

FISP'S SUITE OF FEDERALLY APPROVED SUSPENDED-SEDIMENT/WATER QUALITY COLLAPSIBLE-BAG SAMPLERS

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Abstract: In 1996, the Federal Interagency Sedimentation Project (FISP) began research and development of an isokinetic collapsible-bag suspended-sediment/water-quality depth-integrating sampler. The research has led to the development and approval by the FISP Technical Committee of four collapsible-bag depth-integrating suspended-sediment/water-quality samplers weighing from 30 to 285 lbs (13.6 to 130 kg) and capable of collecting from 1 to 6 liters of sample. The FISP suite of collapsible-bag samplers is capable of sampling stream velocities that range from 2 to 15 ft/sec (0.5 to 4.6 m/sec) and stream depths of up to 220 ft (67 m). The samplers incorporate plastic parts for suspended-sediment sampling and non-contaminating parts that meet the U.S. Geological Survey's (USGS) Office of Water Quality's requirements for collecting non-contaminated water-quality samples for trace-element analysis outlined by Lane and others (2003).

INTRODUCTION

Various investigators including Gluschko and the Rhine Works Authority (FISP 1940), Stevens and others (1980) and Szalona (1982) documented research on the use of a collapsible-bag depth-integrating suspended-sediment sampler. Results were encouraging, but the proposed samplers were not able to collect isokinetic samples at all stream velocities typically encountered in natural streams. An isokinetic sampler collects a water-sediment sample from the stream at a rate such that the velocity in the nozzle is equal to the incident stream velocity at the nozzle entrance. In 1996, the Federal Interagency Sedimentation Project (FISP) began research and development of an isokinetic collapsible-bag depth-integrating suspended-sediment/water-quality sampler. A collapsible-bag sampler has several advantages over traditional rigid-container samplers. A primary advantage is sampling depth. Rigid-container samplers are limited to a maximum depth of 15 ft (4.6 m) due to air compressibility. A bag container is flexible and contains essentially no air. As a result, sampling depth is not limited because of air compressibility, meaning the depth to which the sampler can be used is limited only by the intake diameter of the nozzle and the volume of the bag. It also means the maximum transit rate is limited only by the apparent approach angle of the nozzle facing into the stream flow as the sampler makes its vertical traverse, which is 0.4 times the mean stream velocity (FISP 1952). The minimum transit rate is limited by the volume of the collapsible bag. Another advantage is cost savings in the use of collapsible bags as opposed to a rigid container or bottle.

The initial development effort beginning in 1996 resulted in a 3-liter sampler designated the US D-96 and patented by Davis and O'Neal (2001a). The sampler was designed, tested, and approved for use by the FISP Technical Committee as reported by Davis (2001b). The US D-96 sampler weighs 130 lbs (59 kg). In 1999, design and testing of a 6-liter collapsible-bag sampler was initiated. The result was the US D-99, a 285 lb (130 kg) sampler and is described by the FISP (2005). In 2003 an 80 lb (36 kg) version of the US D-96, designated the US D-96-A1, was designed, tested, and approved by the FISP Technical Committee and reported by Davis (2003).

In 2002, development of a bag sampler deployable by handline was initiated. The result was the US DH-2, a 30 lb (13.6 kg), 1-liter sampler described by Davis (2005). The samplers incorporate plastic parts for suspended-sediment sampling and non-contaminating parts that meet the U.S. Geological Survey's (USGS) Office of Water Quality's requirements for collecting non-contaminated water-quality samples for trace-element analysis outlined by Lane and others (2003). These samplers are in wide-spread use throughout the United States and other countries.

US D-96

The US D-96 is 35 in (89 cm) long, 8 in (20 cm) diameter at its widest point, and weighs 130 lbs (59 kg). The nozzle is located at the centerline of the sampler resulting in an unsampled zone (distance from centerline of nozzle to bottom of sampler) of 4 in (10) cm. The sampler (figure 1) is composed of various parts including a top section, bottom section, tail section, nose section with tray, nozzle holder, and nose insert. The top section is made of cast bronze with a plastic liner on its bottom side. The bottom section is a cast aluminum shell that mates with the top section to form the cavity inside the sampler. The inside of the bottom section is lined with plastic. The nose section is cast aluminum and has a slot machined in the front that matches the slot in the top section for the nose insert. The nose section is also fitted with a plastic tray. The tray slides into the cavity formed by the bottom section and is designed to support the bag. All metal parts are plastic coated to minimize the possibility of contamination of samples for trace-

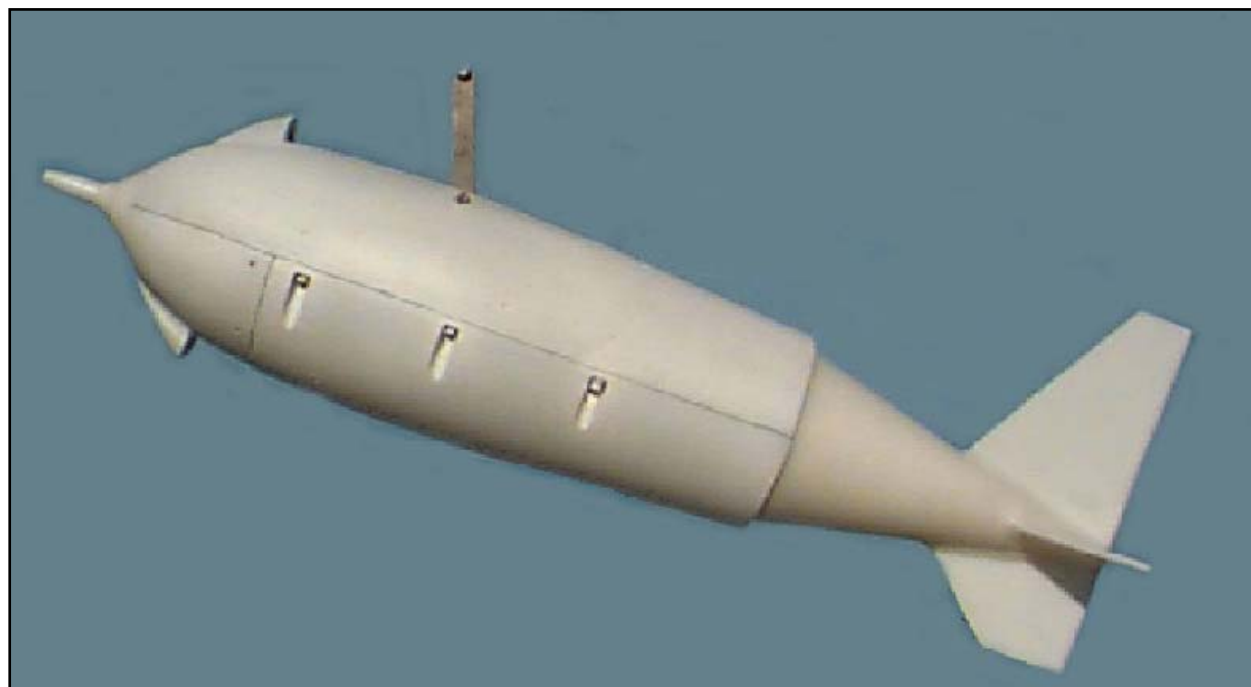


Figure 1 US D-96.

metal analyses. The nose insert is fabricated from plastic and is machined to fit in the slot in the nose section. The nozzle holder is fabricated from either plastic or tetrafluoroethylene (TFE), and mates with the nose insert. A nozzle threads into the front of the nozzle holder and the bag is attached to the rear of the nozzle holder with a hook-and-loop strap. Figure 2 shows the



Figure 2 US D-96 nozzle holder with nozzle and bag attached.

nozzle/nozzle holder/bag assembly. The tail section is fabricated from high-density polyethylene plastic (HDPE). HDPE is neutrally buoyant in water, which allows the suspension point of the sampler to be located such that in air, the sampler maintains a tail-down attitude allowing it to orient itself facing into the streamflow. Once submerged, the sampler assumes a horizontal position.

Plastic and perfluoroalkoxy (PFA) bags are available for use with the US D-96. Plastic and TFE nozzles with internal diameters of 3/16, 1/4, and 5/16 in (0.48, 0.64, and 0.79 cm) are available for use with the US D-96. Plastic nozzles and bags are generally used for suspended-sediment sampling, and PFA bags and TFE nozzles for water-quality sampling. The US D-96 can sample to a depth of 110 ft (33.5 m) with a 3/16 in (0.48 cm) internal diameter nozzle, 60 ft (18.3 m) with a 1/4 in (0.64 cm) internal diameter nozzle, and 39 ft (11.9 m) with a 5/16 in (0.79 cm) internal diameter nozzle. The US D-96 sampler will collect flow-weighted samples in streams with velocities that range from 2 to 12.5 ft/sec (0.5 to 3.8 m/sec). An acceptable velocity range is one at which a representative flow-weighted sample is collected at a sampler inflow efficiency between 90 and 110 pct. Inflow efficiency is defined as the ratio of the sample velocity in the nozzle to the ambient stream velocity. An inflow efficiency of 100 pct is referred to as isokinetic.

US D-96-A1

The success and wide-spread use of the US D-96 revealed a need for a lighter version that would still collect a 3-liter sample. Changing the top section material from bronze to aluminum and the bottom section material from aluminum to bronze resulted in a sampler that weighs 80 lbs (36 kg). The sampler is designated the US D-96-A1. The US D-96-A1 is identical in appearance and uses the same parts as the US D-96. The maximum sampling depths are theoretically the same, but in practice the drift angle will determine the useful depth of operation. The recommended stream velocity range for the US D-96-A1 is 2 to 6 ft/sec (0.5 to 1.8 m/sec).



Figure 3 US D-99.

The US D-99 (figure 3) collapsible-bag sampler is capable of collecting up to a 6-liter sample. It is 41 in (104 cm) long, 9.5 in (24 cm) in diameter at its widest point and weighs 285 lbs (130 kg). It has a 5.5 in (14 cm) diameter hollow cavity inside the sampler body. It is fabricated from a bronze casting with a HDPE tail. All metal parts are plastic coated to minimize possible sample contamination. The sampler employs a hinged head with a plastic insert that holds the nozzle holder with nozzle in place. The bag is attached to the nozzle holder with a hook-and-loop strap. Figure 4 shows the sampler head open for insertion of the bag.

The US D-99 uses 3- or 6-liter plastic or PFA bags. Plastic and TFE nozzles with internal diameters of 3/16, 1/4, and 5/16 in (0.48, 0.64, and 0.79 cm) are available for use with the US D-99. With a 6-liter bag, the US D-99 can sample to a depth of 220 ft (67 m) with a 3/16 in (0.48 cm) internal diameter nozzle, 120 ft (37 m) with a 1/4 in (0.64 cm) internal diameter nozzle, and 78 ft (24 m) with a 5/16 in (0.79 cm) internal diameter nozzle. Maximum sampling depth with a 3-liter bag is half that of the 6-liter bag. The acceptable stream velocity range for the US D-99 is 2 to 15 ft/sec (0.5 to 4.6 m/sec). Based on data collected during inflow efficiency test, it is recommended that a 3-liter bag be used with all samples collected in the velocity range of 2 to 3.5 ft/sec (0.5 to 1 m/sec). For samples collected from 3.5 to 15 ft/sec (1 to 4.6 m/sec) the 6-liter bag should be used. The unsampled zone for the US D-99 is 9.5 in (24 cm).

US DH-2

The success of the large-volume collapsible-bag samplers generated the desire for a small, lightweight sampler that would collect a sample volume of 1 liter and sample to a depth of approximately 35 ft (10.7 m). Such a sampler fills the gap between lightweight rigid-container samplers that have a depth limitation of 15 ft (4.6 m), and the heavier collapsible-bag samplers already in use. Research and development resulted in a handline deployable sampler designated the US DH-2 which collects a 1-liter sample. The US DH-2 (Figure 5) is 19 in (48 cm) long

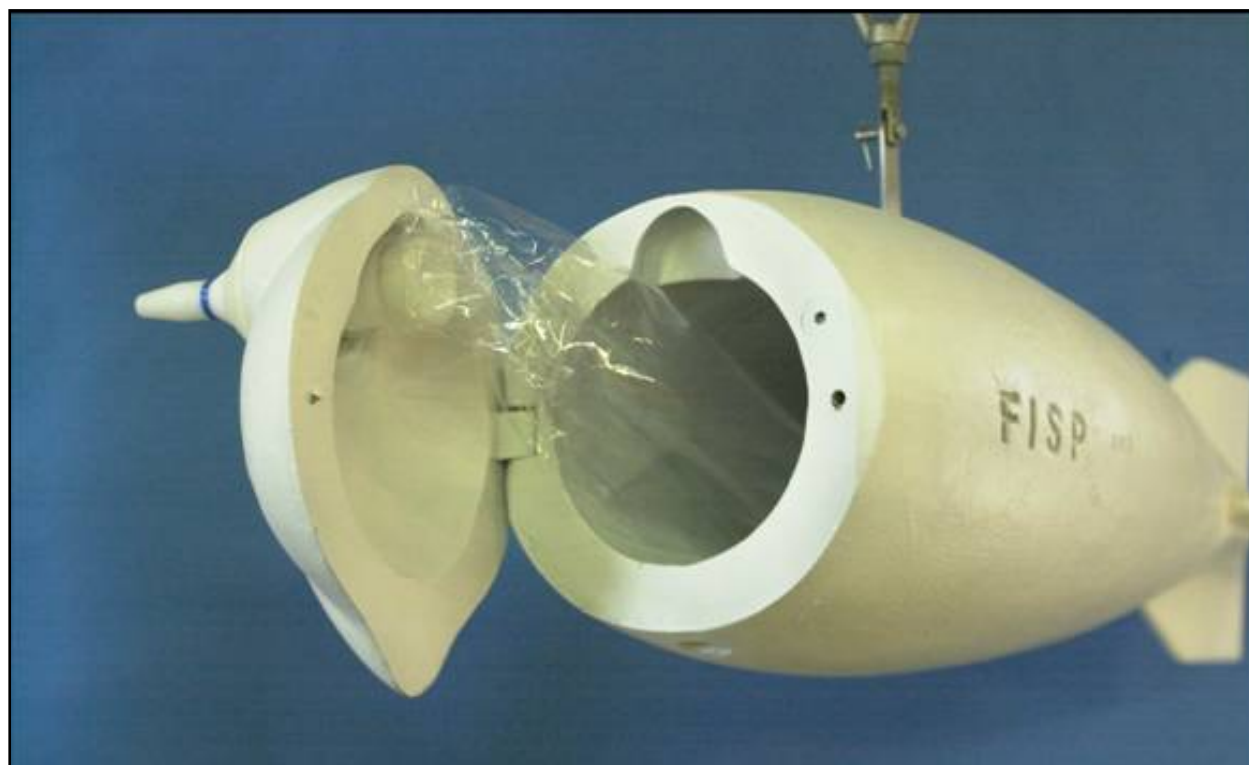


Figure 4 US D-99 with hinged head open.

with a 6 in (15.2 cm) diameter at its widest point, and weighs 30 lbs (13.6 kg). The sampler is composed of a cast bronze body with a 3.75 in (9.5 cm) diameter longitudinal cavity, a neutrally buoyant plastic tail section that has a hollow cavity, and a plastic nose. A nozzle holder fits into the back of the nose. The nozzle threads into the front of the nozzle holder, and the collapsible bag is attached to the rear of the nozzle holder with a hook-and-loop strap (figure 6). The bag slides into the cavity of the sampler and the nose snaps into the front of the sampler body with an O-ring friction fit (Figure 7). The cavity of the bronze body is lined with a clear plastic tube and the outside of the body is plastic coated to minimize possible sample contamination.

The US DH-2 uses plastic or PFA bags. Plastic and TFE nozzles with internal diameters of 3/16, 1/4, and 5/16 in (0.48, 0.64, and 0.79 cm) are available for use with the US DH-2. The US DH-2 can sample to a depth of 35 ft (10.7 m) with a 3/16 in (0.48 cm) internal diameter nozzle, 20 ft (6.1 m) with a 1/4 in (0.64 cm) internal diameter nozzle, and 13 ft (4 m) with a 5/16 in (0.79 cm) internal diameter nozzle. The acceptable stream velocity range for the US DH-2 is 2 to 6 ft/sec (0.5 to 1.8 m/sec). The unsampled zone for the US DH-2 is 3.5 in (9 cm).

Table 1 presents the characteristics and operating parameters of the samplers. Guidance for collecting suspended-sediment samples can be found in Edwards and Glysson (1999). Guidance for collecting water-quality samples can be found in Wilde and others (1999).



Figure 5 US DH-2.



Figure 6 US DH-2 nose, nozzle, nozzle holder and bag assembly.



Figure 7 Insertion of nose with nozzle and bag into US DH-2.

Table 1 Characteristics and operating parameters of FISP bag samplers.

Sampler Designation	Nozzle ID in (cm)	Sample Size liters	Maximum Depth ft (m)	Minimum Velocity ft/sec (m/sec)	Maximum Velocity ft/sec (m/sec)	Weight lbs (kg)
US D-96	3/16 (0.48)	3	110 (33.5)	2 (0.5)	12.5 (3.8)	130 (59)
US D-96	1/4 (0.64)	3	60 (18.3)	2 (0.5)	12.5 (3.8)	130 (59)
US D-96	5/16 (0.79)	3	39 (11.9)	2 (0.5)	12.5 (3.8)	130 (59)
US D-96-A1	3/16 (0.48)	3	110 (33.5)	2 (0.5)	6 (1.8)	80 (36)
US D-96-A1	1/4 (0.64)	3	60 (18.3)	2 (0.5)	6 (1.8)	80 (36)
US D-96-A1	5/16 (0.79)	3	39 (11.9)	2 (0.5)	6 (1.8)	80 (36)
US D-99	3/16 (0.48)	6	220 (67)	2 (0.5)*	15 (4.6)	285 (130)
US D-99	1/4 (0.64)	6	120 (37)	2 (0.5)*	15 (4.6)	285 (130)
US D-99	5/16 (0.79)	6	78 (24)	2 (0.5)*	15 (4.6)	285 (130)
US DH-2	3/16 (0.48)	1	35 (10.7)	2 (0.5)	6 (1.8)	30 (13.6)
US DH-2	1/4 (0.64)	1	20 (6.1)	2 (0.5)	6 (1.8)	30 (13.6)
US DH-2	5/16 (0.79)	1	13 (4)	2 (0.5)	6 (1.8)	30 (13.6)

* A 3-liter bag is used for stream velocities of 2 to 3.5 ft/sec (0.5 to 1 m/sec).

SUMMARY

The FISP has developed a suite of collapsible-bag depth-integrating suspended-sediment/water-quality samplers that make it possible to collect flow-weighted samples from un-wadeable streams and rivers that are typically encountered. The samplers will collect suspended-sediment

and/or water-quality samples in stream velocities ranging from 2 to 15 ft/sec (0.5 to 4.7 m/sec) and depths up to 220 ft (67 m). The samplers have been approved for use by the FISP Technical Committee.

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