International Standard ISO 1100/1

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Liquid flow measurement in open channels — Part 1 : Establishment and operation of a gauging station

Mesure de débit des liquides dans les canaux découverts — Partie 1 : Établissement et exploitation d'une station de jaugeage

Second edition — 1981-10-15

UDC 532.57 : 532.543 : 627.133 **Ref. No. ISO 1100/1-1981 (E)**

Descriptors : liquid flow, water flow, open channel flow, flow measurement, gauging station, boats, velocity measurement.

Price based on 21 pages

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1100/1 was developed by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*, and was circulated to the member bodies in November 1979.

It has been approved by the member bodies of the following countries :

Canada	Norway	Switzerland
France	Philippines	United Kingdom
Germany, F. R.	Romania	USA
India	South Africa, Rep. of	
Netherlands	Spain	

The member body of the following country expressed disapproval of the document on technical grounds :

Australia

This second edition cancels and replaces the first edition (i.e. ISO 1100-1973).

Liquid flow measurement in open channels — Part 1 : Establishment and operation of a gauging station

1 Scope and field of application

1.1 This International Standard deals with the establishment and operation of a gauging station on a lake, reservoir, river or artificial open channel for the measurement of stage or discharge or both. It is generally applicable to the measurement methods described in the International Standards which are noted in clause 2 and it covers only such additional requirements as are necessitated by its wider scope.

1.2 The requirements for a stage measuring station are set out in clause 5. The requirements for a discharge measuring station are classified under two headings :

a) Individual measurements.

These include methods suitable for a single measurement of discharge or a limited number of measurements often used to calibrate a station.

b) Regular measurements.

These include methods suitable for relatively frequent measurements often made over many years.

2 References

ISO 31, *Quantities, units and symbols.*

ISO 555/1, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 1 : Constant rate injection method.*

ISO 555/2, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 2 : Integration (sudden injection) method.*

ISO 748, *Liquid flow measurement in open channels — Velocity area methods.*

ISO 772, *Liquid flow measurement in open channels — Vocabulary and symbols.*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units.*

ISO 1070, *Liquid flow meausrement in open channels — Slope-area method.*

ISO 1088, *Liquid flow measurement in open channels — Velocity area methods — Collection of data for determination of errors in measurement.*

ISO 1100/2, *Liquid flow measurement in open channels — Part 2 : Determination of the stage-discharge relation.*[1]

ISO 1438/1, *Water flow measurement in open channels using weirs and venturi flumes — Part 1 : Thin-plate weirs.*

ISO 2425, *Measurement of flow in tidal channels.*

ISO 2537, *Liquid flow measurement in open channels — Cup-type and propeller-type current meters.*

ISO 3454, *Liquid flow measurement in open channels — Sounding and suspension equipment.*

ISO 3455, *Liquid flow measurement in open channels — Calibration of rotating element current meters in straight open tanks.*

ISO 3716, *Liquid flow measurement in open channels — Functional requirements and characteristics of suspended load samplers.*

ISO 3846, *Liquid flow measurement in open channels by weirs and flumes — Free overfall weirs of finite crest width (rectangular broad-crested weirs).*

1) At present at the stage of draft.

ISO 3847, *Liquid flow measurement in open channels by weirs and flumes — End-depth method for estimation of flow in rectangular channels with a free overfall.*

ISO 4359, *Liquid flow measurement in open channels using flumes.* 1)

ISO 4360, *Liquid flow measurement in open channels by weirs and flumes — Triangular profile weirs.*

ISO 4363, *Liquid flow measurement in open channels — Methods of measurement of suspended sediment.*

ISO 4364, *Liquid flow measurement in open channels — Bed material sampling.*

ISO 4366, *Echo sounders for water depth measurements.*

ISO 4369, *Measurement of liquid flow in open channels — Moving-boat method.*

ISO 4373, *Measurement of liquid flow in open channels — Water level measuring devices.*

ISO 4375, *Measurement of liquid flow in open channels — Cableway system for stream gauging.*

ISO 4377, *Measurement of liquid flow in open channels — Flat-V weirs.* 1)

ISO 5168, *Measurement of fluid flow — Estimation of uncertainty of a flow-rate measurement.*

ISO/TR 7178, *Measurement of liquid flow in open channels — Investigation of the total error in measurement of flow by velocity area methods.* 1)

WMO *(World Meteorological Organisation)* — No. 168, *Guide to Hydrometeorological Practices.*

WMO *(World Meteorological Organisation)* — No. 49, *Technical Regulations.*

3 Definitions

For the purpose of this International Standard, the definitions and symbols given in ISO 772 apply.

4 Units of measurement

The units of measurement used in this International Standard are SI Units in accordance with ISO 31 and ISO 1000.

5 Water level (stage) gauging station

5.1 Principle

5.1.1 The stage of a stream or lake is the height of the water surface above an established datum plane. Water levels of rivers, lakes and reservoirs are used directly in hydrological forecasting, in delineating flood hazard areas, and in the design of structures in, or near, water bodies. When correlated with discharge of streams, or with the volume of storage in reservoirs and lakes, water levels are used as the basis for computation of records of discharge, or changes in storage. Records of water level are obtained by systematic observations on a reference gauge, or from a water level recorder.

5.2 Preliminary survey

5.2.1 A preliminary survey should be made of the physical and hydraulic features of the proposed site to ensure that it conforms to the requirements necessary for the measurement of water level as specified in ISO 4373.

5.3 Selection of site

5.3.1 The site selected for observation of stage should be governed by the purpose for which the records are collected, the accessibility of the site, and the availability of an observer if the gauge is non-recording. Gauges on lakes and reservoirs are normally located near the outlet, but upstream from the zone where an increase in velocity causes a drawdown in water level. Gauges on large bodies of water should also be located so as to reduce the fetch of strong winds which may cause damage or misleading data. Hydraulic conditions are an important factor in site selection on channels, particularly where water levels are used to compute discharge records.

5.3.2 Gauging stations should conform to the requirements of the relevant sections of ISO 4373 which includes recommendations for the design of the reference gauge, recorder, and stilling well.

5.4 Design and construction

5.4.1 A water level gauging station shall consist essentially of a reference gauge or gauges. Where a continuous record of stage is not required see 7.1.7.2. It is usual however for a continuous record of stage to be required and for this purpose a water level recorder is installed in addition to the reference gauge (see 7.1.7.3).

1) At present at the stage of draft.

5.4.2 Reference gauge (see ISO 4373)

Reference gauges may be either the direct or the indirect type, with measuring instruments of the fixed or movable type, such as vertical and inclined gauges, needle gauges, float gauges, and wire weight gauges classified as direct reading instruments. The signifiant feature of this group of water-level indicators is that the reading may be made directly in units of length, without any intervening influences. Indirect water-level indication devices include those gauging systems which convert a pressure or electrical signal to an output which is proportional to the water level. Of the indirect devices available, those in most common usage are the pressure type, such as the servo-manometer and the servo-beam balance.

5.4.2.1 Vertical and inclined gauges

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

5.4.2.1.1 Functional requirements

These gauges should meet the following functional requirements :

a) they should be accurate and clearly marked;

b) they should be durable and easy to maintain;

c) they should be simple to install and use.

5.4.2.1.2 Material

The material of which a gauge is constructed should be durable, particularly in alternating wet and dry conditions and also in respect to 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.

5.4.2.1.3 Graduation

a) The graduations of a vertical gauge must be clearly and permanently marked directly on a smooth surface or on a gauge board. The numerals shall be distinct and placed so that the lower edge of the numeral is close to the graduation to which it refers.

b) The graduations of an inclined gauge may be directly marked on a smooth surface or on a gauge board as described in a) above, or may be carried on manufactured gauge plates designed to be set for particular slopes. Except where use is made of 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 bench mark.

c) Gauge plates should be manufactured in suitable lengths with the face of the scale not less than 50 mm in width.

d) 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 normally be 10 mm.

e) The markings of the subdivisions shall be accurate to ± 0,5 mm, and the cumulative error in length shall not exceed 0,1 % or 0,5 mm, whichever is greater.

5.4.2.1.4 Installation and use

5.4.2.1.4.1 General

The gauge should preferably be placed near the bank so that a direct reading of water level may be made. If this is impracticable 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 closely follows the fluctuations of the water level in the channel. To ensure this, intakes to stilling wells should be properly designed and located.

The gauge should be located as closely as possible to the measuring section without affecting the flow conditions at this point. It should not be placed where the water is disturbed by turbulence, or there is danger of damage by drift. Bridge abutments or piers are generally unsuitable locations. Wherever the gauge is situated, it must be readily and conveniently accessible so that an observer may take readings as nearly as possible at eyelevel. Where necessary, the construction of a flight of steps to give convenient access is recommended. The gauge board or plate should 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.

5.4.2.1.4.2 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 should be attached to the surface so as to present a truly vertical face to receive the graduations. The gauge board and backing plate should be securely fastened to the wall. Gauges may be fixed to piles, either driven firmly into the bed or banks, or set in concrete so as to be free from sinking, tilting, or being washed away. In either case the anchorage should 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 be streamlined 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 capacity of a single vertical gauge, additional sections may be installed on the line of the cross section normal to the direction of flow. The scales on such a series of stepped gauges should have adequate overlap. These stepped gauges should be installed at such intervals as to ensure the measurement of water level at all stages of flow.

5.4.2.1.4.3 Inclined gauges

An inclined gauge should be installed in such a manner as to closely 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 5.4.2.1 apply.

5.4.2.2 Needle gauges

5.4.2.2.1 General

A needle water-level gauge consists of a point and some means of determining its exact vertical position relative to a datum. It is mainly used for checking or calibrating other gauges or recorders. 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.

The vertical position may be determined by a graduated scale, a tape with some vernier arrangement, or a digital indicator. The scale is movable and graduated to read downward from top to bottom. Application of needle gauges consists of positioning the needle of the gauge near the water surface and detecting the moment the tip just touches the free surface, apparently trying to pierce its skin. Setting a point exactly at the water surface may be facilitated by electrical means.

The advantage of water-level needle gauges is their high measuring accuracy, whereas their disadvantage 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.

5.4.2.2.2 Functional requirements

a) A needle gauge installation should permit measurement of stage to be made at all levels from below the lowest to above the highest level anticipated.

b) There must be good illumination of the place where the tip meets the free liquid surface.

c) The hook or point should be made of metal sufficiently strong to resist deformation in transport and under field conditions of use. The tip should 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.

5.4.2.2.3 Material

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

5.4.2.2.4 Graduation

The graduations 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.

5.4.2.2.5 Installation and use

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

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

c) The gauging point 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.

d) 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 channel; 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.

e) Datum plates and brackets should be mounted on a secure foundation which extends below the frost line.

f) The elevation of the datum plates, with reference to which the level of the free surface is determined, should be established with great care. This elevation should be checked from the station bench mark (see 5.5.4) at least annually. The uncertainty on the transfer of level from the station bench mark to each datum plate shall not exceed ± 1,0 mm.

5.4.2.3 Float gauge

5.4.2.3.1 General

The float gauge is used chiefly as an inside reference gauge in water stage measurements. The typical float gauge consists of 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 tape, and mounted on a support. The tape is fastened to the upper side of the float and runs slip-free over the pulley in the gauge shed above the well. The tape is kept tight by a counterweight at the free end or by a spring. In this way stage fluctuations are sensed by the float which positions the tape with respect to the pointer.

5.4.2.3.2 Functional requirements

a) A float gauge installation should permit measurement of stage to be made at all levels from below the lowest to above the highest level anticipated.

b) Float and counterweight dimensions and the quality of the elements of the mechanical device for remote indication should be selected so that there is a sufficiently high indication accuracy and working reliability.

c) The float should be made of durable corrosion-resistant and antifouling material. It should be leak-proof and function in a truly vertical direction. Its density should not change significantly.

d) The float should float properly and the tape or wire should be free of twists or kinks.

5.4.2.3.3 Graduation

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

5.4.2.4 Wire-weight gauge

5.4.2.4.1 General

A typical wire-weight gauge consists of a drum wound with a single layer of cable, a weight attached to the end of the cable, a graduated disc, and a counter, all housed within a cast-aluminium box. 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.

5.4.2.4.2 Functional requirements

a) A wire-weight gauge installation should permit measurement of stage to be made at all levels from below the lowest to above the highest level anticipated.

b) The tape or wire should be free of twists or kinks.

c) The weight should be made of durable corrosion-resistant material.

d) The installation should be provided with a horizontal checking bar for checking the calibration datum of the graduated disc or counter.

5.4.2.4.3 Installation and use

a) The wire-weight gauge is used as an outside reference gauge where other outside gauges are difficult to maintain. The wire-weight gauge is normally mounted where there is a bridge, deck, or other structure over the water.

b) The gauging point should not be installed in a location where the water surface is disturbed by turbulence, wind effects, or afflux. The vicinity of bridge abutments or piers is generally unsuitable.

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

5.4.2.5 Crest stage gauge

The crest stage gauge is used to obtain a record of the peak level reached during a flood when other methods of recording levels cannot be used. Peak discharges may be calculated from the water levels at two gauges installed some distance apart in a stretch of channel, provided that the time lag between measurements is negligible. These gauges do not meet the accuracy requirements of 5.6.

These gauges are locally made to different designs. Basically they may be a tube of about 50 mm internal diameter down the centre of which runs a rod. The tube is perforated to permit rising water to enter, the perforations being located to prevent drawdown or velocity head from affecting the static water level. The top of the tube must be closed to prevent the entry of rain, but it should have an air vent to permit water to rise up the tube without significant delay. Powdered cork in the bottom of the tube floats on the surface of the floodwater being deposited on the centre rod as the water recedes. Alternatively the centre rod is coated with a paint whose colour is permanently affected by water.

5.4.2.6 Pressure gauges

Pressure gauges are frequently used at sites where it would be too expensive to install stilling wells. They are also used on sand-channel streams because the intake line can be extended to follow a stream channel that shifts its location, and if the gas-purge technique is used, the gas flow tends to keep the orifice from becoming plugged with sand.

5.4.2.6.1 General

One widely-used method of measuring water level is to measure the height of a column of water with respect to some datum plane. This can be accomplished indirectly by sensing the water pressure at a fixed point below the water surface, and then utilizing the hydrostatic principle that the pressure of a liquid is proportional to the depth.

5.4.2.6.2 Functional requirements

The range of the instrument must be adequate to accommodate any anticipated ranges in water level and the response must be sufficiently rapid to follow any expected rate of change in water level.

The method of transmitting pressure from the water column to the sensor may be direct or indirect. When the sensor is located below the point in the water column at which the pressure is to be measured, the water pressure may be transmitted directly to the sensor. However, if the sensor is located above the water column, the direct method is usually not satisfactory because gases entrained in the water can create air locks in the line. Also, if the water is highly corrosive, it is undesirable to bring it into direct contact with the sensor.

5.4.2.6.3 Gas-purge (bubbler) technique

The most successful and widely used method of transmitting pressure is the gas-purge technique. This technique may be used regardless of the elevation of the pressure device with respect to the water column; and because the water does not come into direct contact with the pressure sensor, it is suitable for use in highly corrosive waters.

In the gas-purge technique, a small discharge of non-corrosive gas or compressed air is allowed to bleed into a tube, the free end of which has been lowered into the water and fixed at an elevation below the water column to be measured. For example, dry nitrogen is frequently used. The sensor, which is located at the opposite end, detects the pressure of the gas required to displace the liquid in the tube, this pressure is directly proportional to the head of liquid above the orifice.

When using the gas-purge technique there are certain installation and operation requirements that should be observed. The principal ones are listed below.

a) An adequate supply of gas or compressed air must be provided. A continuous flow of gas to the tube is necessary to prevent the liquid from entering it when the water level is rising. A particular rate of gas supplied will cause the pressure in the system to rise at the same rate as the head. If gas is supplied at a lower rate, liquid will enter the tube; and conversely, a higher rate will provide a continuous discharge of gas from the opening in the bottom of the tube. The gas is usually supplied from a cylinder or by an air compressor. In either case, the supply must have a delivery pressure in excess of the range to be measured.

b) A pressure reducing valve must be provided so that a pressure safely in excess of that of the maximum range can be set. A flow control valve and some form of visual flow-rate indicator is necessary, so that the discharge of gas supplied to the system can be properly adjusted. The pressure should be set to prevent water from entering the tube, even under the most rapid rates of change expected.

c) Incorrect readings due to the friction of the gas moving through the tube should be minimised. Long lengths of tube or very small diameter tubing aggravate the friction problem. This problem is frequently solved by running two tubes to a junction very near to the orifice with one tube serving as a gas-supply line and the other as a pressure-detection line. Under this arrangement the movement of gas in the pressure detection line is kept to a minimum, thereby reducing the friction to a minimum.

d) The tubing should be installed with a continuous down slope to the orifice.

5.4.2.6.4 Pressure bulb system

Where there is no gas supply available, a pressure bulb system is sometimes used to transmit pressure to the sensor. This device, frequently referred to as an elastic pressure bulb, is usually made of casting in the form of a short hollow cylinder with one open end. The open end is sealed with a slack, highly flexible diaphragm, and the cylinder is connected by means of tubing to the pressure sensor. The whole unit forms a closed gas system with pressure initially equal to atmospheric pressure. The cylinder is lowered into the water and fixed at an elevation below the water column to be measured. The slack diaphragm permits water pressure to compress the gas in the cylinder until the pressure within the system is proportional to the height of the water column above. One of the major disadvantages of this device is that ultimately an excessive amount of gas will escape from the system with a resultant stretching of the diaphragm. When this occurs the pressure within the system will no longer be equal to the pressure head. This disadvantage can be overcome by periodic renewal of the gas in the system by opening and re-sealing under atmospheric pressure and checking the calibration. It is difficult to maintain the accuracy stipulated under 5.6 with this device.

5.4.2.6.5 Servo-manometer and servo-beam balance

Both the servo-manometer and the servo-beam balance are pressure sensors that convert the pressure detected to a rotational shaft position proportional to the height of the column of water. The shaft rotation is used for driving a recorder and a water-level indicator. As the name implies, the servo-manometer is essentially a manometer with a servo-system detecting and following the liquid differential within the manometer. The servo-beam balance is a beam balance with a pressure balance on one side of the beam and a weight on the other. Here the servo-system positions the weight so that the beam is in balance and detects this position.

5.4.2.6.6 Water density compensation

Since the density of the water in which the sensor operates will vary with temperature and also with chemical and silt content, either automatic or manual means of compensating for these changes should be provided.

5.4.2.6.7 Changes in gas weight

If one of the gas techniques is used to transmit pressure, provisions should be made for compensating for changes in the density of the gas, as all gases vary in volume with temperature and pressure changes.

5.4.2.6.8 Miscellaneous pressure sensors

There are numerous pressure sensors available commercially operating on numerous principles. Most of these have an electrical output which is proportional to the pressure sensed. They are occasionally used for the detection of water level. The proper selection is dependent upon the particular application involved.

Their application is generally restricted to limited ranges because the accuracy requirements set out in 5.6 are difficult to meet over extended ranges.

5.4.3 Stilling well

5.4.3.1 Functional requirements of stilling well

5.4.3.1.1 General

The function of the stilling well is :

a) to accommodate the instrument and protect the float system;

b) to provide within the well an accurate representation of the water level in the channel;

c) to damp out oscillations of the water surface.

5.4.3.1.2 Specific

a) The well may be circular, oval, square or rectangular in plan and may be made of any suitable material.

b) The well may be placed in the bank of a channel or directly in the stream when attached to a bridge pier or abutment. It should not, however, be located directly in the channel where flow conditions would lead to separation and stagnation effects. When placed in the bank, the well shall be connected to the channel by intake pipe(s). When placed directly in the channel, the intakes may take the form of holes or slots cut in the well itself.

c) The well shall not interfere with the flow pattern in the approach channel and if set in relation to a control, it shall be located far enough upstream to be outside the area affected by the control.

d) The well shall be firmly founded when placed in the bank and firmly anchored when standing in the stream so that it shall remain stable at all times.

e) The well and all construction joints of well and intake pipes shall be watertight so that water can enter or leave only by the intake itself.

f) The well shall be vertical within acceptable limits and have sufficient height and depth to allow the float to travel freely the full range of water levels.

g) The dimensions of the well shall be such as to allow unrestricted operation of all equipment installed in it. Clearance between walls and float shall be at least 75 mm and where two or more floats are used within the well, clearance between them shall be at least 150 mm. In silt laden rivers, it is an advantage to have the well large enough to be entered and cleaned.

h) When placed in the bank of the stream the stilling well shall have a sealed bottom to prevent seepage into or leakage out of the chamber.

j) In wells with sealed bottoms the bottom of the well shall be at least 300 mm below the invert of the lowest intake to provide space for sediment storage and to avoid the danger of the float grounding at times of low flow.

5.4.3.2 Functional requirements of intakes

5.4.3.2.1 General

The function of the intakes to the stilling well is :

a) to allow water to enter or leave the stilling well so that the water in the well is maintained at the same elevation as that in the stream under all conditions of flow;

b) to permit some form of control to limit lag and oscillating effects within the well.

5.4.3.2.2 Specific

a) Intakes may take the form of one or more pipes connecting the well to the river when the well is set back into the bank or a series of holes or slots cut into the well itself when it is set directly into the river. In rivers with a permanent high silt content, a well set in the stream may have a hopper-shaped bottom to serve as an intake and also as a means of self-cleansing.

b) The dimensions of the intakes shall be large enough to allow the water level in the well to follow the rise and fall of river stage without appreciable delay.

c) The dimensions of the intakes shall be small enough to damp oscillations caused by wave action or surges.

d) Two or more intakes may be installed, one vertically above the other, to ensure operation of the system if the lowest pipe becomes blocked.

e) For a pipe well set into a bank the lowest intake shall be at least 150 mm below the lowest anticipated stage and shall enter the pipe well at least 300 mm above the well bottom.

f) Intake pipes shall be laid at a constant gradient on a suitable foundation which will not subside.

g) The intake shall be so oriented in the stream that it will sense the true water level. When velocities in the stream at the point of measurement are sufficiently large, that the dynamic pressure is of sensible magnitude, the intake shall incorporate a static pressure sensing device (wall piezometer, piezometer in a plate, surface parallel to flow, static tubes etc.).

h) It is desirable that intake pipes more than 20 m in length shall be provided with an intermediate manhole fitted with internal baffles to act as a silt trap and provide access for cleaning.

j) Means of cleaning the intakes shall be provided, either by a flushing system where water under head can be applied to the stilling well end of the intake, by pumping water through the intake or by hand cleaning with collapsible draining rods.

k) Where velocity past the river end of the intake is high, drawdown of the water level in the well may occur. This can be reduced by attaching a capped and perforated static tube to the river end of the intake.

5.4.3.3 Protection under ice conditions

For precautions to be taken under ice conditions see clause 9.

5.4.4 Water level recorders (see ISO 4373)

5.4.4.1 Mechanical recorders

Mechanical recorders can be classified as either analog or digital, depending upon the mode used in recording the rotational position of the input shaft. The analog recorder produces a graphic record of the rise and fall of parameter values with respect to time, while the digital recorder punches coded parameter values on paper tape at preselected time intervals. Anolog recorders can further be classified into two types, those which record continuously or at intervals for a fixed period of time (daily, weekly, monthly, etc).

5.4.4.2 Pressure-actuated recorders

Pressure-actuated recorders are simple in design and relatively rugged in construction. They are, however, susceptible to errors and, consequently, are not frequently used in recording water level.

They usually consist of a pressure-sensing element, a stylus linked to the pressure element by a lever arrangement, and a chart driven by a clock.

5.4.4.3 Electronic recorders

The electronic recorder consists of a case, an operating mechanism, a stylus, and a chart transport mechanism. The function of the operating mechanism is to position the stylus at the proper location on the chart in response to a signal. Although there is an extremely wide assortment of electronic recorders available, there are basically only two types, those with a direct-acting operating mechanism and those with a servo-operated mechanism. The low torque and relatively limited output motion of a direct acting mechanism will position only a light, low friction stylus over a limited range, whereas the sturdy servo-operated mechanism has ample power and a much wider motion capability.

The operating mechanism is the heart of the electronic recorder. Its quality and the techniques employed in its design determine the characteristics of the entire recorder.

5.4.4.4 *Regardless of the type of recorder used it should* satisfy the requirements enumerated in ISO 4373.

5.5 Gauge datum

5.5.1 The datum of the gauge may be a recognised datum, such as mean sea level, or an arbitrary datum plane selected for the convenience of using gauge readings of relatively low numbers. It is generally desirable to avoid negative values for these readings, therefore, the datum selected for operating purposes should be below the elevation of zero flow on the control. At sites that are subject to severe scour care must be taken to select a datum that is sufficiently low.

5.5.2 If an arbitrary datum plane is used, it should be referred to a bench mark of known elevation by accurate levelling so that the arbitrary datum may be recovered if the gauge and reference marks are destroyed. A permanent datum must be maintained so that only one datum for the stage record is used for the life of the station .

5.5.3 Gauge zero

The zero of the gauge should be correlated with a national datum through a station bench mark. The relation between the gauge zero and the station bench mark shall be checked at least annually. The relation between the gauge zero and other gauge sections shall be checked from time to time. As far as possible the gauge zero shall be kept the same. The uncertainty in the *transfer of the level from the station bench mark to the gauge* shall not exceed ± 1,0 mm.

5.5.4 Station bench mark

The station bench mark shall be set in a position offering maximum security against disturbance. It should be securely fixed in a concrete block or similar mounting that extends below the ground surface to a level free from disturbance, such as frost. It should be correlated with a national survey datum by accurate levelling. To facilitate accurate levelling between the station bench mark and the gauge zero, the bench mark should be located in a position such that the transfer of the level may be carried out by reciprocal levelling or with equally balanced foresights and backsights on the setting of the level. Where it is not feasible to correlate the bench mark with the national survey datum more than one (preferably three) station bench marks shall be established in significantly different locations.

5.6 Accuracy

For the measurement of stage, in certain installations an uncertainty of ± 10 mm may be satisfactory; in others an uncertainty of ± 3 mm or better may be required; however, in no case should be uncertainty be worse than ± 10 mm or ± 0,1 % of the range, whichever is greater.

6 Station for the measurement of discharge : individual measurements

The methods which follow are most suitable for a single measurement, a limited number of measurements or infrequent measurements of discharge.

6.1 Velocity area method

6.1.1 Principle of method of measurement

The principle of the method is to measure the velocity and area of cross section of flow in an open channel, the product of which is the discharge. The recommendations which follow restrict the application of the method to the case in which velocity is measured using current meters or floats.

6.1.2 Preliminary survey

A preliminary survey should be made to ensure that the physical and hydraulic features of the proposed site conform to the requirements of ISO 748. Several such surveys under different flow conditions may be required to ensure that the site is not subject to, for example, standing waves at high flow, weed conditions, adverse ice conditions, and so forth.

6.1.3 Selection of site

6.1.3.1 The site selected should be such that it is possible to measure the whole range and all types of flow which may be encountered or which it is required to measure.

6.1.3.2 Particular attention should be paid to the following features :

a) sites where weed growth is prevalent should be avoided, if possible;

b) there should be no vortices, dead water or other abnormalities of flow;

c) sites where poor ice conditions are prevalent should be avoided, if possible;

d) access to the site should be feasible under most conditions.

6.1.4 Survey for a permanent gauging station

6.1.4.1 After a preliminary survey, a topographical survey should be made when selecting a permanent site for a suitable measuring section. This should include a plan of the site indicating the width of the water surface at a stated stage, the edges of the natural banks of the channel(s), the line of any definite discontinuity of the slope of these banks and the toe and crest of any artificial flood bank.

6.1.4.2 The detailed survey of the reach should be extended through the floodway to an elevation well above the highest anticipated flood level. The spacing of levels or soundings should be close enough to reveal any abrupt change in the contour of the channel.

6.1.4.3 The bed of the reach should be examined carefully for the presence of rocks or boulders, particularly in the vicinity of the measuring section.

6.1.4.4 Where velocities are to be measured by current meter, exploratory measurements of velocities should be made in the proposed measuring section and in the cross-section immediately upstream and downstream. When possible, the method of velocity distribution described in ISO 748 should be used for these measurements to determine the feasibility of using reduced point methods.

6.1.4.5 When floats are to be used for velocity measurements trial runs of floats should be closely spread across the width of the channel.

6.1.5 Design and construction

6.1.5.1 The positions of each cross-section should be defined on the banks of the river by clearly visible and readily identifiable permanent markers, and a station bench mark shall be established to conform to 5.5.4.

6.1.5.2 The design of the station should be based on the features disclosed by the survey described in 6.1.4.

6.1.5.3 A water level gauge should be installed for checking changes in the water level which may occur during a gauging. The gauge should be located as closely as possible to the measuring reach, unless floats are used to measure velocities in which case the gauge should be located near the mid-point of the measuring reach.

6.1.5.4 Where the main requirements necessary for a suitable gauging site as specified, are not present, conditions may be improved as described below :

a) The loss of water from the main channel by spillage can often be avoided by constructing flood banks to confine the flow in a defined floodway.

b) Minor irregularities in the bank or bed causing local eddies may be eliminated by trimming the bank to a regular line and a stable slope and by removing from the bed any large stones or boulders.

c) Unstable banks should be protected wherever possible. Such protection should extend upstream and downstream of a measuring section for a distance equal to at least one quarter of the bankfull width of the channel in each direction. In the case of float gauging the whole of the measuring reach should be protected.

6.1.5.5 Where in the normal measuring section there is insufficient depth to comply with the requirements of ISO 748, or where there is excessively low velocity at low stages, these discharges may often be measured in the same reach of the channel at another section which is more suitable under these conditions but which may not be satisfactory for higher flows.

6.1.5.6 Trees obstructing the clear view of the measuring section or measuring reach should be trimmed or removed. The field of view of a measuring section should extend sufficiently upstream to enable floating debris, which might damage any measuring instrument, to be seen in sufficient time to permit the removal of the instrument from the stream.

6.1.5.7 Where not already existing, a suitable access to the site should be constructed, where possible, to provide safe passage at all stages of flow and in all weathers for personnel and for any vehicles used for the conveyance of instruments and equipment.

6.1.5.8 All key points at the site should be permanently marked on the ground by markers sunk to such a depth below the surface as will secure them against movement. Cross-section markers should be set on the line of the cross-section to facilitate the repetition of levels or soundings when the section is checked.

6.1.5.9 Reference gauge

The reference gauge shall conform to 5.4.2 and to ISO 4373.

6.1.5.10 Station bench mark

A station bench mark shall be established to conform to 5.5.4.

6.1.5.11 Stilling well

The stilling well shall conform to 5.4.3 and to ISO 4373.

6.1.5.12 Water level recorder

The water level recorder shall conform to 5.4.4 and to ISO 4373.