



Standard Practice for The Selection of Maximum Transit-Rate Ratios and Depths for the U.S. Series of Isokinetic Suspended-Sediment Samplers¹

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1. Scope

1.1 This practice covers the maximum transit-rate ratios and depths for selected suspended-sediment sampler-nozzle-container configurations.

1.2 This practice explains the reasons for limiting the transit-rate ratio and depths that suspended-sediment samplers can be correctly used.

1.3 This practice give maximum transit-rate ratios and depths for selected isokinetic suspended-sediment sampler/nozzle/container size for samplers developed by the Federal Interagency Sedimentation Project.

1.4 Throughout this practice, a samplers lowering rate is assumed to be equal to its raising rate.

1.5 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 1129 Terminology Relating to Water²

D 4410 Terminology for Fluvial Sediment²

D 4411 Guide for Sampling Fluvial Sediment in Motion³

3. Terminology

3.1 Definitions:

3.1.1 For Definitions of terms used in this practice, refer to Terminology D 1129 and Terminology D 4410

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *approach angle*—the angle between the velocity vector of the approaching flow and the centerline of the nozzle.

3.2.2 *approaching flow*—flow immediately upstream of a nozzles entrance.

3.2.3 *compression rate*—the rate at which the air is compressed in the sample container and is a function of the speed at which the sampler is lowered in the sampling vertical.

3.2.4 *isokinetic*—the conditions under which the direction and speed of the flowing water/sediment mixture are unchanged upon entering the nozzle of a suspended-sediment sampler.

3.2.5 *maximum transit rate*—the maximum speed at which the sampler can be lowered and raised in the sampling vertical and still have the sample collected isokinetically.

3.2.6 *transit rate*—the speed at which the suspended sediment sampler is lowered and raised in the sampling vertical.

3.2.7 *transit-rate ratio*—the ratio computed by dividing the transit rate by the mean stream velocity in the vertical being sampled.

4. Summary of Practice

4.1 This practice describes the maximum transit-rate ratios and depths that can be used for selected isokinetic suspended-sediment sampler/nozzle/container configurations to insure isokinetic sampling. (Manufacturing differences in the production of sediment samplers may result in some samplers not collecting a sample isokinetically. It is the users responsibility to insure through calibration that the sampler does collect a sample isokinetically. Guide D 4411 describes a process for checking calibration of suspended-sediment samplers.)

5. Significance and Use

5.1 This practice describes the maximum transit-rate ratios and depths that can be used for selected isokinetic suspended-sediment sampler/nozzle/container configurations in order to insure isokinetic sampling.

5.2 This practice is designed to be used by field personnel collecting whole-water samples from open channel flow.

¹ This practice is under the jurisdiction of ASTM Committee D19 on Water and the direct responsibility of Subcommittee D19.07 on Sediment, Geomorphology, and Open Channel Flow.

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² *Annual Book of ASTM Standards*, Vol 11.01.

³ *Annual Book of ASTM Standards*, Vol 11.02.

6. Background

6.1 The distribution of velocity and sediment concentration in a sampling vertical is very complex. The velocity of the flow will generally decrease with depth while the suspended-sediment concentration will normally increase with depth in a vertical. For a sediment sampler to collect a representative volume, the water-sediment mixture must enter the nozzle without undergoing a change in direction or speed. Ideally, the water must enter the nozzle at the same velocity as the approaching flow. When the velocity is unchanged upon entering the nozzle, the condition is termed isokinetic. Depth- and point-integrating samplers with rigid sample containers sample isokinetically only if their nozzles point directly into the flow and the samplers are used within certain ranges of depths. Depth-integrating samplers also operate isokinetically only when their vertical transit rate is within a given range.

6.2 If the velocity of the water-sediment mixture entering the nozzle exceeds that of the approach velocity, the sample sediment concentration is smaller than the concentration of the approaching flow. Decreasing the velocity in the nozzle compared to the approach velocity will cause the sample sediment concentration to be greater than that of the approaching flow. The magnitude of the difference between nozzle and approach velocity is related to the degree of increase or decrease in concentration. The concentration shift is also related to the sizes of the grains in suspension. The larger the grain size, the larger the potential shift in concentrations will be.

6.3 The sampler will not operate properly if the transit rate is too fast and/or sampling depth is too great. See Guide D 4411 for more details on proper use of depth integrating suspended sediment samplers.

6.4 Two factors control the maximum transit rate for a sampler: approach angle and the compression rate.

6.4.1 At a given sample vertical, as the transit rate increases, the approach angle increases. If the transit-rate exceeds 0.4 times the mean flow velocity in the vertical, the intake velocity undergoes a significant acceleration due to changes in flow direction. The maximum vertical transit rate for a depth-integrating sampler or point-integrating sampler used for depth integrating, should not exceed 0.4 times the mean stream velocity of the section.

6.4.2 The compression rate, which is related to the compression limit, may restrict the vertical transit rate to less than 0.4 times the mean stream velocity. As the sampler is lowered through the water, the increasing water pressure compresses the air in the sampler container. If the sampler is lowered slowly, the volume of the incoming water exceeds the volume lost, the displaced air exits through the sampler's exhaust vent. If the sampler is lowered rapidly, the volume of the incoming water is less than the volume lost to compression. Pressure inside the sampler container is less than the hydrostatic pressure outside the sampler. The self regulating properties of the sampler loose control. The intake velocity increases above the stream velocity. In severe cases, water enters the sampler through the air-exhaust vent. If the sampler is raised too rapidly, the air inside the bottle expands and, if not relieved by venting, will not escape fast enough through the air-exhaust vent. The pressure unbalance causes the intake velocity to be

TABLE 1 Maximum Transit-Rate Ratios and Depths for Sampler/Bottle/Nozzle Configurations

Sampler US	Nozzle Size, In. (mm)	Nozzle Color	Container Size	Maximum Depth, ft (m)	Max ratio Rt/Vm ^A
DH-48	¼ (6.35)	Yellow	Pint	9 (2.74)	0.4
DH-48	⅜ (4.76)	Yellow	Pint	15 (4.57)	0.4
DH-75P	⅜ (4.76)	White	Pint	15 (4.57)	0.4
DH-75Q	⅜ (4.76)	White	Quart	15 (4.57)	0.2
DH-75H	⅜ (4.76)	White	2 L	15 (4.57)	0.1
DH-59	⅛ (3.17)	Red	Pint	15 (4.57)	0.2
DH-59	⅜ (4.76)	Red	Pint	15 (4.57)	0.4
DH-59	¼ (6.35)	Red	Pint	9 (2.74)	0.4
DH-76	⅛ (3.17)	Red	Quart	15 (4.57)	0.1
DH-76	⅜ (4.76)	Red	Quart	15 (4.57)	0.2
DH-76	¼ (6.35)	Red	Quart	15 (4.57)	0.4
DH-81	⅛ (3.17)	White	Pint	15 (4.57)	0.2
DH-81	⅜ (4.76)	White	Pint	15 (4.57)	0.4
DH-81	¼ (6.35)	White	Pint	9 (2.74)	0.4
DH-81	⅝ (7.93)	White	Pint	6 (1.83)	0.4
DH-81	⅛ (3.17)	White	Quart	15 (4.57)	0.1
DH-81	⅜ (4.76)	White	Quart	15 (4.57)	0.2
DH-81	¼ (6.35)	White	Quart	15 (4.57)	0.4
DH-81	⅝ (7.93)	White	Quart	10 (3.05)	0.4
D-49/D-74	⅛ (3.17)	Green	Pint	15 (4.57)	0.2
D-49/D-74	⅜ (4.76)	Green	Pint	15 (4.57)	0.4
D-49/D-74	¼ (6.35)	Green	Pint	9 (2.74)	0.4
D-74	⅛ (3.17)	Green	Quart	15 (4.57)	0.1
D-74	⅜ (4.76)	Green	Quart	15 (4.57)	0.2
D-74	¼ (6.35)	Green	Quart	15 (4.57)	0.4
D-77	⅛ (3.17)	White	3 L	15 (4.57)	0.03
D-77	⅜ (4.76)	White	3 L	15 (4.57)	0.07
D-77	¼ (6.35)	White	3 L	15 (4.57)	0.1
D-77	⅝ (7.93)	White	3 L	15 (4.57)	0.2
P-61 ^B	⅜ (4.76)	Blue	Pint	180 (54.86)	0.4
P-63 ^B	⅜ (4.76)	Blue	Pint	180 (54.86)	0.4
P-72 ^B	⅜ (4.76)	Blue	Pint	72 (21.95)	0.4
P-61 ^B	⅜ (4.76)	Blue	Quart	120 (36.58)	0.2
P-63 ^B	⅜ (4.76)	Blue	Quart	120 (36.58)	0.2
P-72 ^B	⅜ (4.76)	Blue	Quart	51 (15.54)	0.2

^A Rt = transit rate; Vm = mean stream velocity in the vertical being sampled.

^B To sample the full depth, samples must be collected in increments of no more than 30 ft (9.144 m). See Footnote 5 for more details.

less than the approach velocity. The compression-rate limit is a function of the diameter of the nozzle, volume of the sample container, and altitude. For large bottles with small nozzles it can limit the vertical transit rate to less than 3 % of the mean stream velocity. Table 1 lists the maximum transit-rates ratios for commonly used combinations of sampler nozzle and container sizes.

6.5 Edwards and Glysson⁴ discuss the proper use of the samplers and transit-rate ratios for some of the more common combinations used by the US Geological Survey (USGS). Because of difficulties in maintaining a slow transit rate, the USGS' Office of Surface Water does not recommend using the ⅛ or ⅜-in. (3.175 or 4.762 mm) nozzles with the USD-77 sampler.

⁴ Edwards, T.K., and Glysson, G.D., "Field Methods for Measurement of Fluvial Sediment," *U.S. Geological Survey, Techniques of Water Resource Investigations*, Book 3, Chapter C2, 1998.

6.6 Based on compression, isokinetic inflow rates, and limits on sample volumes to prevent overfilling⁵, the maximum depth that any rigid container can be lowered to is about 15 ft (4.572 m) (FISP).⁶ If the sampler is lowered below the maximum depth limit, the bottle overfills. As shown in Table 1, the maximum depth depend on sampler, nozzle, and container size. Depending on the maximum percentage of useful volume, depth limit also varies with sample container size and volume of the pressure compensating chamber for point-integrating samplers. The values given in Table 1 are for sea level conditions. The maximum depth decreases about 1 ft (0.3048 m) for every 1000-ft (304.8 m) increase in elevation.

6.7 For additional information about isokinetic suspended-sediment samplers, see Footnote 8.⁷

7. Procedure

7.1 Table 1 lists the most commonly use suspended-sediment samplers in he United States. A “D” in the name

⁵ Maximum sample volume to prevent over filling is assumed to be approximately $\frac{2}{3}$ the sample container volume.

⁶ FISP, Federal Interagency Sediment Project Report No. 6, 1952, *The Design of Improved Types of Suspended-Sediment Samplers*.

⁷ Contact the Project Chief, Federal Interagency Sedimentation Project, Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

indicates that it is a depth-integrating sampler, a “P” indicates that it is a point-integrating sampler.

7.2 To determine the maximum depth for a sampler, find the nozzle size and container size and then read across to the maximum depth.

7.3 To determine the maximum transit-rate, find the sampler/nozzle/container to be used and read across to the maximum ratio (Rt/Vm). Then multiply this ratio by the mean stream velocity in the vertical to be sampled.

7.3.1 The maximum transit rate determined in 7.3 should be used as a practice, the actual transit rate can be and in most cases should be less than the maximum rate computed.

8. Precision

8.1 The transit-rate ratios given in this practice and determined graphically and rounded to one significant figure.

8.2 The precision of the collected sample is a function of the conditions encountered and the measurement techniques used for each measurement.

9. Keywords

9.1 sampling; sediment; surface-water; isokinetic sampling

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