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Explosive atmospheres –
Part 20-1: Material characteristics for gas and vapour classification – Test methods and data

Atmosphères explosives –
Partie 20-1: Caractéristiques des substances pour le classement des gaz et des vapeurs – Méthodes et données d'essai

IEC 60079-20-1:2010

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES –

Part 20-1: Material characteristics for gas and vapour classification – Test methods and data

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International Standard IEC 60079-20-1 has been prepared by IEC technical committee 31: Equipment for explosive atmospheres.

This first edition of IEC 60079-20-1 cancels and replaces the first edition of IEC 60079-1-1(2002), the second edition of IEC 60079-4 (1975), its amendment 1(1995) and its complement: IEC 60079-4A (1970), the first edition of IEC/TR 60079-12 (1978) and the first edition of IEC 60079-20 (1996). It constitutes a technical revision.

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The text of this standard is based on the following documents:

FDIS	Report on voting
31/837/FDIS	31/855/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60079 series, under the general title: *Explosives atmospheres* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- replaced by a revised edition, or
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The contents of the corrigendum of July 2012 have been included in this copy.

EXPLOSIVE ATMOSPHERES –

Part 20-1: Material characteristics for gas and vapour classification – Test methods and data

1 Scope

This part of IEC 60079 provides guidance on classification of gases and vapours. It describes a test method intended for the measurement of the maximum experimental safe gaps (MESG) for gas- or vapour-air mixtures under normal conditions of temperature[1] and pressure so as to permit the selection of an appropriate group of equipment. The method does not take into account the possible effects of obstacles on the safe gaps[2]. This standard describes also a test method intended for use in the determination of the auto-ignition temperature of a chemically pure vapour or gas in air at atmospheric pressure.

The tabulated values of chemical and engineering properties of substances are provided to assist engineers in their selection of equipment to be used in hazardous areas. It is hoped to publish further data from time to time, as the results of tests made in several countries become available.

The scope of these data has been selected with particular reference to the use of equipment in hazardous areas, and notice has been taken of standard measurement methods.

NOTE 1 The data in this standard have been taken from a number of references which are given in the bibliography.

NOTE 2 Some variations in the data may appear when references are compared, but usually the discrepancy is sufficiently small to be of no importance in the selection of equipment.

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.

IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-14, *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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1 An exception is made for substances with vapour pressures which are too low to permit mixtures of the required concentrations to be prepared at normal ambient temperatures. For these substances, a temperature 5 K above that needed to give the necessary vapour pressure or 50 K above the flash point is used.

2 The design of the test apparatus for safe gap determination, other than that used for selecting the appropriate group of enclosure for a particular gas, may need to be different to the one described in this standard. For example, the volume of the enclosure, flange width, gas concentrations and the distance between the flanges and any external wall or obstruction may have to be varied. As the design depends on the particular investigation which is to be undertaken, it is impracticable to recommend specific design requirements, but for most applications the general principles and precautions indicated in the clauses of this standard will still apply.

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NOTE For the definitions of any other terms, particularly those of a more general nature, reference should be made to IEC 60050(426) or other appropriate parts of the IEV (International Electrotechnical Vocabulary).

3.1
ignition by hot surface (auto-ignition)
a reaction in the test flask described in 7.2.2 which is evidenced by a clearly perceptible flame and/or explosion, and for which the ignition delay time does not exceed 5 min

3.2
ignition delay time
the period of time between the introduction of the ignition source and the actual ignition

3.3
auto-ignition temperature
AIT
lowest temperature (of a hot surface) at which under specified test conditions an ignition of a flammable gas or vapour in mixture with air or air/inert gas occurs

3.4
maximum experimental safe gap
MESG
maximum gap between the two parts of the interior chamber which, under the test conditions specified below, prevents ignition of the external gas mixture through a 25 mm long flame path when the internal mixture is ignited, for all concentrations of the tested gas or vapour in air

3.5
minimum igniting current
MIC
minimum current in resistive or inductive circuits that causes the ignition of the explosive test mixture in the spark-test apparatus according to IEC 60079-11

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4 Classification of gases and vapours

4.1 General

Gases and vapours can be classified according to the group or sub-group of equipment required for use in the particular gas or vapour atmosphere.

The general principles used to establish the lists of gases and vapours in the table of Annex B are given below.

4.2 Classification according to the maximum experimental safe gaps (MESG)

Gases and vapours may be classified according to their maximum experimental safe gaps (MESG) into the groups I, IIA, IIB and IIC.

NOTE The standard method for determining MESG should be the vessel described in 6.2, but where determinations have been undertaken only in an 8 l spherical vessel with ignition close to the flange gap these can be accepted provisionally.

The groups for equipment for explosive gas atmospheres are:

Group I: equipment for mines susceptible to firedamp.

Group II: equipment for places with an explosive gas atmosphere other than mines susceptible to firedamp.

Group II equipment is subdivided and, for the purpose of classification of gases and vapours, the MESG limits are:

Group IIA: MESG ≥ 0,9 mm.

Group IIB: 0,5 mm < MESG < 0,9 mm.

Group IIC: MESG ≤ 0,5 mm.

NOTE 1 For gases and highly volatile liquids the MESG is determined at 20 °C.

NOTE 2 If it was necessary to do the MESG determination at temperatures higher than ambient temperature a temperature 5 K above that needed to give the necessary vapour pressure or 50 K above the flash point is used and this value of MESG is given in the table and the classification of the equipment group is based on this result.

4.3 Classification according to the minimum igniting currents (MIC)

Gases and vapours may be classified according to the ratio of their minimum igniting currents (MIC) with the ignition current of laboratory methane. The standard method of determining MIC ratios shall be with the apparatus described in IEC 60079-11, but where determinations have been undertaken in other apparatus these can be accepted provisionally.

Group II equipment is subdivided and, for the purpose of classification of gases and vapours, the MIC ratios are:

Group IIA: MIC > 0,8.

Group IIB: 0,45 ≤ MIC ≤ 0,8.

Group IIC: MIC < 0,45.

4.4 Classification according to MESG and MIC

For most gases and vapours, it is sufficient to make only one determination of either MESG or MIC ratio to classify the gas or vapour.

One determination is adequate when:

Group IIA: MESG ≥ 0,9 mm, or MIC > 0,9;

Group IIB: 0,55 mm ≤ MESG < 0,9 mm, or 0,5 ≤ MIC ≤ 0,8;

Group IIC: MESG < 0,5 mm, or MIC < 0,45.

Determination of both the MESG and MIC ratio is required when:

for IIA: 0,8 ≤ MIC ≤ 0,9 need to confirm by MESG;

for IIB: 0,45 ≤ MIC ≤ 0,5 need to confirm by MESG;

for IIC: 0,5 ≤ MESG < 0,55 need to confirm by MIC.

4.5 Classification according to a similarity of chemical structure

When a gas or vapour is a member of an homologous series of compounds, the classification of the gas or vapour can provisionally be inferred from the data of the other members of the series with lower molecular weights. However, it is best to run the test if it is possible.

4.6 Classification of mixtures of gases

Mixtures of gases should generally be allocated to a group only after a special determination of MESG or MIC ratio. One method to estimate the group is to determine the MESG of the mixture by applying a form of Le Châtelier relationship:

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$$MESG_{mix} = \frac{1}{\sum_i \left(\frac{X_i}{MESG_i} \right)}$$

This method should not be applied to mixtures and/or streams that have:

a) acetylene or its equivalent hazard;

b) oxygen or other strong oxidizer as one of the components;

c) large concentrations (over 5 %) of carbon monoxide. Because unrealistically high MESG values may result, caution should be exercised with two component mixtures where one of the components is an inert, such as nitrogen.

For mixtures containing an inert such as nitrogen in concentrations less than 5 % by volume, use an MESG of infinity. For mixtures containing an inert such as nitrogen in concentrations 5 % and greater by volume, use an MESG of 2.

An alternate method that includes stoichiometric ratios is presented in the paper by Brandes and Redeker.

5 Data for flammable gases and vapours, relating to the use of equipment

5.1 Determination of the properties

5.1.1 General

The compounds listed in this standard are in accordance with Clause 4, or have physical properties similar to those of other compounds in that list.

5.1.2 Equipment group

The groups are the result of MESG or MIC ratio determination except where there is no value listed for MESG or MIC ratio. For these, the group is based on chemical similarity (see Clause 4).

NOTE If it was necessary to do the MESG determination at temperatures higher than ambient temperature a temperature 5 K above that needed to give the necessary vapour pressure or 50 K above the Flash Point is used and this value of MESG is given in the table of Annex B and the classification of the equipment group is based on this result.

5.1.3 Flammable limits

Determinations have been made by a number of different methods, but the preferred method is with a low energy ignition at the bottom of a vertical tube. The values (in percentage by volume and mass per volume) are listed in the table of Annex B.

If the flash point is high, the compound does not form a flammable vapour air/mixture at normal ambient temperature. Where flammability data are presented for such compounds the determinations have been made at a temperature sufficiently elevated to allow the vapour to form a flammable mixture with air.

5.1.4 Flash point FP

The value given in the table of Annex B is the “closed cup” measurement. When this data was not available the “open cup” value is quoted. The symbol < (less than), indicates that the flash point is below the value (in degree Celsius) stated, this probably being the limit of the apparatus used.

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5.1.5 Temperature class

The temperature class of a gas or vapour is given according IEC 60079-14 in the following table:

Table 1 – Classification of temperature class and range of auto-ignition temperatures

Temperature class	Range of auto-ignition temperature (AIT) °C
T1	> 450
T2	300 < AIT ≤ 450
T3	200 < AIT ≤ 300
T4	135 < AIT ≤ 200
T5	100 < AIT ≤ 135
T6	85 < AIT ≤ 100

5.1.6 Minimum igniting current (MIC)

The apparatus for the determination of minimum igniting current is defined in IEC 60079-11. The test apparatus shall be operated in a 24 V d.c. circuit containing a (95 ± 5) mH air-cored coil. The current in this circuit is varied until ignition of the most easily ignited concentration of the specific gas or vapour in air is obtained.

5.1.7 Auto-ignition temperature

The value of auto-ignition temperature depends on the method of testing. The preferred method and data obtained is given in Clause 7 and in Annex B.

If the compound is not included in these data, the data obtained in similar apparatus, such as the apparatus described by ASTM International standard (ASTM E659), is listed [3].

5.2 Properties of particular gases and vapours

5.2.1 Coke oven gas

Coke oven gas is a mixture of hydrogen, carbon monoxide and methane. If the sum of the concentrations (vol %) of hydrogen and carbon monoxide is less than 75 % of the total, flameproof equipment of Group IIB is recommended, otherwise equipment of Group IIC is recommended.

5.2.2 Ethyl nitrite

The auto-ignition temperature of ethyl nitrite is 95 °C, above which the gas suffers explosive decomposition.

NOTE Ethyl nitrite should not be confused with its isomer, nitroethane.

5.2.3 MESG of carbon monoxide

The MESG for carbon monoxide relates to a mixture with air saturated with moisture at normal ambient temperature. This determination indicates the use of Group IIB equipment in the presence of carbon monoxide. A larger MESG may be observed with less moisture. The lowest MESG (0,65 mm) is observed for a mixture of CO/H_2O near 7: molar ratio. Small

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3 Results from using the apparatus described in ASTM D2155 (now replaced by ASTM E659) were reported by C.J. Hilado and S.W. Clark. The apparatus is similar to the one used by Zabetakis. If there is no determination by either the IEC apparatus, nor similar apparatus, the lowest value obtained in other apparatus is listed. A more comprehensive list of data for auto ignition temperature, with the reference to sources, is given by Hilado and Clark.

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quantities of hydrocarbon in the carbon monoxide/air mixture have a similar effect in reducing the MESG so that Group IIB equipment is required.

5.2.4 Methane, Group IIA

Industrial methane, such as natural gas, is classified as Group IIA, provided it does not contain more than 25 % (V/V) of hydrogen. A mixture of methane with other compounds from Group IIA, in any proportion is classified as Group IIA.

6 Method of test for the maximum experimental safe gap

6.1 Outline of method

The interior and exterior chambers of the test apparatus are filled with a known mixture of the gas or vapour in air, under normal conditions of temperature[4] and pressure (20 °C, 100 kPa) and with the circumferential gap between the two chambers accurately adjusted to the desired value. The internal mixture is ignited and the flame propagation, if any, is observed through the windows in the external chamber. The maximum experimental safe gap for the gas or vapour is determined by adjusting the gap in small steps to find the maximum value of gap which prevents ignition of the external mixture, for any concentration of the gas or vapour in air.

6.2 Test apparatus

6.2.1 General

The apparatus is described in the following subclauses and is shown schematically in Figure 1 It is also possible to use an automatic set-up when it is proven that the same results are obtained as with a manual apparatus.

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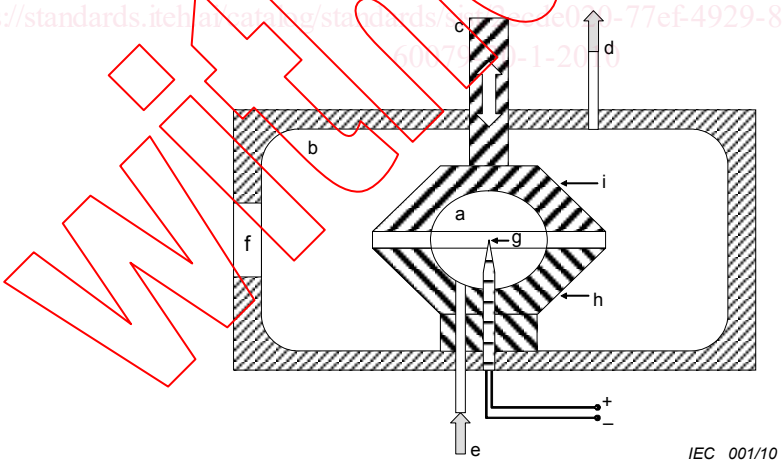

Key

a interior spherical chamber
b exterior cylindrical enclosure
c adjustable part
d outlet of mixture
e inlet of mixture
f observation windows
g spark electrode
h lower gap plate, fixed
i upper gap plate, adjustable

Figure 1 – Test apparatus

4 An exception is made for substances with vapour pressures which are too low to permit mixtures of the required concentrations to be prepared at normal ambient temperatures. For these substances, a temperature 5 K above that needed to give the necessary vapour pressure or 50 K above the flash point is used.

6.2.2 Mechanical strength

The whole apparatus is constructed to withstand a maximum pressure of 1 500 kPa without significant expansion of the gap, so that no such expansion of the gap will occur during an explosion.

6.2.3 Interior chamber

The interior chamber "a" is a sphere with a volume measuring 20 cm^3.

6.2.4 Exterior chamber

The exterior cylindrical enclosure "b" has a diameter of 200 mm and a height of 75 mm.

6.2.5 Gap adjustment

The two parts "i" and "h" of the internal chamber are so arranged that an adjustable 25 mm gap can be set up between the plane parallel faces of the opposing rims. The exact width of the gap can be adjusted by means of the micrometer (part "c").

6.2.6 Injection of mixture

The internal chamber is filled with the gas-air or vapour-air mixture through an inlet ("e"). The exterior chamber is filled with the mixture via the gap. The inlet and outlet should be protected by flame arresters.

6.2.7 Source of ignition

The electrodes "g" shall be mounted in such a way that the spark path is perpendicular to the plane of the joint and should be symmetrically placed on both sides of the plane.

6.2.8 Materials of test apparatus

The main parts of the test apparatus, and in particular the walls and flanges of the inner chamber and the electrodes of the spark-gap, are normally of stainless steel. Other materials may have to be used with some gases or vapours, however, in order to avoid corrosion or other chemical affects. Light alloys should not be used for the spark-gap electrodes.

6.3 Procedure

6.3.1 Preparation of gas mixtures

As the consistency of the mixture concentration, for a particular test series, has a pronounced effect on the dispersion of the test results, it has to be carefully controlled. The flow of the mixture through the chamber is therefore maintained until the inlet and outlet concentrations are the same, or a method of equivalent reliability must be used.

The moisture content of the air used for the preparation of the mixture should not exceed 0,2 % by volume (10 % relative humidity).

6.3.2 Temperature and pressure

The tests are made at an ambient temperature of (20 ± 5) °C, except where otherwise permitted[5]. The pressure within the test apparatus is adjusted to (1 ± 0,01) kPa.

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5 An exception is made for substances with vapour pressures which are too low to permit mixtures of the required concentrations to be prepared at normal ambient temperatures. For these substances, a temperature 5 K above that needed to give the necessary vapour pressure or 50 K above the flash point is used.

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6.3.3 Gap adjustment

The gap is first reduced to a very small value and examined to ensure that the flanges are parallel. The zero setting of the gap is checked but the value of torque applied should be low (e.g. a force of about 10^{-2} N applied at the circumference of the micrometer head).

6.3.4 Ignition

The internal mixture is ignited by an electrical spark with a voltage of approximately 15 kV.

6.3.5 Observation of the ignition process

Ignition of the internal mixture is confirmed by observation through the gap when the test is made. If no internal ignition occurs, the test is invalid. Ignition of the mixture in the external chamber is taken to occur when the whole volume of the chamber is seen to be filled by the flame of the explosion.

6.4 Determination of maximum experimental safe gap (MESG)

6.4.1 Preliminary tests

With a defined mixture of the combustible vapour or gas with air, two ignition tests are carried out on a number of gaps, at 0,02 mm intervals, covering the range from a safe gap to an unsafe gap. From the results, the highest gap, g_0, at which there is 0 % probability of ignition, and the lowest gap, g_{100}, giving 100 % probability of ignition, are determined.

The test series is repeated with a range of mixture concentrations, and the variation of the gap g_0 and g_{100} are obtained. The most dangerous mixture is that for which these values are a minimum.

6.4.2 Confirmatory tests

The results are confirmed by repeating the tests, with 10 explosion tests for each step of gap adjustment, at a number of concentrations in the neighbourhood of the most dangerous mixture found in the preliminary series. The minimum values of g_0 and g_{100} are then determined.

6.4.3 Reproducibility of maximum experimental safe gaps

The highest acceptable difference between the values of $(g_0)_{min}$ obtained from different test series is 0,04 mm.

If all values are within this range, the tabulated value of MESG will be equal to $(g_0)_{min}$ where $(g_{100})_{min} - (g_0)_{min}$ is the smallest. For most substances, this difference will lie within one step of gap adjustment, i.e. within 0,02 mm.

If the difference between the values of $(g_0)_{min}$ taken from different test series exceeds 0,04 mm, the laboratories concerned should repeat their tests after confirming that the test apparatus is able to reproduce the tabulated value for hydrogen.

6.4.4 Tabulated values

The values of the MESG, the difference $(g_{100})_{min} - (g_0)_{min}$ and the most igniting concentration determined in 6.4.1 are tabulated below in Annex B.

The value of the MESG is used to determine the group. The value $(g_{100})_{min} - (g_0)_{min}$ indicates the accuracy of the tabulated value of the MESG.

Withdrawn
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