TECHNICAL REPORT

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Measurement of liquid flow in open channels — Equipment for the measurement of discharge under ice conditions

Mesure de débit des liquides dans les canaux découverts — Équipement pour le mesurage du débit en présence de glace

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 11328, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 113, *Hydrometric determinations*, Subcommittee SC 5, *Flow measuring instruments and equipment*.

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Measurement of liquid flow in open channels — Equipment for the measurement of discharge under ice conditions

1 Scope

This Technical Report deals with equipment used to measure water discharge in rivers and channels under ice conditions. It does not specify techniques for measurement and computation which are dealt with in various International Standards. ISO 9196 specifically deals with the methods for the measurement of flow under ice and this Technical Report is intended to be used with ISO 9196.

The most common technique for determining flow under ice conditions uses a modified form of the velocity-area method. This Technical Report concentrates on the specialized equipment required for gaining access through the ice sheet and obtaining area, velocity, and other information for determining the rate of flow under ice.

2 References

ISO 748:1979, Liquid flow measurement in open channels - Velocity area methods.

ISO 772:1988, Liquid flow measurement in open channels - Vocabulary and symbols.

ISO 1100/1:1981, Liquid flow measurement in open channels - Part 1: Establishment and operation of a gauging station.

ISO 1100/2:1982, Liquid flow measurement in open channels - Part 2: Determination of the stage-discharge relation.

ISO 2537:1988, Liquid flow measurement in open channels - Cup-type and propeller-type current meters.

ISO 3454:1983, Liquid flow measurement in open channels – Direct depth sounding and suspension equipment.

ISO 3455:1976, Liquid flow measurement in open channels - Calibration of rotating-element current-meters in straight open tanks.

ISO 9196:1992, Liquid flow measurement in open channels - Liquid flow measurements under ice conditions.

ISO 9555-1: —[1], Measurement of liquid flow in open channels - Tracer dilution methods for the measurement of steady flow - Part 1: General.

ISO 9555-2:1992, Measurement of liquid flow in open channels - Tracer dilution methods for the measurement of steady flow - Part 2: Radioactive tracers.

ISO 9555-3:1992, Measurement of liquid flow in open channels - Tracer dilution methods for the measurement of steady flow - Part 3: Chemical tracers.

ISO 9555-4:1992, Measurement of liquid flow in open channels - Tracer dilution methods for the measurement of steady flow - Part 4: Fluorescent tracers.

3 Definitions

For the purposes of this Technical Report, the definitions given in ISO 772 and the following definitions apply.

3.1 **anchor ice:** An accumulation of spongy or slush ice adhering to the bottom of a stream.

3.2 **frazil ice:** Fine spicules or plates of ice suspended in water that are formed by supercooling of turbulent water.

3.3 **slush ice:** A mass of loosely packed anchor ice that has released from the bottom, or frazil ice that floats or accumulates under an ice cover.

3.4 **surface ice:** An ice sheet formed on the surface of a lake or river--also known as ice cover or ice sheet.

4 Equipment

4.1 Equipment for the velocity-area method

4.1.1 Ice cutting equipment

Winter field conditions require specialized equipment to cut holes through the ice to gain access for depth and velocity observations.

[1] To be published.

4.1.1.1 Ice Chisels

A variety of ice chisels have been developed for manually cutting holes through the ice for making current-meter measurements, removing ice from around gage plates, removing small amounts of shore ice during the early stages of freezeup or from weirs and flumes. They are also used to test the safety of ice. Chisels are made in lengths of approximately 1,2 to 1,6 meters, with blade widths of 70 to 100 mm. A chisel weighing 5 to 6 kg is recommended. Chisels can be either all metal or have a metal cutting blade with a wooden handle. The blade should be approximately 75 mm wide and be formed with a flat single tapered edge. A "D"-shaped handle is recommended as it keeps the device from slipping through the operator's hands. The chisel cutting edge should be kept sharp at all times.

4.1.1.2 Manual ice drills

A variety of hand-powered ice drills are available for drilling holes through the ice to measure depths and obtain velocity readings. Sizes from about 125 to 200 mm are recommended. Hand-powered ice drills tend to become dull very quickly when used in ice with high sediment content.

4.1.1.3 Power ice drills

A variety of gasoline-powered ice drills are commercially available that are suitable for drilling holes through ice cover for measurement of streamflow. Most use 2-cycle air-cooled engines of 1 800 to 3 000 watts. A gearbox and centrifugal clutch should be attached to the engine so that the cutter will turn only when the engine is accelerated. It is recommended that the engine, gear train, clutch, gas tank, handles, and controls be packaged as a unit, referred to as the "powerpack" or "powerhead," so that the powerhead can be easily removed from the auger or drill.

The drill should usually be a flighted rod or tube with a cutter of various configurations on the cutting end of the assembly. A drill length of 0,75 m is recommended. Diameters of these assemblies are usually 150 to 200 mm, but may be as large as 300 mm. Replaceable cutting teeth are recommended as teeth can be easily damaged during most field use.

4.1.2 Current meters

Cup-type and propeller-type current meters are described in ISO 2537. These types of current meters are frequently used for measurement of velocity under ice cover. Operation during periods of slush ice may cause the rotating elements to become clogged, thereby giving inaccurate readings.

An open-vane meter has been adapted from the cup-type meter for winter work. The larger space between rotator parts was designed to let slush ice pass through easier. However, the meter performs poorly at low velocities and is not recommended for velocities below 0,15 m/s and use of this type meter is generally discouraged.

All rotating element meters are subject to freezing when moved from one ice hole to the next. Therefore, it is important to move rapidly and in extreme cases, heat the meter with direct heat or pour hot water over the meter before lowering it into the next hole. In less extreme cases of meter freeze-up, and in cases where the water is flowing rapidly, the action of the water and slightly above freezing water temperature will release the ice. In cases of extremely cold air temperatures, heated metering sleds can be used to keep the meter from freezing between holes. The user should ascertain that the meter is operating freely before starting a velocity observation.

4.1.3 Depth-measuring equipment

A variety of rod and cable devices are used to obtain the total depth of water and thickness of ice, which is necessary to compute the effective depth of moving water as well as for holding the current meter in the proper location to obtain velocity observations.

4.1.3.1 Rods

A variety of wading rods are available for measuring depth and holding current meters. They can range in diameter from 12,5 to 25 mm. The rod may be a fixed length, usually 1,0 m, or may be assembled by adding multiples of short sections, usually 1,0 to 3,0 m long, together. Rods may be the same type as are used for open-water measurements, may be specially designed for use under ice, or may be modifications of open-water devices. It is recommended that rods be fitted with an "ice-foot" which is a device to protect the meter and assist in determining the depth of the underside of the ice sheet.

The maximum length of rod that can be used depends primarily on the velocity of the water, but also on the diameter and material of the rod. Practical considerations will limit the length and weight of the rod that can be used. Rods shall be marked to measure depth of water in meters. The smallest unit of marking shall be 10 mm.

4.1.3.2 Cable suspension equipment (reel)

Cable suspension equipment consists of a sounding reel wound with special cable that can transmit electrical signals from the current meter. This equipment is identical to that used for open-water measurements.

The sounding reel, when used for measurements from ice cover, can be mounted on a variety of support devices including reel stands and sleds. In extremely cold areas, enclosed sleds may contain meter heating accessories. There is no standardized configuration for this equipment.

4.1.3.3 Cable suspension equipment (handlines)

Cable suspension by handheld methods can be used for measurement of flow under ice cover. The configuration and use is similar to that in open-water conditions.

4.1.3.4 Cable suspension equipment (sounding weights)

Standard sounding weights can be used for measurement of flow under ice, however, the physical size of the equipment requires either the chopping of a hole large enough to accommodate the weight, or drilling two holes with a power drill and removing the ice between them. A variety of specialized weights having sizes capable of passing through a 200 mm diameter ice hole can be used. These weights have less streamlining because of their short lengths and subsequently do not perform as well in high velocities as conventionally shaped weights. They weigh in the range of 8 to 16 kg.

A variety of folding hanger-bar adaptations can be used to allow conventional sounding weight/meter assemblies to pass through 200 mm diameter ice holes. These offer the advantage of greater stability and add to the accuracy of resulting discharge measurements. Each configuration of sounding weight and meter should be individually rated before being used in the field.