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ISO 4373

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Measurement of liquid flow in open channels — Water-level measuring devices

Mesure de débit des liquides dans les chenaux — Appareils de mesure du niveau d'eau

Reference number
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Contents

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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.

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.

International Standard ISO 4373 was prepared by Technical Committee ISO/TC 113, *Hydrometric determinations*, Subcommittee SC 5, *Instruments, equipment and data management*.

This second edition cancels and replaces the first edition (ISO 4373:1979), which has been technically revised.

Annex A forms an integral part of this International Standard.

Introduction

The collection of water-level records with respect to time generally forms the basis for obtaining a systematic record of stream flow at a gauging station. This water-level record, together with periodic discharge measurements, can be converted by one or more methods (see ISO 1100) into a continuous record of discharge. The accuracy of the record of discharge is governed in large part by the accuracy of the record of water level. It is essential that this be detected and recorded efficiently and with an accuracy sufficient for the purposes for which the stream flow data are required.

Water-level records, besides being used to produce stream flow data, also have an intrinsic value in monitoring the level of any body of water. It must also be recognized that, however accurate the inherent performance of a water-level recording installation, the application of routine operational and maintenance procedures is essential to achieving design performance. Although the design and operation of water-level measuring devices is described in terms of the devices in current use, this International Standard is not intended to inhibit further development. Rather it is intended to encourage the introduction of improved instrumentation exhibiting better performance.

Measurement of liquid flow in open channels — Water-level measuring devices

1 Scope

This International Standard specifies the functional requirements and operational procedures for stage detecting, encoding and recording devices for measuring water levels in open channels. Because of the widespread use of stilling wells in the measurement of water levels, information on stilling wells is given in annex A to this International Standard.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 772:—[1)], *Measurement of liquid flow in open channels — Vocabulary and symbols.*

ISO 1100-1:1981, *Liquid flow measurement in open channels — Part 1: Establishment and operation of a gauging station.*

ISO 1100-2:1982, *Liquid flow measurement in open channels — Part 2: Determination of the stage-discharge relation.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 772 and the following definitions apply.

3.1 encoding: Method by which a data signal is changed into a suitable set of bits for data recording.

3.2 parity check: Addition of an extra bit to a data signal so that the total number of bits in a sample are either always even or always odd.

4 Accuracy of stage measurements

For the measurement of stage with respect to a gauge datum, an uncertainty of ± 10 mm may be satisfactory in some installations: in others, uncertainty of ± 3 mm or better may be required. However, in no case should the uncertainty be more than ± 10 mm or 0,1% of the range, whichever is greater. Exceptions can be made if sediment or unstable channel conditions make it impossible to obtain a complete and reliable record with standard equipment, and where special equipment must be used to obtain a complete record but with greater uncertainty (for example, see 8.2).

This clause applies in all cases, unless specifically stated otherwise.

5 Gauge datum

The stage of a stream or lake is the height of the water surface above an established datum plane. The datum of the gauge may be a recognized datum, such as mean sea level, or an arbitrary datum plane selected for the convenience of using gauge readings of relatively low numbers. ISO 1100-1 contains additional requirements regarding gauge datum, gauge zero and benchmarks.

1) To be published. (Revision of ISO 772:1988)

6 Environment

The following criteria generally apply. Exceptions, because of local conditions, shall be specified by the user.

6.1 Operating

Water level sensors and recorders shall operate satisfactorily over temperature, relative humidity and pressure ranges applicable to local conditions. The user shall specify the conditions that are likely to apply.

6.2 *In situ* resistance

Instrumentation shall withstand temperatures from − 50 °C to + 60 °C and relative humidities of 100 % (without condensation) in a non-operating condition.

6.3 Resistance during transport and storage

Instrumentation shall withstand temperatures from − 50 °C to + 60 °C and relative humidities of 100 % (without condensation) in a non-operating condition. Instrumentation shall be capable of withstanding vibrations and bouncing that normally occur in transport.

7 Direct water-level indicating devices

Water-level gauges may determine water levels either directly or indirectly. Measuring devices of the fixed or movable type, such as vertical and inclined gauges, needle gauges and wire weight gauges, are classified as direct-reading instruments. The significant feature of this group of water-level indicators is that the reading may be made directly in units of length, without any intervening conversions. These gauges are often used as a reference gauge for setting a water-level recorder.

7.1 Vertical and inclined gauges

Such gauges comprise a scale marked on or attached to a suitable surface.

7.1.1 Functional requirements

Vertical and inclined gauges shall be

a) accurate and clearly marked;

b) durable and easy to maintain;

c) simple to install and use.

7.1.2 Construction material

The material of which a gauge is constructed shall be durable, particularly in alternating wet and dry conditions, and also in respect of the resistance to wear or fading of the markings. The material should have a low coefficient of expansion with respect to temperature or wetting effects, commensurate with accuracy requirements.

7.1.3 Graduation

7.1.3.1 The graduations shall be clearly and permanently marked directly on a smooth surface or on a gauge board. The numerals shall be legible and placed so that there is no possibility of ambiguity. A typical example is shown in figure 1.

7.1.3.2 The graduations of an *inclined gauge* may be directly marked on a smooth surface or on a gauge board, as described in 7.1.3.1, or marked on manufactured gauge plates designed to be set to a specified slope. An inclined gauge should be calibrated *in situ* by precise levelling from the station benchmark.

7.1.3.3 *Gauge plates* shall be manufactured in suitable lengths, often 1 m, with the width of the scale not less than 50 mm.

7.1.3.4 The marking on the gauge should be made to read in multiples of millimetres. The smallest graduation shall depend on the accuracy required, but may correspond to 10 mm.

7.1.3.5 The markings of the subdivisions shall be accurate to ± 0,5 mm, and the cumulative error shall not exceed 0,1 % or 0,5 mm, whichever is smaller.

7.1.4 Installation and use

7.1.4.1 General

The gauge should preferably be placed near the side of the stream, so that a direct reading of water level may be made. If this is impractical because of excessive turbulence, wind effect or inaccessibility, the measurement may be made in a suitable permanent stilling bay or stilling well in which the wave actions are damped and the level of the water surface follows the fluctuations of the water level in the stream. To ensure this, intakes to stilling wells should be properly designed and located (see annex A).

The gauge should be located as closely as possible to the measuring section without affecting the flow conditions at this point. If possible, the gauge should not be placed where the water is disturbed by turbu-

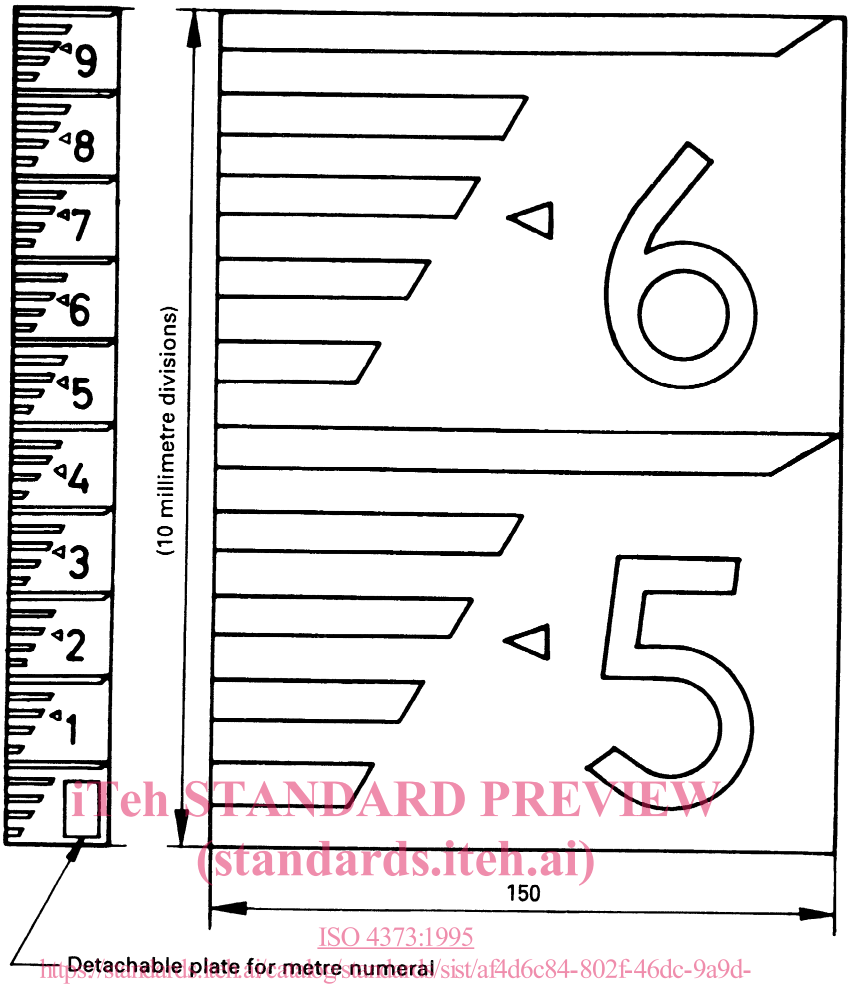

Figure 1 — Typical details of vertical staff gauge

lence, or where there is danger of damage by drift. Bridge abutments or piers are generally unsuitable locations. Wherever the gauge is situated, it shall be readily and conveniently accessible so that the observer may make readings as nearly as possible at eye level. The gauge board or plate shall be securely fixed to the backing but provision must be made for removing the gauge board or plate for maintenance or adjustment. The edges of the gauge board should be protected.

7.1.4.2 Vertical gauges

A suitable backing for a vertical gauge is provided by the surface of a wall having a vertical or nearly vertical face parallel to the direction of flow. The gauge board or backing plate shall be attached to the surface so as to present a vertical face to receive the graduations. The gauge board and backing plate shall be securely fastened to the wall. Gauges may be fixed to piles, either driven firmly into the river bed or banks, or set in concrete so as to be free from sinking, tilting or washing away. In either case the anchorage shall extend below the ground surface to a level free of disturbance by frost. In order to avoid velocity effects which may hinder accurate reading, a pile may be shaped to present a streamlined profile upstream and downstream or the gauge may be situated in a bay where it will not be exposed to the force of the current. Where the range of water levels exceeds the range of a single vertical gauge, additional sections may be installed on the line of the cross-section normal to the direction of flow.

7.1.4.3 Inclined gauges

An inclined gauge shall be installed in such a manner to follow the contour of the river bank. The profile of the bank may be such that a gauge of a single slope may be installed; frequently however, it may be necessary to construct the gauge in several sections, each with a different slope. The general installation requirements given in 7.1.4.1 apply.

7.2 Needle gauges

7.2.1 General

A needle water-level gauge consists of a device with an end point and some means of determining the point's exact vertical position relative to datum. The two types of needle gauges are

a) the **point gauge**, whose tip approaches the free surface from above, and

b) the **hook gauge**, which is hook-shaped, and whose tip is immersed and approaches the free surface from below (see figure 2).

The vertical position may be determined by a graduated scale, a tape with some vernier arrangements, or an arrangement to detect linear movement electronically with a digital indicator similar to a digital micrometer. The scale is movable and graduated to read downward from top to bottom in metres.

Application of needle gauges consists of positioning the needle of the gauge near the water surface and detecting the moment the tip touches the free surface, as if trying to pierce its "skin". Setting a point exactly at the water surface may be facilitated by electrical, visual [light-emitting diode (LED) display] and/or acoustic (electronic buzzer) indicators.

The advantage of water-level needle gauges is their high measuring accuracy, whereas their disavantage is their small measuring range, usually about 1 m. However, this disadvantage can be overcome by installing a series of datum plates at different levels.

7.2.2 Functional requirements

7.2.2.1 A hook- or point-gauge installation shall permit measurement of stage to be made at all levels, from below the lowest to above the highest levels anticipated.

7.2.2.2 There shall be good illumination of the place where the tip meets the free liquid surface; if this is not the case, gauges with electronic meters for indication shall be used.

7.2.2.3 The hook or point shall be made of metal sufficiently strong to resist deformation in transport and under field conditions of use. The tip shall be tapered to a point having an included angle of approximately 60° and the point shall be rounded to a radius of approximately 0,25 mm (see figure 3).

7.2.3 Material

A hook or point gauge and auxiliary parts shall be made throughout with durable corrosion-resistant materials.

7.2.4 Graduation

The graduation of a hook or point gauge shall be in millimetres and shall be clearly and accurately marked. A vernier or micrometer head may be provided which allows reading to 0,1 mm. However, such a reading accuracy is normally only required for laboratory measurements.

7.2.5 Installation and use

7.2.5.1 A hook or point gauge may be mounted over an open water surface at the edge of a stream if conditions permit. If this is not practical because of turbulence, wind effect or inaccessibility, a suitable permanent stilling bay or stilling well should be installed.

7.2.5.2 The location of the hook or point gauge should be as close as possible to the stage-measuring section and should be conveniently accessible to the observer.

7.2.5.3 The gauge shall not be installed in a location where the water surface is disturbed by turbulence, wind effect or afflux. The vicinity of bridge abutments or piers is generally unsuitable.

7.2.5.4 Where more than one datum plate or bracket is provided at different levels, it is preferable that all should lie on the line of a single cross-section normal to the direction of flow in the stream. If this is not practicable and it is necessary to stagger the points, all should lie within a distance of 1 m on either side of the cross-section line.

7.2.5.5 Datum plates and brackets shall be mounted on a secure foundation which extends below the frost line.

7.2.5.6 The elevation of the datum plates, with reference to which the level of the free water surface is determined, shall be established with great care. This elevation shall be checked from the station benchmark at least annually. The tolerance on the transfer of level from the station benchmark to each datum plate shall not exceed ± 1,0 mm.

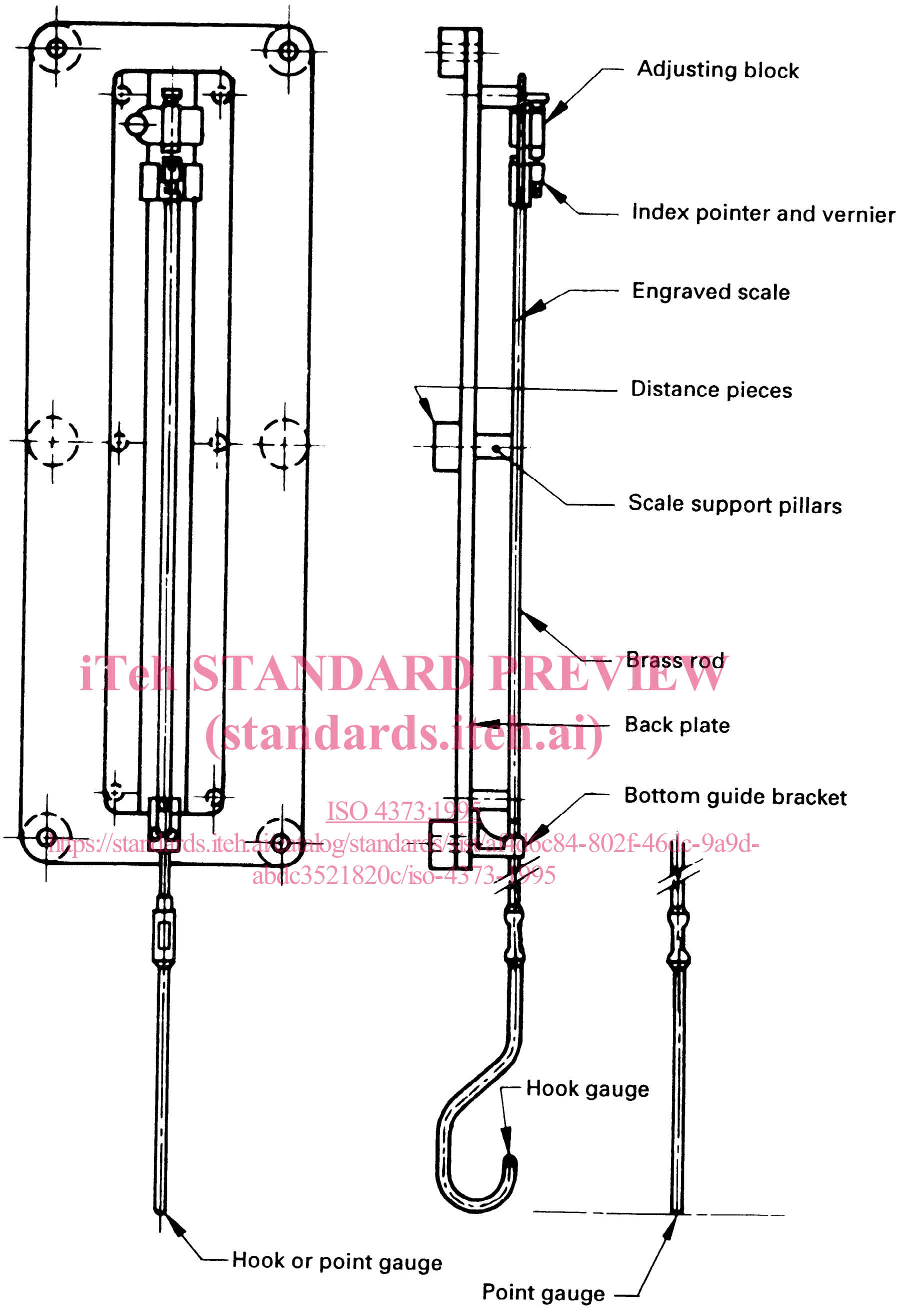

Figure 2 — Arrangement of hook, point and electrical depth gauges

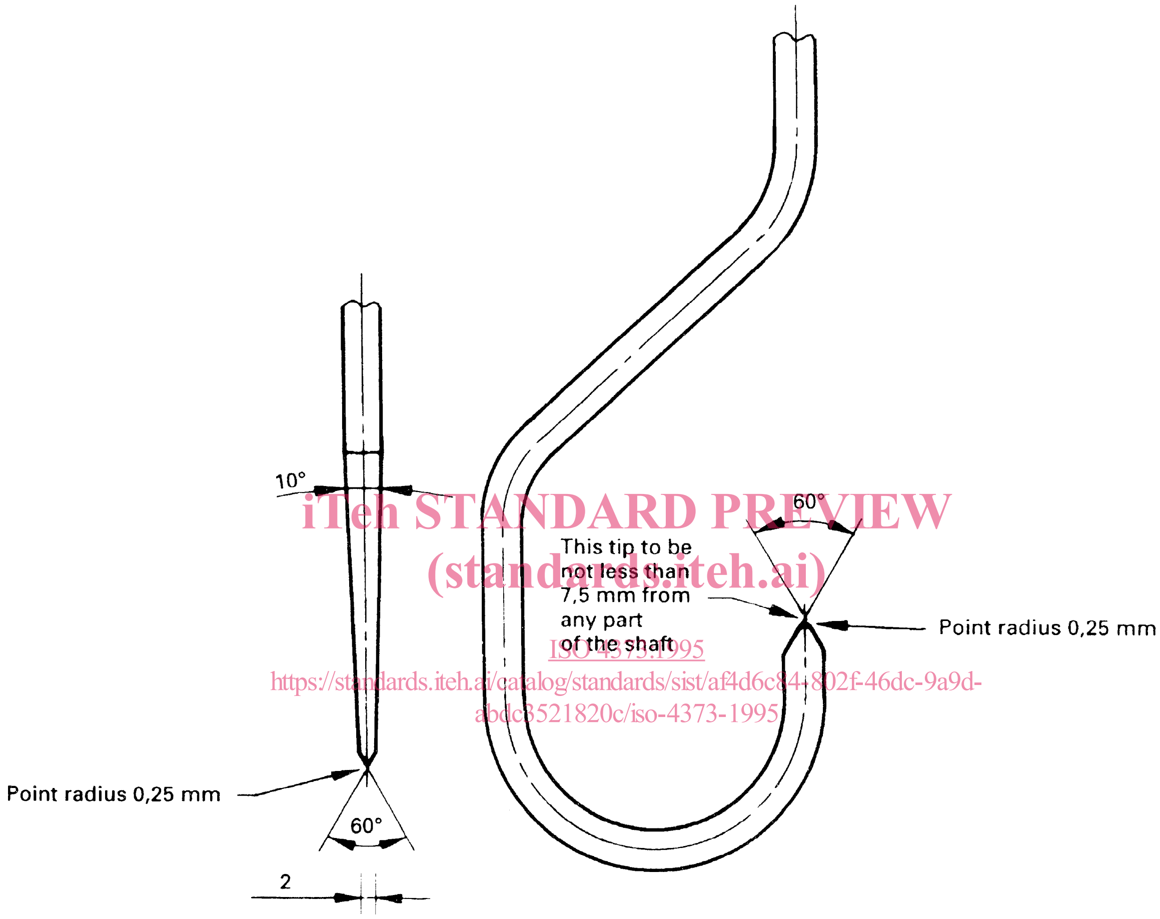

Figure 3 — Details of the hook and of the point of hook and point gauges

7.3 Float gauges

7.3.1 General

The float gauge is used chiefly as an inside reference gauge in water stage measurements. The typical float gauge consists of, for example, a float operating in a stilling well, a graduated steel tape, a counterweight, a pulley and a pointer. The float pulley is grooved on the circumference to accommodate the steel tape, runs slip-free over the pulley in the gauge shelter above the well, and is kept taut by a counterweight at the free end or by a spring. In this way stage fluctuations are detected by the float which positions the tape with respect to the pointer. A float gauge may also be coupled directly to a water-level recorder. Such use, however, is discouraged unless there is another completely independent reference gauge for the recorder.

7.3.2 Functional requirements

7.3.2.1 A float gauge installation shall permit measurement of stage to be made at all levels, from below the lowest to above the highest levels anticipated.

7.3.2.2 Float and counterweight dimensions and the quality of the elements of the mechanical device for remote indication shall be selected so that there is a sufficiently high indication accuracy and working reliability. Clause 10 of this International Standard discusses float system errors.

7.3.2.3 The float shall be made of durable corrosion-resistant and antifouling material. It shall be leakproof and function in a truly vertical direction. Its density shall not change significantly.

7.3.2.4 The float shall be checked at frequent intervals to make sure that it is floating properly, and care should be taken to see that the tape does not become twisted or fouled and that the indicated stage is the same as the water level in the stream. Care should be taken to prevent the float from dragging against the well sides or against other objects.

7.3.3 Graduation

The graduations of the float gauge shall be in millimetres and shall be clearly and accurately marked.

7.4 Wire-weight gauge

7.4.1 General

The typical wire-weight gauge consists of a drum wound with a single layer of cable, a bronze weight attached to the end of the cable, a graduated disc and a counter, all enclosed within a protective housing (see figure 4). The disc is graduated and is permanently connected to the counter and the shaft of the drum. The cable is guided to its position on the drum by a threading sheave. The reel is equipped with a pawl and ratchet for holding the weight at any desired elevation. The gauge is set so that when the bottom of the weight is at the water surface, the gauge height is indicated by the combined readings of the counter and the graduated disc.

7.4.2 Functional requirements

A wire-weight gauge should permit measurement of stage to be made at all anticipated stage levels.

7.4.3 Material

A wire-weight gauge shall be made throughout with durable, corrosion-resistant materials.

7.4.4 Graduation

The graduation of the wire-weight gauge should be in millimetres.

7.4.5 Installation and use

7.4.5.1 The wire-weight gauge may be used as an outside reference gauge where other gauges are difficult to maintain. The wire-weight gauge is usually mounted where there is a bridge or other structure over the water.

7.4.5.2 The gauge shall be installed in a location where the water surface is not disturbed by turbulence, wind effects or afflux.

7.4.5.3 The check bar elevation of the wire-weight gauge should be read frequently to ensure reliability of the correct base elevation.

7.5 Crest stage gauges

The crest stage gauge is used to record the peak stage occurring at a given location during a given time period, or from the time when the gauge was reset. Typically, the gauge consists of a vertical tube containing a float or a floating substance (such as cork dust). The tube is perforated at the bottom to permit