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## Hydrometry — Functional requirements and characteristics of suspended-sediment samplers

*Hydrométrie — Spécifications de fonctionnement et caractéristiques  
des appareils d'échantillonnage pour la détermination des charges  
sédimentaires en suspension*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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

For an explanation 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*.

This second edition cancels and replaces the first edition (ISO/TS 3716:2006), which has been technically revised. The main changes compared with the previous edition are as follows:

- the Scope has been clarified to include samplers for collecting water-sediment mixtures of rivers, streams, lakes and reservoirs and exclude equipment for sampling closed conduits and wastewater discharges;
- clauses on sampling techniques have been removed;
- the types and models of samplers have been expanded.

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).

## Introduction

Suspended-sediment samplers are used to collect a representative sample of the water-sediment mixture of streams, rivers, lakes and reservoirs. Ideally, the sampler should be able to collect samples that represent the mean concentration of suspended sediment or define the horizontal and vertical variation of suspended-sediment concentration so that the mean concentration can be determined. There are different types of samplers available for collecting suspended sediment, including some that are appropriate for sampling in lakes and reservoirs and others that are used for sampling in streams and rivers. Open containers, vertical and horizontal cylinders, bottle samplers and pumping samplers are used primarily in lakes and reservoirs. Point-integrating samplers, depth-integrating samplers, single-stage samplers and pumping samplers are used primarily in streams and rivers. Only samplers that operate isokinetically can collect unbiased, representative samples of suspended sand-size particles in streams and rivers. Some samplers have also been adapted to enable the collection of clean (uncontaminated) samples of trace metal and organic compounds that are commonly associated with suspended sediment in streams and rivers.

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# Hydrometry — Functional requirements and characteristics of suspended-sediment samplers

## 1 Scope

This document specifies the functional requirements and characteristics of the different types of suspended-sediment samplers used for collecting water-sediment mixtures from streams, rivers, lakes and reservoirs.

This document does not include equipment for collecting samples in closed conduits and wastewater discharges.

NOTE The units of measurement used in this document are SI units.

## 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, *Hydrometric determinations — Vocabulary and symbols*

## 3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

### 3.1

#### isokinetic sampling

method of sampling where the intake velocity of the suspended-sediment sampler equals the ambient stream velocity

## 4 Requirements of samplers

To ensure that the samples taken by a sampler are truly representative of the sediment concentration of a stream at a point of sampling, the ideal sampler shall fulfil the following technical requirements.

- a) The sampler shall be streamlined to reduce drag and to minimize disturbances to normal sediment flow. [Figure 1](#) shows an example of a typical streamlined sampler.
- b) The velocity of inflow in the mouth of the sampler, nozzle or sampling tube shall be isokinetic or as close as possible to the velocity of the current at the sampling point, irrespective of what this velocity may be or irrespective of what the depth of submergence at this point may be.
- c) The mouth/intake of the sampler shall always face into the current at the sampling point.
- d) The mouth/intake 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.



**Key**

- 1 nozzle
- 2 body holding sample bottle
- 3 hanger
- 4 tail fin

**Figure 1 — Typical depth-integrating sampler**

- e) Filling arrangements shall be smooth so that there is no sudden inrush of water-sediment mixture; the air escaping from the sampler shall not hinder the entry of the sample; this necessitates a separate port for air exhaust.
- f) Point-type samplers 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) Point-type samplers shall be able to take a sample exactly when and where it is required.
- 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 or sealed and easily transported to a laboratory without loss of contents. Alternatively, if the container forms part of the sampler, it shall be installed to secure complete drainage of the contents.
- k) The volume of the sample collected by the sampler shall be sufficient for determining the concentration and size distribution of the sediment. The minimum sample size is generally 0,5 l.
- l) The sampler shall be able to collect samples of water-sediment mixtures in streams and rivers isokinetically over the depth, width, and velocity conditions to be sampled. If samples cannot be

collected isokinetically because water velocities are lower than the operating limits of sampler or the velocity of the current is not known, large errors in the concentration of sand particles can occur.

## 5 Characteristics of suspended-sediment samplers

Since the sampling conditions encountered in lakes, reservoirs, streams and rivers vary widely, a single sampler for all the conditions cannot be recommended. Factors such as availability, cost and specific requirements of the sampling also influence the choice of the sampler to a great extent. The different types of samplers include open containers, vertical and horizontal cylinders, bottle samplers, pumping samplers, single-stage samplers, point-integrating samplers and depth-integrating samplers. All these types of samplers can collect a representative sample of the water-sediment mixture in a river or stream under the right conditions, but many of them cannot be used in rivers with swift currents and a non-uniform distribution of sediment concentration. For general use in rivers and streams, isokinetic point-integrating and depth-integrating samplers are recommended. The use of trade, product or firm names in this document is for descriptive purposes only and does not imply endorsement.

## 6 Types of samplers

### 6.1 Open containers

This type of sampler consists of an ordinary pail, can or open bottle. The sample is collected by holding the container under the surface of the water or by lowering it to the water surface with a rope or cable. The filled container can be sealed for transport and subsequent analysis or the sample can be transferred into another container that can be sealed. Open-container samplers can only collect a sample at the water surface and do not meet most of the requirements noted in [Clause 4](#). Representative samples are collected only if the water-sediment mixture is thoroughly mixed and contains negligible coarse silt and sand.

It is important to limit any recirculation of water-sediment mixture while obtaining the sample in order to limit sediment settling in the open container resulting in bias (high) errors.

### 6.2 Vertical and horizontal cylinder instantaneous trap samplers

These samplers (see [Figures 2](#) and [3](#)) are typically made of steel, brass or plastic. They are made in various diameters and lengths. The cylinder is lowered to the desired sampling point with the valves at each end of the cylinder in the open position. The sample is collected by closing the valves and retrieving the cylinder. The valves are actuated by an electrical impulse or by sending a weight down the suspension cable to trip spring-loaded valves. The sample is typically transferred to another container, so the cylinder can be reused.

These samplers can collect samples at specific depths. The samples are instantaneous, rather than integrated over any time or space. Under ideal conditions, they will collect a representative sample, particularly if there is negligible coarse silt and sand. They are well suited to sampling lakes and reservoirs and low velocity conditions in streams and rivers.

These samplers, particularly the vertical cylinders, offer considerable resistance to flow and are only stable at very low velocities. Vertical cylinders cannot sample close to the streambed. Horizontal samplers can sample near the streambed.

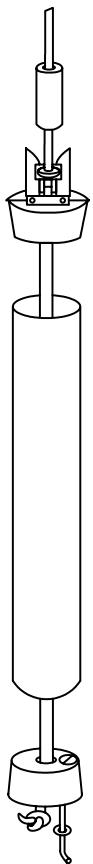


Figure 2 — Kemmerer sampler



Figure 3 — Van Dorn horizontal sampler

### 6.3 Weighted bottle samplers

There are many different variations of bottle samplers. They generally consist of a weighted container to hold a 0,5 l to 2 l sample bottle. The sampler is lowered to the desired depth by a rope or cable and then the cap is removed from the bottle to collect the sample. Some models have the capability of both opening and closing the bottle cap, so the sample is sealed and no intermixing of the sample with the water-sediment mixture occurs while the sampler is being retrieved.

These samplers are not isokinetic. If there is any intermixing, then concentrations can be biased high because of sediment settling within the sample container. They are sometimes able to collect a representative sample for low velocity, well mixed conditions.

These samplers offer considerable resistance to flow and are only stable at very low velocities. Samples cannot typically be collected close to the streambed. The potential for intermixing of the sample and water-sediment mixture in the river is high for those samplers that cannot be sealed at the sampling point.

## 6.4 Pumping samplers

### 6.4.1 General

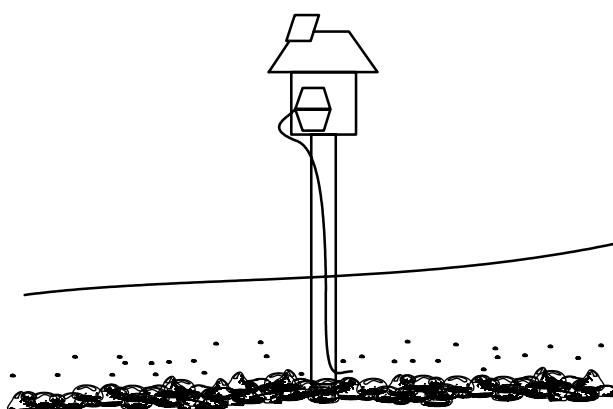
There are two types of pumping samplers used for collecting suspended-sediment samples: those with a fixed orifice that are operated in automatic mode and those with a moveable orifice that are deployed from a boat, cableway, walkway or bridge.

### 6.4.2 Fixed-orifice pumping samplers

Fixed-orifice samplers (see [Figure 4](#)) are typically used at sites where personnel are not available to take samples manually, such as ephemeral and flashy streams or streams in isolated locations. The orifice is typically located at or near the stream bank. The samplers are powered with line power or batteries, and samples are pumped from the stream to sample containers using a vacuum pump, peristaltic pump or submersible pump.

Sampling initiation and frequency are controlled based on time, stage or a combination of both so that samples can be collected at one interval during low flow and more frequently during high flow. Some samplers can be controlled based on turbidity or discharge volume (to obtain a discharge weighted sample). Modern samplers can be controlled by remote communications where available. Discrete samples can be collected into individual bottles by a movable arm in the sampler, or samples can be composited into a single large bottle. In any case, the sampling initiation and frequency should be designed to obtain samples representative of the conditions to address the sediment issue being studied. In streams and rivers, this requires sampling during rising and falling stages over a range of seasons and flows.

The fixed-orifice samplers are an effective method of collecting samples when personnel are not available for collecting manual samples. However, the samples only represent the suspended-sediment concentration at one point in one vertical of the stream and a correction factor is required to determine the mean suspended-sediment concentration. The location of the fixed orifice should be carefully selected and evaluated to optimize the representative characteristics of samples. If possible, it should not be very close to the channel bed or banks and should be in a location of average concentration. Concurrent samples from the fixed-point pumping sampler and cross-section are needed during installation, to determine how representative the fixed-orifice location is, and periodically over the duration of monitoring to determine and verify the correction factor. Also, the sampler is not isokinetic and can introduce bias errors to sand concentrations. Samples also are subject to evaporation until they are sealed and removed for analysis.



**Figure 4 — Diagram of a fixed-orifice pumping sampler**

#### 6.4.3 Moveable-orifice samplers

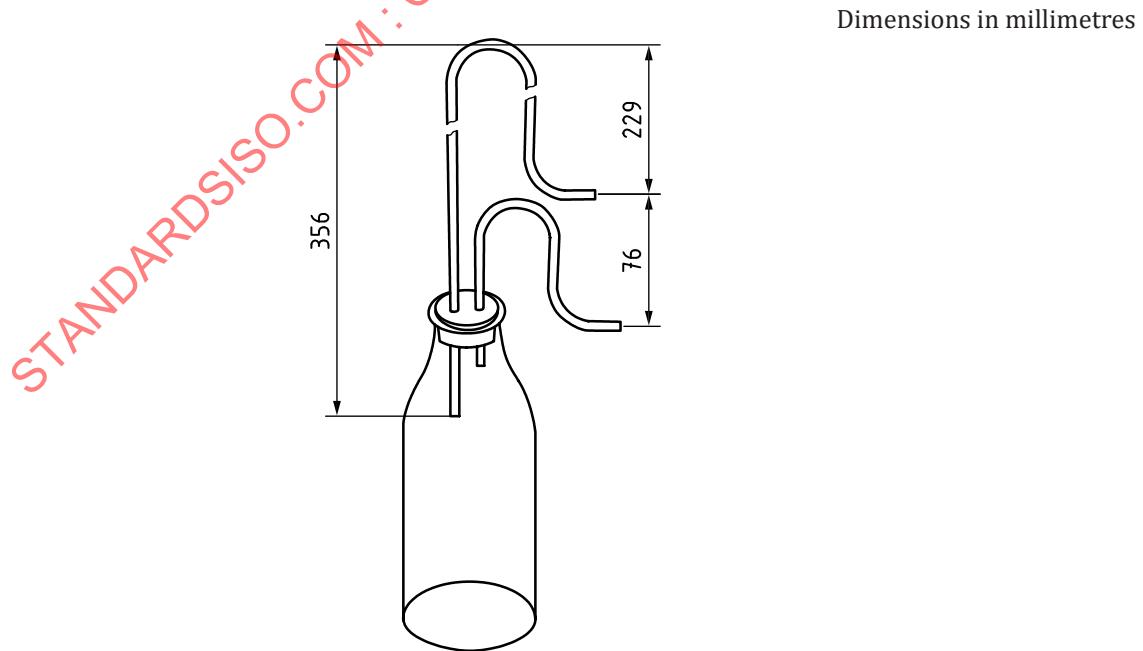
These are usually used to collect large-volume samples for analyses of suspended sediment and other constituents from lakes and rivers. A pump on a boat or other platform above the water surface is used to create a vacuum to raise the water-sediment mixture to a sample container on the boat or work platform. An orifice line is lowered to the desired sampling depth to obtain the sample. The orifice can also be lowered during sampling to collect a depth-integrated sample. A submersible pump can also be lowered on a cable, and then the sample is pumped to containers on the platform or vessel. Some units are equipped with a velocity sensor to automatically adjust the pump speed to collect an isokinetic sample. Alternatively, it is possible to measure the velocity at the point of sampling by current meter and then manually adjust the rate of pumping to match the velocity of sampling with the stream velocity.

These samplers are good for collecting large-volume samples, but the combination of the orifice line and the weight to hold the orifice in place offer much resistance to flow. The vacuum pump versions of these samplers are limited to collecting samples to a depth of about 7 m because of the efficiency of vacuum pumps.

#### 6.5 Single-stage samplers

Single-stage samplers are an inexpensive and effective means of collecting sediment samples on intermittent and flashy streams and at remote locations. The sampling unit consists of a bottle with an intake tube and an exhaust tube (see [Figure 5](#)). The orifice and inverts of the tubes are positioned to collect a representative sample a few centimetres below the water surface; re-circulation within the bottle is prevented by the air lock that occurs between the inverts of the intake and exhaust tubes. Several units may be mounted at different positions on a vertical support to collect samples as the water level rises during a runoff event. After the peak passes, the bottles are removed and sealed for transport and subsequent analysis.

These samplers can only collect near-surface samples during rising stages. Samplers are generally located near the stream bank for ease of servicing and to avoid heavy debris. Sample concentrations will only be representative of the mean concentration of the sediment in the stream if the water-sediment mixture is very well mixed with most particles finer than 0,062 mm.



**Figure 5 — Schematic diagram of a typical single-stage sediment sampler**

## 6.6 Point-integrating samplers

There are many different models and sizes of point-integrating sediment samplers for collecting water-sediment mixtures in streams and rivers. They generally consist of a bronze or aluminium streamlined body with tail vanes for stability in high currents (see [Figure 6](#)). They are raised and lowered in the river with a reel and cable assembly. Water enters through a nozzle at the nose of the sampler body, and the sample is collected in a bottle or other container within the sampler. Some samplers have interchangeable nozzles that are used depending on the flow velocity and river depth. The containers, which are usually 0,5 l or 1 l glass or plastic bottles, are removed from the sampler and sealed for shipment and analysis. The sampler includes an opening and closing mechanism, typically a solenoid that is electronically actuated, that allows samples to be collected at any depth after equalizing the pressure inside the sampler with the pressure at the depth of sampling to ensure isokinetic sampling. These samplers are isokinetic within their operational range and collect relatively accurate, unbiased samples for sand, silt and clay-sized sediments.



**Figure 6 — USP-6<sup>1)</sup> suspended-sediment sampler**

These samplers also are used for collecting depth-integrated samples.

- For depths up to 5 m, the sampler can be lowered and raised with the valve open.
- For depths up to 30 m, the sampler can be lowered and raised at different increments of depth and samples can be combined to obtain a mean suspended-sediment concentration for the vertical.

For example, with a depth of 10 m, a point sampler can be used to collect two samples. Lowering and raising the sampler with the valve open to a depth of 5 m would collect the first sample. Lowering the sampler to 5 m with the valve closed and then lowering and raising it between 5 m and 10 m with the valve open would collect the second sample.

## 6.7 Depth-integrating samplers

Depth-integrating samplers are very similar to point-integrating samplers. They have streamlined bodies with a nozzle at the nose and tail vanes for stability. They do not have a valve for opening and closing the nozzle. These samplers include those that are attached to a wading rod, those that are raised and lowered by hand with a rope, and those that are raised and lowered by a reel and cable assembly. There are two types of depth-integrating samplers: those that contain rigid containers and those that contain a collapsible plastic or fluoropolymer bag. The samplers that contain rigid containers are limited to a sampling depth of 5 m in order to maintain isokinetic sampling and avoid overfilling and excess sediment accumulation in the containers.

1) The US P-6 suspended sediment sampler developed by the Federal Interagency Sedimentation Project in the United States is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

A newer type of depth-integrating sampler has a plastic or fluoropolymer bag instead of a bottle for the samples. All the air is evacuated from the bag before the sampler is lowered in the river, so the depth of sampling is not restricted by the compression of air in the container. The US D-96<sup>2)</sup> (see [Figure 7](#)) sampler can be used for collecting depth-integrated samples of up to 3 l to a maximum depth of 15 m to 30 m depending on the size of nozzle used. When the sampler is retrieved, either the sample is transferred from the bag to another container or the bag is sealed and placed in another container for shipment to the laboratory. The US D-99<sup>3)</sup> sampler can be used for collecting depth-integrated samples of up to 6 l to a maximum depth of 67 m depending on the size of the nozzle used.



**Figure 7 — US D-96 bag sampler**

The depth-integrating and point-integrating samplers are the only samplers that will collect a representative sample of the water-sediment mixture in deep, swift rivers.

## 6.8 Clean samplers

Variations of depth-integrating sediment samplers are special samplers for collecting water-sediment mixtures for chemical analyses. These samplers are very similar to the suspended-sediment samplers, except they are equipped with fluoropolymer and plastic components so the samples will not be in contact with any metal. The DH-95<sup>4)</sup> sampler (see [Figure 8](#)) uses 1 l fluoropolymer or plastic bottles with nozzles that are integral with the bottle caps.

2) The US D-96 sampler developed by the Federal Interagency Sedimentation Project in the United States is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

3) The US D-99 sampler developed by the Federal Interagency Sedimentation Project in the United States is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

4) The US D-95 sampler developed by the Federal Interagency Sedimentation Project in the United States is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.



Figure 8 — US DH-95 sampler

## 6.9 Sand-flux samplers

A flow-through sampler, such as the Delft bottle (see Figure 9), is a special sampler for collecting sand particles larger than 0,10 mm. The water sample mixture enters through the intake nozzle and the water and fine sediment particles exit at the back of the bottle. The large reduction in velocity because of the bottle geometry results in the sand particles settling in the bottle. The overall efficiency of a Delft bottle is rather low, but it is adequate to collect the total suspended sand transport over several minutes or longer.



Figure 9 — Delft bottle sampler

## 7 Models of samplers

Table 1 gives a summary of many of the types and characteristics of suspended-sediment samplers in current use.

Table 1 — Types and models of suspended-sediment samplers

Sampler type	Description	Model	Countries of use	Mass (kg)	Mode of suspension	Min. to max. isokinetic sampling velocities (m/s)	Sample size (l)	Sampling handling and adaptability		
Open container	Ordinary can or pail for collecting near-surface samples in streams, rivers and lakes.		Many	Variable	Hand or rope	Not applicable	Variable	Only surface samples can be collected. Should be transferred to another sample container.		
Vertical or horizontal cylinder	Cylinder is lowered to the desired depth in a river or lake and valves at both ends trap the sample.	Kemmerer	USA		Rope or cable	Not applicable	0,2 to 6,2	Considerable resistance to flow. Should be transferred to another sample container.		
		Van Dorn	USA		Rope or cable	Not applicable	2,2 to 8,2			
		Niskin	Many	4 to 17	Rope or cable	Not applicable	1,2 to 30			
		Vertical pipe	India		Rope	Not applicable	1			
		Horizontal pipe	India		Rope	Not applicable	1			
Bottle	Weighted bottle or a housing that holds a sample bottle used for sampling rivers and lakes.	Punjab	India		Rope	Not applicable		Considerable resistance to flow. Samples only at or near the surface of a stream or lake.		
		US WBH-96	USA		Rope or cable	Not applicable	1			
Fixed-orifice pumping	Nozzle is located near the stream, river or lake bank and sample is pumped by a vacuum or submersible pump to a container in a shelter.	ISCO 3700, 5800 and 6712	France, Germany, Japan, Netherlands, Switzerland, USA		Streambank shelter	Not applicable	Variable	Sample only collected at one point in the vertical near the streambank or lake shore.		
		Lift pump	Germany, Japan, Netherlands, Switzerland, USA		Cable	Not applicable	Many litres			
		Manning PST		11,1	Streambank shelter		1			
		Manning VST	USA	11,1	Streambank shelter					
NOTE The models listed are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.										
<sup>a</sup> Samplers have nozzles with inner diameters of 0,48 cm or 0,64 cm										
<sup>b</sup> Samplers have nozzles with inner diameters of 0,48 cm or 0,64 cm or 0,79 cm. The minimum isokinetic velocity and/or maximum velocity may vary slightly depending on which nozzle is used.										
<sup>c</sup> Samplers have flexible bags instead of rigid bottles for holding samples.										
<sup>d</sup> Similar in function to a US DH-48, but it is not streamlined.										