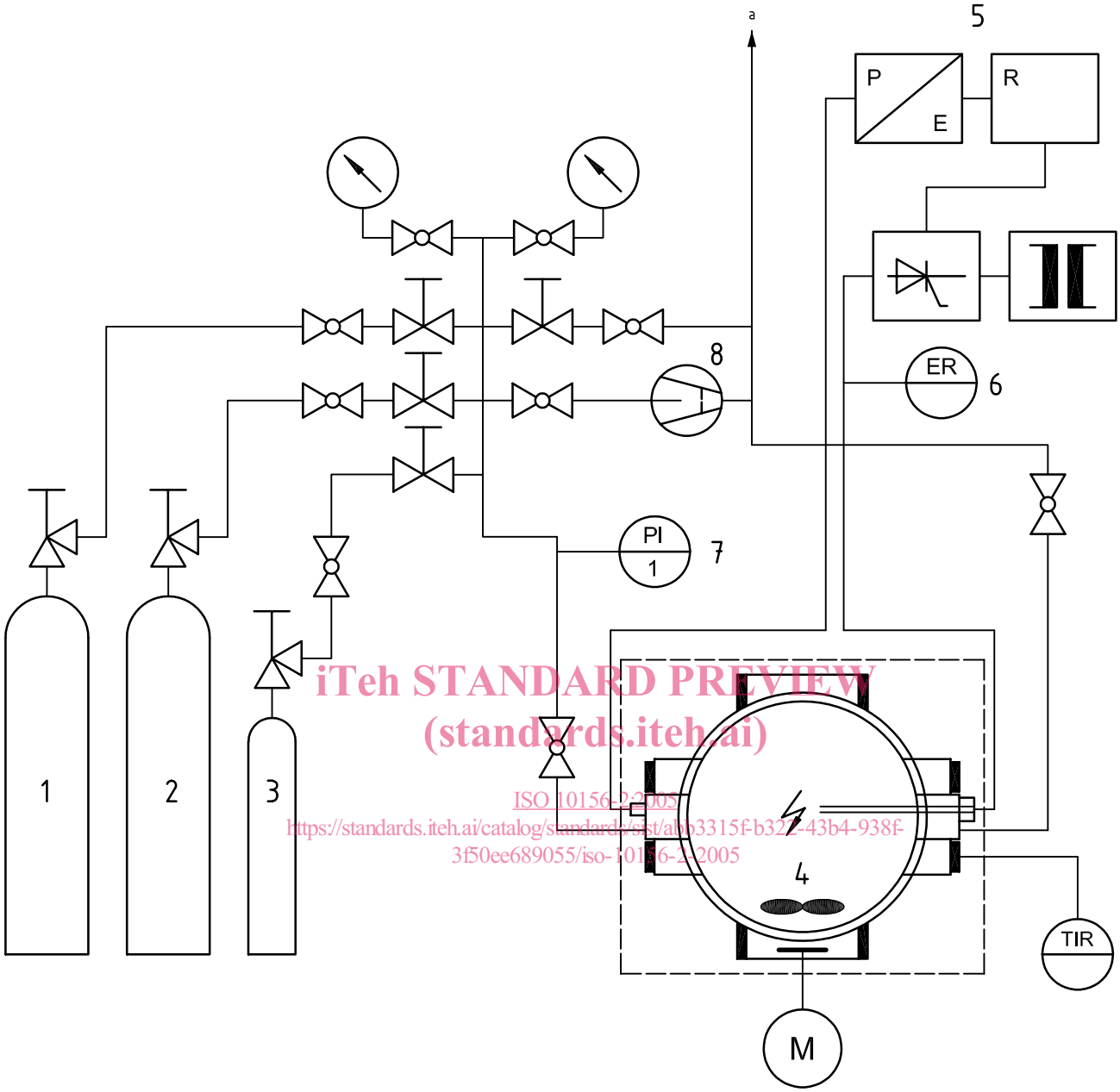
The fusing wire shall be positioned in the centre of the test vessel.

### 2.2.4 Pressure measuring system

The pressure measuring system for the explosion pressure consists of a pressure transducer, an amplifier and a data recording system. The pressure transducer and amplifier shall have a time resolution of at least 1 ms. The transducer shall be pressure resistant to at least a pressure of 30 bar (3 MPa) with a measuring range of 10 bar. The pressure indication system for preparing the test mixtures according to the partial pressure method (pressure transducers or manometers) shall have a measuring range of 2 bar (200 kPa) maximum. Both pressure measuring systems shall have an accuracy of 0,5 % full scale or better.

### 2.2.5 System for checking the test gas composition

The mixture XN or XNC shall be analysed using a gas chromatograph or another suitable type of analyser.






**Key**

1 supply of pressurized oxidizer gas
2 supply of pressurized nitrogen gas
3 supply of pressurized ethane gas
4 test vessel made of stainless steel with magnetic stirrer
5 recording unit for pressure rise inside the ignition vessel
6 fusing wire igniter and electronic control unit
7 pressure indication for preparing test mixtures
8 vacuum pump

[a] Waste gas.

**Figure 2 — Example of apparatus for determination of oxidizing ability of toxic and corrosive gases**

#### 2.2.6 Materials

Ethane (purity > 99,5 %) shall be used as reference combustible (C). Ethane was selected for reference fuel because it has carbon–hydrogen bonds and also a carbon–carbon bond as most of the combustible materials do. Flammability ranges of ethane with many oxidizing gases were already known.

The mixture (XN) shall consist of (43 ± 1) mol % gas to be evaluated and (57 ± 1) mol % nitrogen of a purity 99,995 %. XN can be prepared directly in the test vessel according to the partial pressure of each component. It is also admissible to produce a pressurized mixture (XN) in an evacuated gas cylinder with the aid of an additional metering device and to use this premixed gas for the subsequent procedure.

The mixture (XN), or one of the mixtures (XNC) when this mixture is directly made in the autoclave, shall be analysed.

The moisture content of gases shall be less than 10 μl/l. If for any reason (e.g. hygroscopic gases or unknown substances) this cannot be achieved, this fact shall be indicated in the report.

### 2.3 Procedure

The tests shall be carried out at room temperature and atmospheric pressure. The test mixture (XNC) shall be prepared in the test vessel according to the partial pressures up to a final filling pressure of 1 bar (100 kPa). Ethane is added to the mixture (XN) step by step. For each step, an ignition is initiated and it is observed whether or not a reaction occurs. This reaction is indicated by a pressure rise after ignition of at least 10 % of initial pressure. The tests are started at a fraction of ethane of 1 mol %. If no reaction occurs, the percentage of ethane is increased by steps of 1 mol % until a reaction occurs or until the percentage of ethane is more than 20 mol %.



### 2.4 Results



If reaction has been observed during the tests, the gas or gas mixture to be evaluated has an oxidizing ability greater than air and is to be considered as "highly oxidizing".

## 3 Calculation method

### 3.1 General

This method is only applicable to gas mixtures in small quantities in cylinders. The effect of inert gases other than nitrogen is not considered. If oxidizing gases are mixed with He, Ar, Ne, Kr or Xe, the corresponding coefficient of oxygen equivalency shall be multiplied by 2.

### 3.2 Principle

A gas mixture is considered to be more oxidizing than air if the following condition is satisfied:

$$\sum_i x_i C_i \geqslant 21\,\% \qquad (1)$$

where

$x_i$ is the content of the oxidizing component (mol %);

$C_i$ is the coefficient of oxygen equivalency.