Designation: ~~D5073 – 02 (Reapproved 2021)~~ D5073 – 21

Standard Practice for Depth Measurement of Surface Water[1]

This standard is issued under the fixed designation D5073; 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.

1. Scope

1.1 This practice guides the user in selection of procedures commonly used to measure depth in water bodies that are as follows:

	Sections
Procedure A—Manual Measurement	6 through 11
Procedure B—Electronic Sonic-Echo Sounding	12 through 13
Procedure C—Electronic Nonacoustic Measurement	14 through 15

The text specifies depth measuring terminology, describes measurement of depth by manual and electronic equipment, outlines specific uses of electronic sounders, and describes an electronic procedure for depth measurement other than using sonar.

1.2 The references cited and listed at the end of this practice contain information that may help in the design of a high quality measurement program.

1.3 The information provided on depth measurement is descriptive in nature and not intended to endorse any particular item of manufactured equipment or procedure.

1.4 This practice pertains to depth measurement in quiescent or low-velocity flow. For depth measurement related to stream gauging, see Test Method D3858. For depth measurements related to reservoir surveys, see Guide D4581.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] This practice 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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2. Referenced Documents

2.1 *ASTM Standards:*[2]
D1129 Terminology Relating to Water
D3858 Test Method for Open-Channel Flow Measurement of Water by Velocity-Area Method
D4410 Terminology for Fluvial Sediment
D4581 Guide for Measurement of Morphologic Characteristics of Surface Water Bodies (Withdrawn 2013)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this standard, refer to Terminologies D1129 and D4410.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bar-check, n*—a method for determining depth below a survey vessel by means of a long, narrow metal bar or beam suspended on a marked line beneath a sounding transducer.

3.2.2 *bar sweep, n*—a bar or pipes, suspended by wire or cable beneath a floating vessel, used to search for submerged snags or obstructions hazardous to navigation.

3.2.3 *beam width, n*—the angle in degrees made by the main lobe of acoustical energy emitted from the radiating face of a transducer.

3.2.4 *bottom profile, n*—a line trace of the bottom surface beneath a water body.

3.2.5 *sonar, n*—a method for detecting and locating objects submerged in water by means of the sound waves they reflect or produce.

3.2.6 *sound, vt*—to determine the depth of water (**1**).[4]

3.2.7 *sounding line, n*—a rope or cable used for supporting a weight while the weight is lowered below the water surface to determine depth.

3.2.8 *sounding weight, n*—a heavy object usually of lead, that may be bell-shaped, for use in still water and soft bottom materials or torpedo shaped with stabilizing fins, for use in flowing water.

3.2.9 *stray, n*—spurious marks on the graphic depth records caused by surfaces other than the bottom surface of a water body below the sounding vessel.

3.2.10 *subbottom profile, n*—a trace of a subsurface horizon due to a change in the acoustic properties of the medium through which the sound energy has traveled.

3.2.11 *towfish, n*—a streamlined container, containing acoustical equipment for sounding depth, and designed to be pulled behind or beneath a survey vessel.

3.2.12 *transducer, n*—a device for translating electrical energy to acoustical energy and acoustical energy back to electrical energy.

3.2.13 *transducer draft, n*—the distance from the water surface to the radiating face of a transducer.

[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.
[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] The boldface numbers in parentheses refer to a list of references at the end of this standard.

3.2.14 *vertical control, n*—a horizontal plane of reference used to convert measured depth to bottom elevation.

4. Summary of Practices

4.1 These practices include the following three general techniques for acquiring depth measurements in surface water:

4.1.1 The first general technique is to determine depth by manual procedures. The equipment to perform these procedures may be most readily available and most practical under certain conditions.

4.1.2 The second general technique is to determine depth by electronic sonic-echo sounding procedures. These procedures are most commonly used because of their reliability and the variety of instruments available that meet specific measuring requirements.

4.1.3 The third general technique is to determine depth by an electronic procedure other than acoustic sounding. A procedure using ground penetrating radar is currently being used for measuring water depth for specific applications.

5. Significance and Use

5.1 This is a general practice intended to give direction in the selection of depth measuring procedures and equipment for use under a wide range of conditions encountered in surface water bodies. Physical conditions at the measuring site, the quality of data required, and the availability of appropriate measuring equipment govern the selection process. A step-by-step procedure for actually obtaining a depth measurement is not discussed. This practice is to be used in conjunction with a practice on positioning techniques and another practice on bathymetric survey procedures to obtain horizontal location and bottom elevations of points on a water body.

PROCEDURE A—MANUAL MEASUREMENT

6. Scope

6.1 This procedure explains the measurement of water depth using manual techniques and equipment. These include the use of sounding rods, sounding lines, sounding reels, or a bar sweep.

6.2 Description of techniques and equipment are general in nature. Techniques and equipment may need to be modified for use in specific field conditions.

7. Significance and Use

7.1 Prior to the development of acoustic sounding equipment, manual techniques provided the only means of depth measurement. Some circumstances may still require sounding by manual techniques such as shallow areas where depth is not sufficient for acoustic sounding. Manual procedures continue to serve several useful purposes such as the following:

7.1.1 To search for and confirm the minimum depths over shallow area of sunken obstacles.

7.1.2 To confirm bottom soundings in areas with submerged vegetation, or other soft bottom materials.

7.1.3 To assist in obtaining bottom samples.

7.1.4 To calibrate electronic sounding equipment.

7.1.5 To suspend other measuring instruments to known depths for making various physical or chemical water quality measurements (**2**).

8. Sounding Rod (Manual Procedure)

8.1 The sounding rod (or sounding pole) can be used to measure depth over extensive flat, shallow areas more easily and more accurately than by other means. Use of the sounding rod should be restricted to still water or where the velocity is relatively low, and to depths less than 12 ft (3.7 m). Sounding rods are usually not used in depths over 6 ft (1.8 m) except to provide supplemental soundings to aid in interpreting analog depth records. A weighted, flat shoe (see Fig. 1) should be attached to the bottom of the rod to prevent it from penetration of the bottom sediments. The rod may be graduated in feet and tenths of a foot; zero being at the bottom of the shoe (**3**).

8.2 Modern sounding rods may be made of light-weight metals for strength, neutral buoyancy, and sound transmitting capability. An experienced operator can measure the water depth and can distinguish the relative firmness of the bottom material by the feel of the rod and the tone produced by the metal pole as it contacts the bottom (**4**).

8.3 When sounding in still water the operator should lower the rod into the water until the bottom plate makes contact with the bottom surface. After determining that a firm bottom material has been encountered, the water surface level is visually read on the rod. When sounding in flowing water, to achieve vertical sounding, a long wire or cable anchored upstream and attached to the lower end of the rod may be necessary.

9. Sounding Line (Manual Procedure)

9.1 The sounding line (see Fig. 2) can be used to measure depths of large magnitude but is seldom used for depths greater than 15 ft (4.57 m). The sounding line should be of a material that does not shrink or stretch, or lengthen from wear or corrosion of the material as will occur in chain links over several years of use. Though manila rope and cotton, or other materials that require prestretching before use, have been employed for large depths, small-diameter high-strength steel cable wound and released from a reel with a gear driven depth indicator are readily available and greatly simplify the work (**1**). The stretch of the high-strength cable is very small for its intended use, and therefore, a considerable length of cable may be used without introducing significant error. Depth indicators, calibrated in either inch-pound or metric units, or both, are available (**5**).

9.2 Markings on the sounding line should be easy to see and understand to avoid making errors in determining the readings. For sounding relatively shallow depths, marking at 0.5-ft intervals with different colors to identify the 1, 2, and 10-ft intervals is recommended. Care must be exercised so that the first marker is the correct distance from the bottom of the sounding weight when the weight is attached. When sounding, depths are obtained from the difference in readings at an index point on the bridge or boat rail, when the base of the sounding weight is at the water surface, and when it is at the bottom. A short steel tape or folding rule is usually employed to measure the fractional distance from the line markers to the reference point. Within the minimum 0.5-ft

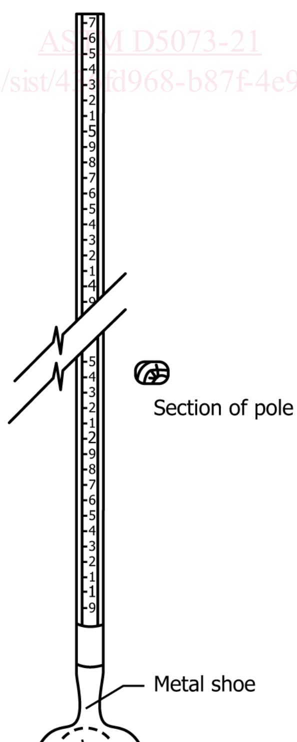


FIG. 1 Graduated Sounding Rod with Shoe Attached

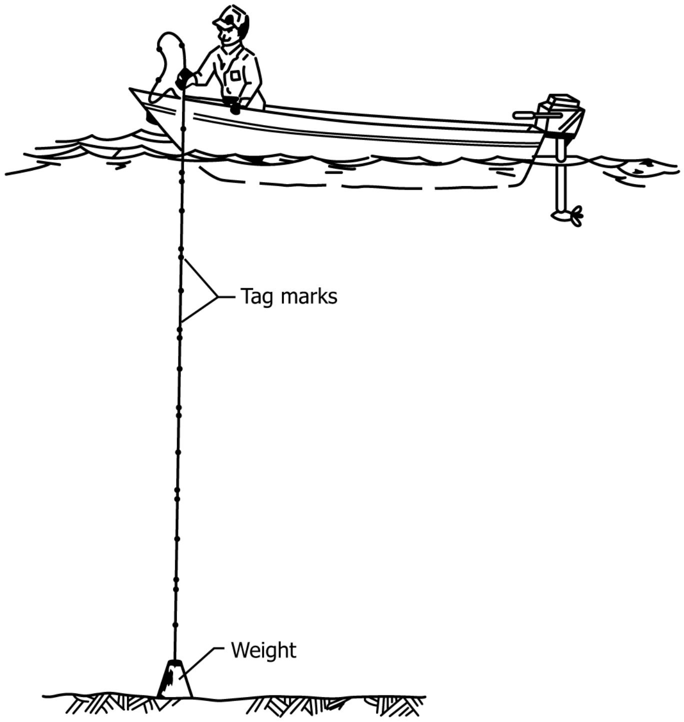


FIG. 2 Sounding Line Used from Small Boat

markings depths are estimated and recorded to the nearest 0.1 ft. For sounding in deep water, a sounding reel with depth indicator and an unmarked high-strength steel cable is recommended (**4**).

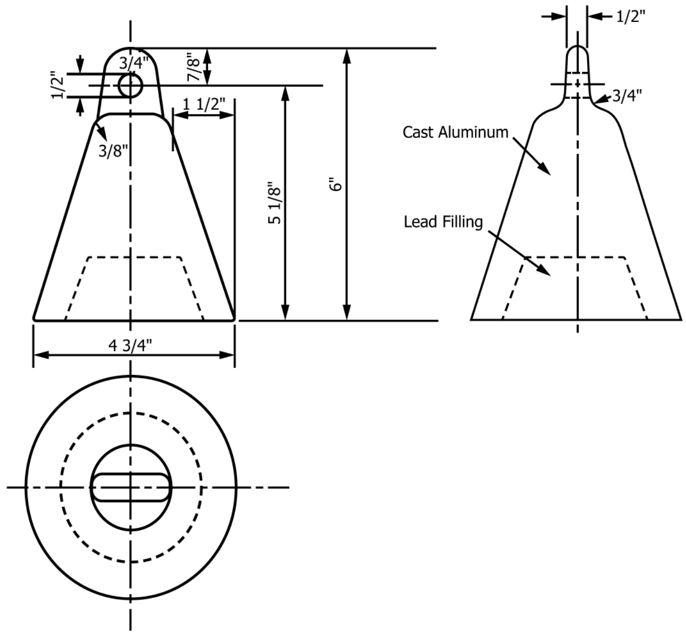
9.2.1 When the metric system of units is used, the sounding line for use in shallow depths is usually marked at 0.5-m intervals with different colors to identify the 1 and 2-m intervals. Depths are recorded to the nearest 0.01 m.

9.3 Weights used in sounding are usually of lead, aluminum, or brass. For application in still water, the weights are bell-shaped (see Fig. 3*a*) and made of cast aluminum or lead. The amount of weight should be from 5 to 10 lb (2.3 to 4.5 kg).

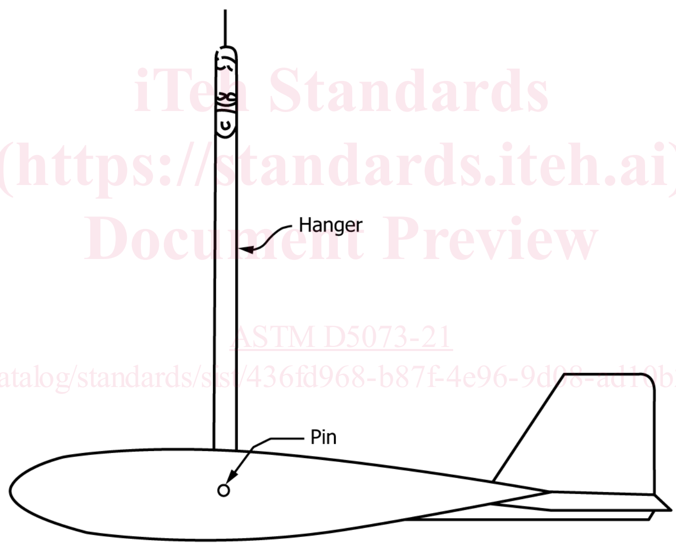
9.3.1 For application in flowing water, the weight should be of circular cross section and steamlined with fins (see Fig. 3*b*) to turn the weight nose first into the current to offer a minimum of resistance to the flow. The amount of weight should be varied, depending on the water depth and flow velocity at a cross section. A rule of thumb is that the weight in pounds should be greater than the maximum product of velocity and depth in the cross section. If debris or ice is flowing or the stream is shallow or swift, use a heavier weight than the rule designates. A variety of sizes of sounding weights from 15 to 300 lb (7 to 136 kg) should be available with appropriate means of attaching to the sounding line (**1**). Sounding weights should always be attached to the sounding line using a hanger bar, clevis, snap hook, or thimble of brass or stainless steel to protect the line from wear or damage.

9.4 The procedure for making soundings will vary depending on depth, current velocity, and means of locating where the soundings are taken. Once at the location where a depth measurement is needed, the basic procedure is to lower the weight until the bottom of the weight is at the water surface. When using a marked sounding line, the distance is read from the sounding line at a reference point on the bridge or boat after which the weight is lowered to the bottom, and a new distance is read from the line and recorded. When using a sounding reel the indicator is set to zero after which the weight is lowered to the bottom and the depth is read and recorded. It is usually of some importance, especially when sounding an uneven bottom, to have the locations of the soundings accurately known relative to the surroundings. When sounding from a boat using weighted line, the boat should be stationary and should remain at that position until the sounding has been completed and the location is determined.

9.5 Sounding through the ice cover of a lake or river may be taken after boring holes in the ice with an ice auger. In this case, a marked sounding line with an appropriate sounding weight attached at the end, is lowered through the hole and the determined depth is recorded.



(*a*) Bell Shaped Sounding Weight (**4**)



(*b*) Torpedo Columbus-Type Sounding Weight

FIG. 3 Typical Weights Used with Sounding Line

10. Sounding Reels (Manual Procedure)

10.1 Sounding reels (see Fig. 4) are used with high strength cable where heavy weights are required or where depths are great. These reels are usually very sturdily constructed having a braking system for controlling rotation of the reel as the cable is let out. For hand operated reels, the hand cranks are hinged to allow the crank to be disengaged from the shaft while the wire is let out and engaged for reeling in. Various devices are employed to drive a counter registering the amount of cable let out from which the depth below water surface is determined. These sounding reels may also be electrically driven, in that case, they may have a depth capacity of more than 5000 ft (1524 m) (**1**).

11. Bar Sweep (Manual Procedure)

11.1 The bar sweep is commonly used to search for and locate any shoal or obstruction within or above navigation depth that may present a hazard to navigation. It augments the hydrographic survey in navigable waters by locating shallow submerged areas that

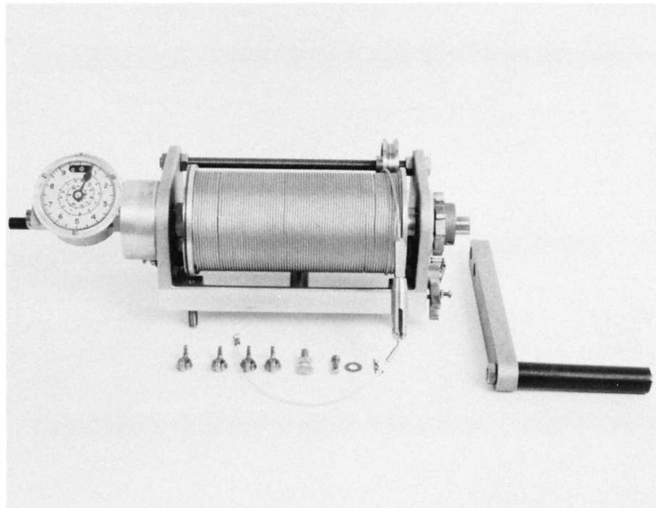


FIG. 4 ~~Hand-operated~~Hand-Operated Sounding Reel (1)

may go undetected by the usual hydrographic procedures. The bar sweep (see Fig. 5) consists of a bar (steel pipe) suspended beneath the survey vessel by graduated wire or cable from hand operated drums. The drums may be mounted either off the stern or at the port and starboard gunwale. Each end of the bar should be packed with lead to add weight and to reduce lift when underway. Pipe weight is the major factor in allowable vessel speed. Trial and error variations are usually necessary to determine the best combination. In a normal operation, the bar is lowered to navigation depth and the vessel moves forward to sweep an area. Whenever a shoal is encountered, the operator raises the bar until it clears the obstruction. The shoal depth and position is then recorded. The bar is then returned to navigation depth and the survey continues (**2**).

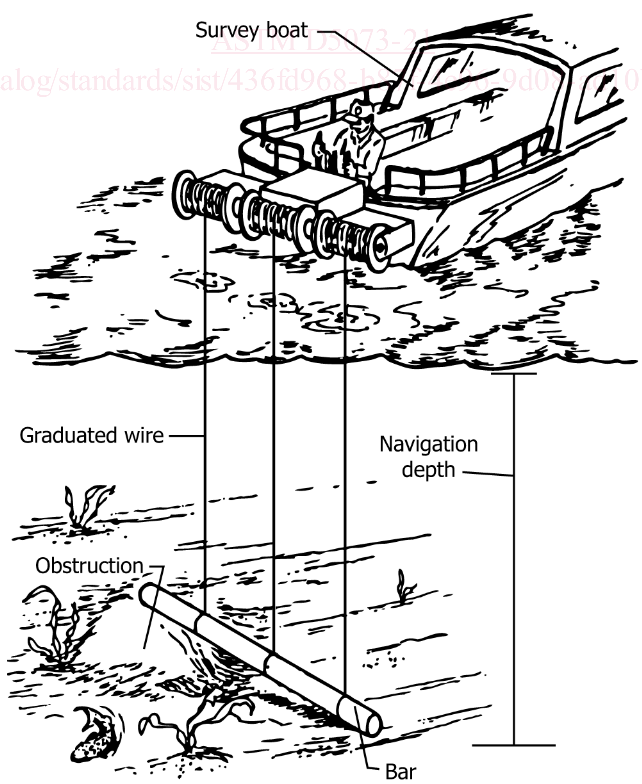


FIG. 5 Bar Sweep for Locating Shoals

PROCEDURE B—ELECTRONIC SONIC-ECHO SOUNDING

12. Scope

12.1 This procedure is applicable to the measurement of water depth using electronic sonic-echo sounding techniques and equipment. Because of the large variety of instrumentation currently available, this discussion is limited to types of equipment in most common use.

12.2 Discussions of the techniques used include methods of measurement, criteria for selection of sounding frequency and recording equipment, means for achieving quality assurance, and factors to consider in interpreting depth records.

13. Sonic-Echo Sounding (Electronic Procedure)

13.1 Water depths are most commonly obtained by echo sounders that record a continuous profile of the bottom surface of the water body under the vessel. Echo sounders measure the time required for a sound wave to travel from its point of origin to the bottom and the reflected wave to return. The sounder then converts this time interval to distance or depth below the face of the transducer. The transmission of sound is dependent on certain properties of the water and the reflecting surface. For a sound wave to travel at a constant velocity from the surface to bottom and be completely reflected off the bottom, the water must have the same physical characteristics throughout its entire depth and the bottom must be a perfect reflector. Because such conditions do not exist in nature, echo sounders are usually designed to permit adjustments for variations in the velocity of sound in water and wave attenuation (**2**).

13.2 *Measuring Principles:*

13.2.1 Echo sounding equipment is designed to generate the sound wave, receive and amplify the returning echo, measure the intervening time interval, convert the time interval into units of depth, and record the results graphically, digitally, or both. The echo sounder only measures time (that is, the time it takes for a sound wave to travel from the transmitter to the bottom or other reflecting surface and back again). The time interval is converted mechanically or electronically to depth beneath the transmitter by the following equation:

$$\text{depth} = 1/2\, vt$$

where:

v = the velocity of sound in water, ft/s (m/s), and
t = the time for the pulse to travel from the transmitter to the reflective surface and back to the transmitter, s.

Because velocity of sound varies with water density, that is a function of temperature, salinity, suspended solids, and depth, a means of correcting the resulting measurements for variations in the velocity of sound must be employed to ensure an acceptable measurement accuracy (**2**). The methods for adjustment are presented in 13.6.

13.2.2 The sound waves transmitted by an echo sounder may be varied in frequency, duration, and shape of the acoustical beam (see Fig. 6). The sound wave may be dispersed in all directions, or contained and concentrated into a narrow beam by a reflector. The suitability of an echo sounder to meet a given requirement depends on how these variables are combined (**2**).

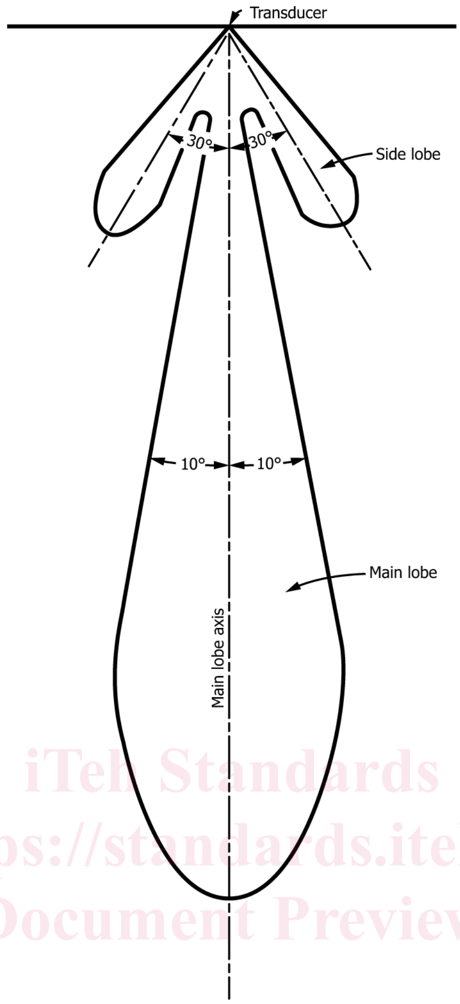


FIG. 6 Shape of a ~~General-purpose~~General-Purpose Echo Sounders' Acoustical Beam (2)

13.3 *Frequency Selection:*

13.3.1 An echo sounding transducer is used to convert electrical energy pulses to acoustical energy. The acoustical energy pulses are then transmitted through a liquid medium and the returning echoes are detected and reconverted back to electrical energy. These energy pulses are then amplified and used to compute and record depth. Transducers are usually designed to operate on specific frequencies, depending on the application and depth range (**2**).

13.3.2 Low-frequency transducers, those operating below 15 kHz, produce sound waves having low absorption rates and high penetrating power. These characteristics make them useful for deep soundings and penetration of the fine deposited material on the bottom of a river or lake. These transducers cannot be used to accurately measure very shallow depths, and they are very susceptible to noise interference in the more audible frequency range. Because of their long wavelengths the lower frequency pulses cannot be beamed directionally unless the transducers are very large (**2**). The use of low-frequency transducers for subbottom penetration is discussed in 13.10.

13.3.3 Medium-frequency transducers (15 to 50 kHz) may be used for water depths less than 1800 ft (549 m) and in situations when it is necessary to penetrate a layer of low density sediment suspended above more compacted sediments. In this range, the transducers may be small in size, the maximum dimension being 8 in. (20.3 cm) or less. These transducers can generate a comparatively narrow beam that results in a more accurate definition of the bottom.

13.3.4 High-frequency transducers (greater than 50 kHz) overcome most of the disadvantages of the low and medium-frequency transducers. With small transmitting units, the ultrasonic acoustical energy can be directed and concentrated in a relatively narrow water column. By narrowing the beam angle, side echoes can be reduced, and a more detailed profile of an irregular bottom can be achieved. In addition, shallow depths can be measured more accurately. Due to greater attenuation of the sound wave, the high frequencies are ineffective in very deep water (**2**).

13.4 *Recording Soundings:*

13.4.1 Analog recorders usually employ one of two methods for registering depth on a chart.

13.4.1.1 In the first method, the depth is recorded by a stylus mounted on a rotating arm that makes a mark on dry, electrosensitive, calibrated paper. The stylus passes over the chart paper at a constant speed marking the chart at the zero (initial) point, at a point designating the draft of the transducer, and at a point representing bottom depth. As continuing echoes are received from the bottom, a bottom profile is recorded (see Fig. 7). The horizontal scale of the plot is determined by the chart speed set by the operator.

13.4.1.2 In the second method, the depth is recorded by a fixed-head thermal recording device (**6**). The printing mechanism consists of a nonmoving print head containing hundreds of thermal dots heated precisely at the proper time to print the chart. The only moving parts on thermal print recorders are the motor and roller assembly that moves the paper across the printhead. Unlike moving-stylus type recorders, the chart and motor timing on the thermal print recorders have no effect on depth measurement accuracy. Thermal print recorders begin with blank thermal paper. The scale grids and other chart features are preprogrammed to be generated by these units, allowing for a variety of chart formats (see Fig. 8).

13.5 *Errors in Measurement:*

13.5.1 Factors that lead to error in depth measurement are numerous and should be recognized when conducting a bathymetric survey or analyzing graphic depth recordings. For a detailed description of these errors, see Ref (**2**). The most significant factors are described in 13.5.2 – 13.5.9.

13.5.2 *Velocity of Sound Wave Propagation*—The velocity of a sound wave traveling through water varies with temperature and density. It is, therefore, necessary to check the effective velocity of sound in a given body of water to achieve the depth accuracy required. In a deep reservoir, temperatures may vary as much as 45°F (25°C) between the surface and the bottom. In an estuary, salinity may also vary in both the vertical and horizontal direction, thus causing density to vary. Calibration of the sounding instrument should be made by the survey crew, at appropriate times to adjust the depth readings for changes in water temperature and density (see 13.6).

13.5.3 *Signal Transit Time*—Water depth is determined by the time required for a signal to travel from the transducer, strike a reflective surface, and return to the transducer. With the high quality instruments currently available, errors in time measurement are insignificant (**7**).

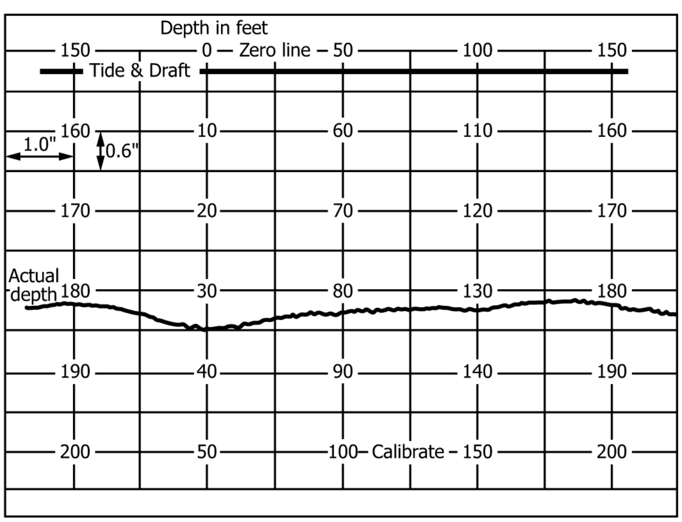


FIG. 7 Analog Bottom Profile Charted with Stylus

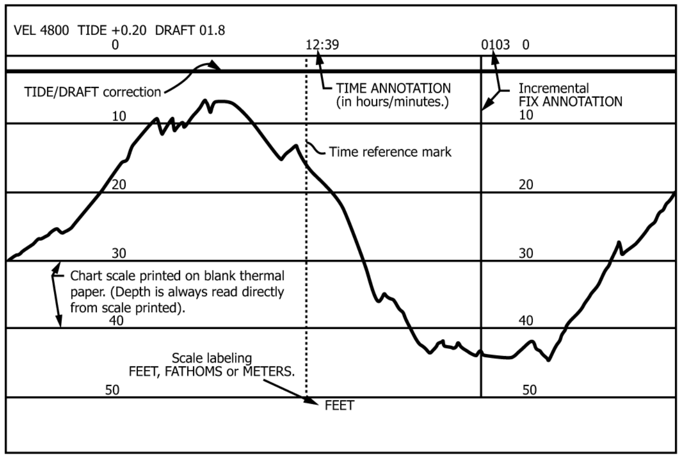


FIG. 8 Analog Bottom Profile Charted by Thermal Printer

13.5.4 *Transducer Location*—The draft or vertical location of the transducer with respect to water surface can be set into most high precision echo sounders. The vertical location, when set for static conditions, will change with the motion of the boat. The effect of boat motion on draft, may be corrected during calibration of the instrument.

13.5.5 *Wave Action*—The vertical and rotational motion of a boat due to wave action can result in severe fluctuations in the bottom trace. Some smoothing of the trace may be necessary during data processing to eliminate the fluctuations. The motion effects, described as survey vessel roll, pitch, yaw, and heave, were once difficult errors to correct in hydrographic surveying. Measurements from accurate, compact, and relatively inexpensive motion compensation instruments have significantly reduced these errors (**7**).

13.5.6 *Bottom Conditions*—The condition of the reflective surface of a reservoir or river bottom may vary widely, resulting in a sounding chart that gives an erroneous impression of the actual bottom profile. Vegetation attached to or suspended above the bottom, isolated boulders, or submerged man-made objects, may produce a nonrepresentative bottom profile. Depending on the purpose of the survey, the cause of these bottom reflections may have to be determined by other means before choosing to eliminate them from the trace.

13.5.7 *Nature of Bottom Sediments*—Very low density sediment, suspended as a nepheloid layer or zone above more compacted sediments, can result in an erroneous depth reading when a transducer with a frequency higher than 50 kHz is used. A waterway bottom may be described in nautical terms as any water/solid interface level that blocks or impedes the passage of ships, boats, or barges. A low or medium-frequency transducer may be used to determine depth to the more consolidated sediment layer.

13.5.8 *Tidal Effects*—When surveying in tidal zones of rivers and estuaries, a continuous record must be kept of tidal fluctuations within the area during the surveys in order to adjust the depth readings for the changing water surface. The measured depths are generally referred to a reference level, such as mean sea level. By exercising good technique in determining tidal changes and making tidal corrections, the errors in measuring bottom elevations can be significantly reduced.

13.5.9 *Other Causes*—Errors may occur due to special conditions during a survey that may be either unknown or overlooked by the survey crew. Examples of these conditions are as follows: a reservoir water surface elevation may fluctuate appreciably due to inflow or outflow, thus changing the conditions for vertical control during the survey; when downstream flow occurs in narrow canyon areas or in river portions of a reservoir, a water surface slope may extend in the upstream direction and produce error when a constant reservoir water surface elevation is assumed for vertical control; a constant wind blowing from one side of a water body to another may raise the water surface on the downwind side of the water body and introduce error should a specific water surface elevation be assumed for vertical control (**8**). Real time kinematic global positioning systems (RTK GPS) can provide 2 to 5 centimetre accuracies both horizontally and vertically for the receiver on the moving survey vessel. The proper use of RTK GPS technology can monitor and minimize the errors from tidal and other vertical effects (**7**).

13.6 *Calibration:*

13.6.1 Depth measurements by an echo sounder require a number of corrections. The largest correction results from the variability of sound velocity in water. The velocity varies with the temperature, salinity, and depth of water. In fresh water at 60°F, echo