



**International  
Standard**

**ISO 6640**

**Measurement of density of water-  
sediment mixture using radiation  
transmission method**

**First edition  
2024-05**

**iTeh Standards  
(<https://standards.itih.ai>)  
Document Preview**

[ISO 6640:2024](https://standards.itih.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024)

<https://standards.itih.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024>

iTeh Standards  
(<https://standards.iteh.ai>)  
Document Preview

[ISO 6640:2024](https://standards.iteh.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024)

<https://standards.iteh.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024>



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, 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  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

**Contents**

Page

<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Protection against ionizing radiation</b> .....	<b>2</b>
<b>5 Properties of sediments</b> .....	<b>2</b>
5.1 General.....	2
5.2 Particle size.....	2
<b>6 Principles of radiation transmission and backscattering methods</b> .....	<b>2</b>
6.1 General.....	2
6.2 Principle of gamma and X-ray transmission method.....	2
6.3 Principle of gamma ray backscattering method.....	5
<b>7 Calibration procedure</b> .....	<b>6</b>
<b>Annex A (informative) Prototypes of instruments</b> .....	<b>7</b>
<b>Annex B (informative) Calibration</b> .....	<b>9</b>
<b>Annex C (informative) Case study: Measurement of vertical profile of water-sediment mixture density</b> .....	<b>12</b>
<b>Bibliography</b> .....	<b>14</b>

iTech Standards  
(<https://standards.itih.ai>)  
Document Preview

[ISO 6640:2024](https://standards.itih.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024)

<https://standards.itih.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024>

## 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 document 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](http://www.iso.org/directives)).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at [www.iso.org/patents](http://www.iso.org/patents). ISO shall not be held responsible for identifying any or all such patent rights.

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

For an explanation of 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 [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 6 *Sediment transport*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

ISO 6640:2024

<https://standards.iteh.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024>

## Introduction

Radiation transmission method for measuring the density of water-sediment mixture in water bodies such as rivers, dams and harbours has been employed for many years. It can continuously measure the suspended sediment concentrations providing data for optimal operation and better management of dams, reservoirs and navigation channels. The major applications of the radiation transmission method are:

- a) maintenance of navigation channels,
- b) optimization of dredging operations,
- c) management of dams and reservoirs.

Dams and reservoirs are vital in terms of water supply, irrigation and electricity generation. Large investments are needed for maintenance and efficient operation of dams and reservoirs. Sustainable operation of dams and reservoirs requires an in-depth understanding and monitoring of sedimentation rates.

In harbour navigation channels, radiation transmission method is applied to measure nautical depth. The method supplements the preliminary indications provided by ultrasound devices.

# iTeh Standards (<https://standards.iteh.ai>) Document Preview

[ISO 6640:2024](https://standards.iteh.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024)

<https://standards.iteh.ai/catalog/standards/iso/6253b950-28b4-4b00-9e68-4d430f53a2a3/iso-6640-2024>



# Measurement of density of water-sediment mixture using radiation transmission method

## 1 Scope

This document specifies the radiation transmission method for measurement of density of the water-sediment mixture, suspended or deposited, in water bodies such as streams, canals, harbour basins, dams and reservoirs.

The method is based on principles of transmission of X or Gamma rays. This document covers brief description of the operating principle of the method and details of some of the instruments used.

This document applies to the measurement of water-sediment mixture density in water bodies using radiation transmission method, particularly gamma and X-ray transmission method. The working principles, applications, advantages and associated instruments are elaborated in this document.

## 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 772, *Hydrometry — Vocabulary and symbols*

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

ISO 11657, *Hydrometry — Suspended sediment in streams and canals — Determination of concentration by surrogate techniques*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 772, ISO 4363, ISO 11657 and the following apply.

ISO and IEC maintain terminology 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 radiation transmission method

gamma, X-ray transmission method to measure the density of water-sediment (3.2) mixture in water bodies

### 3.2 sediment

solid particles derived from rocks, biological materials or chemical precipitants, that are transported by, suspended in or deposited by flowing water

Note 1 to entry: Sediment usually means inorganic material and consists of clay, silt, sand or gravel.

## 4 Protection against ionizing radiation

Exposure of any part of the human body to ionizing radiation can be injurious to health.

## 5 Properties of sediments

### 5.1 General

Water-sediment mixture density is affected by physical properties of the sediments.

### 5.2 Particle size

Sediments under study can be classified by their grain size, from clay to sand. The Wentworth's classification is one of the most widely used classifications for sediments, as given below:

- sand: particles between 0,063 mm to 2 mm in diameter,
- silt: particles between 0,002 mm to 0,063 mm in diameter,
- clay: particles less than 0,002 mm in diameter.

Sediments can be divided into cohesive and non-cohesive classes. Silt and clay are cohesive while the sand is non-cohesive. According to the Wentworth classification, fine or pelitic sediments, known as mud, are those with dimensions lesser than 0,063 mm.

## 6 Principles of radiation transmission and backscattering methods

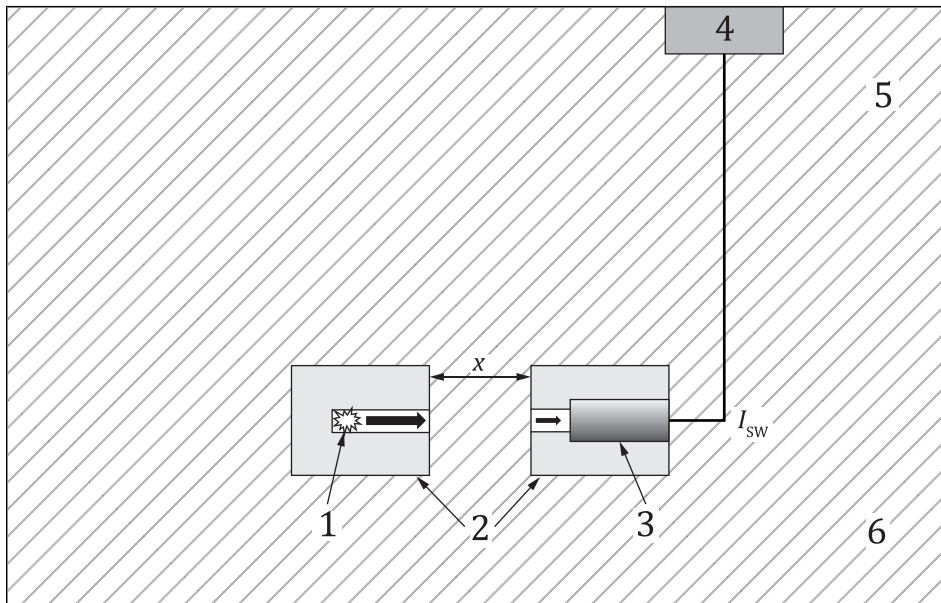
### 6.1 General

Both radiation transmission and backscattering methods can be used for measurement of density of water-sediment mixture in water bodies. The methods enable measurement of a wide range of densities. The typical instruments used in these methods are presented in [Annex A](#).

### 6.2 Principle of gamma and X-ray transmission method

The measurement is based on the attenuation of a collimated beam of gamma or X-rays traversing through the water-sediment mixture in the direction of a collimated detector mounted on opposite side of the source (see [Figure 1](#)).





**Key**

- 1 radiation source
- 2 collimators
- 3 radiation detector
- 4 data acquisition system on a boat
- 5 water
- 6 sediment water mixture
- $x$  thickness of water column
- $I_{SW}$  intensity of transmitted radiation

**Figure 1 — Principle of the gamma and X-ray transmission method**

When a monoenergetic beam of radiation impinges on a water column of thickness  $x$  cm, the intensity of the transmitted radiation  $I_w$  (counts/unit time) is given as:

$$I_w = I_0 \cdot e^{-\mu_w \cdot x} \quad (1)$$

where

$I_0$  is the radiation intensity measured in the air;

$\mu_w$  is the linear attenuation coefficient of water, in  $\text{cm}^{-1}$ .

In the water-sediment mixture, the intensity of the transmitted radiation,  $I_{SW}$ , is given as:

$$I_{SW} = I_0 \cdot e^{-\mu_{sw} \cdot x} \quad (2)$$

where  $\mu_{sw}$  is the linear attenuation coefficient of the water-sediment mixture.

The linear attenuation coefficient,  $\mu_{sw}$ , is defined as:

$$\mu_{sw} = v_w \mu_w + v_s \mu_s \quad (3)$$

where,  $\mu_s$  is the linear attenuation coefficient of sediment;  $v_w$  and  $v_s$  are the volume fraction of water and sediment in the mixture, respectively. As the sediment concentration is  $c$ , (the weight of sediment in 1 cm<sup>3</sup> of the mixture) the volume fractions are defined as:

$$v_s = \frac{c}{\rho_s} \quad (4)$$

$$v_w = 1 - v_s = 1 - \frac{c}{\rho_s} \quad (5)$$

where,  $\rho_s$  is the sediment density.

[Formula \(3\)](#) can be modified by substituting the volume fractions:

$$\mu_{sw} = v_w \mu_w + v_s \mu_s = \left(1 - \frac{c}{\rho_s}\right) \mu_w + \frac{c}{\rho_s} \mu_s = \mu_w + \frac{c}{\rho_s} (\mu_s - \mu_w) \quad (6)$$

[Formula \(2\)](#) can be modified by substituting the linear attenuation coefficient,  $\mu_{sw}$ :

$$I_{sw} = I_0 \cdot e^{-\mu_{sw} \cdot x} = I_0 \cdot e^{-\left(\mu_w + \frac{c}{\rho_s} (\mu_s - \mu_w)\right) \cdot x} = I_0 \cdot e^{-\mu_w \cdot x} \cdot e^{-\frac{c}{\rho_s} (\mu_s - \mu_w) \cdot x} = I_w \cdot e^{-\frac{\mu_s - \mu_w}{\rho_s} \cdot x \cdot c} \quad (7)$$

By taking natural logarithm of [Formula \(7\)](#):

$$\ln \frac{I_{sw}}{I_w} = -\frac{\mu_s - \mu_w}{\rho_s} \cdot x \cdot c \quad (8)$$

The density ( $\rho_m$ ) of water-sediment mixture with concentration  $c$  can be calculated using the following formula:

$$\rho_m = c + \left(1 - \frac{c}{\rho_s}\right) \rho_s = \frac{\rho_s - 1}{\rho_s} c + \rho_s \quad (9)$$

Therefore:

$$c = \frac{\rho_s}{\rho_s - 1} \rho_m - \frac{\rho_s}{\rho_s - 1} \quad (10)$$

[Formula \(8\)](#) can be modified by substituting the concentration  $c$  using [Formula \(10\)](#):

$$\ln \frac{I_{sw}}{I_w} = -\frac{\mu_s - \mu_w}{\rho_s} \cdot x \cdot \left(\frac{\rho_s}{\rho_s - 1} \rho_m - \frac{\rho_s}{\rho_s - 1}\right) = -\frac{\mu_s - \mu_w}{\rho_s - 1} \cdot x \cdot \rho_m + \frac{\mu_s - \mu_w}{\rho_s - 1} \cdot x \quad (11)$$

Let the constant terms,  $-\frac{\mu_s - \mu_w}{\rho_s - 1} \cdot x$  and  $\frac{\mu_s - \mu_w}{\rho_s - 1} \cdot x$  be denoted by  $A$  and  $B$ , respectively, then [Formula \(11\)](#)

is simplified as:

$$\ln \frac{I_{sw}}{I_w} = A \cdot \rho_m + B \quad (12)$$

To obtain the values of constant,  $A$  and  $B$ , the intensities of the transmitted radiation,  $I_{sw}$ , are measured with water-sediment mixtures of known densities. A calibration curve is obtained by plotting the measured data. The slope and intercept of the curve provide the values of constant  $A$  and  $B$ . Once values of  $A$  and  $B$