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Liquid flow measurement in open channels — Functional requirements and characteristics of suspended sediment load samplers

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FOREWORD

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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.

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Belgium	Ireland	Switzerland
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Liquid flow measurement in open channels — Functional requirements and characteristics of suspended sediment load samplers

0 INTRODUCTION

Suspended sediment load samplers are classified according to their mode of operation into two general types : "instantaneous" and "time-integrating". A number of samplers that have been devised do not strictly qualify for either of these classifications on account of their design, sampling action, or method of operation. As the name implies, the "instantaneous" sampler is designed to trap a specimen of the water-sediment mixture passing the selected sampling point at a given point of time. The "time-integrating" sampler, on the other hand, takes the sample more slowly over an extended period of time to obtain a specimen in which the instantaneous or time-to-time fluctuations in the suspended load are averaged over the sampling period of time. The "time-integrating" samplers may be again divided into "point-integrating samplers" and "depth-integrating samplers". The "point-integrating" sampler is held stationary at the point in the sampling vertical during the time the sample is taken, and then moved, with the sampling action stopped, to a second point, and so on, the process being repeated. The "depth-integrating" sampler is lowered to the bottom of the stream and raised again to the surface at a uniform rate, sampling continuously during both periods of transit; or it is lowered only for sampling continuously from the surface to the stream bed, so that a mean sample from the vertical, with uniform weight accorded to the increments of the water-sediment mixture at various depths, is obtained. Some improved-type samplers enable operators, be means of a remote control, to take samples either over the whole, or only from a portion, of the vertical.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the functional requirements and characteristics of the different types of suspended sediment load samplers.

2 REQUIREMENTS OF SAMPLERS

In order that the samples taken by a sampler be truly representative of the sediment concentration of a stream at a point of sampling, the ideal sampler should fulfil the following technical requirements :

a) The sampler shall be streamlined so as to minimize disturbances to normal sediment flow.

b) The velocity of inflow at the mouth of the sampler or sampling tube shall be as close as possible to the velocity of the current of water at the sampling point, irrespective of what this velocity may be. This aspect is most important if large sampling errors are to be avoided.

c) The mouth of the sampler shall always face into the current and the water shall be taken parallel to the current direction at the sampling point.

d) The mouth of the sampler shall be outside the zone of the disturbances of the flow set up by the body of the sampler and its operating gear, and the flow lines shall be disturbed as little as possible, especially near the mouth.

e) Filling arrangements shall be smooth so that there is no sudden inrush or gulping; the air escaping from the sampler shall not hinder the entry of the sample; this necessitates a separate port for air exhaust.

f) The sampler shall be able to collect samples at the desired depth without the samples being disturbed or contaminated by the water-sediment mixture at other points while the sampler is being raised or lowered.

g) It shall be possible to take a sample exactly when and where it is required, in particular when sampling close to the stream bed.

h) The sampler shall be portable, yet sufficiently heavy to minimize deflection of the supporting cable from the vertical due to current drag.

i) The sampler shall be simple in design and robust in construction and shall require minimum care in maintenance and operation.

j) The removable-type container within the sampler shall be easily removed, readily capped and easily transported to a laboratory without loss of contents. Alternatively, if the container forms a part of the sampler, it shall be installed so as to secure complete drainage of the contents.

k) The volume of the sample collected by the sampler shall be sufficient for the determination of concentration and size analysis. The present practice is generally to use 0,5 l as a minimum.

l) Depth-integrating samplers should be lowered or raised at a uniform and slow speed, a fraction of the current velocity (for example, between 1/5 and 1/15 — see note).

NOTE — *Depth integration* (with uniform vertical motion — see figure)

$A \cdot v \cdot t = V$ . . . (1)

$i = k \cdot v$ . . . (2)

$h = i \cdot t$ . . . (3)

where

A is the area of the mouth or tube;

v is the current velocity;

t is the maximum duration of sampling;

V is the sample volume to be taken;

i is the uniform rate for sampler movement;

h is the maximum vertical distance for sampling.

From equations (1), (2) and (3),

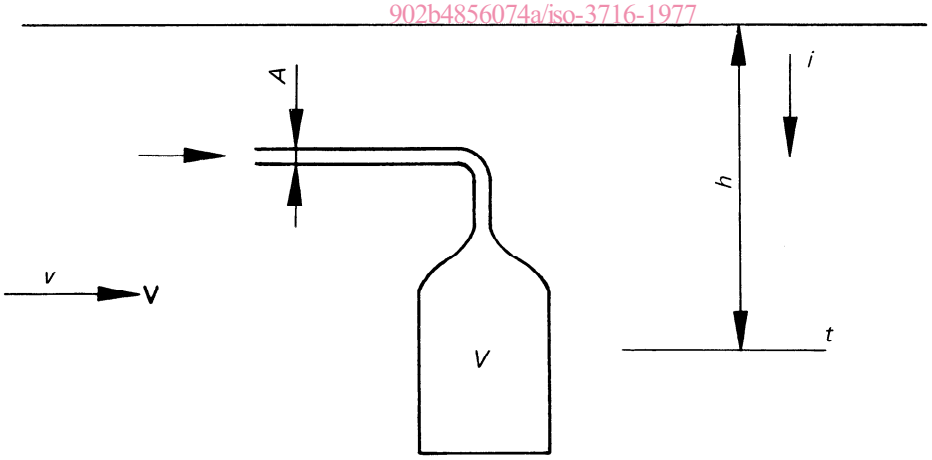
$$h = k \frac{V}{A}$$

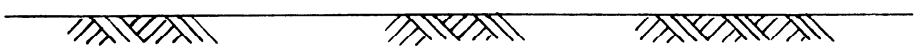
For example, with $A = 28{,}3\ mm^2$ (ϕ 6 mm), $k = 1/10$, and $V = 0{,}51$, the maximum depth of sampling is 1,76 m only. If the flow depth is larger, sampling should be effected from two or more sections.

3 CHARACTERISTICS OF SUSPENDED SEDIMENT LOAD SAMPLERS

3.1 Since the sampling conditions encountered in streams vary widely, a single sampler for all the conditions cannot be recommended. Factors such as cost, availability, and specific requirements of the sampling also influence the choice of the sampler to a great extent. Therefore, the table summarizing the characteristics of most samplers in use will help in the selection of the sampler in given conditions. For general use, the point-integrating samplers are recommended. A depth-integrating sampler is, however, called for under special conditions.

3.2 As the data obtained are affected by the sampling action and the mechanism of the sampler, any change in the sampler would itself introduce a variable. Therefore, the result obtained from different samplers might not be comparable to one another.





FIGURE

TABLE — **Characteristics of suspended sediment load samplers**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sampler No.	**Type**	**Description**	**Disturbance to flow characteristics**	**Intermixing of sample with water**	**Sampling action**	**Field handling**	**Adaptability to various field conditions**
A1	Can or pail	Ordinary can or pail	Considerable	Considerable	Instantaneous	Not necessary to transfer the contents	Offers considerable resistance to current. Only surface sampels are taken
A2	Vertical pipe	With a vertical cylinder or pipe forming the container. When the sampler is lowered to the desired depth, water sediment mixture flows upward through the container. Valves at either end close and trap the sample	Considerable	None	Instantaneous. Samples are not weighted according to velocity distribution	Necessary to transfer into another container	Offers considerable resistance to current. Not satisfactory when close to stream bed. Effective in still water or at very low velocities
A3	Instantaneous vertical	A vertical sampler with arrangement to open the sampler for the instantaneous (rapid) intake of samples at the desired time and depth	Effect not evaluated	None	Instantaneous	Necessary to transfer into another container	Not satisfactorily streamlined or adapted for use near stream bed. Effective in still water or at very low velocities
A4	Vertical	A vertical sampler with opening arrangement for slow intake of samples at the desired time and depth	Effect not evaluated	None	Slow filling, no initial inrush	Necessary to transfer into another container	Allows sampling very close to stream bed. Effective in still water or at very low velocities
A5	Bottle	Consisting of a standard container held in a case with a device for lowering and opening at the sampling point. The mouth is kept open for the minimum time required to fill the bottle	Considerable	Considerable, if not opened and closed at the sampling point	Bubbling or slow filling after initial inrush	Container with sample removable	Not capable of sampling close to stream bed. Has high efficiency in trapping fine grade sediment and the efficiency is less with the increase in grade
A6	Bottle (modified)	Consisting of a 1 l capacity container fitted in a case with a device for lowering or raising and opening at the sampling point. Provided also with separate water intake and air exhaust device for equalizing pressure inside and outside the container	Considerable	Considerable, if not opened and closed at the sampling point	Slow filling, no initial inrush present	Container with sample detachable	Not capable of sampling close to stream bed

TABLE (*continued*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sampler No.	**Type**	**Description**	**Disturbance to flow characteristics**	**Intermixing of sample with water**	**Sampling action**	**Field handling**	**Adaptability to various field conditions**
A7	Single-stage suspended sediment sampler (automatic)	Used for automatic collection of samples from flashy, intermittent streams at remote sites. The sampling unit consists of a bottle with an intake and an exhaust tube, each tube bent to an appropriate shape. Several sampling units are mounted one above another on a vertical support. As the water surface rises in the stream, it also rises in the intake tube of the sampler. When water reaches the crown of the intake, flow starts and the bottle fills. The sampling ceases when the water level in the bottle reaches the inner end of the air exhaust which is kept at a lower level than the inner end of the intake	Inconsider-able	Inconsider-able	Slow-filling, no initial inrush	Container with sample removable	Not capable of sampling close to stream bed. Samples are usually obtained near the edge of the stream. No samples are taken during the falling stages. There are two types of intake, namely vertical and horizontal. Vertical type is used for sediments finer than 62 μm and the horizontal intake is used for sediments coarser than 62 μm
B1	Instantaneous horizontal	With a horizontal cylinder equipped with end valves which can be closed suddenly to trap instantaneous samples at any desired time and depth	Inconsider-able	Inconsider-able	Instantaneous	Necessary to transfer into another container	Allows sampling very close to stream bed. Adaptable to any stream or depth
B2	Point-integrating	A streamlined body with tail vanes, containing a sampling bottle designed to fill continuously at a given point over an interval of time. Therefore, it is provided with an opening and closing mechanism and also with a pressure equalizer to minimize the initial inrush of water. Many of these samplers are capable of being used as depth-integrating samplers also	Inconsider-able	Inconsider-able	Smooth-filling, minimum initial inrush	Container with sample removable	

B3	Vacuum (suction developed by pump)	The sediment mixture is sucked in through a pipe or hose, the intake of which is placed at the desired sampling point. By regulating the intake velocity an undisturbed sample can be obtained	Inconsider-able	None	Time-inte-grated	Container with sample removable	Present design not transportable. Somewhat limited in use owing to resistance to current. Heavy sediment loss in pipeline may limit the use. As there is a difference between the average concentration in the stream and that at the intake, a correction is required which varies with stage and sediment
B4	Intermittent pumping (automatic)	Designed for use at sites where personnel are not available to take samples manually, for example ephemeral and flashy streams or streams in isolated locations. Samples are taken from an intake in the stream by means of a pump. Prior to sampling the intake system is flushed. The sampling frequency is controlled on the basis of stage at the installation so that samples may be collected at a certain interval during low water and at more frequent intervals during higher stages. Some models also permit sampling on a time as well as a stage basis	Inconsider-able	None	Smooth-filling	Container with sample removable	The sampler is transportable. More efficient in trapping fine sediments. As there is a difference between the average concentration in the stream and that at the intake, a correc-tion is required which varies with stage and sediment
B5	Depth-inte-grating	A streamlined body with tail vanes, con-taining a sampling bottle and designed to fill continuously during lowering from surface to bed (as well as on the return trip from bed to surface). These do not have an opening and closing system as in the point-integrating type. The samplers designed to fill during lowering only are provided with a foot trigger which closes both inlet and exhaust upon contact with the bed	Considerable	Inconsider-able	Smooth-filling. Although the sampled fila-ment will enter the in-take nozzle at an angle, pro-visions exist for making inlet velocity essentially equal to the local velocity of the stream	Container with sample removable	Capable of sampling close to the stream bed.

See note page 6.

NOTE — Report No. 1 — *Field Practice and Equipment used in Sampling Suspended Sediment* — of *A study of Methods Used in Measurement and Analysis of Sediment Loads in Streams* — by the US Federal Inter-Agency makes a comprehensive survey of about 65 samplers that have been used in the past. This International Standard covers only the main types of well-known samplers without going into the details of the models.

In the instantaneous horizontal type, there are different models, for example Elwood Mead, Collet Sampler, U.S.A., Italian, Swiss, Tait Binkley (United Kingdom), Zukosvasky Batometer (U.S.S.R.), Sind (India), Puri (India), Uppal (India), Leitz.

In the bottle-type samplers, there are different models, for example earlier models of USGS, later model of USGS known as Colorado bottle samplers and the Punjab type (with local improvements, for example to indicate the condition of filling and with provision for attaching sounding weights so that the sampler can be used for greater depths). The Punjab-type sampler is widely used in India.

Under the general heading of time-integrating samplers (of which point-integrating and depth-integrating are two classifications) there are many models, for example Haigh, Anderson-Einstein, Vacuum Batometer (U.S.S.R.).

In the point-integrating type, there are two varieties — the turbisonde (Neyrpic — Grenoble — France) and the US type. The turbidisonde weighs about 92 kg; it has to be used with a crane and needs a special type of cable to provide the air supply for equalizing the pressure inside the sampler with that of the outside when the sampler is immersed in the stream; it allows a remote-controlled sampling either from the surface to the stream bed or from the stream bed to the surface, continuously or only from a portion of the vertical. Sampling down to 0,12 m distance from the bottom is possible. In the US-type of samplers, there are different models — USP 43, USP 46, USP 46R, USP 50, USP 61 and USP 63 — and all are suspended by means of cable and crane. These models consist of a streamlined shell with an inner recess to hold the sample container and an air chamber which are interconnected, and connected through a valve. At present, USP 50, USP 61 and USP 63 samplers are in use and they weigh 135 kg, 47 kg and 90 kg respectively. Generally, the greater the mass of the sampler, the better is the adaptability to larger depths and higher velocities; while the USP 50 can be used down to a depth of 60 m, the other two can be used down to a depth of 50 m only.

In the depth-integrating type of samplers, there are two types, namely, hand-operated — which are light in weight — and those operated by cable and crane, which are heavier. There are models such as USD 43, USDH 45, USDH 48 and USDH 59 of U.S.A. besides two Russian types — horizontal bottle sampler (wading type) and State Hydrological Institute type. Of these, USD 49, USDH 48 and USDH 59 are currently used. The USD 49 weighs about 28 kg, USDH 48 weighs 2 kg and USDH 59 weighs 10 kg. USDH 48 is operated with a wading rod and can take samples up to 0,1 m from the bed of the stream. USDH 59 is attached to a flexible suspension line and operated by hand.