INTERNATIONAL

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Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation ~~D1587;~~D1587/D1587M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

~~ε1 NOTE—Editorial changes were made throughout in May 2012.~~

1. Scope

1.1 This practice covers a procedure for using a thin-walled metal tube to recover ~~relatively~~ intact soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. ~~Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section~~This practice provides guidance on proper sampling equipment, procedures, and sample quality evaluation 6.3 ~~of this practice which describes the thin-walled tubes.~~that are used to obtain intact samples suitable for

~~NOTE 1—This practice does not apply to liners used within the samplers.~~ laboratory testing.

1.2 This practice is limited to fine-grained soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing ~~gravel~~ coarse sand, gravel, or larger size soil particles, cemented, or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices ~~(~~(Test Methods D1586, D3550, and Practice D6151). For information on appropriate use of other soil samplers refer to Practice D6169.

1.3 This practice is often used in conjunction with ~~fluid~~ rotary drilling ~~(~~(Practice D1452~~,~~ and Guides D5783 and D6286) or hollow-stem augers ~~(~~(Practice D6151). Subsurface geotechnical explorations should be reported in accordance with ~~practice (~~Practice D5434~~)~~.. This practice discusses some aspects of sample preservation after the sampling event. For more information on preservation and transportation process of soil samples, consult Practice D4220. ~~This practice does not address environmental sampling; consult D6169 and D6232 for information on sampling for environmental investigations.~~

1.4 This practice may not address special considerations for environmental or marine sampling; consult Practices D6169 and D3213 for information on sampling for environmental and marine explorations.

1.5 ~~The values stated~~ Thin-walled tubes meeting requirements of 6.3~~in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to~~ can also be used in piston samplers, or inner liners of double tube push or rotary-type soil core samplers (Pitcher barrel, Practice D6169~~SI units that are provided for~~). Piston samplers in Practice D6519 ~~information only and are not considered standard.~~use thin-walled tubes.

~~1.4.1 The tubing tolerances presented in Table 1 are from sources available in North America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.~~

~~*1.5 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.*~~

1.6 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

1.7 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

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***A Summary of Changes section appears at the end of this standard**

TABLE ~~1~~2 Dimensional Tolerances for Thin-Walled Tubes

Nominal Tube Diameters from Table ~~2~~1[A] Tolerances						
Size Outside Diameter	2 in.	~~50.8~~[50 ~~mm~~mm]	3 in.	~~76.2~~[75 ~~mm~~mm]	5 in.	~~127~~[125 ~~mm~~mm]
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] ~~Intermediate~~ Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

adequacy of a given professional service must be judged, nor should this document be applied without consideration of a ~~project's~~project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.8 The values stated in either inch-pound units or SI units presented in brackets are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.9 *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:*[2]

A513/A513M Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
A519 Specification for Seamless Carbon and Alloy Steel Mechanical Tubing
A787 Specification for Electric-Resistance-Welded Metallic-Coated Carbon Steel Mechanical Tubing
B733 Specification for Autocatalytic (Electroless) Nickel-Phosphorus Coatings on Metal
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1452 Practice for Soil Exploration and Sampling by Auger Borings
D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
D2166 Test Method for Unconfined Compressive Strength of Cohesive Soil
D2435 Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D2850 Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
D3213 Practices for Handling, Storing, and Preparing Soft Intact Marine Soil
D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4186 Test Method for One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled-Strain Loading
D4220 Practices for Preserving and Transporting Soil Samples
D4452 Practice for X-Ray Radiography of Soil Samples
D4767 Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D6026 Practice for Using Significant Digits in Geotechnical Data
D6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations
~~D6232~~D6286 Guide for Selection of ~~Sampling Equipment for Waste and Contaminated Media Data Collection Activities~~Drilling Methods for Environmental Site Characterization

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D6519 Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *area ratio, A_r, %, n*—the ratio of the soil displaced by the sampler tube in proportion to the area of the sample expressed as a percentage (see Fig. 1).

3.2.2 *inside clearance ratio, C_r, %, n*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.3 *ovality, n*—the cross section of the tube that deviates from a perfect circle.

3.3 *Symbols:*

3.3.1 A_r—area ratio (see 3.2.1).

3.3.2 C_r—clearance ratio (see 3.2.2).

4. Summary of Practice

4.1 A relatively intact sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

5. Significance and Use

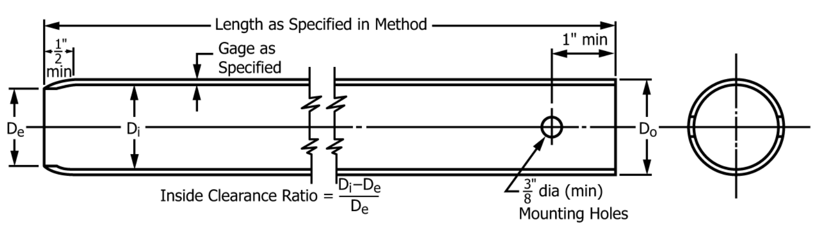
5.1 Thin-walled tube samples are used for obtaining intact specimens of fine-grained soils for laboratory tests to determine engineering properties of soils (strength, compressibility, permeability, and density). Fig. 2 shows the use of the sampler in a drill hole. Typical sizes of thin-walled tubes are shown on Table 1. The most commonly used tube is the 3-in. [75 mm] diameter. This tube can provide intact samples for most laboratory tests; however some tests may require larger diameter tubes. Tubes with a diameter of 2 in. [50 mm] are rarely used as they often do not provide specimens of sufficient size for most laboratory testing.

5.1.1 Soil samples must undergo some degree of disturbance because the process of subsurface soil sampling subjects the soil to irreversible changes in stresses during sampling, extrusion if performed, and upon removal of confining stresses. However, if this practice is used properly, soil samples suitable for laboratory testing can be procured. Soil samples inside the tubes can be readily evaluated for disturbance or other features such as presence of fissures, inclusions, layering or voids using X-ray radiography (D4452) if facilities are available. Field extrusion and inspection of the soil core can also help evaluate sample quality.

5.1.2 Experience and research has shown that larger diameter samples (5 in. [125 mm]) result in reduced disturbance and provide larger soil cores available for testing. Agencies such as the U.S Army Corps of Engineers and US Bureau of Reclamation use 5-in. [125-mm] diameter samplers on large exploration projects to acquire high quality samples (**1, 2, 3**).[3]

5.1.3 The lengths of the thin-walled tubes (tubes) typically range from 2 to 5 ft [0.5 to 1.5 m], but most are about 3 ft [1 m]. While the sample and push lengths are shorter than the tube, see 7.4.1.

[3] The boldface numbers in parentheses refer to a list of references at the end of this standard.



$$\text{Area Ratio} = (D_o^2 - D_i^2)/D_i^2$$

NOTE 1—The sampling end of the tube is manufactured by rolling the end of the tube inward and then machine cutting the sampling diameter, D_e, on the inside of the rolled end of the tube.

NOTE 2—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).[100 mm]. Minimum of four mounting holes equally spaced for D_o equal to 4 in. [100 mm] and larger.

NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.

NOTE 3—Tube held with hardened set screws or other suitable means.

NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gauge wall thickness to comply with area ratio criteria accepted for "intact samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gauge tubes are generally readily available.

FIG. 1 Thin-Walled Dimensions for Measuring Tube Clearance Ratio, C_r (approximate metric equivalents not shown)

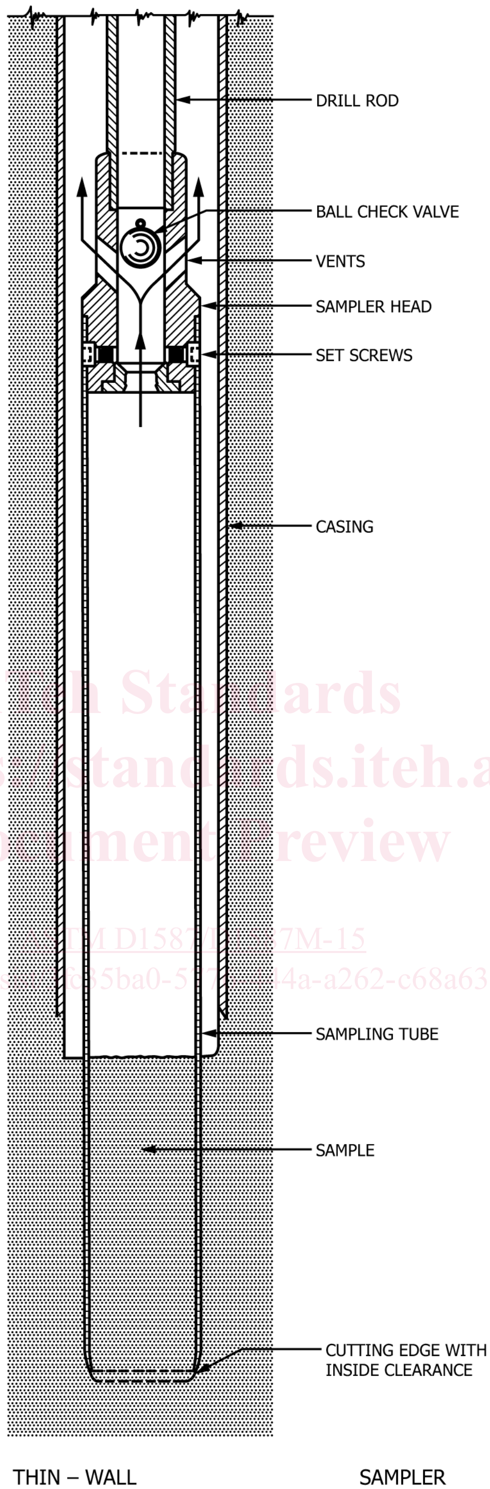


FIG. ~~1~~2 Thin-Walled Tube ~~for Sampling~~Sampler Schematic and Operation (1)

5.1.4 This type of sampler is often referred to as a "Shelby Tube."

5.2 Thin-walled tubes used are of variable wall thickness (gauge), which determines the Area Ratio (A_r). The outside cutting edge of the end of the tube is machined-sharpened to a cutting angle (Fig. 1). The tubes are also usually supplied with a

TABLE ~~2~~1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
~~in.~~	~~2~~	~~3~~	~~5~~
~~mm~~	~~50.8~~	~~76.2~~	~~127~~
in.	2	3	5
mm	50	75	125
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
~~mm~~	~~1.24~~	~~1.65~~	~~3.05~~
mm	1.25	1.65	3.05
Tube length:			
~~in.~~	~~36~~	~~36~~	~~54~~
~~m~~	~~0.91~~	~~0.91~~	~~1.45~~
in.	36	36	54
m	1.0	1.0	1.5
~~Inside clearance ratio, %~~	~~<1~~	~~<1~~	~~<1~~

[A] The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions. Wall thickness may be changed (5.2.1, 6.3.2). Bwg is Birmingham Wire Gauge (Specification A513/A513M).

machine-beveled inside cutting edge which provides the Clearance Ratio (C_r). The recommended combinations of A_r, cutting angle, and C_r are given below (also see 6.3 and Appendix X1, which provides guidance on sample disturbance).

5.2.1 A_r should generally be less than 10 to 15 %. Larger A_r of up to 25 to 30 % have been used for stiffer soils to prevent buckling of the tube. Tubes of thicker gauge may be requested when re-use is anticipated (see 6.3.2).

5.2.2 The cutting edge angle should range from 5 to 15 degrees. Softer formations may require sharper cutting angles of 5 to 10 degrees, however, sharp angles may be easily damaged in deeper borings. Cutting edge angles of up to 20 to 30 degrees have been used in stiffer formations in order to avoid damage to the cutting edges.

5.2.3 Optimum C_r depends on the soils to be tested. Soft clays require C_r of 0 or less than 0.5 %, while stiffer formations require larger C_r of 1 to 1.5 %.

5.2.3.1 Typically, manufacturers supply thin-walled tubes with C_r of about 0.5 to 1.0 % unless otherwise specified. For softer or harder soils C_r tubes may require special order from the supplier.

5.3 The most frequent use of thin-walled tube samples is the determination of the shear strength and compressibility of soft to medium consistency fine-grained soils for engineering purposes from laboratory testing. For determination of undrained strength, unconfined compression or unconsolided, undrained triaxial compression tests are often used (Test Methods D2166 and D2850). Unconfined compression tests should be only used with caution or based on experience because they often provide unreliable measure of undrained strength, especially in fissured clays. Unconsolidated undrained tests are more reliable but can still suffer from disturbance problems. Advanced tests, such as consolidated, undrained triaxial compression (Test Method D4767) testing, coupled with one dimensional consolidation tests (Test Methods D2435 and D4186) are performed for better understanding the relationship between stress history and the strength and compression characteristics of the soil as described by Ladd and Degroot, 2004 (**4**).

5.3.1 Another frequent use of the sample is to determine consolidation/compression behavior of soft, fine-grained soils using One-Dimensional Consolidation Test Methods D2435 or D4186 for settlement evaluation. Consolidation test specimens are generally larger diameter than those for strength testing and larger diameter soil cores may be required. Disturbance will result in errors in accurate determination of both yield stress (5.3) and stress history in the soil. Disturbance and sample quality can be evaluated by looking at recompression strains in the One-Dimensional Consolidation test (see Andressen and Kolstad (**5**)).

5.4 Many other sampling systems use thin-walled tubes. The piston sampler (Practice D6519) uses a thin-walled tube. However, the piston samplers are designed to recover soft soils and low-plasticity soils and the thin-walled tubes used must be of lower C_r of 0.0 to 0.5 %. Other piston samplers, such as the Japanese and Norwegian samplers, use thin-walled tubes with 0 % C_r (see Appendix X1).

5.4.1 Some rotary soil core barrels (Practice D6169-Pitcher Barrel), used for stiff to hard clays use thin-walled tubes. These samplers use high C_r tubes of 1.0 to 1.5 % because of core expansion and friction.

5.4.2 This standard may not address other composite double-tube samplers with inner liners. The double-tube samplers are thicker walled and require special considerations for an outside cutting shoe and not the inner thin-walled liner tube.

5.4.3 There are some variations to the design of the thin-walled sampler shown on Fig. 2. Figure 2 shows the standard sampler with a ball check valve in the head, which is used in fluid rotary drilled holes. One variation is a Bishop-type thin-walled sampler that is capable of holding a vacuum on the sampler to improve recovery (**1, 2**). This design was used to recover sand samples that tend to run out of the tube with sampler withdraw.

5.5 The thin-walled tube sampler can be used to sample soft to medium stiff clays[4]. Very stiff clays[4] generally require use of rotary soil core barrels (Practice D6151, Guide D6169). Mixed soils with sands can be sampled but the presence of coarse sands and gravels may cause soil core disturbance and tube damage. Low-plasticity silts can be sampled but in some cases below the water table they may not be held in the tube and a piston sampler may be required to recover these soils. Sands are much more difficult to penetrate and may require use of smaller diameter tubes. Gravelly soils cannot be sampled and gravel will damage the thin-walled tubes.

5.5.1 Research by the US Army Corps of Engineers has shown that it is not possible to sample clean sands without disturbance (**2**). The research shows that loose sands are densified and dense sands are loosened during tube insertion because the penetration process is drained, allowing grain rearrangement.

5.5.2 The tube should be pushed smoothly into the cohesive soil to minimize disturbance. Use in very stiff and hard clays with insertion by driving or hammering cannot provide an intact sample. Samples that must be obtained by driving should be labeled as such to avoid any advanced laboratory testing for engineering properties.

5.6 Thin-walled tube samplers are used in mechanically drilled boreholes (Guide D6286). Any drilling method that ensures the base of the borehole is intact and that the borehole walls are stable may be used. They are most often used in fluid rotary drill holes (Guide D5783) and holes using hollow-stem augers (Practice D6151).

5.6.1 The base of the boring must be stable and intact. The sample depth of the sampler should coincide with the drilled depth. The absence of slough, cuttings, or remolded soil in the top of the samples should be confirmed to ensure stable conditions (7.4.1).

5.6.2 The use of the open thin-walled tube sampler requires the borehole be cased or the borehole walls must be stable as soil can enter the open sampler tube from the borehole wall as it is lowered to the sampling depth. If samples are taken in uncased boreholes the cores should be inspected for any sidewall contamination.

5.6.3 Do not use thin-walled tubes in uncased fluid rotary drill holes below the water table. A piston sampler (Practice D6519) must be used to ensure that there is no fluid or sidewall contamination that would enter an open sampling tube.

5.6.4 Thin-walled tube samples can be obtained through Dual Tube Direct Push casings (Guide D6282).

5.6.5 Thin-walled tube samples are sometimes taken from the surface using other hydraulic equipment to push in the sampler. The push equipment should provide a smooth continuous vertical push.

5.7 Soil cores should not be stored in steel tubes for more than one to two weeks, unless they are stainless steel or protected by corrosion resistant coating or plating (6.3.2), see Note 1~~This practice, or Practice~~. This is because once the core is in contact with the steel tube, there are galvanic reactions between the tube and the soil which generally cause the annulus core to harden with time. There are also possible microbial reactions caused by temporary exposure to air. It is common practice to extrude or remove ~~D3550 with thin wall shoe, is used when it is necessary to obtain a relatively intact specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.~~the soil core either in the field or at the receiving laboratory immediately upon receipt. If tubes are for re-use, soil cores must be extruded quickly within a few days since damage to any inside coatings is inevitable in multiple re-use. Extruded cores can be preserved by encasing the cores in plastic wrap, tin foil, and then microcrystalline wax to preserve moisture.

5.7.1 Soil cores of soft clays may be damaged in the extrusion process. In cases where the soil is very weak, it may be required to cut sections of the tube to remove soil cores for laboratory testing. See Appendix X1 for recommended techniques.

NOTE 1—The one to two week period is just guideline typically used in practice. Longer time periods may be allowed depending on logistics and the quality assurance requirements of the exploration plan.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective sampling. Users of this ~~practice.~~practice are cautioned that compliance with Practice D3740 does not in itself ~~assure~~ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled ~~sampler.~~ sampler (Guide D6286). Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment,* shall be adequate to provide a relatively rapid continuous penetration force.~~ For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.~~

6.3 *Thin-Walled ~~Tubes,~~ Tubes—*~~should be manufactured to the dimensions as shown~~The tubes are either steel or stainless steel although other metals may be used if they can meet the general tolerances given in ~~Fig. 1~~Table 2~~. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having~~ and have adequate strength for the ~~type of~~ soil to be sampled. Electrical Resistance Steel welded tubing meeting requirements of Specification A513/A513M are commonly used but it must meet the strict the SSID (Special Smooth Inside Diameter) and DOM (Drawn Over Mandrel) tolerances. Table 2 is taken from

[4] Soil Mechanics in Engineering Practice, Terzaghi, K. and R.B Peck, (1967) Second Edition, John Wiley & Sons, New York, Table 45.2, pg. 347.