BS ISO 11657:2014

BSI Standards Publication

Hydrometry — Suspended sediment in streams and canals — Determination of concentration by surrogate techniques

bsi.

...making excellence a habit.™

Document Sharing Hub

Full document details: BS ISO 11657:2014

National foreword

This British Standard is the UK implementation of ISO 11657:2014.

The UK participation in its preparation was entrusted to Technical Committee CPI/113, Hydrometry.

A list of organizations represented on this committee 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.

© The British Standards Institution 2014.
Published by BSI Standards Limited 2014

ISBN 978 0 580 75617 7

ICS 17.120.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2014.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: BS ISO 11657:2014

INTERNATIONAL STANDARD

ISO 11657

First edition
2014-07-01

Hydrometry — Suspended sediment in streams and canals — Determination of concentration by surrogate techniques

Hydrométrie — Sédiments en suspension dans les cours d'eau et dans les canaux — Détermination de la concentration par des techniques de substitution

Reference number
ISO 11657:2014(E)

Documents
Document Sharing Hub

© ISO 2014

Full document details: BS ISO 11657:2014

COPYRIGHT PROTECTED DOCUMENT

© ISO 2014

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 11657:2014

Contents

Page

Foreword ... **iv**

Introduction ... **v**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions ... **1**

4 Measuring principles ... **2**
- 4.1 Transmission ... 2
- 4.2 Scattering ... 2
- 4.3 Transmission — Scattering ... 3
- 4.4 Diffraction ... 3

5 Properties of sediment of importance for sediment surrogate techniques ... **3**
- 5.1 General ... 3
- 5.2 Particle size ... 4
- 5.3 Particle colour ... 4

6 Methods for determination of suspended sediment concentration by surrogate techniques ... **4**
- 6.1 General ... 4
- 6.2 Bulk optics ... 4
- 6.3 Laser diffraction (LD) ... 5
- 6.4 Acoustic back scatter (ABS) ... 5

7 Calibration and validation ... **6**

Annex A (informative) **Determination of the concentration of suspended sediment by optical techniques** ... **9**

Annex B (informative) **Determination of the concentration of suspended sediment by laser diffraction technique** ... **12**

Annex C (informative) **Determination of the concentration of suspended sediment by acoustic back scatter** ... **14**

Bibliography ... **18**

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 11657:2014

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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 113, *Hydrometry*, Subcommittee SC 6, *Sediment transport*.

© ISO 2014 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 11657:2014

Introduction

Sedimentation and sediment transport in streams, rivers, reservoirs and estuaries are key parameters in many scientific, environmental, engineering, and agricultural problems. Success in managing and solving sedimentation problems requires comprehensive knowledge of sediment movement. This requires reliable methods of estimation of sediment load with high-quality data. The amount of sediment transport data being collected, however, has steadily declined in recent decades largely due to difficulty and costs associated with field methods used for data collection. High temporal resolution data of high quality are needed to better understand and more adequately describe many sedimentation processes.

The bed load and suspended load broadly constitute total sediment load. However, the scope of this International Standard is confined to the measurement of suspended sediment. Conventional methods for measurement of suspended sediment concentrations in streams rely on the principle of collecting samples of water-sediment mixture at various points in time and space using suitable sampling equipment and deployment methods and analysing the samples in laboratory for estimating the sediment concentration. These methods are labour intensive, expensive and can be hazardous. Moreover, the accuracy of these methods in estimating the sediment concentration of rivers and streams over a period of time may not be dependable due to the large spatial and temporal variability associated with the transport of suspended sediment.

Continuous and accurate estimation of suspended sediment concentration is essential in certain situations such as:

a) in hydropower projects for the safety of the turbines and other machinery, reservoir silting and flushing;

b) water-supply projects for monitoring water quality;

c) storm water run-off from urban areas;

d) silting of wetlands; and

e) long-term monitoring of sediment transport in rivers and streams, in order to obtain reliable base lines that can be used for decision making.

In such situations, automatic and cost-effective techniques are essential to collect high-quality data on suspended sediment concentrations and particle sizes.

Recent technological advances in the fields of optics and acoustics have provided new sediment-surrogate technologies and methods to determine suspended sediment fluxes and characteristics. Some of these methods can be used to measure suspended sediment concentration at higher resolution, with greater automation and potentially lower cost than traditional methods. These methods involve surrogate technologies that derive the suspended sediment concentration from measurements of optical backscatter, laser diffraction and acoustic backscatter.

The measurement of suspended sediment concentration (SSC) in the water samples can be carried out with the help of nephelometry, transmission, laser diffraction and acoustic back scatter techniques. The working principles, applications, advantages and disadvantages, limitations and usable instruments of the above techniques are elaborated in this International Standard. The optical backscatter technique is readily available and relatively inexpensive. Optical backscatter sensor sensitivity depends on grain size, colour and composition. The advantages are small size and small sample volume, linear and high frequency response, insensitive to ambient light, large measuring range and low cost. The laser diffraction (LD) technique is also readily available and cost effective. The acoustic backscatter is another technique for measurement of SSC in the aquatic ecosystems. Measurements are possible for a range of sediment sizes that is dependent on the acoustic frequency. The available maximum sampling depth will be limited at high concentrations.

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 11657:2014

Documents
Document Sharing Hub

INTERNATIONAL STANDARD ISO 11657:2014(E)

Hydrometry — Suspended sediment in streams and canals — Determination of concentration by surrogate techniques

1 Scope

This International Standard specifies methods for determination of the concentrations and particle-size distributions of suspended sediment in streams and canals by surrogate techniques. Methods based on bulk-optical principle of water such as transmission and nephelometry are the most commonly used surrogates for determining suspended sediment concentrations (SSC). Instruments and techniques based on acoustic attenuation and/or acoustic backscatter principles are also in use for measurement of suspended sediment concentration. Instrumentation based on the laser diffraction principle is also used for the measurement of particle size distribution. This International Standard covers brief description of the operating principle of each method and details of some of the instruments available.

The detailed method and principle of optical and acoustical transmission, nephelometry, and optical back scatter (OBS), laser diffraction technique (LD) and acoustic back scatter technique (ABS) with their limitations are described in Annex A, Annex B and Annex C respectively.

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.

ISO 772, *Hydrometry — Vocabulary and symbols*

ISO 4363, *Measurement of liquid flow in open channels — Methods for measurement of characteristics of suspended sediment*

ISO 13320, *Particle size analysis — Laser diffraction methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 772, ISO 4363 and ISO 13320 and the following apply.

3.1
surrogate technique
indirect method in which a substitute object or property is used for measurement in place of the original object or property

Note 1 to entry: Optical and acoustic properties of water-sediment mixture such as optical transmission, acoustic scattering and laser diffraction are some of the surrogates for measurement of suspended sediment concentration.

3.2
nephelometry
any method for estimating the concentration of particles in suspension by measuring the intensity of scattered light

Note 1 to entry: Light scattering depends upon number, size distribution, colour, composition (as manifested in the complex index of refraction) and shape characteristics of the particles.

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 11657:2014

4 Measuring principles

Optical and acoustical methods can be used for continuous measurement of sediment concentration. The measuring principles for the above surrogate techniques are similar and can be classified in three categories as described in 4.1 to 4.4 (see Figure 1).

4.1 Transmission

The source and detector are placed opposite to each other at a distance l as shown in Figure 1 A. The source emits a collimated light beam with intensity l_o. The sediment particles in the measuring volume reduce the beam intensity by absorption and scattering resulting in a reduced detector signal. The relationship between the detector signal (l_t) and the sediment concentration (c) is described by Beer's Law[43] and is given by Formula (1):

$$l_t = l_o e^{-kcl} \tag{1}$$

where

l_t is the transmitted light through a sample of length l in water of sediment concentration c;

l_o is the incident intensity of the emitter source;

k is a constant depending on the sediment, water, and instrument characteristics.

4.2 Scattering

The source and detector are placed at an angle φ relative to each other shown in Figure 1 B. The detector receives a part of the radiation scattered by the sediment particles in the measuring volume. The relationship between detector signal (l_s) and sediment concentration (c) is given by Formula (2):

$$l_s = k_3 l_o c e^{-k_2 c} \tag{2}$$

where

l_o is the incident intensity of the emitter source;

k_2 is a constant depending on the sediment, water, and instrument characteristics;

k_3 is a calibration coefficient depending on instrument geometry, particle properties (size distribution, shape, index of refraction or composition), optical /acoustic wave length and travel distance (l).

NOTE Often, the distance l cannot be defined in optical backscatter type systems.

An important limitation of the scattering method is the strong nonlinearity of the relation between the detector signal and sediment concentration for large concentrations. Even in low concentrations where the response is linear, the output depends strongly on grain size and colour. For instance, colour alone may change the calibration by a factor of 10 for higher concentration[37] and the grain size may cause an additional change in calibration. For example, the calibration is shown to change by a factor of 20 between a white 5 µm sediment and a grey 10 µm sediment. As such, changes in sediment properties are not uncommon in nature, which are generally not known during the course of monitoring. Spot calibration from samples is likely to be contaminated by unknown errors when sediment properties change in space/time. The errors can reach several hundred percent and greater. However, the use of laser sensors is able to overcome these errors to great extent.

© ISO 2014 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 11657:2014