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# Standard Guide for Collection of Water Temperature, Dissolved-Oxygen Concentrations, Specific Electrical Conductance, and pH Data from Open Channels<sup>1</sup>

This standard is issued under the fixed designation D6764; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide describes procedures to collect cross-sectional means of temperature, dissolved oxygen, specific electrical conductance, and pH of water flowing in open channels.

1.2 This guide provides guidelines for preparation and calibration of the equipment to collect cross-sectional means of temperature, dissolved oxygen, specific electrical conductance, and pH of water flowing in open channels.

1.3 This guide describes what equipment should be used to collect cross-sectional means of temperature, dissolved oxygen, specific electrical conductance, and pH of water flowing in open channels.

1.4 This guide covers the cross-sectional means of temperature, dissolved oxygen, specific electrical conductance, and pH of fresh water flowing in open channels.

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 requirements prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

[D888 Test Methods for Dissolved Oxygen in Water](#)

[D1125 Test Methods for Electrical Conductivity and Resistivity of Water](#)

[D1129 Terminology Relating to Water](#)

[D1293 Test Methods for pH of Water](#)

[D4410 Terminology for Fluvial Sediment](#)

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.07 on Sediments, Geomorphology, and Open-Channel Flow.

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

[D4411 Guide for Sampling Fluvial Sediment in Motion](#)  
[D5464 Test Method for pH Measurement of Water of Low Conductivity](#)

## 3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this guide, refer to Terminology [D1129](#) and [D4410](#).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *electronic temperature sensor*—an electrical device that converts changes in resistance to a readout calibrated in temperature units. Thermistors and resistance temperature detectors are examples of electronic temperature sensors.

3.2.2 *thermometer*—any device used to measure temperature, consisting of a temperature sensor and some type of calibrated scale or readout device.

## 4. Summary of Guide

4.1 This guide establishes criteria and describes procedures for the collection of cross-sectional means of temperature, dissolved oxygen (DO), specific electrical conductance (SC), and pH of water flowing in open channels.

4.2 This guide provides only generic guidelines for equipment use and maintenance. Field personnel must be familiar with the instructions provided by equipment manufacturers. There are a large variety of available field instruments and field instruments are being continuously updated or replaced using newer technology. Field personnel are encouraged to contact equipment manufacturers for answers to technical questions.

## 5. Significance and Use

5.1 This guide describes stabilization criteria for recording field measurements of Temperature, DO, SC, and pH.

5.2 This guide describes the procedures used to calibrate and check meters to be used in the field to records these measurements and the procedures to be use in the field to obtain these data.

5.3 This guide describes quality assurance procedures to be followed when obtaining cross-sectional means of temperature,

dissolved oxygen, specific electrical conductance, and pH of water flowing in open channels.

5.4 Field measurement must accurately represent the water flowing in the open channel being measured. Methods need to be used that will result in an accurate representation of the mean of the parameter of interest. Procedures must be used that will take into consideration the variation in the parameter across the sections and with depth.

5.5 Temperature and DO must be measured directly in the water in the open channel. SC and pH are often measured in situ, but also may be measured in a subsample of a composite sample collected using discharge-weighted methods.

## 6. Procedure

### General Comments

6.1 Field measurements should represent, as closely as possible, the natural condition of the surface-water system at the time of sampling. Field teams must determine if the instruments and method to be used will produce data of the type and quality required to fulfill study needs. Experience and knowledge of field conditions often are indispensable for determining the most accurate field-measurement value.

6.1.1 To ensure the quality of the data collected **(1)**<sup>3</sup>:

6.1.1.1 Calibration is required at the field site for most instruments. Make field measurements only with calibrated instruments.

6.1.1.2 Each field instrument must have a permanent log-book for recording calibrations and repairs. Review the log-book before leaving for the field.

6.1.1.3 Test each instrument (meters and sensors) before leaving for the field. Practice your measurement technique if the instrument or measurement is new to you.

6.1.1.4 Have backup instruments readily available and in good working condition.

<sup>3</sup> The boldface numbers in parentheses refer to the list of references at the end of this guide.

**TABLE 1 Stabilization Criteria for Recording Field Measurements (1)**

NOTE 1—[±, plus or minus value shown; °C, degrees Celsius; ≤ less than or equal to values shown; μS/cm microsiemens at 25°C, >, greater than value shown; unit, standard pH unit; mg/L milligram per liter].

Standard Direct Field Measurement	Stabilization Criteria for Measurements (Variability Should Be Within the Value Shown)
Temperature:	
Electronic Temperature Sensor	±0.2°C
Liquid-in-glass thermometer	±0.5°C
Specific Electrical Conductance:	
when ≤ 100 mS/cm	±5 %
when > 100 mS/cm	±5 %
pH:	
Meter displays to 0.01	±0.1 unit
Dissolved oxygen:	
Amperometric method	±0.3 mg/L

6.1.2 Before making field measurements, sensors must be allowed to equilibrate to the temperature of the water being monitored. Sensors have equilibrated adequately when instrument readings have “stabilized,” that is, when the variability among measurements does not exceed an established criterion. The criteria for stabilized field readings are defined operationally in **Table 1**, for a set of three or more sequential measurements. The natural variability inherent in surface water at the time of sampling generally falls within these stability criteria and reflects the accuracy that should be attainable with a calibrated instrument.

6.1.3 Allow at least 60 s (or follow the manufacturer’s guidelines) for sensors to equilibrate with sample water. Take instrument readings until the stabilization criteria in **Table 1** are met. Record the median of the final three or more readings as the value to be reported for that measurement point.

### 6.2 Locating Points of Measurement in Cross-Section:

6.2.1 The location and the number of field measurements depend on study objectives. Generally, a single set of field-measurement data is used to represent an entire stream cross section at a sampling site and can be useful when calculating chemical loads.

6.2.2 To obtain data representative of the section, the variability of discharge and field measurements across the stream must be known. This information is used to determine if the equal-discharge-increment (EDI) or equal-width-increment (EWI) method of locating field-measurement points should be used. See Terminology **D4410** for definitions of these terms.

6.2.2.1 Check the cross-sectional profile data of the stream site to determine the variability of discharge per unit width of the stream and of field-measurement values across the section.

Make individual measurements at a number of equally-spaced verticals along the cross section and at multiple depths within each vertical; or, consult previous records for the site.

Make in situ (see **6.2.3.3**) field measurements for the profile.

Field-measurement profiles of stream variability are needed for low- and high-flow conditions and should be verified at least every 2 years or as study objectives dictate.

6.2.2.2 Select the EDI or EWI method to locate points of measurement (see reference **(2)** for information on EDI and EWI methods) to select and execute the appropriate method.

If stream depth and velocities along the cross section are relatively uniform, use the EWI method.

If stream depth and velocities along the cross section are highly variable, use the EDI method.

In a small and well-mixed stream, a single point at the centroid of flow may be used to represent the cross section. The centroid of flow is defined as the point in the increment at which discharge in that increment is equal on both sides of the point.

6.2.3 Use the following procedure when making a field measurement using the EDI method.

6.2.3.1 Divide the cross section into equal increments of discharge (see reference **(1)** for details on how to properly do this.)

6.2.3.2 Select either the in situ or subsample method and follow the instructions in 6.3 or 6.4.

6.2.3.3 *In Situ Method*—Go to the centroid of the first equal-discharge increment. Using submersible sensors, measure at mid-depth (or multiple depths) in the vertical. Repeat at each vertical. The value recorded at each vertical represents the median of values observed within approximately 60 s after sensor(s) have equilibrated with stream water.

6.2.3.4 *Subsample Method*—Collect an isokinetic depth-integrated sample at the centroid of each equal-discharge increment, emptying the increment sample into a compositing device. Measure field parameters either in the sample collected at each increment or in a subsample taken from the composite of all the increment samples.

6.2.3.5 The final field-measurement value is the mean of the in situ or individual increment-sample value for all the EDI verticals in the section (the composite subsample yields a single value). Note for pH it is necessary to calculate the mean by (1) converting each pH measurement to its antilogarithm times minus one ( $10^{-(\text{pH})}$ ), (2) using these transformed values to calculate the mean, and (3) converting the mean value to a logarithm multiplied by minus one (refer to 6.8.4.5).

6.2.3.6 Enter data on a field form.

6.2.3.7 *Example*—Table 2 is an example of how mean conductivity measured in situ is calculated using the equal-discharge-increment method.

6.2.3.8 In the example, the correct value for the discharge-weighted mean conductivity is 163  $\mu\text{S/cm}$ , calculated from 815 divided by 5 (the sum of the recorded median values divided by the number of median measurements). Note that at the midpoint of the center centroid of flow (increment 3) the median conductivity would have been reported as 155  $\mu\text{S/cm}$ ; if conductivity had been measured near the left edge of the water (increment 1), the conductivity would have been reported as 185  $\mu\text{S/cm}$ .

6.2.4 Use the following procedure when making a field measurement using the EWI method.

6.2.4.1 Divide the cross section into equal increments of width (see reference (1) for details on how to properly do this.)

6.2.4.2 In situ field measurements are made at the midpoints of each increment. Area-weighted concentrations can be computed from these measurements (Table 3).

6.2.4.3 Subsample field measurements are made in discrete samples that usually are withdrawn from a composite sample

collected using an isokinetic sample and isokinetic depth-integrating method. The volume of the isokinetic sample must be proportional to the amount of discharge in each increment and measurements in subsamples taken from the compositing device result in discharge-weighted values.

6.2.4.4 Select either the in situ or subsample method and follow the instructions in 6.3 or 6.4.

6.2.4.5 *In Situ Method*—Measure at the midpoint of each equal-width increment. Using submersible sensors, measure at mid-depth in the vertical.

6.2.4.6 *Subsample Method*—Collect an isokinetic depth-integrated sample at the midpoint of each equal-width increment, emptying each sample into a compositing device. Use of the correct sampling equipment is critical to execute this method successfully: standard samplers cannot meet isokinetic requirements when stream velocity is less than 1.5 ft/s.

6.2.4.7 Record a value for each field measurement for each vertical. The value recorded represents the stabilized values observed within approximately 60 s after the sensor(s) have equilibrated with the stream or subsample water.

6.2.4.8 *Example*—Table 3 provides an example of an area-weighted median measurement for conductivity measured in situ. In the example, the area-weighted median conductivity equals 130  $\mu\text{S/cm}$ . To calculate an area-weighted median, multiply the area of each increment by its corresponding field measurement, sum the products of all the increments, and divide by total cross-sectional area. Note that if the conductivity reported was selected at mid-depth of the vertical of centroid of flow (Section 10), it would have been reported as 125  $\mu\text{S/cm}$ ; if the conductivity reported was near the left edge of water, it would have been reported as 150  $\mu\text{S/cm}$ .

6.2.4.9 The final field-measurement value normally is calculated as the mean of the values recorded at all EDI increments, resulting in an area-weighted mean (for pH it is necessary to calculate the mean by (1) converting each pH measurement to its antilogarithm times minus one ( $10^{-(\text{pH})}$ ), (2) using these transformed values to calculate the mean, and (3) converting the mean value to a logarithm multiplied by minus one.)

6.3 *In Situ Measurement Procedures :*

6.3.1 In situ measurement (Fig. 1), made by immersing a field-measurement sensor directly in the water body, is used to determine a profile of variability across a stream section. In situ

TABLE 2 Example of Field Notes for a Discharge-Weighted Conductivity Measurement

NOTE 1—[ft/sec, feet per second; ft, feet; ft<sup>2</sup>, square feet; ft<sup>3</sup>/s, cubic feet per second;  $\mu\text{S/cm}$ , microsiemens per centimeter at 25°C; LEW, left edge of water; —, not available; REW, right edge of water].

Equal Discharge Increment	Percent of Flow in Increment	Mean Velocity, in ft/s	Width of Increment, in ft	Depth of Increment, in ft	Area of Increment, in ft <sup>2</sup>	Increment Discharge, in ft <sup>3</sup> /s	Median Conductivity, in $\mu\text{S/cm}$
LEW	0	—	—	—	—	—	—
1	20	2.0	22	5.7	125	250	185
2	20	2.2	11	10.4	114	250	170
3	20	2.3	9	12.0	109	250	155
4	20	3.9	5	12.8	64	250	155
5	20	3.4	10	7.4	74	250	150
REW	0	—	—	—	—	—	—

Calculation of conductivity: mean of median conductivity measurements (815 divided by 5) = 163  $\mu\text{S/cm}$ .

**TABLE 3 Example of Field Notes for an Area-Weighted Conductivity Measurement**

NOTE 1—[ft, feet; LEW, left edge of water; ft<sup>2</sup>, square feet;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; —, not available; REW, right edge of water].

Section Number	Cumulative Percent of Flow in Section	Vertical Location, in ft from LEW	Width of Section, in ft	Depth of Vertical, in ft	Area of Section, in ft <sup>2</sup>	Median Conductivity, in $\mu\text{S}/\text{cm}$	Product of Median Conductivity and Area
LEW	0	0	—	—	—	—	—
1	2	2	4	1.0	4.0	150	600
2	4	6	4	2.0	8.0	145	1 160
3	6	10	4	2.6	10.4	145	1 508
4	10	14	4	3.2	12.8	140	1 792
5	16	18	4	3.5	14.0	135	1 890
6	22	22	4	4.0	16.0	130	2 080
7	28	26	4	4.5	18.0	130	2 340
8	34	30	4	5.4	21.6	125	2 700
9	42	34	4	6.0	24.0	125	3 000
10	50	38	4	5.7	22.8	125	2 850
11	62	42	4	5.1	20.4	125	2 550
12	76	46	4	4.6	18.4	125	2 300
13	88	50	4	3.5	14.0	12	1 750
14	96	54	4	1.4	5.6	135	756
15	99	58	4	1.0	4.0	140	560
REW	100	60	—	—	—	—	—

Calculation of conductivity: sum of values in last column divided by the total cross-sectional area  $27\ 836/214 = 130\ \mu\text{S}/\text{cm}$ .

measurement can be repeated if stream discharge is highly variable and measurement points need to be located at increments of equal discharge. However, in situ measurements are point samples, and, thus, are not depth integrated.

6.3.2 Measurements made directly (in situ) on the surface-water body are preferable in order to avoid changes that result from removing a water sample from its source. In situ measurement is necessary to avoid changes in chemical properties of anoxic water.

6.3.2.1 In situ measurement is mandatory for determination of temperature and dissolved-oxygen concentration.

6.3.2.2 In situ measurement also can be used for pH and conductivity.

#### 6.4 Subsample Measurement:

6.4.1 Depth- and width-integrating sampling methods are used to collect and composite samples that can be subsampled for some field measurements. The same field measurements can be performed on discrete samples collected with thief, bailer, or grab samplers. Subsamples or discrete samples that have been withdrawn from a sample-compositing device or point sampler can yield good data for conductivity and pH as long as correct procedures are followed and the water is not anoxic (Fig. 2).

6.4.2 Before using a sample-compositing/splitting device, preclean and field rinse the device in accordance with approved procedures such as described in Horowitz and others, 1994 (3).

6.4.3 When compositing and splitting a sample, follow instructions for the clean hands/dirty hands technique such as those detailed in Horowitz and others (3), as required.

#### 6.5 Temperature:

6.5.1 Measurements of water and air temperatures at the field site are essential for water-data collection. Determinations of dissolved-oxygen concentrations, conductivity, pH, rate and equilibria of chemical reactions, biological activity, and fluid properties rely on accurate temperature measurements.

##### 6.5.2 Equipment:

6.5.2.1 Liquid-in-glass thermometers and electronic temperature sensors are most commonly used to measure water temperature.

6.5.2.2 Recommended liquid-in-glass thermometers are total-immersion thermometers filled with alcohol. Before measuring temperature, check the type of liquid-filled thermometer being used. (Partial-immersion thermometers are not recommended: these have a ring or other mark to indicate the immersion depth required.)

6.5.2.3 Thermometers can easily become damaged or out of calibration. Take care to:

Keep thermometers clean (follow manufacturer's recommendations).

Carry thermometers in protective cases; thermometers and cases must be free of sand and debris.

Store liquid-filled thermometers in a bulb-down position and in a cool place away from direct sunlight.

6.5.2.4 As an additional precaution on field trips, carry extra-calibrated thermometers as spares, and a supply of batteries for instrument systems.

##### 6.5.3 Calibration:

6.5.3.1 To calibrate a thermometer, instrument readings are checked across a range of temperatures against those of a thermometer of certified accuracy. Calibrate liquid-in-glass and electronic temperature sensors in the office at regularly scheduled intervals. Tag acceptable thermometers with date of calibration.

6.5.3.2 Calibrate a liquid-in-glass thermometer every 3 to 6 months, using a 2-point calibration, and annually, using a 3-point calibration.

6.5.3.3 Calibrate an electronic temperature sensor annually using a 5-point calibration check and every 3 to 4 months check several reading against reading from a NIST-certified thermometer.

6.5.3.4 For further information and instructions on calibrations see reference (1).

##### 6.5.4 Measurement:

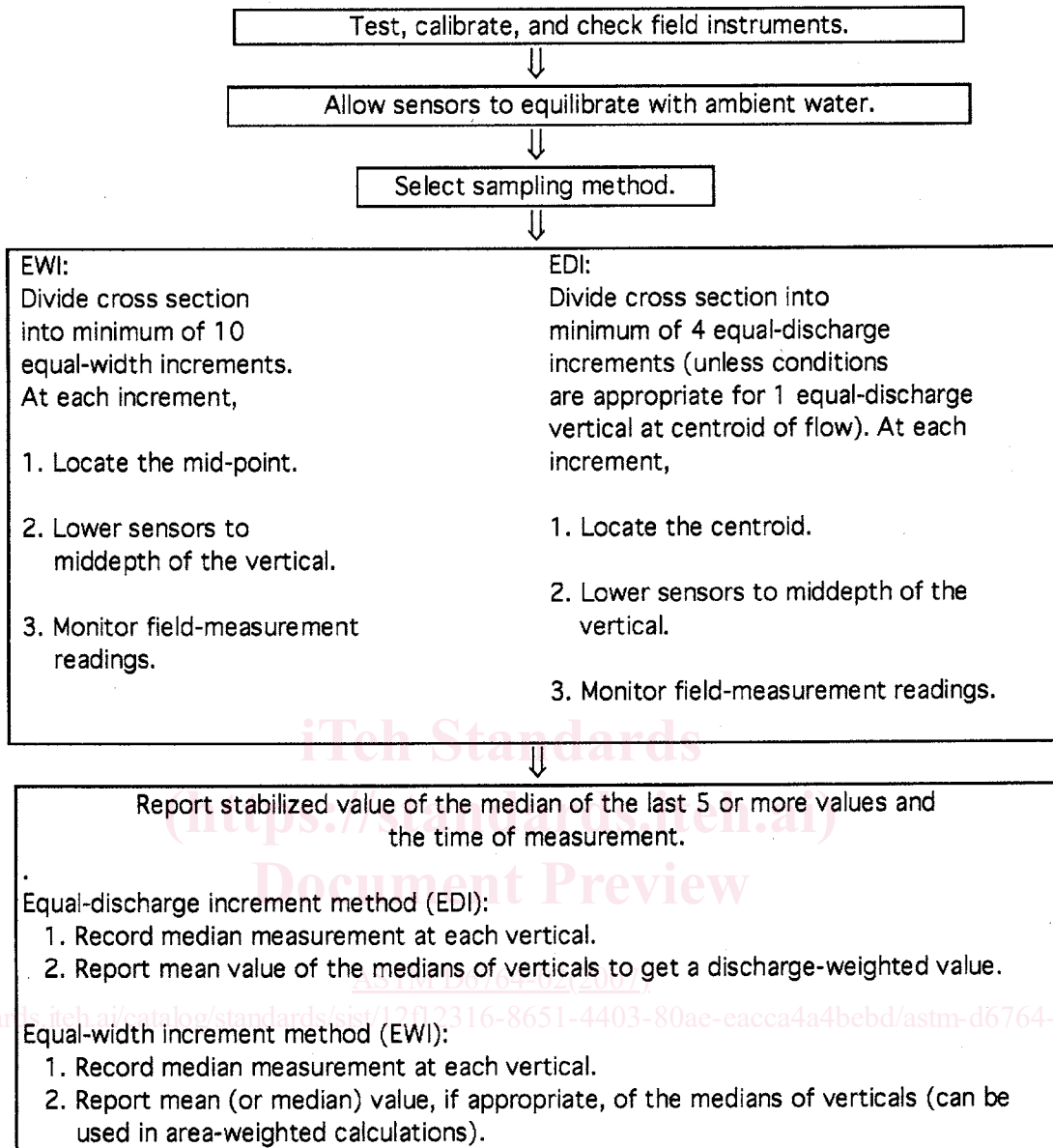


FIG. 1 In Situ Field-Measurement Procedures (1)

6.5.4.1 Before measuring temperature:

Inspect liquid-in-glass thermometers to be certain liquid columns have not separated.

Inspect bulbs to be sure they are clean.

Inspect protective cases to be sure they are free of sand or debris.

6.5.4.2 The reported surface-water temperature must be measured in situ. Do not measure temperature on subsamples from a sample compositing device.

6.5.4.3 To measure the temperature of surface water:

Make a cross-sectional temperature profile to determine temperature variability; an electronic temperature sensor works best for purpose.

Determine from the cross-sectional profile and from study objectives which sampling method to use (see 6.2).

Measure temperature in those sections of the stream that represent most of the water flowing in a reach. Do not make temperature measurements in or directly below stream sections with turbulent flow or from the stream bank (unless this represents the condition to be monitored).

6.5.4.4 Use either a liquid-in-glass thermometer tagged as “certified” within the past 12 months, or an electronic temperature sensor tagged “certified” within the past 4 months.

6.5.4.5 Record on field forms the temperature variation from the cross-sectional profile, and the sampling method selected.

Flowing, shallow stream—wade to the location(s) where temperature is to be measured. To prevent erroneous readings caused by direct solar radiation, stand so that a shadow is cast on the site for temperature measurement.

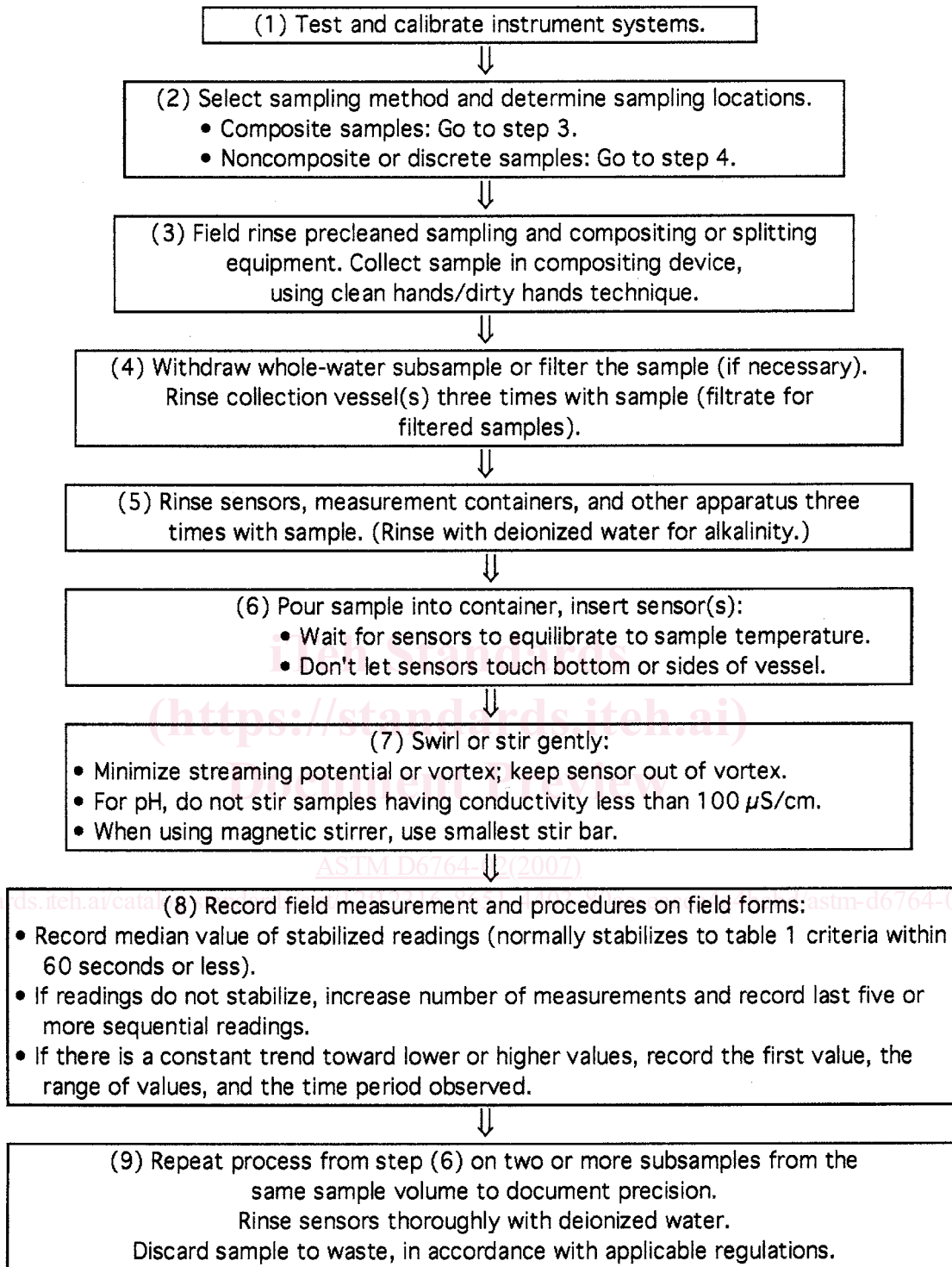


FIG. 2 Subsample Field-Measurement Procedures for Conductivity and pH (1)

Stream too deep or swift to wade—measure temperature by lowering from a bridge, cableway, or boat an electronic temperature sensor attached to a weighted cable. Do not attach a weight to the sensor or sensor cable.

Still-water conditions—measure temperature at multiple depths at several points in the cross section.

6.5.4.6 Immerse the sensor in the water to the correct depth and hold it there for no less than 60 s until the sensor equilibrates thermally. The sensor must be immersed properly while reading the temperature; this might require attaching the thermistor to a weighted cable. (Technical Note: For in situ measurement with liquid-filled thermometers; the water depth