

Compressed air —

Part 6: Test methods for gaseous contaminant content

ICS 71.100.20

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Compressed air —

Part 6:

Test methods for gaseous contaminant content

Air comprimé —

*Partie 6: Méthodes d'essai pour la détermination de la teneur en
polluants gazeux*



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Foreword

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ISO 8573-6 was prepared by Technical Committee ISO/TC 118, *Compressors, pneumatic tools and pneumatic machines*, Subcommittee SC 4, *Quality of compressed air*.

ISO 8573 consists of the following parts, under the general title *Compressed air*:

- *Part 1: Contaminants and purity classes*
- *Part 2: Test methods for aerosol oil content*
- *Part 3: Test methods for measurement of humidity*
- *Part 4: Test methods for solid particle content*
- *Part 5: Test methods for oil vapour and organic solvent content*
- *Part 6: Test methods for gaseous contaminant content*
- *Part 7: Test method for viable microbiological contaminant content*
- *Part 8: Test methods for solid particle content by mass concentration*
- *Part 9: Test methods for liquid water content*

Introduction

This part of ISO 8573 is one in a series of standards (planned or published) with the ambition of harmonizing air contamination measurements. It is also intended to be used for reference when stating purity classes according to ISO 8573-1.

In this part of ISO 8573, *gaseous contamination of compressed air* means that a sample of compressed air could contain small quantities of carbon monoxide (CO), carbon dioxide (CO₂), sulphur dioxide (SO₂), hydrocarbons and oxides of nitrogen (NO_x) — the latter being a mixture of nitric oxide (NO) and nitrogen dioxide (NO₂), without a specified ratio between the two components. It is possible to obtain separate concentration values for NO and NO₂ using either the laboratory equipment recommended here or on-site equipment, while under the recommended laboratory analytical procedure, hydrocarbons are the sum of a variety of species assuming a ratio of C₁H_{1,85}.

Compressed air —

Part 6:

Test methods for gaseous contaminant content

1 Scope

This part of ISO 8573 provides a selection of suitable test methods from those available for the measurement of contamination gases in compressed air. It specifies sampling technique, measurement and evaluation, uncertainty considerations and reporting for the applicable gaseous contaminants carbon monoxide, carbon dioxide, sulphur dioxide, nitric oxide, nitrogen dioxide and hydrocarbons in the range C₁ to C₅ (see ISO 8573-5 for C₆ and above). The methods given are also suitable for other gases.

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 1219-1, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols*

ISO 2602, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*

ISO 2854, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances*

ISO 8573-1, *Compressed air — Part 1: Contaminants and purity classes*

3 Terms, definitions, units and symbols

For the purposes of this document, the terms and definitions given in ISO 8573-1, and the symbols given in ISO 1219-1 apply. See Table 1 for an explanation of the units and other symbols used.

Table 1 — Preferred units and symbols (and their non-preferred equivalents) used in this part of ISO 8573

Unit/symbol	Explanation
MPa [bar]	1 bar = 100 000 Pa = 0,1 MPa
ml/m ³ (= ppm _v) ^a	Volume fraction expressed in millilitres per cubic metre [= one part per million (1 ppm) on a volume basis: 1/10 ⁶ (m ³ /m ³)]
ml/m ³ (= ppm _v) C ₁	Volume fraction expressed in millilitres per cubic metre [= one part per million (1 ppm) on a volume basis: 1/10 ⁶ (m ³ /m ³)], referred to a theoretical C ₁ -molecule
µg/g (= ppm _w)	Mass fraction expressed in micrograms per gram [= parts per million on a weight basis ^b]
1 % by volume	Volume fraction of 1 %: 1/10 ² (m ³ /m ³)
MPa(e) [bar(e)]	Effective pressure
MPa(a) [bar(a)]	Reference condition absolute pressure
^a Parts per million (ppm) is a deprecated unit, i.e. not accepted by the International System of Units, SI. See, for example, ISO 31-0:1992, 2.3.3.	
^b In common parlance, the word "weight" continues to be used to mean <i>mass</i> , but this practice is deprecated. See ISO 31-3.	

4 Selection guide and available methods

There are two options for the measurement of contaminant content:

- a) sampling and analysis on-site;
- b) sampling on-site, analysis in the laboratory.

The recommended methods and equipment within these options are given in Table 2.

Table 2 — Recommended measurement methods/equipment

	Gaseous contaminant	Measurement equipment
Off-site	Carbon monoxide (CO)	Non-dispersive infrared (NDIR) absorption spectrometer
	Carbon dioxide (CO ₂)	Non-dispersive infrared (NDIR) absorption spectrometer
	Sulphur dioxide (SO ₂)	Non-dispersive infrared (NDIR) absorption spectrometer
		UV-fluorescence
	Hydro-carbons (HC) (C ₁ to C ₅)	Heated flame ionisation detector (HFID)
	Nitrogen oxides (NO _x)	Chemiluminescent detector (CLD) with an NO ₂ /NO converter, and in a heated version (HCLD)
On-site	All identified gases	Gas detector tubes with colour change

5 Sampling techniques

5.1 Gas sampling in bags

The gas sample shall be taken at atmospheric conditions and collected in a special gas sampling bag made for the purpose. A sample of the compressed air shall be collected in a gas sampling bag for the evaluation of the contaminant concentration values. All measurements on the sample shall be carried out under atmospheric pressure conditions.

Use of a commercially available gas sampling bag (e.g. one made of fluoroethylene propylene) to collect a sample of air for analysis should be made by the following method.

The gas sampling bag should be of the type suitable for gas collection. Turbulent flow conditions are required in the main system pipe to ensure a mixing of the gaseous contaminants to give a representative sample of the air.

Connect the gas sampling bag to the sampling point using a probe (see Figure 1), through a pressure reducing valve, by a polytetrafluoroethylene (PTFE) tube and a PTFE, or stainless steel, connector, depending upon the expected gas impurities. The piping should be protected from the possible formation condensation. The bag should have a vent valve to allow for flushing. Flushing should take place for 5 min with system air before taking the sample. Care should be taken to ensure that the bag is not over-inflated and of a size consistent with the sample required. The bag should only be re-used if permitted by the manufacturer.

Together with the filled gas-sampling bag an empty unused gas-sampling bag shall be brought to the laboratory for a blind test.

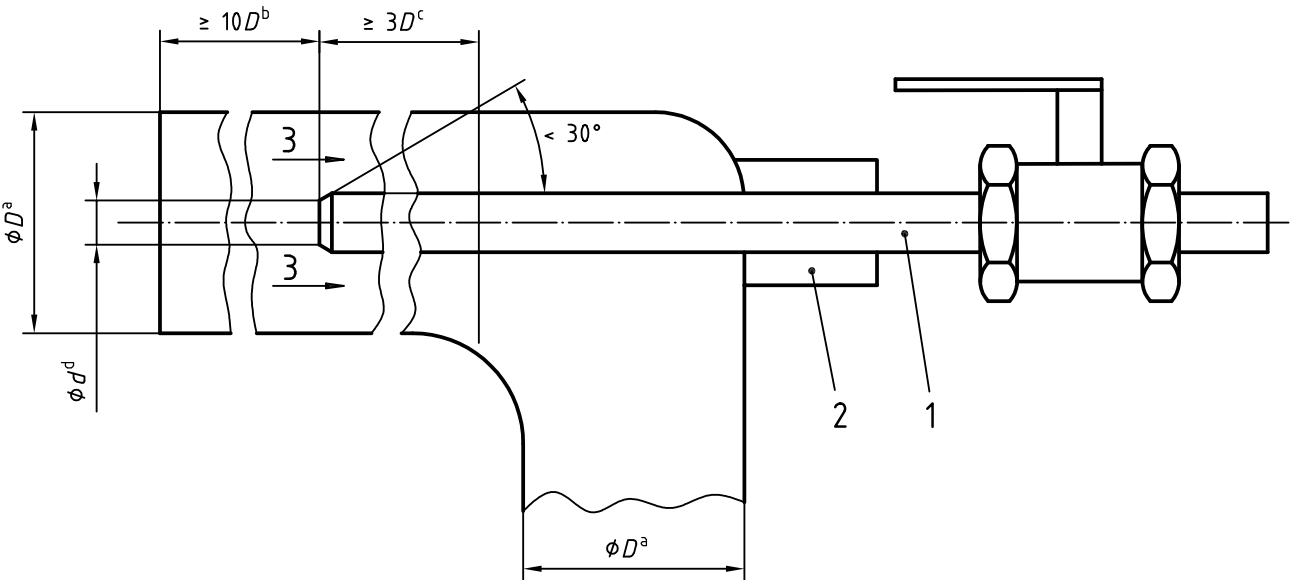
5.2 On-line sampling

The gas sample shall be taken at system pressure using a stainless steel probe (see Figures 1 and 2). The end of the probe outside the compressed air pipe shall have a valve, which shall be suitable for all pressure conditions of the compressed air pipe. The probe shall be free from contaminants affecting the readings.

See Annex C for the procedure.

5.3 Sampling in gas detector tube

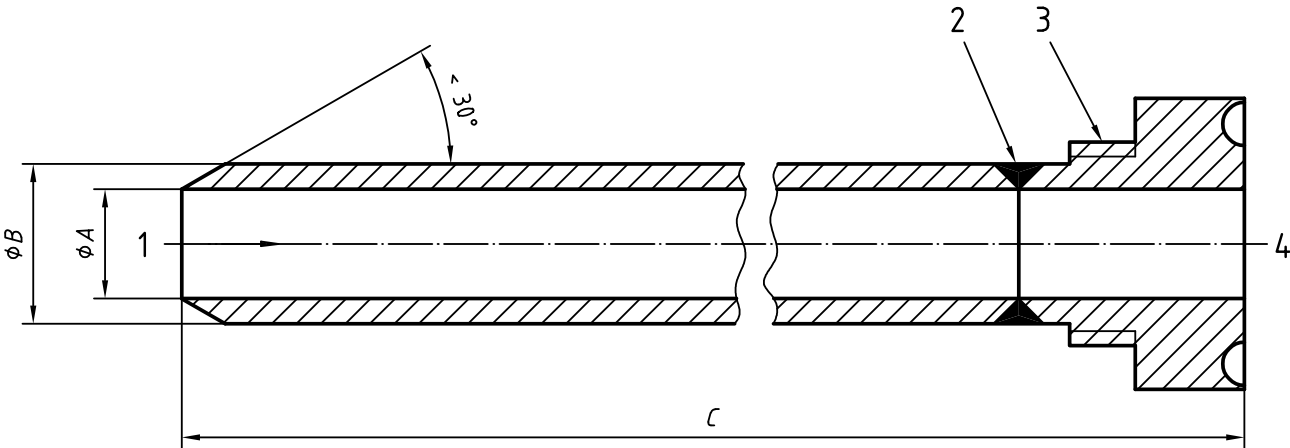
See Annex D for the procedure.



Key

- 1 sampling probe in the main pipe
- 2 adjustable gland to allow adjustment of probe
- 3 direction of air flow
- a main pipe diameter, D
- b minimum straight length before probe, $10 \times D$
- c probe insertion point at minimum of $3 \times D$
- d internal probe diameter, d

Figure 1 — Equipment set-up of probe insertion for sampling



Key

- 1 direction of flow
- 2 crevice-free joint
- 3 suitable pressure-tight thread connection
- 4 to membrane holder

Probe size	A mm	B mm	C mm
1	7	9,6	200
2	10	12,6	200
3	17	19,6	400

Figure 2 — Stainless steel sampling probe

6 Measurement methods

The recommended procedure for the evaluation of the contaminant concentration values in a laboratory is given in Annex C. The analytical equipment proposed for use by Annex C is based on the detector principles identified in Table 2.

Consideration shall be given to the measurement system integrity and the calibration requirements of the measurement equipment, which shall be used in accordance with the applicable instructions and to the degree of gaseous contamination measured.

For the measurement of the concentration values, on-site gas detector tubes may be employed. This offers a direct reading from a scale via a chemical reaction with a colour change proportional to the actual contaminant concentration in the actual compressed air sample taken. See Annex D.

7 Reference conditions

Unless otherwise agreed, the reference conditions for gaseous contaminant concentration shall be in accordance with Table 3:

Table 3 — Reference conditions

Air temperature	20 °C
Air pressure	0,1 MPa(a) [1 bar(a)]
Relative water vapour pressure	0

8 Evaluation of test result

The results of the measurements are given as concentration values of the contaminants as volume fractions or percentages by volume. See Table 1.

9 Uncertainty

NOTE A calculation of the probable error according to this clause is not always necessary.

Due to the very nature of physical measurements it is impossible to measure a physical quantity without error or, in fact, to determine the true error of any particular measurement. However, if the conditions of the measurement are sufficiently well known, it is possible to estimate or calculate a characteristic deviation of the measured value from the true value, such that it can be asserted with a certain degree of confidence that the true error is less than the said deviation. The value of such deviation (normally 95 % confidence limit) constitutes a criterion of the accuracy of the particular measurement.

It is assumed that all systematic errors that may occur in the measurement of the individual quantities measured and of the characteristics of the gas can be compensated for by corrections. A further assumption is that the confidence limits in errors in reading and integration errors may be negligible if the number of readings is sufficient: the (small) systematic errors that could occur are covered by the inaccuracy of measurements.

The information about asserting the uncertainty of measurement of individual quantities measured and on confidence limits of the gas properties are approximations. These approximations can only be improved by efforts of disproportionate expense (see ISO 2602 and ISO 2854).

10 Test report

10.1 Statements

Statements of the concentration of gaseous contaminants in the compressed air shall be made as volume fractions (see Table 1). The statement shall be sufficiently detailed to allow the values to be verified according to the procedures of this part of ISO 8573.

10.2 Statement format

The report/statement used to declare the concentration of gaseous contaminants in accordance with this part of ISO 8573 shall contain the following information:

- a) a description of the compressed air system and its working conditions, with sufficient detail to enable the applicability of the declared concentration value to be determined;
- b) a description of the sampling point where the samples were taken;
- c) a description of the sampling and analytical system that was used (particularly materials used) and details of its calibration record if applicable;
- d) the words “Declared concentration of the contaminant CO/CO₂/SO₂/HC/NO/NO₂ in accordance with ISO 8573-6”, followed by
 - the figure for the actual, average measured value evaluated according to Clause 8,
 - the actual atmospheric conditions, and
 - the date of the sampling and measurement;
- e) a statement regarding the applicable uncertainty.

See Annex A for an example report.

Annex A (informative)

Compressed air contaminant concentration report — Example

See Figure A.1.

Statement In the compressed air system at, consisting of four air compressors, after-coolers and refrigerant type dryers, with one compressor on stand-by, two compressors working at full load and one compressor loaded to approx. 50 % and working at 0,7 MPa(e) [= 7 bar(e)] network pressure, measurements on the concentrations CO, CO ₂ , SO ₂ , HC and NO ₂ were made. The probe to obtain the samples was installed where the supply pipe enters the B-shop. Samples were taken regularly at hourly intervals during a 48 h period. Each sample consisted of three plastic gas collection bags, manufactured by Atmospheric conditions during sampling and measurement were as follows:			
Starting date:	19,5 °C	0,101 5 MPa	49 % relative humidity
Finishing date:	22 °C	0,101 6 MPa	42 % relative humidity
NOTE Average of 48 samples for every three measurements. The analysis was made in laboratory, with the analytical equipment manufactured by The calibration of the analytical equipment was validated on Before and after each measurement, the analyser setting was controlled by span and zero gases. The declared concentrations in accordance with ISO 8573-6 are as follows:			
Carbon monoxide (CO)	(12 ± 4) ml/m ³ or ppm _V	used full scale range	(0 to 25) ml/m ³ or ppm _V
Carbon dioxide (CO ₂)	(349 ± 8) ml/m ³ or ppm _V	used full scale range	(0 to 1 000) ml/m ³ or ppm _V
Sulphur dioxide (SO ₂)	< 3 ml/m ³ or ppm _V	used full scale range	(0 to 10) ml/m ³ or ppm _V
Hydro-carbons (HC)	(2 ± 1) ml/m ³ C ₁ or ppm _V C ₁	used full scale range	(0 to 10) ml/m ³ C ₁ or ppm _V C ₁
Nitrogen oxides (NO _x)	< 3 ml/m ³ or ppm _V	used full scale range	(0 to 10) ml/m ³ or ppm _V
Report prepared by (Signature) (Location, date)			

Figure A.1 — Example report

Annex B (informative)

Measurement and sampling procedures on site and analysis in laboratory

B.1 Gas sampling bag

The gas sampling bags shall be gas-tight.

The material of which the bags are manufactured shall be inert.

The gas sampling bags shall have fittings for inflating and discharge of sample to a gas chromatograph.

EXAMPLE Sampling through a membrane using a gas-tight syringe.

The gas sampling bags shall be identified with temperature-specifications for the sake of the temperature of the gas sampled from the system (compatibility with temperature for bag and sample).

If sulphur compounds in the compressed air are expected to be found, gas sampling bags with black layers and fittings of polytetrafluoroethylene (PTFE) should be used.

Under no circumstance shall stainless steel be used in sampling vessels when sulfur compounds are present.

B.2 Sampling on site

The sample shall be taken in accordance with Clause 6.

B.3 Analysing in laboratory

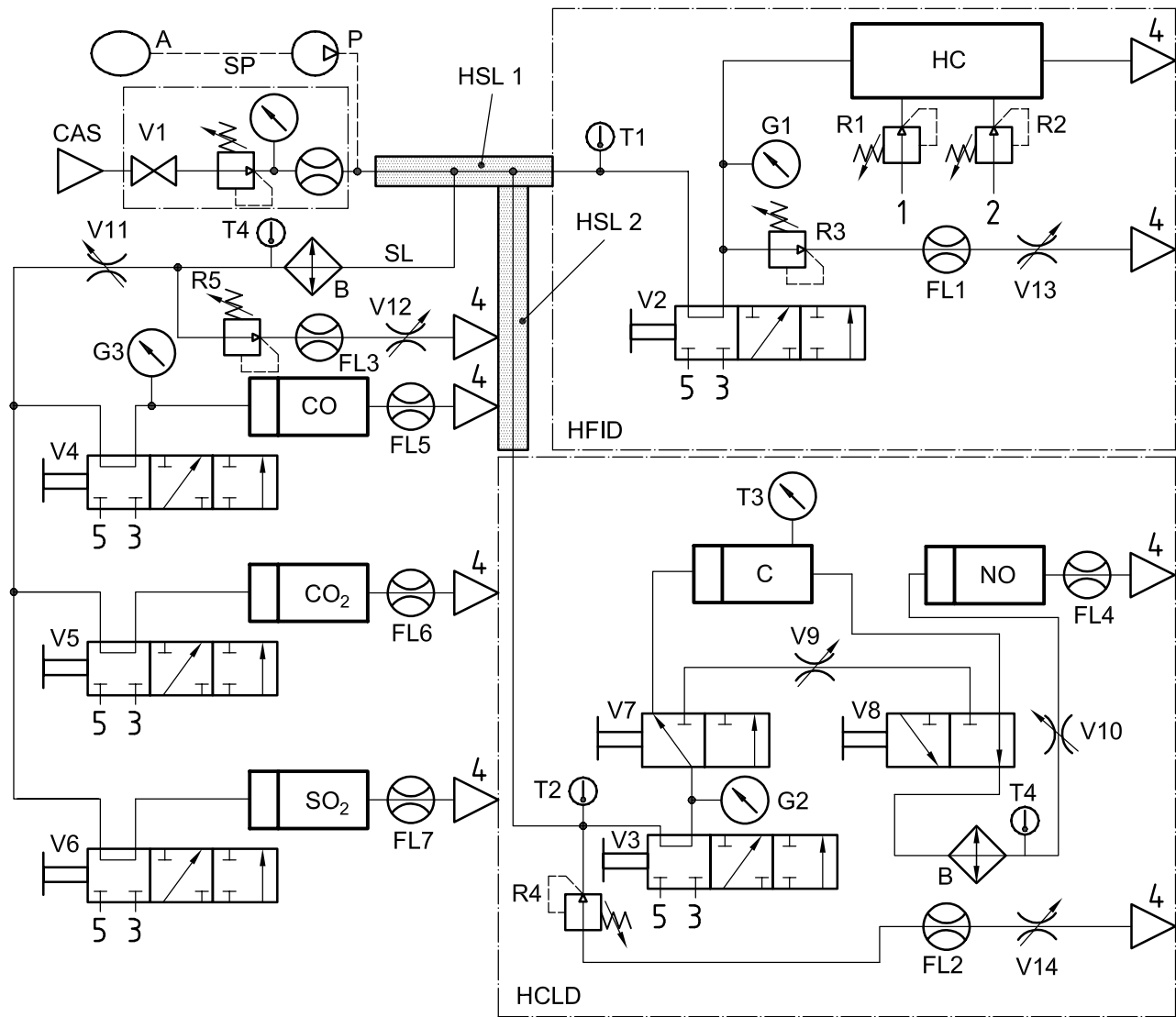
The analysis of the gas sample shall be carried out in accordance with the recommendations made by appropriate organizations.

Annex C
(informative)

Analytical and on-line sampling systems

C.1 Determination of gaseous contaminants

This annex presents the analytical system for gaseous contaminants. Other systems or analysers proved to have given equivalent results may be used. See Figure C.1 for a schematic diagram of the compressed air analysis system and Table C.1 for the symbols used in the schematic.



Key

- | | |
|------------|------------|
| 1 air | 4 vent |
| 2 fuel | 5 zero gas |
| 3 span gas | |

Figure C.1 — Compressed air analysis system for CO, CO₂, SO₂, NO_x (analysis by HCLD and heated sample line) and HC (analysis by HFID and heated sample line)

Table C.1 — Key to symbols used in Figure C.1

Symbol	Description	Symbol	Description
A	bag with sample	R1, R2	pressure regulators for air and fuel
B	bath to cool and condense water from sample ^a	R3, R4, R5	pressure regulator to control sample flow
C	converter for the NO ₂ to NO conversion	SL	sample line ^c
CAS	compressed air sample	SO ₂	NDIR analyser for sulphur dioxide
CO	NDIR analyser for carbon monoxide	SP	sample point pressure control and flow monitoring from the compressed air pipe
CO ₂	NDIR analyser for carbon dioxide	T1	thermometer of sample stream entering HFID analyser
FL1, FL2, FL3	flow meter to measure sample by-pass flow	T2	thermometer of sample stream entering HCLD analyser
FL4, FL5, FL6, FL7	flow meter for measuring flow through analysers	T3	thermometer of NO ₂ to NO converter
G1, G2, G3	pressure gauge for measuring pressure in sample lines to analysers	T4	thermometer of bath temperature
HC	HFID	V1	valve for taking sample and closing of sample probe line
HCLD	HCLD analyser for oxides of nitrogen	V10, V11	needle valves to regulate flows to the analysers
HFID	HFID analyser for hydrocarbons	V2, V3, V4, V5, V6	valves to direct sample, zero gas or calibrating gas streams to the analysers
HSL1, HSL2	heated sampling lines made in stainless steel or PTFE ^b	V7, V8	three-way valve to by-pass NO ₂ to NO converter
NO	heated chemiluminescent detector (HCLD)	V9	needle valve to balance flow through NO ₂ to NO converter and by-pass
P	pump	V12, V13, V14	needle valves to provide restriction to exhausting air from pressure reducing valves
^a The bath shall be maintained at a temperature of 0° to +4 °C by ice or refrigeration. ^b The temperature shall be kept between 95 °C and 200 °C. ^c The line shall be made in PTFE or in stainless steel. It may be heated or unheated.			

C.2 Measurement of samples

After control of the setting of the analysers, recorded on a strip chart recorder or with an equivalent data acquisition system, the bag with the sample is connected to the analytical system at the three-way valve whilst room air or synthetic air is pumped through the system. Then the valve is switched to the position where the sample is pumped through the system so that the analysers show the reading of the contaminant concentration. The reading must be stable for at least 3 min in order for a concentration value representative of that sample to be produced. The reading is recorded during the whole time. The actual concentration values can be produced manually via interpretation of the record or via an electronic data evaluation device which identifies automatically a stable response of the analysers for a period of 3 min and then prints the concentration values.

Annex D (informative)

Equipment for on-site measurement — Sampling and measurement procedures — Sampling in gas detector tube

D.1 Sampling equipment

The sample is taken from the compressed air line. The measured concentration can be recognized as the progress of the colour change frontal area with reference to the scale on the glass tube. The sampling measurement should be repeated to arrive at an acceptable confidence level.

Figure D.1 shows a schematic diagram of a possible arrangement using the detector tube technology as an analytical system.

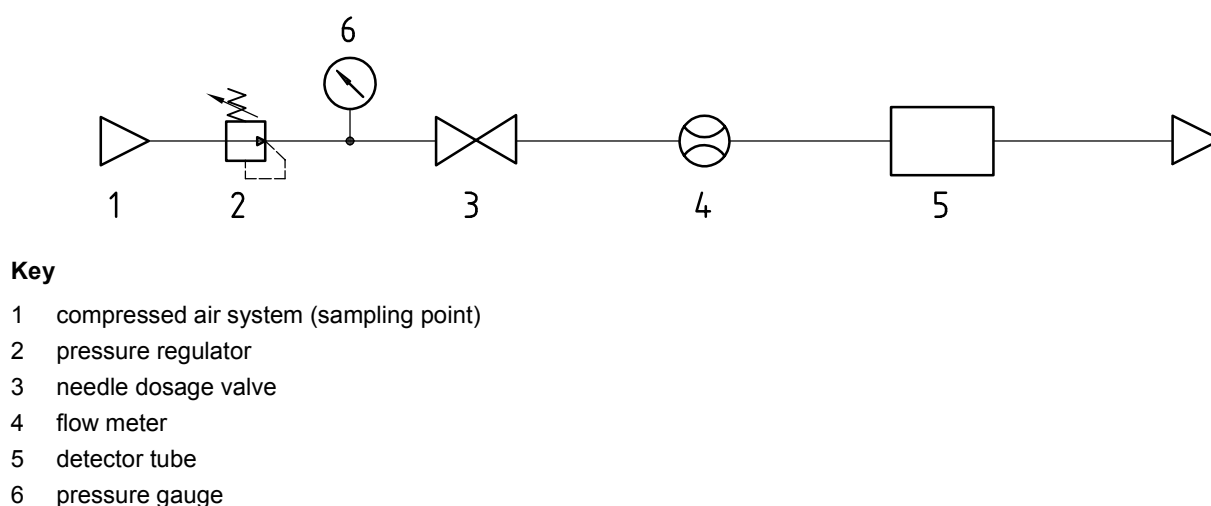


Figure D.1 — Example arrangement using gas detector tube method

D.2 Measurement equipment

The procedure for measuring the concentration values of gases that could be contaminating a compressed air supply is described here. The method, which is widely used, is commonly identified as *detector tubes*.

Detector tubes are available for nearly all relevant gaseous contaminants and, in some cases, for more than one contaminant. See EN 1231.

The principle of these detector tubes is a specific chemical reaction of the component to be measured with a change of colour. There is a defined amount of reagent equivalent to the expected concentration range in the tube. Because the chemical reaction follows stoichiometric relations, the reading of the detector tube produces valid figures, provided the measured concentration is contained in an exactly defined volume.

The measurement response of this method is a colour change with a frontal area that proceeds proportional to the contaminant concentration, the sample flow rate through the tube and the sampling time.

Bibliography

- [1] ISO 3857-1, *Compressors, pneumatic tools and machines — Vocabulary — Part 1: General*
- [2] ISO 5598, *Fluid power systems and components — Vocabulary*
- [3] ISO 8178-1, *Reciprocating internal combustion engines — Exhaust emission measurement — Part 1: Test-bed measurement of gaseous and particulate exhaust emissions*
- [4] ISO 8573-3, *Compressed air — Part 3: Test methods for measurement of humidity*
- [5] EN 1231, *Workplace atmospheres — Short term detector tube measurement systems — Requirements and test methods*

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