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Compressed air — Contaminant measurement —

Part 4: Particle content

Air comprimé — Mesurage des polluants —

Partie 4: Teneur en particules

Reference number
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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 118, *Compressors and pneumatic tools, machines and equipment*, Subcommittee SC 4 *Compressed air treatment technology*.

This second edition cancels and replaces the first edition (ISO 8573-4:2001), which has been technically revised. It also incorporates the Technical corrigendum ISO 8573-4:2001/Cor.1:2002.

A list of all parts in the ISO 8573 series can be found on the ISO website.

Introduction

Particles are a common contaminant in compressed air and this document details the correct sampling methodology and assists the user in selecting equipment and instrumentation and the determination of particle size and concentration.

In addition, it is to be used to assess compressed air purity such that the purity class can be stated in accordance with ISO 8573-1 for particles of Class 1, 2, 3, 4 and 5, and can be used only by agreement between consenting parties when measurements to purity Class 0 are to be performed.

This document does not detail the methods to be used to determine the mass concentration of particles as required for the particle purity Classes of 6, 7 and *X* as detailed in ISO 8573-1 of the series, for which ISO 8573-8 is required.

Historically it was the intention to only consider solid particles for the purposes of the particle purity class measurement. The detection methods detailed here however are not substance selective and thus this standard reports all particles present in the compressed air within the size ranges measured.

By reference to the other standards in the ISO 8573 series the component parts of the particle concentration can be assessed e.g. oil, water or solid particles. Solid particles may also include debris, carbonaceous matter and viable microorganisms.

The annexes of this document provide general guidance to the types of equipment available to the user for the measurement of particle concentration in compressed air.

Compressed air — Contaminant measurement —

Part 4:
Particle content

1 Scope

This document provides a method for sampling compressed air and a guide for choosing suitable measuring equipment to determine its particle size and concentration by number (to be referenced as "concentration" throughout this document). It also describes the limitations of the various measurement methods and describes the evaluation and uncertainty considerations.

This document will report the particle size and concentration of all types of particle combined and does not aim to be able to segregate the separate solid and liquid particle fractions. When it is required that the concentration of a specific fraction is to be determined then recourse to the relevant standard method from the ISO 8573 series is recommended.

NOTE 1 The test methods described in this document are those suitable for determining the purity classes given in ISO 8573-1.

NOTE 2 Particle content determined as concentration by mass is dealt with in ISO 8573-8.

NOTE 3 This document does not address instances where non-isothermal conditions exist, and separate arrangements should be made where particles may be formed by vapour condensation or lost through evaporation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 3857-4, *Compressors, pneumatic tools and machines — Vocabulary — Part 4: Air treatment*

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

ISO 21501-1, *Determination of particle size distribution — Single particle light interaction methods — Part 1: Light scattering aerosol spectrometer*

ISO 21501-4, *Determination of particle size distribution — Single particle light interaction methods — Part 4: Light scattering airborne particle counter for clean spaces*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3857-4 and ISO 8573-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
optical aerosol spectrometer
OAS
light scattering aerosol spectrometer used for measuring the size, number concentration and number/size distribution of particles suspended in a gas

Note 1 to entry: This device is described in ISO 21501-1.

3.2
optical particle counter
OPC
light scattering airborne particle counter used for measuring the size and particle number concentration of particles suspended in air

Note 1 to entry: This device is described in ISO 21501-4.

4 Units

General use of SI units (see ISO 80000-1) as given throughout this document is recommended. However, in agreement with accepted practice in the pneumatic industry sector, some non-preferred SI units, accepted by ISO, are also used.

1 bar = 100 000 Pa

NOTE bar(e) is used to indicate effective pressure above atmospheric.

1 l (litre) = 0,001 m^3

5 Reference conditions

Reference conditions for volume statements are as follows:

— air temperature: 20 °C

— absolute air pressure: 100 kPa [1 bar (a)]

— relative water vapour pressure: 0

6 Particle type

6.1 General

Particles are characterized by their properties of material, particularly their size, density, shape, transparency, colour, vapour pressure and hardness. A particle may be in the solid or liquid phase. Solid particles may also comprise microbiological viable and non-viable particles.

NOTE Agglomerates may be comprised of all types of particles.

6.2 Liquid particles

Liquid particles are sized, counted and their concentration determined using this document. If it is necessary to determine the fraction which comprises oil by mass, then ISO 8573-2 should be applied. Where liquid water content is to be determined by mass then ISO 8573-9 should be applied.

6.3 Solid particles

6.3.1 General

Solid particles are sized, counted and their concentration determined using this document. On occasion that the concentration by mass is to be determined then ISO 8573-8 should be applied.

6.3.2 Microbiological particles

The compressed air may include in its composition microorganisms of a viable and/or non-viable nature which will be counted as part of the total concentration reported by this document. Viable particles include pollen, bacteria, fungi and their spores. If it is necessary to determine the fraction which comprises viable particles, then ISO 8573-7 should be applied.

7 Selection of method

7.1 General

The method of measurement to be selected depends on the size range of the particles in the compressed air. For choosing the method most suitable for the sizes of particles estimated to be present in the sample, see Table 1.

The applicability of any chosen measurement equipment to a method should be verified with the equipment manufacturer.

Table 1 — Guidance to selection of method

Method	Applicable particle diameter *d* µm
Sampling disc sampling and sizing/counting by light optical microscopy (LM) (BS 3406-4)[7]ab	≥5,0
Sampling disc sampling and sizing/counting by scanning electron microscope (SEM) (BS 3406-4)[7]ab	≥0,005
Optical particle sizing and counting instrument	≥0,06 to ≤100

[a] Manual full sampling disc surface counting, sizing and classifying is a laborious process, therefore an automated technique to perform these tasks is recommended.

[b] Determination of mass concentration is also possible by pre-weighing the sampling discs and calculating their weight increase after the test followed by elemental analysis if required.

7.2 Sampling on sampling disc surface in conjunction with a microscope

This system employs a sampling disc with a classification suitable for the intended measurement range, in conjunction with a microscope. It is not as fast as light scattering methods in that detection is carried out after the sampling has taken place. The range of particle sizes that can be counted and sized depends on the type of microscopic technique applied, further guidance is given in Annex B. To determine particle size and number by microscopy, the method described in BS 3406-4 should be applied.

The optimum duration of a test measurement may be determined after an initial test to determine the approximate particle concentration present. When carrying out full flow tests, it is possible to route the air back into the compressed air systems, preventing loss of the product. Conversely, it is also possible to vent the flow to the atmosphere. Flow measurement is required, taking into account pressure and temperature, to determine the volume of air used during the test, whichever method is adopted. Take precautions to prevent shock depressurization, which may damage the test equipment, or ingress of atmospheric contamination. Guidance for the recording of parameters, e.g. temperature, pressure, sampling time and flowrate, and their presentation in the test report is given in Clause 10.

Sampling disc sampling may be unsuitable for the sizing of liquid particles in compressed air due to evaporation effects. One advantage of this method is its ability to determine a particle's elemental or chemical composition by other analytical means such as energy dispersive X-ray spectroscopy often coupled to an SEM.

Once the particles collected on the sampling disc have been counted and sized their concentration can be determined using Formula (2).

7.3 Sampling using particle sizing and counting instruments

7.3.1 General

There are many types of particle sizing and counting instruments. An instrument with the capability to measure the size and concentration of the particles in air shall be selected. Instrument sample air flow rates are typically low and thus it is likely that sizing and counting using an instrument-based approach will be performed on a representative sample of the air obtained using isokinetic sampling principles.

There are particle sizing and counting instruments that can be operated at the same pressure as that of the compressed air. These are preferable to instruments that only operate at atmospheric pressure but may be limited in sensitivity due to the detection method. When sampling from a compressed air system using an instrument that cannot withstand the system pressure, a compressed air diffuser shall be used (see Annex E). Pressure regulators shall not be used in place of a compressed air diffuser to reduce the pressure and obtain a sample of air.

7.3.2 Instrument selection

The instrument used shall be based upon the light scattering measurement principle for single particle measurements. It may either be an optical aerosol spectrometer (OAS) described as a light scattering aerosol spectrometer in ISO 21501-1, or an optical particle counter (OPC) described as a light scattering airborne particle counter in ISO 21501-4. For more information see Annex B.

Take care to ensure that the instrument selected is suitable for the particle size and concentration range to be measured (see Table 2).

Table 2 — Guidance to particle size and concentration by number OAS and OPC counters

Instrument type	Typical particle size range µm	Typical maximum particle concentration particles/m^3
Optical aerosol spectrometer (OAS)	≥0,06 to ≤100	1×10^{12}
Optical particle counter (OPC)	≥0,1 to ≤10	5×10^{7}

7.3.3 Instrument calibration

The instrument selected shall have a valid calibration certificate, wherein the calibration has been performed using certified and NIST traceable polystyrene latex microspheres (PSL), selected to cover the size range or ranges in which the particle size measurement will be performed. Calibration of the OAS or OPC shall have been conducted in accordance with ISO 21501-1 or ISO 21501-4 respectively, in the range of interest and be no more than 12 months old.

When using instruments supplied with a test dust for the purposes of checking calibration and performance, the dust shall have a valid calibration certificate from the manufacturer and be not more than 12 months old.

7.3.4 Coincidence and dilution

Take care to ensure when operating the particle counting instrument that the maximum concentration is not exceeded. If the maximum concentration is exceeded this would result in coincidence. Particle coincidence would result in the instrument reporting a larger particle size than actually present and a lower total number of particles counted per unit of volume. Where concentrations are present that exceed the allowable limits of the instrument in use, a particle dilution system shall be used (see Annex F). Consult the instrument manufacturer to identify a suitable particle dilution system for performing this task. The dilution ratio shall remain constant over the operating concentration range of the equipment.

8 Sampling techniques

8.1 General

The sampling equipment measurements can be carried out at full or partial flow.

a) Full flow — sampling of total airflow.

b) Partial flow — a representative sample taken from a percentage of the airflow.

In both cases to determine the concentration of the particles in the air sampled, the total volume of air sampled shall be known. This can either be recorded directly by a totalising flowmeter or as the product of the set flow rate and the period the air was being sampled.

The sample air flow rate shall not exceed the operating limits of the sampling device. The air flow rate should be constant.

8.2 Full flow sampling

For full flow sampling procedures refer to Annex C. Full flow sampling is likely to only be practical when applying the principle to sizing and counting using sampling discs due to the small sample flowrates generally in use with particle counting instruments.

8.3 Partial flow sampling

Where partial flow sampling is required then refer to Annex D.

The sample shall be collected at isokinetic conditions relative to the flow of the air being sampled. Isokinetic sampling devices shall exhibit the following characteristics;

a) The probe entrance shall be a minimum distance of 10 pipe diameters from upstream bends or restrictions and 3 diameters from downstream bends or restrictions.

b) The probe shall be inserted to an approximate central position across the pipe diameter

c) The probe entrance shall be tapered at an angle ≤30° to prevent the probe from influencing the flow at the sampling point and should be of the same cross-sectional shape as the pipe inside which it is situated. The nozzles may vary in shape and construction (see Figure D.2).

d) The probe shall be checked visually internally and cleaned, if necessary, before and after use and any impaction onto the internal surface of the probe during sampling shall be taken into account.

e) Turbulent flow conditions within the main air stream are required (Reynolds number, R_e, greater than 4 000). In normal industrial use, compressed air is in a state of turbulent flow, which occurs when the following conditions are met in Formula (1):

$$\left(q_w + q_p\right) > D/20 \qquad (1)$$