Comparator Installation to Calibrate Current Meters

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Abstract

In situ calibration of hydrometeorological instruments is very important for large countries like Russia where there are 24 regional branches of the Russian Federal Services for Hydrometeorology and Environmental Monitoring (Roshydromet). Verification and calibration of current meters can be performed by the traditional method in a large current-meter-rating tank and by checking them against a standard meter in a measuring flume. The current meters are of the same type as the working ones but are individually selected and verified against a standard meter.

The State Hydrological Institute (SHI) has developed and since 2007 has produced a comparator installation to calibrate current meters that includes a 1.7-m long measuring flume. This installation allows calibration of propeller-type current meters with all types of horizontal rotation axes. This installation can also be used to calibrate measuring instruments of different types (including electromagnetic and acoustic current meters) to measure water flow velocities at a given point.

These installations are being used in many subjects of the Russian Federation to avoid the expense of transporting working current meters to calibration centers.

When operating, the installation creates a climbing flow with possible velocity change in the closed flume where the calibration of a current meter is being performed. The created water flow velocities are in the range of 0.01 to 3.0 m/s and the calibration process is fully automated. Installations can be accommodated in small areas.

Introduction

The metrology provision of water flow velocity meters (as a component of measuring instruments for hydrological characteristics) is regulated by the state standard specification GOST 8.486-83 “State special standard and state calibration scheme for water flow velocity meters in the range of 0.005 to 25 m/s”. In addition, there is the Roshydromet regulating document RD 52.08.272-89 “Methodological instructions. Departmental calibration scheme for water flow velocity meters” that make it possible to transmit a velocity measurement unit from standard meters to working prototype standard meters that are used by metrology services at the local administrations for hydrometeorological services (UGMS).

At Roshydromet, a working standard flow-velocity meter is a large current-meter-rating tank or a prototype standard current meter that along with a measuring flume compose a calibration system (comparator).

In regions remote from the base metrology institution (SHI), the UGMS metrology services provide current meter calibration. At the present time, UGMS use large current-meter-rating tanks and measuring flumes GR-19 and GR-19M produced in the 1960-70s to calibrate current meters. These flumes are worn out and obsolete. There is an urgent need to replace them with modern ones.

The use of calibration systems based on measuring flumes is a time-and-finance consuming procedure because of transporting working current meters to the centers equipped with large current-meter-rating tanks.

The metrology provision of current velocity meters includes the procedure of current meter verification, i.e., the determination of their individual functions of transformation and errors. This verification is being carried out once every two years.

The State Hydrological Institute developed a new automated system for current meter calibration: a comparator installation for current meter calibration (UKPGV). This installation makes it possible to calibrate and verify the current meters by using the comparison method, i.e., to check them against a standard meter of the same type that are those to be calibrated.

Within the framework of the project "Upgrading and re-equipment of Roshydromet institutions and organizations" 12 regional administrations for hydrometeorology and environmental monitoring (UGMS) have received and have been using the new measuring flumes UKPGV. These flumes are designed for primary and periodic calibration of propeller-type current meters.

Description and principle of work

The comparator-measuring flume works on the principle of creating different flow velocities at a working segment in the range of 0 to 3 m/s and consequently measuring these velocities first with standard and then working current meters. The standard meter is used to transmit a water flow velocity unit by the comparison method.

The comparator installation for calibrating current meters (UKPGV) includes a measuring flume, electric motor, variable speed drive, personal computer, system integration block, software, and standard current meters.

A measuring flume is designed to give the necessary current velocities and to accommodate standard and working current meters. The measuring flume is a closed rectangular pipeline with water flow circulating on a horizontal plane due to rotation of a working propeller (Fig. 1). The measuring flume body is made of stainless steel. The pipeline has two horizontal straight segments: on the first one, a hydrodynamic head is being created. Standard and calibrated meters are placed on the second segment. The flume geometry is made so that a flow with highly stable current having only minor turbulent fluctuations can be created on the measuring segment.

Figure 1. Measuring flume UKPGV.

Working propeller is rotated by an asynchronous electric motor.

A variable speed drive is used to regulate revolutions of the asynchronous motor in order to change the water flow velocity in the device. The frequency transformer of ATV31HU22M2 type is used in the installation to change the water flow velocity within a wide range.

The system integration block (BSU) is designed to interface the standard and calibrated meters with PC and to take control over the variable speed drive. The system integration block has four inlets, therefore simultaneously two meters, the standard and calibrated, can be hooked up. There are separate inlets to hook up the meters with contacts to occur every one and twenty revolutions. Connection to the computer is performed via the consecutive interface of the RS-232 standard (an adapter for USB interface is also available).

Special software (program “Poverka” - calibration) serves for automation of the meter calibration process and performs the following functions:

a) Setup and support of the water flow velocity within the velocity range of 0.01 to 3 m/s at 15 measuring points;
b) Real-time collection and primary processing of measurement information from the standard and calibrated meters simultaneously for two measuring channels;
c) Processing of measurement results and their analysis, printing output documentation of calibration results, and archiving calibration data.

The software has the following basic functional modules:

- module of input adjustments – gives primary information about standard and calibrated meters, determines the calibration method, tunes the software to work with the available output interfaces;
- control module – provides setup and support of the water flow velocity at 15 measuring points;
- module of automated input of measurement data on the standard and calibrated meters – calculates the flow velocity in the flume by the coefficients of the individual function of standard meter transformation and calculates the frequency of calibrated meter rotation. These data then come to the processing module.
- module of statistic processing – accumulates the data and performs their further processing with the results sent to the report formation module;
- module of the report formation and viewing – is the terminating component of the scheme that forms output documentation and manages the databases of standard and calibrated meters.

The system integration block analyzes the impulse incoming from meters and registers possible contact skips. Operator receives information about the possible meter impulse skips and makes a decision to either continue the calibration or to repair the meter.

The installation is equipped with standard meters that require calibration for every individual user.

Measurements are performed in fully automated mode and the calibration results are printed on standard forms.

Tests

Every installation UKPGV is being certified to experimentally determine its normalized precision characteristics and serviceability. When being certified, the created flow velocity range, flow velocity support and replication errors, and the comparison error are determined..

Twelve UKPGV installations have been tested with the use of current meters of GR-21M type.

The minimum flow velocity created on the flume working segment has been found to be below 0.01 m/s, which means that calibration can be performed for current meters of all types. The maximum flow velocity of up to 3 m/s can be created in the flume.

The support error characterizes the degree of flow stability in the flume. It is determined by consecutive measurements of flow velocities at a given velocity point. The range of root-mean-square deviations of the measured flow velocities from the average value is depicted in Table 1.

Table 1. Flume tests.

Flow velocity in flume, m/s	Support error, %	Replication error, %	Comparison error, %
0,06	1,1-7,5	1,4-5,4	2,8-6,4
0,5	1,3-3,3	1,0-2,7	1,0-4,1
3,0	0,7-2,1	0,8-2,5	1,1-2,8

All flumes have passed the tests. Errors are in permissible limits for the given measurement type.

Application

In Russia at the present time, the installation UPKGV with standard meters is used at 12 UGMS to calibrate current meters of GR-21M, GR-55, GR-99, IST-1, ISP-1, and ISVP types.

Reliability and protection against corrosion provide a long period of structure exploitation. Automation of calibration and certificate output increases considerably the extent of accuracy and measurement quality, which makes it possible to avoid potential sources of subjective errors, related to human factor. With its multiple functionality, the device is simple enough in use and does not require high qualification of the personnel and the calibrator.

The use of UKPGV diminishes time and expenses for calibration procedures, as well as increases the reliability of flow velocity and therefore water discharge measurements in case the hydrological stations are timely provided with calibrated working instruments to measure the basic hydrological element.

This calibration method is most important for regions remote from the base metrology centers equipped with large current-meter-rating tanks. This is of importance not only for Russia. National hydrometeorological services of other countries are also interested in this method because they do not have their own large current-meter-rating tanks.