

Measurement and characterization of particles by acoustic methods —

Part 1: Concepts and procedures in ultrasonic attenuation spectroscopy

ICS 19.120

National foreword

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Measurement and characterization of particles by acoustic methods —

Part 1:

Concepts and procedures in ultrasonic attenuation spectroscopy

*Mesurage et caractérisation des particules par des méthodes
acoustiques —*

*Partie 1: Concepts et modes opératoires en spectroscopie d'atténuation
ultrasonique*



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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 20998-1 was prepared by Technical Committee ISO/TC 24, *Sieves, sieving and other sizing methods*, Subcommittee SC 4, *Sizing by methods other than sieving*.

ISO 20998 consists of the following parts, under the general title *Measurement and characterization of particles by acoustic methods*:

— *Part 1: Concepts and procedures in ultrasonic attenuation spectroscopy*

The following parts are under preparation:

— *Part 2: Guidelines for linear theory*

— *Part 3: Guidelines for non-linear theory*

Introduction

It is well known that ultrasonic spectroscopy can be used to measure particle size distribution (PSD) in colloids, dispersions, and emulsions (see ^[6]^[7]^[8]^[9]). The basic concept is to measure the frequency-dependent attenuation or velocity of the ultrasound as it passes through the sample. This attenuation includes contributions due to scattering or absorption by particles in the sample, and the size distribution and concentration of dispersed material determines the attenuation spectrum (see ^[10]^[11]^[12]). Once this connection is established by empirical observation or by theoretical calculations, one can in principle estimate the PSD from the ultrasonic data. Ultrasonic techniques are useful for dynamic on-line measurements in concentrated slurries and emulsions. Traditionally, such measurements have been made off-line in a quality control laboratory, and constraints imposed by the instrumentation have required the use of diluted samples. By making in-process ultrasonic measurements at full concentration, one does not risk altering the dispersion state of the sample. In addition, dynamic processes (such as flocculation, dispersion, and comminution) can be observed directly in real time (see ^[13]). This data can be used in process control schemes to improve both the manufacturing process and the product performance.

ISO 20998 consists of three parts:

- Part 1 introduces the terminology, concepts and procedures for measuring ultrasonic attenuation spectra;
- Part 2 provides guidelines for determining particle size information from the measured spectra for cases where the spectrum is a linear function of the particle volume fraction;
- Part 3 addresses the determination of particle size for cases where the spectrum is not a linear function of volume fraction.

Measurement and characterization of particles by acoustic methods —

Part 1: Concepts and procedures in ultrasonic attenuation spectroscopy

1 Scope

This part of ISO 20998 describes ultrasonic methods for determining the size distributions of one or more material phases dispersed in a liquid. Colloids, dispersions, slurries and emulsions are within the scope of this part of ISO 20998. The typical particle size for such analysis ranges from 10 nm to 3 mm, although particles outside this range have also been successfully measured. Measurements can be made for concentrations of the dispersed phase ranging from 0,1 % by volume up to 50 % or more by volume, depending on the density contrast between the continuous and the dispersed phases. These methods can be used to monitor dynamic changes in the size distribution, including agglomeration or flocculation in concentrated systems.

2 Terms and definitions

For the purposes of this document, the following terms apply:

2.1

absorption

direct reduction of incident ultrasonic energy by means other than scattering

2.2

attenuation

extinction

total reduction of incident ultrasonic energy, including both scattering and absorption.

NOTE The recommended measurement unit is the decibel (dB), which is defined as 10 times the common (base 10) logarithm of the ratio of incident intensity to transmitted intensity, or equivalently 20 times the common logarithm of the ratio of incident amplitude to transmitted amplitude. The neper (Np) is a permitted alternative measurement unit based on the natural logarithm, rather than the common logarithm. The conversion factor is $1 \text{ Np} = 8,686 \text{ dB}$.

2.3

attenuation coefficient

extinction coefficient

attenuation (extinction) per unit length of ultrasonic propagation through a material, measured in units of dB/cm or Np/cm.

NOTE Attenuation coefficients are sometimes scaled by frequency, or frequency-squared, to identify the dominant attenuation mechanism. For clarity, in this part of ISO 20998, only the attenuation per unit length (in dB/cm) is considered.

2.4

attenuation spectrum

attenuation coefficient measured as a function of frequency