

BS EN 12021:2014

Incorporating corrigenda October 2014 and November 2014



BSI Standards Publication

Respiratory equipment — Compressed gases for breathing apparatus

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National foreword

This British Standard is the UK implementation of EN 12021:2014. It supersedes BS EN 12021:1999, which is withdrawn. It partially supersedes BS 8478:2011, as the test methods in clause 5 specified in BS 8478:2011 have been retained.

This European standard specifies that 'compressed gas for breathing shall not contain contaminants at a concentration which can cause toxic or harmful effects' and that 'all contaminants shall be kept to as low a level as possible'. In the opinion of the UK committee, contaminants that are not listed in this standard may also be present for various reasons; including leakage of ambient contaminants into the face mask. In some cases the effects of these contaminants could be additive or even considerably greater than the sum of their individual effects. In addition, an individual's susceptibility to similar chemicals can vary significantly.

In regards to the UK implementation of this standard, for compressed breathing air, the concentration level of the contaminants should be as low as possible. For those contaminants that are not listed in this standard, the level should not be greater than one tenth of the relevant time (8 h) weighted average Workplace Exposure Limit (WEL). The UK National WEL for substances hazardous to health are published by the Health and Safety Executive and can be found in the publication, Workplace Exposure limits (EH40).

To ensure consistency in the application of this standard and in the analysis of the gases and any contaminants, a National Annex is included which includes the test methods previously specified in BS 8478.

The UK participation in its preparation was entrusted by Technical Committee PH/4, Respiratory protection, to Subcommittee PH/4/7, Underwater breathing apparatus.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Date	Text affected
31 October 2014	Correction to supersession details in national foreword
30 November 2014	Correction to paragraph 3 of the national foreword

English Version

Respiratory equipment - Compressed gases for breathing apparatus

Appareils de protection respiratoire - Gaz comprimés pour
appareil de protection respiratoire

Atemgeräte - Druckgase für Atemschutzgeräte

This European Standard was approved by CEN on 6 February 2014.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Foreword

This document (EN 12021:2014) has been prepared by Technical Committee CEN/TC 79 “Respiratory protective devices”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2014, and conflicting national standards shall be withdrawn at the latest by October 2014.

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

This document supersedes EN 12021:1998.

Annex B provides details of significant technical changes between this European Standard and the previous edition.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies requirements for the quality of compressed gas supplied for mixing or use in respiratory protective devices and hyper- and hypobaric operations. Account is taken of the use of compressed gases for normal atmospheric pressure as well as for hyper- and hypobaric pressures.

This European Standard does not apply to compressed gases used for medical purposes or for aerospace applications.

2 Normative references

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

EN 132:1998, *Respiratory protective devices - Definitions of terms and pictograms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 132:1998 and the following apply.

- 3.1**
hydrocarbon
organic compound consisting of hydrogen and carbon
- 3.2**
oil
mixture of hydrocarbons and other organic compounds composed of six or more carbon atoms (C6+)
- 3.3**
trimix
gas comprising a specified mixture of oxygen, helium and nitrogen, capable of supporting human life under appropriate diving or hyperbaric conditions

Note 1 to entry: This includes manufactured gas mixtures made up from combinations of pure oxygen, pure helium and pure nitrogen, with or without compressed air.

- 3.4**
heliox
gas comprising a specified mixture of oxygen and helium, capable of supporting human life under appropriate diving or hyperbaric conditions

- 3.5**
oxygen and nitrogen gas mixture
gas comprising a specified mixture of oxygen and nitrogen, capable of supporting human life under appropriate diving or hyperbaric conditions

Note 1 to entry: Oxygen and nitrogen gas mixtures are also known as "nitrox".

Note 2 to entry: This definition does not cover gas mixtures produced using oxygen compatible air or nitrogen depleted air.

3.6

oxygen compatible air

compressed natural breathing air where the level of impurities has been reduced to make it suitable for use in gas mixtures including those containing oxygen concentrations greater than 22 %

Note 1 to entry: Oxygen compatible air is also known in the diving industry as “oil free air”, “clean air” or “double filtered air”.

3.7

nitrogen depleted air

oxygen compatible air from which some nitrogen has been removed to make it suitable for use in, or as, a gas mixture containing oxygen concentrations greater than 22 %

Note 1 to entry: Nitrogen depleted air is also known as “nitrox”.

3.8

oxygen enriched air

compressed natural breathing air to which some oxygen has been added prior to compression and the level of some impurities reduced to make it suitable for use in or as a gas mixture containing oxygen concentrations greater than 22 %

Note 1 to entry: Oxygen enriched air is also known as “nitrox”.

3.9

dewpoint

at a specified pressure, the temperature at, or below which, condensation from the gas phase will occur

Note 1 to entry: This also includes frost point.

3.10

synthetic air

mixture of oxygen and nitrogen that has an oxygen content of $(21 \pm 1) \%$

Note 1 to entry: Synthetic air is also known as “nitrox”.

4 Units

General use of SI units (see ISO 80000) as given throughout this International Standard is recommended. However, in agreement with accepted practice, some non-preferred SI units accepted by ISO are also used.

EXAMPLE 100 kPa = 1,00 bar.

IMPORTANT — The acronym ‘ppm’ (parts per million) is used throughout the world to indicate the absolute content of a substance within a mixture. So in this case the ml m^{-3} equivalent notation “ppm” has been used in brackets in the tables. In this European Standard ppm is understood as concentration of a gas in parts per million per volume.

5 Reference conditions

All data given in the tables or required in this European Standard are valid for normal atmospheric pressure (1 013 mbar absolute, 20 °C). All percentage requirements are given in % by volume (dry gas).

All pressures in this European Standard are in bar absolute.

Typical composition of natural air is given in Annex A.

Maximum allowable concentrations of impurities for compressed gases are quoted as values calculated at normal atmospheric pressure.

6 Requirements

6.1 General

Compressed gas for breathing shall not contain contaminants at a concentration which can cause toxic or harmful effects. In any event, all contaminants shall be kept to as low a level as possible and shall be less than one tenth of a national 8 h exposure limit. For breathing air only the limit shall be less than one sixth of a national 8 h exposure limit. For breathing at hyperbaric pressures greater than 10 bar or exposure times greater than 8 h the levels shall be revised to take into account the effects of pressure and exposure times.

In the absence of more stringent national regulations, the values in Table 1 to Table 10 shall be applied.

6.2 Breathing air

Typical composition of natural air is given in Annex A.

Table 1 — Composition of breathing air

Component	Concentration at 1 013 mbar and 20 °C
Oxygen	(21 ± 1) %
Carbon dioxide	≤ 500 ml m ⁻³ (ppm)
Carbon monoxide	≤ 5 ml m ⁻³ (ppm)
Oil	≤ 0,5 mg m ⁻³

Compressed breathing air shall have a dew point sufficiently low to prevent condensation and freezing. Where the apparatus is used and stored at a known temperature the pressure dew point shall be at least 5 °C below the likely lowest temperature.

Where the conditions of usage and storage of any compressed air supply is not known the pressure dew point shall not exceed -11 °C.

Table 2 — Water content of high pressure breathing air

Nominal maximum supply pressure bar	Maximum water content of air at atmospheric pressure and 20 °C mg m ⁻³
40 to 200	≤ 50
> 200	≤ 35

The water content of the air supplied by the compressor for filling 200 bar or 300 bar cylinders should not exceed 25 mg m⁻³.

Table 3 — Water content for supplied breathing air up to 40 bar

Nominal maximum supply pressure (bar)	Maximum water content of air at atmospheric pressure and 20 °C mg m ⁻³
5	290
10	160
15	110
20	80
25	65
30	55
40	50

6.3 Mixing of gases

6.3.1 General

Where any of the gases specified in Table 4 to Table 10 are mixed to produce a breathing gas, the resultant gas mixture shall be tested for oxygen content. The oxygen content shall conform to the relevant value as given for the particular gas mixture, as applicable.

Where any of the gases specified in Table 8 to Table 9 are mixed to create a diving breathing gas, the resultant gas mixture shall also be tested for helium content. The helium content shall conform to the relevant value as given for the particular gas mixture in Table 8 to Table 9, as applicable.

As the purity and contaminant levels of the gases used for mixing are specified in Table 4 to Table 9 it is only the ratio of the mixing that needs to be confirmed. Therefore, post mixing, only the oxygen and, where applicable, the helium content need to be tested to confirm that the correct mixture has been achieved.

6.3.2 Oxygen compatible air

Table 4 — Composition of oxygen compatible air

Component	Concentration at 1 013 mbar and 20 °C
Oxygen	(21 ± 1) %
Water	≤ 25 mg m ⁻³
Carbon dioxide	≤ 500 ml m ⁻³ (ppm)
Carbon monoxide	≤ 5 ml m ⁻³ (ppm)
Oil	≤ 0,1 mg m ⁻³

6.3.3 Nitrogen depleted air and oxygen enriched air

Table 5 — Composition of nitrogen depleted air and oxygen enriched air

Component	Concentration at 1 013 mbar and 20 °C
Oxygen	(Stated ^a ± 1,0) %
Water	≤ 25 mg m ⁻³
Carbon dioxide	≤ 500 ml m ⁻³ (ppm)
Carbon monoxide	≤ 5 ml m ⁻³ (ppm)
Oil	≤ 0,1 mg m ⁻³
^a Percentage as stated by the supplier.	

6.3.4 Breathing oxygen

Table 6 — Composition of breathing oxygen

Component	Concentration at 1 013 mbar and 20 °C
Oxygen	> 99,5 %
Water	≤ 15 mg m ⁻³
Carbon dioxide	≤ 5 ml m ⁻³ (ppm)
Carbon monoxide	≤ 1 ml m ⁻³ (ppm)
Oil	≤ 0,1 mg m ⁻³
Total volatile non-substituted hydrocarbons (vapour or gas) as methane equivalent	≤ 30 ml m ⁻³ (ppm)
Total chlorofluorocarbons and halogenated hydrocarbons	≤ 2 ml m ⁻³ (ppm)
Other non-toxic gases ^a	< 0,5 %
^a These gases include argon and all other noble gases (see reference [10]).	

6.3.5 Oxygen and nitrogen gas mixtures

Table 7 — Composition of oxygen and nitrogen gas mixtures

Component	Concentration at 1 013 mbar and 20 °C
Oxygen mixtures containing < 20 % by volume	(Stated ^a ± 0,5 ^b) %
≥ 20 % by volume	(Stated ^a ± 1,0 ^b) %
Nitrogen	Remainder
Water	≤ 15 mg m ⁻³
Carbon dioxide	≤ 5 ml m ⁻³ (ppm)
Carbon monoxide	≤ 3 ml m ⁻³ (ppm)
Oil	≤ 0,1 mg m ⁻³
Total volatile non-substituted hydrocarbons (vapour or gas) as methane equivalent	≤ 30 ml m ⁻³ (ppm)
Other non-toxic gases ^c	< 1 %
^a Percentage as stated by the supplier.	
^b Tolerance value is a percentage of the total gas mixture.	
^c These gases include argon and all other noble gases (see reference [10]).	

6.3.6 Oxygen and helium gas mixtures

Table 8 — Composition of oxygen and helium gas mixtures

Component	Concentration at 1 013 mbar and 20 °C
Oxygen mixtures containing ≤ 10 % by volume	(Stated ^a ± 0,25 ^b) %
> 10 % to ≤ 20 % by volume	(Stated ^a ± 0,5 ^b) %
> 20 % by volume	(Stated ^a ± 1,0 ^b) %
Helium	Remainder
Water	≤ 15 mg m ⁻³
Carbon dioxide	≤ 5 ml m ⁻³ (ppm)
Carbon monoxide	≤ 0,2 ml m ⁻³ (ppm)
Oil	≤ 0,1 mg m ⁻³
Total volatile non-substituted hydrocarbons (vapour or gas) as methane equivalent	≤ 30 ml m ⁻³ (ppm)
Hydrogen	≤ 10 ml m ⁻³ (ppm)
Other non-toxic gases ^c	< 0,5 %
^a Percentage as stated by the supplier.	
^b Tolerance value is a percentage of the total gas mixture.	
^c These gases include argon and all other noble gases (see reference [10]).	

6.3.7 Oxygen, helium and nitrogen gas mixtures

Table 9 — Composition of oxygen, helium and nitrogen gas mixtures

Component	Concentration at 1 013 mbar and 20 °C
Oxygen mixtures containing ≤ 10 % by volume	(Stated ^a $\pm 0,25$ ^b) %
> 10 % to ≤ 20 % by volume	(Stated ^a $\pm 0,5$ ^b) %
> 20 % by volume	(Stated ^a $\pm 1,0$ ^b) %
Helium	(Stated ^a $\pm 1,0$ ^b) %
Nitrogen	Remainder
Water	$\leq 15 \text{ mg m}^{-3}$
Carbon dioxide	$\leq 5 \text{ ml m}^{-3}$ (ppm)
Carbon monoxide	$\leq 0,2 \text{ ml m}^{-3}$ (ppm)
Oil	$\leq 0,1 \text{ mg m}^{-3}$
Total volatile non-substituted hydrocarbons (vapour or gas) as methane equivalent	$\leq 30 \text{ ml m}^{-3}$ (ppm)
Hydrogen	$\leq 10 \text{ ml m}^{-3}$ (ppm)
Other non-toxic gases ^c	< 1 %
^a Percentage as stated by the supplier. ^b Tolerance value is a percentage of the total gas mixture. ^c These gases include argon and all other noble gases (see reference [10]).	

6.3.8 Helium

WARNING — Helium is specified in this standard as a gas for mixing with other gases to produce an appropriate breathing gas for diving or hyperbaric operations. Helium is an asphyxiant; it shall never be used alone as a breathing gas.

Table 10 — Composition of helium

Component	Concentration at 1 013 mbar and 20 °C
Oxygen	< 0,1 %
Helium	> 99,9 %
Water	≤ 15 mg m ⁻³
Carbon dioxide	≤ 5 ml m ⁻³ (ppm)
Carbon monoxide	≤ 0,2 ml m ⁻³ (ppm)
Oil	≤ 0,1 mg m ⁻³
Total volatile non-substituted hydrocarbons (vapour or gas) as methane equivalent	≤ 30 ml m ⁻³ (ppm)
Hydrogen	≤ 10 ml m ⁻³ (ppm)
Other non-toxic gases ^a	Remainder
^a These gases include argon and all other noble gases (see reference [10]).	

6.4 Odour

The gas shall be free from unsatisfactory odour or taste.

NOTE For guidance on measuring odour or taste detection thresholds, see ISO 13301. For determination of odour concentration, see EN 13725.

7 Sampling and testing

Any appropriate method may be employed.

- For measuring and assessing results the accuracy of the method shall be taken into consideration.
- The detection limit of the method employed shall be below the required limit value.

NOTE 1 For standards on gas analysis see ISO 7504 (vocabulary), ISO/TS 14167 (use of calibration mixtures) and EN ISO 14912 (conversion of composition data).

NOTE 2 See also EN 482 and EN 689.

8 Designation

Designation of breathing gases meeting the requirements of Clause 7.

Name of breathing gas – Mixture – EN 12021

If the mixture indicates values the first stands for the oxygen content and the second for the helium content.

EXAMPLES Air – EN 12021

Oxygen compatible air – EN 12021

Oxygen – EN 12021

Nitrox – 30 – EN 12021

Heliox – 14/86 – EN 12021

Trimix – 16/40 – EN 12021

Annex A
(informative)

Natural air

Table A.1 — Nominal dry clean air composition near sea level (ISO 2533:1975)

Component	Molar mass M kg·kmol ⁻¹	Volume %
Oxygen (O ₂)	31,998 8	20,947 6
Nitrogen (N ₂)	28,013 4	78,084
Argon (Ar)	39,948	0,934
Carbon dioxide (CO ₂)	44,009 95 ^a	0,031 4
Hydrogen (H ₂)	2,015 94	50 × 10 ⁻⁶
Neon (Ne)	20,183	1,8 × 10 ⁻³
Helium (He)	4,002 6	524 × 10 ⁻⁶
Krypton (Kr)	83,80	114 × 10 ⁻⁶
Xenon (Xe)	131,30	87 × 10 ⁻⁶
^a Since 1975 CO ₂ level has increased.		

Annex B (informative)

Details of significant technical changes between this European Standard and the previous edition

The significant technical changes between this European Standard and the previous edition are the following:

- a) change of title to include compressed gases for breathing apparatus;
- b) inclusion of relevant definitions;
- c) inclusion of tables for breathing gases other than air;
- d) inclusion of additional designations.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 89/686/EEC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 89/686/EEC on Personal Protective Equipment.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 89/686/EEC on Personal Protective Equipment

Clause(s)/subclause(s) of this EN	Basic Requirement (EU Directive 89/686/EEC, Annex II)	Qualifying remarks/Notes
6	1.2.1.1 Suitable constituent materials	
6	3.10.1 Respiratory protection	
6	3.11 Safety devices for diving equipment	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this European Standard.

Bibliography

- [1] EN 482, *Workplace exposure - General requirements for the performance of procedures for the measurement of chemical agents*
- [2] EN 689, *Workplace atmospheres - Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy*
- [3] EN 13725, *Air quality - Determination of odour concentration by dynamic olfactometry*
- [4] EN ISO 14912, *Gas analysis - Conversion of gas mixture composition data (ISO 14912)*
- [5] ISO 2533, *Standard Atmosphere*
- [6] ISO 7504, *Gas analysis — Vocabulary*
- [7] ISO 13301, *Sensory analysis — Methodology — General guidance for measuring odour, flavour and taste detection thresholds by a three-alternative forced-choice (3-AFC) procedure*
- [8] ISO/TS 14167, *Gas analysis — General quality assurance aspects in the use of calibration gas mixtures - Guidelines*
- [9] ISO 80000 (all parts), *Quantities and units*
- [10] INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY. Periodic Table of the Elements, available at: http://www.iupac.org/fileadmin/user_upload/news/IUPAC_Periodic_Table-1Jun12.pdf

National Annex NA to BS EN 12021 (informative)

NA.1 Introduction

This European standard specifies requirements for the quality of compressed gas supplied for mixing or use in respiratory protective devices and hyper- and hypobaric operations. However, it does not specify the test methods to be used.

To ensure consistency in the application of this standard and in the analysis of the gases and any contaminants, this informative national annex has included the test methods previously specified in BS 8478:2011.

NA.2 Freedom from toxic components

For UK application, where the gas is to be used for breathing at ambient pressures greater than 10 bar and/or periods in excess of 8 h (subclause 6.1), the calculations given in EH 75/2 to take account of the increased pressure and/or duration should be applied.

NOTE At ambient pressures greater than 10 bar the level of contaminants needs to be less than 1/10th of the workplace exposure limit given in EH 40. Therefore the calculations given in EH 75/2 need to be applied.

NA.3 Test Methods

This Annex specifies the test methods to fulfil the requirements of clause 6 in BS EN 12021, as identified in Table NA. 1.

Table NA.1 – Clauses containing test method

Component	Table 1 Breathing air	Table 2 & 3 Water content breathing air	Table 4 Oxygen compatible air	Table 5 Nitrogen depleted air and oxygen enriched air	Table 6 Breathing oxygen	Table 7 Oxygen and nitrogen gas mixtures	Table 8 Oxygen and helium mixtures	Table 9 Oxygen, helium and nitrogen mixtures	Table 10 Helium
Odour	NA.5	-	NA.5	NA.5	NA.5	NA.5	NA.5	NA.5	NA.5
Oxygen	NA.11	-	NA.11	NA.11	NA.11	NA.11	NA.11	NA.11	NA.11
Carbon Dioxide	NA.7, NA.8 or NA.16	-	NA.7, NA.8 or NA.16	NA.7, NA.8 or NA.16	NA.7, NA.8 or NA.16	NA.7, NA.8 or NA.16	NA.7, NA.8 or NA.16	NA.7, NA.8 or NA.16	NA.7, NA.8 or NA.16
Carbon Monoxide	NA.7, NA.8 or NA.16	-	NA.7, NA.8 or NA.16	NA.7, NA.8 or NA.16	NA.7 or NA.8	NA.7 or NA.8	NA.7 or NA.8	NA.7 or NA.8	NA.7 or NA.8
Oil	NA.15 or NA.16	-	NA.15 or NA.16	NA.15 or NA.16	NA.15	NA.15	NA.15	NA.15	NA.15
Water	-	NA.6 or NA.16	NA.6 or NA.16	NA.6 or NA.16	NA.6	NA.6	NA.6	NA.6	NA.6

Component	Table 1 Breathing air	Table 2 & 3 Water content breathing air	Table 4 Oxygen compatible air	Table 5 Nitrogen depleted air and oxygen enriched air	Table 6 Breathing oxygen	Table 7 Oxygen and nitrogen gas mixtures	Table 8 Oxygen and helium mixtures	Table 9 Oxygen, helium and nitrogen mixtures	Table 10 Helium
Total volatile non-substituted hydrocarbons (vapour or gas) as methane equivalent	-	-	-	-	NA.7 or NA.8	NA.7 or NA.8	NA.7 or NA.8	NA.7 or NA.8	NA.7 or NA.8
Total chlorofluorocarbons and halogenated hydrocarbons	-	-	-	-	NA.7 or NA.9	-	-	-	-
Helium	-	-	-	-	-	-	NA.14	NA.14	NA.14
Hydrogen	-	-	-	-	-	-	NA.12	NA.12	NA.12
Nitrogen	-	-	-	-	-	NA.13	-	NA.13	-
Other non-toxic gases	-	-	-	-	NA.10	NA.10	NA.10	NA.10	NA.10

NA. 4 Test methods

WARNING 1 Care should be taken to ensure that the gas stream issuing from an outlet port is vented safely to waste when tests are carried out on gases containing more than 21 % oxygen or less than 12 % oxygen as these could otherwise give rise to oxygen enrichment or oxygen depletion respectively.

WARNING 2 Gas samples should not be taken directly from a high pressure source as this could be hazardous. The pressure of the gas being sampled should always be reduced by means of a pressure regulator.

NA.4.1 General

All gas analysis results should be corrected to 1.013 bar¹ and 20 °C.

NA.4.2 Sampling

Samples should be taken from a pressure receptacle (cylinder), or from the point of supply (charging connection).

Samples should be taken and analysed at least every three months or more frequently if there has been a change in, or concerns relating to, the production process.

NOTE Stored gases that have been shown to conform to this standard do not need to be retested. However, if the gases have been stored for an extended period of time it is recommended that the oxygen level is checked prior to use.

NA. 5 Method for assessment of odour

WARNING Assessments should always be carried out under close supervision by a person qualified in first aid, in case an assessor should become unwell.

¹ 1 bar = 10⁵ Pa.

NA.5.1 Assessors

At least two assessors should assess each gas mixture. The assessors should be non-smokers and should be free from symptoms of upper respiratory tract infection. The assessors should be instructed to avoid environments containing tobacco smoke and to avoid using perfumed products, including perfumed soap, deodorant or aftershave, for the 12 h preceding the assessment. They should also be instructed to wear clothing that is free from odours such as perfumed detergents or fabric softeners and tobacco smoke.

The assessors should wash their hands in unperfumed soap immediately before the assessment, and should wear eye protection and ear protection during the assessment. The assessors should have a break of not less than 30 min in fresh air, away from the laboratory, between assessments of different gas mixtures.

NA.5.2 Apparatus

NA.5.2.1 Glass beakers, 200 ml capacity, which have been washed in hot water and unperfumed detergent and allow to air dry. A fresh beaker should be used for each assessment.

NA.5.2.2 Procedure

For each assessor, a regulated flow of the gas being assessed should be passed into a beaker (NA.5.2.1) and the assessor should sniff the gas, taking short breaths only.

The assessor should rate the gas as follows:

NA.5.2.2.1 Satisfactory: Gas has no detectable odour, or has a slight odour that, in the opinion of the assessor, could be easily tolerated for an extended period of time.

NA.5.2.2.2 Unsatisfactory: Gas has an unpleasant odour, or one that, in the opinion of the assessor, could not be tolerated for an extended period of time.

If the gas has any odour, the assessor should give a brief description,

e.g. oily, acidic, musty or sulfurous.

The assessors' ratings, and descriptions of any odour, should be recorded in the test report.

NA.6 Method for determination of water content

NA.6.1 Apparatus

NA.6.1.1 Direct reading hygrometer, of one of the following types:

- cooled mirror dew point;
- electrolytic;
- capacitance;
- piezoelectric.

The hygrometer should have a current certificate of calibration demonstrating traceability to a national or international standard of measurement which, in the UK, is the responsibility of the National Physical Laboratory (NPL).

When not in use the hygrometer should be purged with a dry gas having a water content $<2 \text{ mg}\cdot\text{m}^{-3}$ (milligrams per cubic metre).

NA.6.1.2 Sample lines, made of an impermeable material, such as stainless steel, or a material of low permeability, such as polytetrafluoroethylene.

NOTE The sample lines should be kept as short as is practicable, with a minimum number of joints.

NA.6.1.3 Procedure

Fit an open sample line to the outlet of the hygrometer to minimize any back diffusion of water vapour through the outlet port.

Pass a sample of the gas under test into the hygrometer in accordance with the manufacturer's instructions. Measure and record the temperature and pressure of the gas.

Operate the hygrometer in accordance with the manufacturer's instructions and record the reading.

NA.6.2 Calculations

Correct the reading obtained from the hygrometer to a water content at 1.013 bar and 20 °C, expressed in milligrams per cubic metre ($\text{mg}\cdot\text{m}^{-3}$).

Record the corrected value in the test report.

NA. 7 Method for determination of infra-red active trace contaminants

COMMENTARY ON NA. 7

The determination of oil content as described in NA.15 may be carried out as part of this determination. It is not necessary to run a separate test.

NA.7.1 Principle

An infra-red spectrometer is used to determine the infra-red absorption spectrum of the gas. As oxygen, nitrogen and helium have no oscillating dipole moments they do not have an infra-red absorption spectrum.

Thus, the infra-red absorption spectrum produced in the test can be used to identify trace impurities.

NA.7.1.2 Apparatus

NA.7.1.2.1 Scanning infra-red spectrometer, fitted with a gas cell with a minimum optical path length of 10 m.

NA.7.1.3 Materials

NA.7.1.3.1 Reference samples of the relevant trace contaminants.

NA.7.1.4 Procedure

Measure and record the temperature and pressure of the gas under test. Introduce a sample of the gas under test into the spectrometer, and measure the infra-red absorption spectrum, in accordance with the manufacturer's instructions.

Identify trace contaminants in the gas using the relevant infra-red frequency bands as given in Table NA.2.

For each contaminant identified, calibrate the apparatus in accordance with the manufacturer's instructions using the relevant reference sample, or samples, (NA.7.1.3.1). Use this calibration to determine the concentration of the contaminant.

NA.7.1.5 Calculations

Correct the concentrations of trace contaminants to 1.013 bar and 20 °C, expressed in parts per million (ppm).

Record the corrected values in the test report.

Table NA.2 – Infra-red absorbance bands

Band	Compound	Frequency band(s) cm ⁻¹
1	Ethane (under methane peak)	3 200 to 2 700
2	Carbon dioxide	3 750 to 3 550 2 400 to 2 250 800 to 600
3	Carbon monoxide	2 250 to 2 000
4	Nitrous oxide	3 500 to 3 450 2 600 to 2 500 2 250 to 2 150
5	Freon 12 (dichlorodifluoromethane)	1 180 to 1 060 940 to 850
6	Freon 22 (chlorodifluoromethane)	1 180 to 1 060 860 to 760
7	Freon 134a (1,1,1,2-tetrafluoroethane)	1 300 to 1 100
8	Ethylene (Interferes with freon 12)	1 100 to 840
9	Acetylene	820 to 650
10	Methane	1 380 to 1 200
11	Water	4 050 to 3 400 2 000 to 1 300
12	Solvent region	1 300 to 600

NA. 8 Method for determination of CO, CO₂ and volatile non-substituted hydrocarbons**NA.8.1 Apparatus**

NA.8.1.1 Infrared gas analyser(s), using the absorption bands 1, 2 and 3 identified in Table NA.2.

The equipment should be calibrated in accordance with the manufacturer's instructions.

NA.8.2 Procedure

Measure and record the temperature and pressure of the gas under test. Introduce sample(s) of the gas under test into the measuring equipment(s) in accordance with the manufacturer's instructions and record the CO and CO₂ content and volatile non-substituted hydrocarbon content as methane equivalent.

NA.8.3 Calculations

Correct the concentrations of CO and CO₂ and volatile non-substituted hydrocarbon to 1.013 bar and 20 °C, and express the concentration as parts per million by volume of the whole sample.

Record the corrected value in the test report.

NA.9 Method for determination of trace contaminants

NA.9.1 Apparatus

NA.9.1.2 Gas chromatograph or mass spectrometer, with reference spectra.

NA.9.2 Materials

NA.9.2.1 Reference samples of the relevant trace contaminants.

NA.9.3 Procedure

Measure and record the temperature and pressure of the gas sample. Pass a sample of the gas under test through the apparatus. Identify the trace contaminant(s) by use of the reference spectra (NA.9.1.2).

For each contaminant identified, calibrate the apparatus in accordance with the manufacturer's instructions using the relevant reference sample, or samples, (NA.9.2.1). Use this calibration to determine the concentration of the contaminant.

NA.9.4 Calculations

Correct the concentration of each gas to 1.013 bar and 20 °C, and express the concentration in parts per million by volume of the whole sample.

Record the corrected values in the test report.

NA.10 Method for determination of other non-toxic gases

NA.10.1 Apparatus

NA.10.1.1 Gas chromatograph or mass spectrometer, with reference spectra.

NA.10.2 Materials

NA.10.2.1 Reference samples of the relevant non-toxic gases.

NA.10.3 Procedure

Measure and record the temperature and pressure of the gas sample. Pass a sample of the gas under test through the apparatus. Identify the trace contaminant(s) by use of the reference spectra (NA.10.1.1).

For each contaminant identified, calibrate the apparatus in accordance with the manufacturer's instructions using the relevant reference sample, or samples, (NA.10.2.1). Use this calibration to determine the concentration of the contaminant.

NA.10.4 Calculations

Correct the concentration of each gas to 1.013 bar and 20 °C, and express the concentration as a percentage by volume of the whole sample.

Record the corrected values in the test report.

NA.11 Method for determination of oxygen concentration

NA.11.1 Apparatus

NA.11.1.1 Oxygen measurement equipment.

For gas mixtures containing ≥ 40 % oxygen the equipment should be able to measure gaseous oxygen levels to ± 1.0 %.

For gas mixtures containing < 40 % oxygen the equipment should be able to measure gaseous oxygen levels to ± 0.5 %.

For gas mixtures containing ≤ 20 % oxygen the equipment should be able to measure gaseous oxygen levels to at least ± 0.25 %.

For pure oxygen (i.e. as specified in Table 6) the equipment should be able to measure gaseous oxygen levels to ± 0.25 %.

The equipment should be calibrated in accordance with the manufacturer's instructions.

NA.11.2 Procedure

Measure and record the temperature and pressure of the gas under test. Introduce a sample of the gas under test into the measuring equipment in accordance with the manufacturer's instructions and record the oxygen content.

NA.11.3 Calculations

Correct the concentration of oxygen to 1.013 bar and 20 °C, and express the concentration as a percentage by volume of the whole sample.

Record the corrected value in the test report.

NA.12 Method for determination of hydrogen concentration

NA.12.1 Apparatus

NA.12.1.1 Gas chromatograph, fitted with a sample loop and a suitable detector, such as a helium ionization detector or a thermal conductivity detector. The gas chromatograph should be calibrated in accordance with the manufacturer's instructions.

NA.12.2 Procedure

Measure and record the temperature and pressure of the gas under test. Introduce a sample of the gas under test into the gas chromatograph using the sample loop, and measure the concentration of hydrogen in accordance with the manufacturer's instructions.

NA.12.3 Calculations

Correct the concentration of hydrogen to 1.013 bar and 20 °C, and express the concentration as a percentage by volume of the whole sample.

Record the corrected value in the test report.

NA.13 Method for determination of nitrogen concentration

NA.13.1 Apparatus

NA.13.1.1 Nitrogen measurement equipment, able to measure gaseous nitrogen levels to an accuracy of 0.1 % (e.g. a respiratory gas mass spectrometer). The equipment should be calibrated in accordance with the manufacturer's instructions.

NA.13.2 Procedure

Measure and record the temperature and pressure of the gas under test. Introduce a sample of the gas under test into the measuring equipment in accordance with the manufacturer's instructions and record the nitrogen content.

NA.13.2 Calculations

Correct the concentration of nitrogen to 1.013 bar and 20 °C, and express the concentration as a percentage by volume of the whole sample.

Record the corrected value in the test report.

NA.14 Method for determination of helium concentration

NA.14.1 Apparatus

NA.14.1.1 Helium measurement equipment, able to measure gaseous helium levels to at least ± 1.0 % (e.g. a helium gas analyser or a respiratory gas mass spectrometer). The equipment should be calibrated in accordance with the manufacturer's instructions.

NA.14.2 Procedure

Measure and record the temperature and pressure of the gas under test. Introduce a sample of the gas under test into the measuring equipment in accordance with the manufacturer's instructions and record the helium content.

NA.14.3 Calculations

Correct the concentration of helium to 1.013 bar and 20 °C, and express the concentration as a percentage by volume of the whole sample.

Record the corrected value in the test report.

NA.15 Method for determination of oil content

COMMENTARY ON NA.15

The determination of oil content as described in NA.15 may be carried out as part of the determination of infra-red active contaminants as described in NA.7. It is not necessary to run a separate test.

NA.15.1 General

The oil content should be determined either in accordance with BS ISO 8573-2 or by using an infra-red spectrometer to determine the infra-red spectrum of the gas under test in accordance with NA.15.2 to NA.15.4. In the latter case the spectrum produced should be used to identify and quantify traces of oil as n-hexane equivalent.

NA.15.2 Apparatus

NA.15.2.1 Scanning infra-red spectrometer, fitted with a gas cell with a minimum optical path length of 10 m. The equipment should be calibrated in accordance with the manufacturer's instructions.

NA.15.3 Procedure

Measure and record the temperature and pressure of the gas under test. Introduce a sample of the gas under test into the spectrometer and measure the peak height in the frequency band 3000 cm⁻¹ to 2800 cm⁻¹.

Determine the concentration of oil in the sample, in milligrams per cubic metre (mg•m⁻³), as n-hexane equivalent.

NA.15.4 Calculation

Correct the concentration of oil to 1.013 bar and 20 °C. Record the corrected value in the test report.

NA.16 Method for stain detector tube and stain system analysis

NA.16.1 Apparatus

NA.16.1.1 Reagent tubes specific for detection of carbon monoxide, carbon dioxide, and water.

NA.16.1.2 Reagent tube or deposition system for detection of oil.

NA.16.2 Procedure

Set up the apparatus in accordance with the manufacturer's instructions. Pass a sample of the gas under test through the apparatus. Take a reading from the scale on the tube or deposition system.

NA.16.3 Calculation and expression of results

For each reading, add the maximum error for the relevant substance, as specified by the manufacturer of the testing system, to the reading obtained. Compare this value with the maximum value specified in BS EN 12021 in Table 1, Table 2, Table 3 or Table 4 as applicable. If the sum of the reading plus the error is less than or equal to the value given in Table 1, Table 2, Table 3 or Table 4, the level of the substance concerned should be deemed to conform to the standard. If the sum is greater than the value given in Table 1, Table 2, Table 3 or Table 4, the level of the substance concerned should be deemed not to conform to the standard.

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