INTERNATIONAL STANDARD

ISO
13322-2

Particle size analysis — Image analysis methods —

Part 2:
Dynamic image analysis methods

Analyse granulométrique — Méthodes par analyse d'images —

Partie 2: Méthodes par analyse d'images dynamiques

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 13322-2 was prepared by Technical Committee ISO/TC 24, *Sieves, sieving and other sizing methods*, Subcommittee SC 4, *Sizing by methods other than sieving*.

ISO 13322 consists of the following parts, under the general title *Particle size analysis — Image analysis methods*:

— *Part 1: Static image analysis methods*

— *Part 2: Dynamic image analysis methods*

Introduction

The purpose of this part of ISO 13322 is to provide guidance for measuring and describing particle size distribution, using image analysis methods where particles are in motion. This entails using techniques for dispersing particles in liquid or gas, taking in-focus, still images of them while the particles are moving and subsequently analysing the images. This methodology is called dynamic image analysis.

There are several image capture methods. Some typical methods are described in this part of ISO 13322.

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Particle size analysis — Image analysis methods —

Part 2:
Dynamic image analysis methods

1 Scope

This part of ISO 13322 describes methods for controlling the position of moving particles in a liquid or gas and on a conveyor, as well as the image capture and image analysis of the particles. These methods are used to measure the particle sizes and their distributions, the particles being appropriately dispersed in the liquid or gas medium or on the conveyor. The practical limitations of the derived particle size are addressed when using this part of ISO 13322.

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 13322-1:2004, *Particle size analysis — Image analysis methods — Part 1: Static image analysis methods*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
flow-cell
measurement cell inside which the fluid-particle mixture flows

3.1.2
orifice tube
tube with an aperture through which a stream of fluid with dispersed particles flows

3.1.3
sheath flow
clean fluid flow surrounding particle-laden fluid for directing particles into a specific measurement zone

3.1.4
particle illumination
continuous illumination for image capture device with an electronic exposure time controller, or illumination of short duration for synchronized image capture device

3.1.5
measurement volume
volume in which particles are measured by an image analyser

3.1.6
depth of field
region where the sharpness of the edges of the images reaches the pre-set optimum

3.1.7
image capture device
matrix camera or line camera

3.2 Symbols

a moving distance of a particle during time t

A_i projected area of particle i

b measured diameter of binary image

t exposure time

v particle velocity

x diameter of particle

x_{Ai} projected area equivalent diameter of particle i

$x_{i\max}$ maximum Feret diameter of particle i

$x_{i\min}$ minimum Feret diameter of particle i

ε ratio of the measured particle diameter to the static particle diameter

4 Principle

4.1 General

A general diagram for dynamic image analysis is shown in Figure 1.
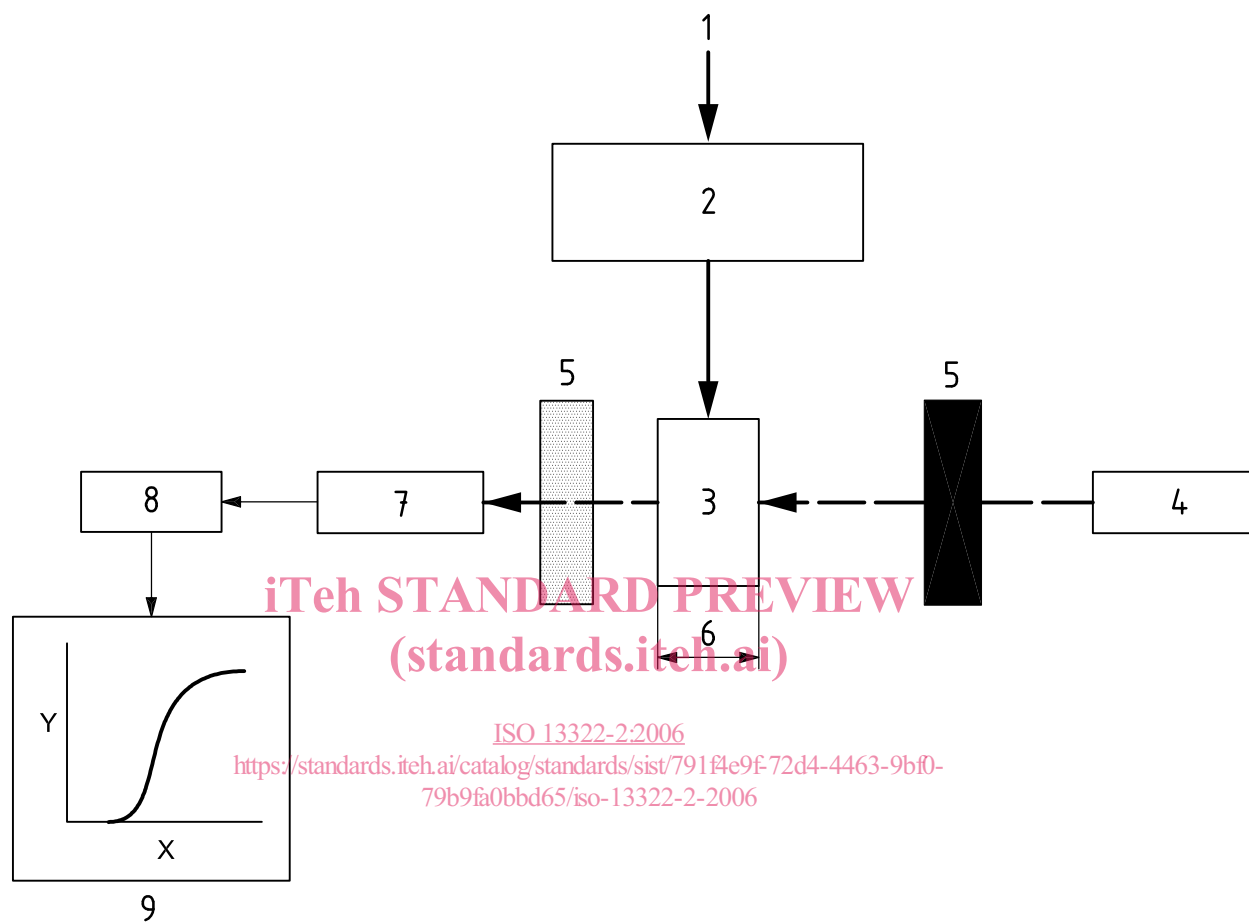
Key

1   dispersed particles
2   device for control of particle motion
3   measurement volume
4   light source
5   optical system
6   depth of field
7   image capture device
8   image analyser
9   display

Figure 1 — Flow diagram for typical dynamic image analysis method

4.2 Particle motion

Moving particles can be introduced into the measurement volume by three means:

a) particle motion in a moving fluid (e.g. particles in suspension, in an aerosol, in a duct, in an air jet, in a sheath flow, in turbulent flow or in a push-pull flow regime);

b) particle motion in a still fluid, i.e. in an injection or free-falling system, where particles are intentionally moved by an external force (e.g. gravity, electrostatic charge);

c) particle motion with a moving substrate, where particles are on the moving substrate (e.g. conveyor belt).

4.3 Particle positioning

Particles are introduced into the measurement volume and an image is taken when particles reach the object plane. The depth of the measurement volume is determined by the depth of field of the optical system used.

Figure 2 shows an example of measurement volume.
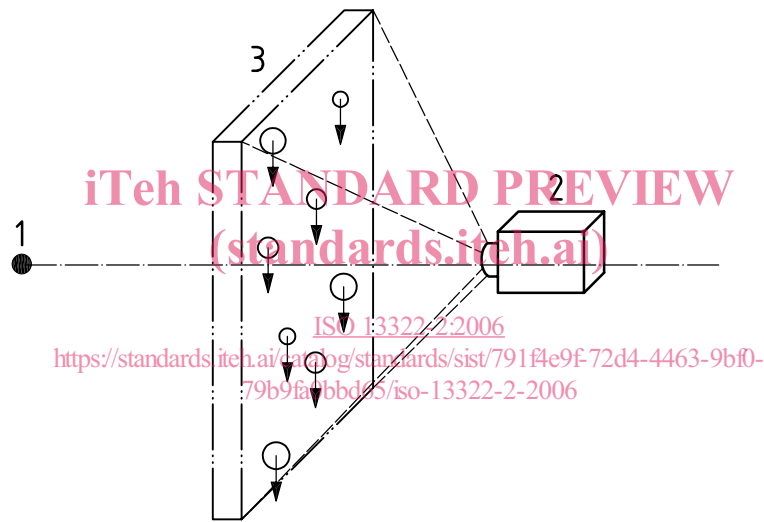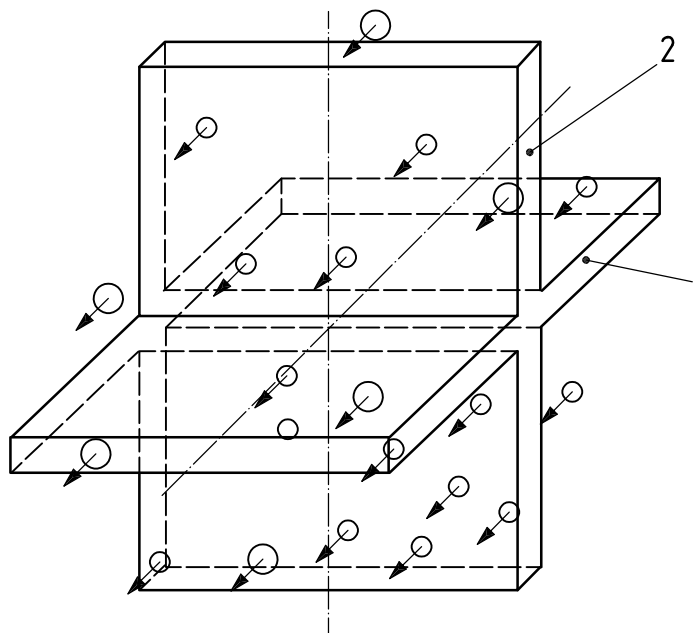

Key

1   light source
2   camera
3   measurement volume

Figure 2 — Example of measurement volume

The direction of observation (e.g. parallel or perpendicular) of the particles affects the interpretation of particle size and shape, as shown in Figure 3. However, this part of ISO 13322 is not concerned with the influence of particle shape on the overall measurement.

Key

1 measurement volume parallel to particle motion

2 measurement volume perpendicular to particle motion

Figure 3 — Particle movement and direction of observation

The focus of the image capture equipment shall be adjusted so as to acquire the exact image of the particles moving in the fluid. There are two recommended ways to achieve this:

a) by controlling the position of the moving particles so that they pass only within the measurement volume of the image capture equipment;

b) by illuminating the particles for a short time period (e.g. by flash light) or capturing the image of the moving particles when they pass through the measurement volume of the image capture equipment.

5 Operational procedures

5.1 General

Modern image analysers usually have algorithms to enhance the quality of the image prior to analysis. It is acceptable to use enhancement algorithms provided that the measured results are traceable back to the original image.

5.2 Still image resolution

The resolution of an image captured by a dynamic image analysis system depends not only on the optical system (lens magnification and camera resolution) but also on the lighting system and the velocity of the particles.

When a spherical particle of diameter x moves at a velocity v, the centre of the projected area of the particle moves a distance a during a time t, where t is either the strobe light emission time or camera shutter opening time (see Figure A.1), i.e.

$$a = v \times t \tag{1}$$

Without appropriate grey level handling, a shall not exceed either 0,5 pixel or $x \times (\varepsilon^2 - 1)$ pixel, where ε is the ratio of the measured particle diameter to the static particle diameter.

Grey level handling between pixel level and background level should ensure that the measured diameter of binary image b equals the diameter, x, of the static particle.

The total system resolution should be determined based on the particle size distribution and the desired confidence limits (see ISO 13322-1).

5.3   Calibration and traceability

The equipment shall be calibrated to convert pixels into SI length units (e.g. nanometres, micrometres, millimetres) for the final results. The calibration procedure shall include verification of the uniformity of the field of view. An essential requirement of the calibration procedure is that all measurements shall be traceable back to the standard metre. This can be achieved by calibration of the image analysis equipment with a certified standard stage micrometre.

Movement of particles during the capture of particle images, especially for smaller particles, may introduce serious error in determining particle sizes. It is therefore recommended that the whole system be verified with a standard reference material under motion.

The calibration particles shall be selected to include the dynamic range of the entire system. It is recommended to calibrate with three sizes of certified particles, i.e. with values near the maximum, mid-point and minimum particle sizes to be measured with the system.

5.4   Size classes and magnification

The theoretical limit for resolution of objects by size using image analysis is 1 pixel, and counts should be stored particle by particle, with the maximum resolution of 1 pixel. However, it is necessary to define size classes for the final reporting of the result, which is a function of the total number of particles, the dynamic range and the number of pixels included in the smallest considered objects. It is recommended that pixel size be converted to actual size prior to any reporting of size for quantitative analysis.

For a system in which not all the particles are measured, large particles may often be positioned on an edge of the image frame. Therefore, the magnification should be selected so that the maximum diameter of the largest particle does not exceed one-third of a shorter side of a rectangular image frame of the measuring area (see Annex B).

It is strongly recommended to address within the report any errors resulting from the loss of information of larger particles positioned at the edge of an image frame.

Optical resolution, where applicable, is normally better than electronic resolution.

5.5   Particle edges

In an image, the particle edge shall be defined by a suitable threshold level. The technique for doing this depends on the sophistication of the image analysis equipment.

It is strongly recommended that the threshold level be adjusted by comparing the processed binary images with the original grey images, in order to ensure that they are a reliable representation of the original grey images.