# Foreword

According to the requirements of Document JIANBIAO [2006] No.77 issued by the Ministry of Construction(MOC)—"Notice on Printing and Distributing 'the Development and Revision Plan of National Engineering Construction Standards in 2006'", this code is formulated by Bureau of Hydrology of the Ministry of Water Resources of the People's Republic of China (Water Resources Information Center, Ministry of Water Resources) and other related institutes through revision of its previous edition, GB 50179-93 *Code for Liquid Flow Measurement in Open Channels* issued in 1993.

In preparing this code, the development team carried out extensive investigations, summarized the relevant engineering practices about discharge measurement, absorbed advanced achievements in domestic hydrological testing demand analysis, testing methods and technological innovation, etc., requested and consolidated comments from involved organizations, reviewed and finalized this code.

This code consists of 6 chapters and 5 appendixes, covering: general provisions, selection of measuring reach and setting-up of cross-section, cross-section measurement, stage gradation and means and methods of discharge measurement, check and analysis of discharge measurement results, assessment of discharge measurement accuracy, etc.

The main contents of this revision are:

—Integration of the stage gradation and the discharge measurement under the conditions of high flood, low flow, dry flow, icing, tidal current, etc. into the chapter of "Stage Gradation and Means and Methods of Discharge Measurement", supplement of current commonly used means and methods of discharge measurement and applicable conditions.

—Modification and supplement of the classification standard of hydrometric station accuracy, the comprehensive index of the permissible error of a single discharge measurement and the selection table of the discharge measurement scheme of current meter method.

—Integration of partial contents of the appendixes of the previous version.

The provisions printed in bold type are mandatory ones and must be implemented strictly.

The Ministry of Housing and Urban-Rural Development of the People's Republic of China is in charge of administration of this code and explanation of its mandatory provisions, the Ministry of Water Resources of the People's Republic of China is responsible for its routine management, and Bureau of Hydrology of the Ministry of Water Resources of the People's Republic of China (Water Resources Information Center, Ministry of Water Resources) is in charge of explanation of specific technical contents. During implementation of this code, any comments and advices can be posted or passed on to Bureau of Hydrology of the Ministry of Water Resources of the People's Republic of China (Address: No.2, 2nd lane Baiguang Road, Xicheng District, Beijing, Postcode: 100053) for reference in the future revision.

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# Contents

# 1 General provisions

**1.0.1** This code is formulated to standardize the techniques of discharge measurement methods, and analysis and calculation of rivers, and ensure the quality of discharge measurement.

**1.0.2** This code is applicable to the discharge measurement of natural rivers, lakes, reservoirs, artificial open channels, and reaches affected by tides and hydraulic projects.

**1.0.3** According to the accuracy grade and requirements of discharge measurement, benchmark hydrometric stations may be classified as Class Ⅰ, Class Ⅱ and Class Ⅲ. The classification method shall meet the requirements of Appendix A of this code.

**1.0.4** If new discharge measurement technology is applied, discharge measurement methods recommended in this code shall be used for comparative gauging, and the accuracy of results evaluated. The discharge measurement results of the multi-vertical and multi-point current meter method may be used as the criteria for the calibration or check of other discharge measurement methods.

**1.0.5** The accuracy of various items specified in this code may be used for the quality control and evaluation of discharge measurement scheme. Basin or provincial institutions of hydrology shall select representative stations for the collection and accumulation of measurement data for a long term and accuracy check.

**1.0.6** In addition to the requirements of this code, discharge measurement in rivers shall also comply with those specified in the relevant current national standards.

# 2 Selection of measuring reach and setting-up of cross-section

## 2.1 Selection and survey of measuring reach

**2.1.1** A measuring reach shall fulfill the purpose of setting-up a hydrometric station, ensure the accuracy of measurement data, meet the requirements of facilitating observation and the computation and processing of the data, and shall be in accordance with the following requirements:

**1** An upstream reach of stone beams, rapids, bends, constricted sections, artificial weirs, etc., where cross-section control is easily formed, should be selected as the measuring reach. The distance of the upstream reach of stone beams, rapids, bends and constricted sections to cross-section control should be 5 times the river width, and that of a mountain stream to cross-section control distance may be relaxed to 3 times the stream width. Or a reach, where the bottom slope, cross-section shape, roughness and other factors of channel are relatively stable and the channel is easily controlled by resistance along the channel, may be selected. There shall be no huge stone blocking water, huge vortex, or turbulence in a measuring reach.

**2** If cross-section control and channel control occur at different locations of a reach, a reach with cross-section control shall be selected as the measuring reach. Among several reaches with the same controlling characteristics, a narrow reach with a larger depth shall be selected as the measuring reach.

**3** If it is difficult for the measuring reach of small or medium-sized rivers to meet the requirements stipulated in Item 1 of this article, the requirements may be relaxed appropriately. But the application conditions of measuring methods shall be met.

**2.1.2 A location prone to landslide, collapse and debris flow must be avoided as a measuring reach.**

**2.1.3** A reach measured by the current meter method should be straight and stable, with concentrated flow and without diversion flow, oblique flow, backflow, stagnant water, etc. The length of a straight measuring reach should be greater than 5 times the main channel width during a flood. The impacts of variable backwater, large flood plain, rapid scouring and silting, etc. produced by the inflow of major tributaries or by large water bodies of lakes and reservoirs on the measuring reach should be avoided, and the measuring reach shall be in accordance with the following requirements:

**1** For rivers in plain areas, a measuring reach should be straight and regular. The width, depth and channel slope of the whole measuring reach shall have no obvious variation. The river bed of single channel should be free of water plants. If it is impossible to avoid wandering reach, shifting sand bar shall be avoided.

**2** For tidal rivers, a reach with narrow water surface, straight path of flood tide and ebb tide, good intervisibility, relatively simple cross-section, and less impact of winds and waves should be selected as the measuring reach.

**3** For reservoir and lake outlet station or weir station, a measuring reach should be selected downstream of structures, and the impacts of large flow fluctuations and abnormal turbulence avoided. If it is difficult to measure at downstream cross-section and there is a long straight reach upstream of structures, a measuring reach may be selected at the upstream.

**4** For frozen rivers, there should not have ice accumulation, ice jam or ice dam in a measuring reach. For the river reach with multi-layer ice structures intercalated with ice layers and water layers, a measuring reach shall be selected where investigation shows the freezing conditions are relatively simple. For special topographical and geographical conditions, an unfrozen reach should be selected as the measuring reach.

**5** For the measuring reach affected by hydraulic projects or human activities of a measuring reach for tour gauging cross-section, selection requirements may be appropriately relaxed according to the purpose or needs of setting up a hydrometric station and based on the principle of meeting measuring accuracy requirements.

**2.1.4** If other discharge measurement methods are used at a hydrometric station, a measuring reach shall be selected according to the following requirements:

**1** For the measuring reach with the float method, the length of straight reach shall be greater than 2 times the distance between the cross-sections of the upstream and downstream floats. The medium cross-section of floats shall be of representativeness, without large erosion ditches or backflows. There shall be good intervisibility and communication among cross-sections.

**2** For the measuring reach with the slope-area method, the length of straight reach shall satisfy the one required for the accuracy requirement of slope observation, the slope contour lines of both banks shall be nearly parallel, the transverse slope of water surface shall be small, and longitudinal slope shall be uniform without an obvious turning point. Sand bars, shoals, branching reaches and obviously diffused reaches shall be avoided.

**3** For the measuring reach with the acoustic Doppler current profiler method, a reach with large water depth, small side shoal, no influence of water traffic on discharge measurement, and no intensive impacts of river bed sediment movement (moving bed) should be selected under the condition of meeting the requirements stipulated in Article 2.1.3 of this code.

**4** For the measuring reach with the measuring structure method, the length of straight reach shall be greater than 5 times the maximum water surface width of approach channel, and steep and turbulent reaches shall be avoided. There shall be a smooth flow in approach channel section with regular channel cross-section and symmetrical and uniform flow velocity distribution in the cross-section, and no water blocking objects such as ripraps, soil piles, water plants, etc. in the river bed or along the banks. If a natural river channel fails to meet the above requirements, it shall be artificially regulated to meet the hydraulic conditions for discharge measurement by the measuring structure method.

**5** For the measuring reach with the dilution method, a reach with bends, narrow sections, shoals, submerged reefs and hydraulic drops and without water plants or stagnant water may be selected, and the inflow, diversion flow and bank overflow of tributaries shall be avoided. The length of measuring reach shall be such that tracer injected into water flow can be fully and uniformly diffused.

**6** For the measuring reach with other discharge measurement methods, it shall meet the applicable conditions of instrument performance and hydrologic data processing requirements.

**2.1.5** At the time of the location determination of measuring reach and the arrangement of cross-sections, the geological and geomorphic features, underlying surface, river characteristics, upstream and downstream projects and water resources development planning, etc. of the measuring reach shall be surveyed and investigated in detail, and the river regime shall also be investigated to understand the lengths of bends and straight sections of the river, the flood control ability of banks, and whether there is an overflow outlet. On the premise of fulfilling the purpose of setting up a hydrometric station, the site of the station should be close to urban residential area, with consideration of the conditions of transportation, electricity, communication, etc.

**2.1.6** The survey of river characteristics shall mainly cover the following:

**1** To investigate the position of control cross-section and identify the stability extent of cross-section control or channel control.

**2** To investigate whether diversion flows, erosion ditches, backflows, stagnant waters and the width of side shoals are in favor of measuring facilities arrangement. A number of channel cross-sections are set up in the preliminarily selected measuring reach, and the velocity distribution of one cross-section is mapped.

**3** To understand river bed composition, cross-section shape, scouring and silting changes, the history of sand bars and river channel changes, as well as main flow, flow velocity, flow direction and their changes at all stages, and investigate the distribution of rocks, gravels, pebbles, boulders, sand, loam, clay, silt, etc. on the river bed of measuring reach.

**4** To understand the growing season and range of water plants, the time of freezing-up and drifting ice, the location of ice dams and ice jams, and the height of backwater.

**2.1.7** The measuring reach of a non-tidal current station should be selected outside the range of variable backwater, and the distance and probability of downstream variable backwater shall be identified according to the following requirements:

**1** If there are hydraulic structures at the downstream of measuring reach, the backwater calculation data at the design highest flood stage of the hydraulic structures at the nearest downstream location shall be used to identify whether the measuring reach is affected, and to estimate the distance of backwater.

**2** If there are inflow rivers or lakes within a certain distance downstream of measuring reach, the probability of backwater occurrence and limit distance shall be estimated.

**2.1.8** At the time of measurement scheme and equipment selection, the speed of flood rise and fall, the highest and lowest stage in history and the maximum flood plain boundary shall be understood, the maximum and minimum discharge shall be estimated roughly, and the source of flood and the causes of soil and water losses and debris flow shall be surveyed.

**2.1.9** The survey of the physical and geographical of a basin shall include the following:

**1** To investigate ground features and landforms, understand the closure of a watershed, and check whether there is external water inflow and internal water outflow.

**2** To investigate soil distribution and vegetation conditions, and understand soil and water losses and upstream sediment production.

**3** To understand geological and hydrogeological conditions, with focus on the development and distribution of karsts in limestone areas.

**2.1.10** The survey of construction projects measures, plane coordinates and control conditions in a basin shall include the following:

**1** The current situation of the scale and quantity of water storage and diversion projects and their short-term and long-term planning.

**2** The types of measures of irrigation, drainage, rural water supply and soil and water conservation and their possible impacts on sediment induced by flood.

**3** Waterway navigation and timber rafting season, and mode of rafting operation.

**4** The coordinate position, elevation and grade of elevation control points and plane control points near a proposed hydrometric station.

**2.1.11** The preparation of survey report shall include the following:

**1** The purpose, tasks, time and scope of the survey, and the professional category and technical level of main staffs.

**2** Sorting out various survey data and summarizing them into concise results by classification.

**3** The recommendation of selected measuring reach for survey, the elaboration of analysis opinions, and proposals on the arrangement of hydrological measuring items and methods, basic facilities, etc.

## 2.2 Layout of measuring cross-section

**2.2.1** Basic staff gauge cross-section and corresponding discharge gauging cross-section may be set up as appropriately according to the discharge measurement methods of a hydrometric station.

**2.2.2** The layout of a basic staff gauge cross-section shall be in accordance with the following requirements:

**1** There is smooth flow with no transverse slope of water surface or small transverse slope of water surface, and no vortex, backflow or stagnant water, etc. at the cross-section. Topographic conditions are favorable for manual observation and the installation of stage auto-recorders and other instruments.

**2** The cross-section should be perpendicular to the mean flow direction at the cross-section and may be located in the middle of a measuring reach and coincide with or approach the gauging cross-section. If the basic staff gauge cross-section does not coincide with the gauging cross-section, the stages of the two cross-sections shall be of a stable correlation.

**3** Once the position of the basic staff gauge cross-section is determined, it should not be changed. If the position of the cross-section has to be relocated in the event of unforeseen special situations, the stages of the current and previous cross-sections shall be comparatively gauged, and the stage variation of comparative gauging shall reach more than 75% of mean annual range of stage.

**4** If there is a fixed diversion flow in a reach, and the diversion discharge exceeds 20% of the total discharge of the cross-section, and there is no stable correlation between the diversion discharge and total discharge, staff gauge cross-sections shall be set up additionally.

**2.2.3** The layout of current meter gauging cross-section shall be in accordance with the following requirements:

**1** The cross-section should be selected at the middle of a river reach with straight banks, approximately parallel contour lines and concentrated flow. If discharge measurement by the float method or slope-area method is required, the float gauging cross-section, cross-section for slope observation and gauging cross-section may be overlapped and arranged for concerted operation. If the physical conditions of a measuring reach allow, the gauging cross-section, the medium cross-section of floats and the basic staff gauge cross-section should coincide with each other.

**2** Flow velocity and direction are measured according to high, medium and low stages, respectively. The measurement method of flow direction shall comply with the requirements stipulated in Section B.10 of this code. The gauging cross-section should be perpendicular to the mean flow direction of the cross-section, and deflection angle shall not exceed 10°. If the deflection angle exceeds 10° due to the constraint of physical conditions, gauging cross-sections shall be arranged according to the flow direction in different periods, and there shall be no inflow or outflow between gauging cross-sections in different periods.

**3** If there are diversion flows and erosion ditches in a river in the low-flow period and the diversion flow directions are quite different from that of the main stream, gauging cross-sections perpendicular to different flow directions should be arranged respectively.

**4** The current meter gauging cross-section on the upstream or downstream of hydraulic projects such as reservoirs, weir gates, etc. shall be laid out to avoid the influence of abnormal turbulence of flow.

**5** For the various types of hydrometric stations affected by tides, gauging cross-sections may be arranged in accordance with the requirements stipulated in Items 1 to 4 of this article.

**2.2.4** In addition to Article 2.2.3 of this code, the layout of float gauging cross-section shall be in accordance with the following requirements:

**1** The middle cross-section for the float method should coincide with the current meter gauging cross-section and basic staff gauge cross-section. They may be set up separately if it is constrained by topographic conditions, but there shall not have inflow or outflow between the middle cross-section of the float method and current meter gauging cross-section.

**2** The upstream and downstream cross-sections of the float method shall be parallel to the middle cross-section of the float method with equal spacing, and the change of river topography in between shall be small. The distance between the upstream and downstream cross-sections of the float method shall be greater than 50 times the maximum mean flow velocity at a cross-section. If restricted by topographic conditions, it may be shortened appropriately, but shall not be less than 20 times the maximum mean flow velocity at a cross-section.

**3** If the mean flow velocities at a cross-section at medium and high stages differ greatly, the upstream and downstream cross-sections of the float method may be set up separately according to different stages.

**2.2.5** There should be no obvious transverse slope at the gauging cross-section of the slope-area method, and the following shall be complied with:

**1** The up-section, mid-section and down-section are arranged in a reach for water surface slope observation. The spacing between the up-section and mid-section shall be equal to that between the mid-section and down-section. The mid-section of the slope should coincide with the current meter gauging cross-section or the mid-section of the float method.

**2** The spacing between up-section and down-section for slope observation shall make water surface fall much larger than fall observation error.

**2.2.6** The layout of gauging cross-section by other methods shall meet the applicable conditions for instrument performance and the requirements for hydrologic data processing.

**2.2.7** Base line layout shall be in accordance with the following requirements:

**1** If the distance from initial point is measured by theodolite, electronic total station, distance gauge or the intersection method of flat panel meter, base line should be perpendicular to gauging cross-section, and the starting point of the base line shall be set on the cross-section. If restrained by topographic conditions, the base line may not be required to be perpendicular to the cross-section. The base line length shall be such that the angle between the farthest point of the view line of the instrument and a cross-section vertical is greater than 30°, and no less than 15° in special cases. Corresponding base lines at high and low stages may be set up on the shore and the beach respectively for stations with the large wide variation of water surface width at different stages.

**2** If the distance from initial point is measured by the method of sextant intersection at a hydrometric station, the base line layout shall make the angle between the two view lines of sextant greater than or equal to 30° and less than or equal to 120°. The distance from the two ends of the base line to the nearshore water edge should be greater than 7 times the height difference between the intersection sign and dry stage. If one base line cannot meet the above requirements, the intersection base lines of high and low stages may be set up respectively.

**3** The base line length should be an integral multiple of 10m. The discrepancy value of round-trip measurement results with a steel ruler or other calibrated gauges shall not exceed 1/1 000.

**2.2.8** The layout of elevation base point shall be in accordance with the following requirements:

**1** The distance from initial point may be measured by the polar coordinate intersection method if there is a tall and sturdy building on the cross-section. Elevation base point shall be set up on the cross-section, and its height shall be such that the depression angle of instrument to the farthest point of sight is no less than 4°, or no less than 2° in special cases. If restricted by physical conditions such as topography and others, elevation base point may be set up near the upstream or downstream of the cross-section.

**2** The elevation base point shall be set up on a solid rock or stake, and its elevation shall be determined by the fourth-grade-leveling. If the difference between the elevation of the base point and the highest flood stage is less than 5m, the third-grade-leveling shall be used to measure the elevation.

**2.2.9** After the positions of base line and cross-section are determined, measuring signs such as base line stake, cross-section stake and cross-section sign stake need to be laid out, which shall be set according to the follow requirements:

**1** Base line stakes should be set up at the start and end of the base line, and the base line stake at the start point may be used as cross-section stake. The base line stakes of high stage shall be set up above the highest flood stage over the years.

**2** Permanent cross-section stakes shall be set up on the banks of various water staff gauge cross-section and gauging cross-section, respectively. The cross-section stakes of high stage shall be located at 0.5m to 1.0m above the highest flood stage over the years. For rivers far from flood plains, they may be located outside the flood boundary. For rivers with levees, they may be located on the ground of the back sides of the rivers.

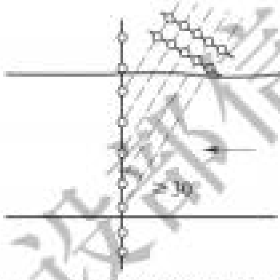
**3** Solid and eye-catching cross-section signs shall be set up on banks of the gauging cross-sections laid out for various discharge measurement methods. If a river surface is narrow, two cross-section sign stakes may be set up on the same bank, the spacing between the two stakes shall be 5%-10% of the distance from the nearshore sign stakes to the farthest measuring point, and shall not be less than 5m. If cableways, bridges and other structures at hydrometric stations are used, gauging cross-section sign stakes may not be set up.

**4** If a river surface is particularly wide and positioned with a sextant, an eye-catching base line sign should be set up on banks.

**2.2.10** Temporary cross-sections positioned by satellite positioning system may not be marked with cross-section signs.

**2.2.11** Hydrological protection signs shall be set up for a hydrometric reach. Safety signs shall be set up on navigable river channels as required and shall comply with the relevant requirements of waterways or maritime administration departments.

**2.2.12** For a river with large flood plain area, a sign rod may be set up at the fixed vertical of the flood plain, and its top shall be higher than the highest flood stage over the years. For a hydrometric station where the positions of flow velocity-measuring and sounding verticals are fixed by the radiation or directional line method, fixed signs set up ashore shall make the angle between each radiation line or directional line and gauging cross-section no less than 30°, and the distance between the front and rear signs in the same line of sight shall not be less than 5% to 10% of the distance from the nearshore sign to the fixed flow velocity-measuring and sounding verticals and shall not be less than 5m (Figure 2.2.12).




(a) Directional line method


(b) Radiation line method

Figure 2.2.12 Radiation and directional lines

**2.2.13** For each type of hydrometric stations, station identification shall be carried out at the beginning of its construction, and a record sheet of a hydrometric station identification formulated, which shall be comprehensively revised in the year ending with 0 and 5. In case of any change, the changed part shall be supplemented and revised in the same year. For a station with more changes, the sheet shall be revised in a comprehensive way. Basin or provincial institutions of hydrology shall adopt the uniform format of the sheet. The sheet shall include the following:

**1** Station location.

**2** Station purpose.

**3** Station evolution.

**4** General situation and physical geography of river basin.

**5** Layout and variation of basic staff gauge cross-section, slope measuring staff gauge cross-section and gauging cross-section, etc.

**6** Elevation and its change of datum, reference benchmark, basic benchmark, check benchmark and staff gauge zero, and description of benchmarks.

**7** Measuring facilities and equipment and their changes.

**8** Observation items and their changes.

**9** Measurement time interval of hydrological elements such as stage and discharge and maximum and minimum characteristic values of stage and discharge over the years.

**10** Investigation of rainstorm and flood in a region.

**11** River situation and station location map of a measuring reach and its adjacent area, topographic map of hydrometric station, possible maximum cross-section map, layout map of measuring facilities, basic situation table and distribution map of main hydraulic projects in a certain range of the upstream and downstream of hydrometric station.

# 3 Cross-section measurement

## 3.1 Possible maximum cross-section measurement

**3.1.1** The basic staff gauge cross-section and gauging cross-section of a new hydrometric station shall be measured with possible maximum cross-section.

**3.1.2** Possible maximum cross-section measurement shall include underwater and land cross-section measurements.

**3.1.3** For the measuring range of possible maximum cross-section, the land part shall be measured to 0.5m to 1.0m above the highest flood stage over the years. For a river far from flood plain, it may be measured to the maximum flood boundary. For a river with levee, it shall be measured to the ground of the back side of the river.

**3.1.4** For the hydrometric station with a stable river bed at gauging cross-section, the possible maximum cross-section shall be measured once a year before or after the flood season if the stage-area relation points deviate from the stage-area relation curve within the range from $-3\%$ to $+3\%$. For the station with an unstable river bed at gauging cross-section, the possible maximum cross-section shall be measured each year before and after the flood season, and the wetted cross-section measured in time after the flood.

**3.1.5** The cross-section stake at a high stage shall be taken as the zero starting point for the distance from initial point of the both possible maximum cross-section and channel cross-section. Distance from initial point and water depth shall be measured in accordance with Section B.8 of this code. The round-trip measurement discrepancy of the total distance between the stakes at the start and end of the cross-section on banks shall not exceed 1/500.

**3.1.6** The elevation measurement of the possible maximum cross-section on shore shall be carried out according to the accuracy requirement of the fourth-grade-leveling. If topography is complex, the measurement requirement may be lower than that of the fourth-grade-leveling. But the discrepancy of height difference between round-trip measurements shall be controlled in the range from $-30\sqrt{k}$mm to $+30\sqrt{k}$mm, the difference between front and rear visual distances shall not be greater than 5m, and the accumulated difference shall not be greater than 10m. When the possible maximum cross-section is repeatedly measured, one-way measurement may be closed at a fixed point of known elevation.

Note: $k$ is the mean kilometer of the measured route length calculated by the round-trip measurement or the left and right routes.

**3.1.7** The arrangement of the sounding verticals at possible maximum cross-section shall be in accordance with the following requirements:

**1** If a new hydrometric station is set up or a possible maximum cross-section is added, continuous depth detection along the river width shall be carried out in the period of stable stage. If the width of water surface is greater than 25m, the number of sounding verticals shall not be less than 50. If the width of water surface is no greater than 25m, sounding verticals may be laid out with a minimum spacing of 0.5m. The number of sounding verticals shall satisfy the requirement of understanding the shape of channel cross-sections.

**2** Sounding verticals should be evenly arranged and shall reflect the turning points of river bed change so as to avoid the major compensation or major cutting of each segment area of channel cross-section. The sounding verticals of the main channel shall be more intensified than that of the beach if there is an obvious beach of a river.

**3** The number of sounding verticals of a tidal river may be reduced as appropriate.

**3.1.8** At the beginning and ending of underwater cross-section measurement, stage shall be observed or extracted respectively.

### 3.2 Channel cross-section measurement

**3.2.1** The measurement of channel cross-section shall be in accordance with the following requirements:

**1** The sounding verticals of channel cross-section shall be arranged in accordance with the requirements given in Article 3.1.7 of this code and in conformity with flow velocity-measuring verticals. For a hydrometric station with unstable river bed, sounding verticals may be added properly in addition to flow velocity-measuring verticals.

**2** For new hydrometric station and station with unstable river bed, depth shall be measured simultaneously with each discharge measurement. If there are no significant scouring and silting variation in the cross-section of the hydrometric station with an obvious change regularity, depth may not be measured simultaneously with each discharge measurement. When special water regimes occur and it is difficult to measure depth during discharge measurement, channel cross-section may be measured at a favorable time before or after discharge measurement.

**3** A hydrometric station with stable river bed shall be overall sounded once a year before and after the flood season, and depth shall be additionally measured after each major flood in the flood season. The number of channel cross-section measurements may be reduced for a station with rocky river bed.

**4** In the icy period, the depth, ice surface boundary, ice thickness, immersed ice thickness and frazil slush thickness shall be measured at the same time of discharge measurement. If ice bottom is not flat, the distance from initial point of ice bottom edge shall be measured by the detection method. If ice bottom is flat, the location of the ice bottom may be found by using the bottom elevation profile of ice holes along bank.

**3.2.2** The methods of width measurement sounding of channel cross-section shall be determined according to river width, depth, equipment conditions and measuring accuracy requirements, and comply with the requirements stipulated in Section B.8 of this code. Uncertainty shall comply with the relevant requirements stipulated in Section B.12 of this code.

### 3.3 Error sources and control

**3.3.1** The error sources of cross-section measurement shall include the following:

**1** The following cases shall be considered as the sources of sounding error:

**1**) Large waves or the large water resistance of gauges affects the measurement.

**2**) Sounding position deviates from cross-section vertical.

**3**) The deflection angle of suspension cableways is large.

**4**) The marking of sounding rod or rope is not accurate.

**5**) A sounding rod or hammer is trapped in river bed.

6) The acoustic speed setting of the ultrasonic sounder is different from the actual acoustic speed.

7) The instruments and equipment for sounding are not checked and calibrated as required before measurement.

**2** The following cases shall be considered as the sources of measurement error of distance from initial point:

1) The accuracy of base line measurement or the length of base line does not meet the requirements.

2) The expansion and sag variation of cableways make measurement inaccurate.

3) When the theodolite intersection method is used, rear-view observation is inaccurate or instrument is displaced.

4) When the method of intersection by sextant is used, the swaying of measuring ship makes positioning inaccurate.

5) Poor satellite signals cause inaccurate positioning.

6) Measuring point deviates from cross-section vertical.

7) The calibration and observation of instrument do not meet code requirements.

**3.3.2** During cross-section measurement, measuring error shall be controlled according to the following requirements:

**1** The measurement shall be carried out strictly in accordance with the relevant operation regulations.

**2** If waves are large, a sounding vertical shall not be observed less than 3 times and the mean of the two closest values shall be taken.

**3** The measuring position of depth and distance from initial point shall be controlled on gauging cross-section vertical.

**4** If an elliptical type weight is applied for sounding, deflection angle shall be reduced. A heavy elliptical type weight shall be used within the tolerance range of suspension cableways. If the deflection angle exceeds 10°, it shall be corrected.

**5** Suitable ultrasonic sounder shall be selected.

**6** Width measurement and sounding instruments and tools shall be calibrated as required.

# 4 Stage gradation and means and methods of discharge measurement

## 4.1 General requirements

**4.1.1** Discharge measurement methods selected for hydrometric stations shall be so mature at present as to be applied in practices, satisfy certain accuracy requirements, and comply with the following requirements:

**1** The selected measurement methods shall be suitable for the flow characteristics and measurement conditions of a hydrometric station(cross-section included).

**2** Measurement accuracy shall meet the requirements of data purpose.

**4.1.2** The instrumentation used in various methods shall be compared with current meter before being put into hydrometric station service, and comply with the following requirements:

**1** Comparative gauging should be carried out when flow is relatively stable, and measurement times shall be uniformly distributed at different stages(or discharge)of high, medium and low stages.

**2** The effective times of comparative gauging shall not be less than 30.

**3** The random uncertainty of comparative gauging shall not exceed 6%, or 7% under poor comparative gauging conditions. Systematic error shall not exceed ±1%, or ±2% under poor comparative gauging conditions.

**4.1.3** Hydrometric stations shall select two or more methods for discharge measurement according to the measurement conditions of the stations, one of which is for daily use with the rest as backup.

**4.1.4** The times of discharge measurement shall be arranged in accordance with the following requirements:

**1** The times of discharge measurement at a hydrometric station in a year shall be determined comprehensively according to the flow characteristics of high, medium and low stages, the flow control conditions, the accuracy of measurement, the requirements of the determination of relation curve and the discharge computation, demands, etc. so as to accurately understand water regime changes in various periods and reasonably control the turning point of different stages and water regime change process. When a flood or a dry flow exceeds the equivalent stage of measured discharge over the years, additional discharge measurements shall be conducted for the excessive stages.

**2** The times of tidal discharge measurement shall be arranged reasonably in representative tidal current period according to measurement data. Tidal discharge velocity measurement in each tidal current period shall be properly distributed according to the magnitude and urgency of flow velocity changes, so that the turning point of flow velocity changes during the whole tidal process can be accurately understood.

**3** The times and distribution of discharge measurements for ice-frozen rivers shall be able to control the discharge change process or the change process of the correction coefficient of the icy period. If the drift ice period is less than 5 days, discharge shall be measured once every 1 day or 2 days. If the drift ice period is more than 5 days, discharge shall be measured once every 2 days or 3 days. The times of discharge measurements in the stable freeze-up period may be appropriately reduced compared with that in the drift icy period. Additional discharge measurements may be conducted as appropriate before freezing and after thawing. For hydrometric stations with large daily variation of discharge, measurement timing with representativeness in one day shall be determined by increasing measurement times and conducting experimental analysis.

**4** The times of discharge measurement at the initial stage of a new hydrometric station shall be increased appropriately compared with that specified in Item 1 of this article.

### 4.2 Selection of measurement means

**4.2.1** Discharge may be measured by means of stationary gauging (permanent stationary gauging or stationary gauging in the flood season), tour gauging and intermittent gauging according to the change of flow and sediment characteristics, measurement accuracy, requirements for data processing, accessibility, etc.

**4.2.2** Class Ⅰ accuracy stations with a catchment area of more than 10 000km² and all accuracy stations with a catchment area of less than 10 000km² where the conditions of tour gauging and intermittent gauging are not satisfied shall be subject to permanent stationary gauging or stationary gauging in the flood season.

**4.2.3** Tour gauging may be adopted at various accuracy hydrometric stations with a catchment area of less than 10 000km² if one of the following conditions is satisfied:

**1** If stage-discharge relation is in a single curve, the determination of stage-discharge relation curve can reach specified accuracy, and there is no need to measure peak discharge or flood discharge process.

**2** For hydrometric stations with intermittent gauging, test gauging shall be carried out in the suspension period.

**3** If the stage-discharge relation in the dry period and icy period is relatively stable or discharge change is gentle, the discharge may be calculated by tour gauging data, and the error of annual runoff shall be within a permissible range.

**4** Regular discharge measurements shall be adopted in the dry period.

**5** Although stage-discharge relation is not in a single curve, the discharge can be measured in time according to the change of water regime if the accessibility and communication are convenient.

**6** There are special hydrometric stations on small and medium-sized rivers.

**4.2.4** For all accuracy hydrometric stations with a catchment area of less than 10 000km², where more than 10 years of data prove that measured discharge and equivalent stage have controlled more than 80% of stage variation over the years (including flood and dry years), and the stage-discharge relation over the years is in a single curve, intermittent gauging may be adopted if one of the following is satisfied:

**1** The maximum relative error of the deviation between the annual stage-discharge relation curve and the comprehensive relation curve over the years shall not exceed the following requirements:

**1**) Class Ⅰ accuracy station: 3% for high stage, 5% for medium stage and 10% for low stage.

**2**) Class Ⅱ accuracy station: 5% for high stage, 8% for medium stage and 12% for low stage.

**3**) Class Ⅲ accuracy station: 8% for high stage, 10% for medium stage and 15% for low stage.

**2** Discharge measurement may be suspended for one year when the maximum relative error of the combination of the stage-discharge relation curves of each adjacent year does not exceed the following requirements:

**1**) Class Ⅰ accuracy station: 4% for high stage and 5% for medium stage.

2)Class Ⅱ accuracy station: 6% for high stage and 8% for medium stage.

3)Class Ⅲ accuracy station: 8% for high stage and 10% for medium stage.

**3** Within a partial range of stage variation, the stage-discharge relation is in a single curve and complies with Item 1 of this article.

**4** The stage-discharge relation is in a multiple loop curve, but conforms to Item 1 or Item 2 of this article through uniformization treatment.

**5** In the dry period, the amplitude of discharge variation is little, and the total runoff of the dry period accounts for less than 5% of the total annual runoff, so it is not necessary to measure discharge process. And according to the analysis of runoff data of many years, it is proved that there is a good relationship between monthly runoff and factors such as previous runoff, precipitation, etc.

**6** The relationship between tidal elements and tidal discharge at a tidal current station is proved stable by many years of data.

**4.2.5** For hydrometric stations subject to intermittent gauging, test gauging shall be carried out in the suspension period. If one of the following occurs in the period of intermittent gauging, the times of test gauging shall be increased or normal discharge measurement restored:

**1** Flood or dry flow occurs beyond the scope of intermittent gauging plan for the station.

**2** It is found that hydraulic projects or other human activities have significantly changed the control conditions of the station.

**3** Permissible error exceeds the value specified in Item 1 or Item 2 in Article 4.2.4 of this code.

## 4.3 Selection of measurement methods

**4.3.1** Measurement methods suitable for the characteristics of a hydrometric station may be selected according to the measurement conditions of a measuring reach and technical level.

**4.3.2** The current meter method may be adopted if the following are met:

**1** The flow velocity of most measuring points on the cross-section does not exceed the measuring range of a current meter.

**2** The depth at verticals shall not be less than the necessary depth measured by the one-point method.

**3** In the beginning and ending time of a discharge measurement, the fluctuation difference of stage shall not be greater than 10% of the mean depth, and that for a river with small depth and the sharp fluctuation of stage shall not be greater than 20% of the mean depth.

**4** Floating objects flowing through a gauging cross-section shall not affect the normal operation of a current meter.

**4.3.3** The float method may be adopted if the following are met:

**1** Discharge is measured under the conditions of high flow velocity, low flow velocity or small depth, etc., which is difficult to measure by a current meter or exceeds the application range and conditions of the current meter.

**2** The depth at verticals is less than the necessary depth of the one-point method in the current meter method.

**3** Stage rises and falls sharply, and the fluctuation of the stage during the measurement by the current meter exceeds the range specified in Item 3 in Article 4.3.2 of this code.

**4** Too many floating objects on water surface affect the normal rotation of current meter.

**5** Diversion flood or breach flood occurs.

**4.3.4** The slope-area method may be adopted in the following cases:

**1** The measuring reach with relatively stable cross-section and large surface slope in high flood period.

**2** In the case of sharp stage fluctuation, small depth and many floating objects, it is not suitable to use the current meter method or the float method to measure the discharge.

**3** Flood exceeds the discharge measurement capacity of a hydrometric station.

**4** Due to the missing measurement of flood peak, it is necessary to carry out flood survey to calculate the flood peak discharge.

**5** Tour and intermittent gauging stations where flood exceeds allowable stage variation.

**4.3.5** The acoustic Doppler current profiler method may be adopted when a measuring reach is in non-high sediment concentration or non-clear water area.

**4.3.6** If there are various hydraulic structures such as dams, sluice gates and pumping stations in a measuring reach, and there is a stable functional relation between discharge and relevant hydraulic factors, the hydraulic structure stream gauging method may be adopted.

**4.3.7** The measuring structure method includes various flow measurement weirs and flumes. It is applicable to a measuring reach with small water surface width, small water quantity, large slope, and low sediment concentration.

**4.3.8** For a straight and even measuring reach with low sediment concentration and little suspended solids and without water plants or bubbles, the ultrasonic transit time method may be adopted.

**4.3.9** For a measuring reach with many water plants and floating objects, the electromagnetic method may be adopted.

**4.3.10** For a measuring reach with small water quantity, unstable cross-section and strong turbulence, the dilution method(also known as tracer method)may be adopted.

**4.3.11** For a measuring reach with stage and storage capacity change induced by flow and controllable intake and outlet, the volume method may be adopted.

**4.3.12** In the case of a high flood discharge measurement beyond conventional means and water quantity survey without fixed discharge measurement facilities, the electric wave current meter method may be adopted.

**4.3.13** Other discharge measurement methods recommended by the International Organization for Standardization(ISO)may be adopted according to the measurement conditions of a station.

## 4.4 Gradation of stage(discharge)

**4.4.1** River characteristics, the flood measuring capacity of a hydrometric station and various factors affecting stage change shall be considered for stage(discharge)grading, and gradation methods suitable for the characteristics of the hydrometric station shall be selected.

**4.4.2** When the water quantity of a river is abundant or stage is basically in its natural state, the occurrence frequency of stage in free flow period may be used for stage gradation, and the following requirements shall be complied with:

**1** The frequency may be calculated according to the following formula:

$$p=\frac{m}{n+1} \tag{4.4.2}$$

where　$p$—frequency;

$m$—ordinal number of random variables in decreasing order of value;

$n$—sequence number of random variables, which should not be less than 20.

**2**　For Class Ⅰ accuracy hydrometric stations, the annual eigenvalue method may be adopted for stage gradation, and the following requirements shall be complied with:

**1**) According to the highest instantaneous stage $Z_M$ in each year of a station, the frequency is calculated and the frequency distribution curve drawn. The stage corresponding to frequency $p$ of 90% is taken as a high stage.

**2**) According to the average stage $\bar{z}$ of each year of a station, the frequency is calculated and the frequency distribution curve drawn. The stage corresponding to frequency $p$ of 50% is taken as a medium stage.

**3**) According to the minimum instantaneous stage $Z_m$ in each year of a station, the frequency is calculated and the frequency distribution curve drawn. The stage corresponding to frequency $p$ of 10% is taken as a low stage.

**3**　For Class Ⅱ and Class Ⅲ accuracy hydrometric stations, the typical year method may be adopted for stage gradation, and the following requirements shall be complied with:

**1**) According to the total water quantity $W_f$ of each flood season of a station, the frequency is calculated and the frequency distribution curve drawn. The years with similar runoff corresponding to the runoff frequency $p$ of 10%, 50% and 90% in the flood season are taken as the typical years of wet flow, normal flow and dry flow.

**2**) According to the daily highest stage $z'_m$ of three typical years in the flood season, the frequency is calculated and the frequency distribution curve drawn. The stages corresponding to the runoff frequency $p$ of 10%, 50% and 90% are taken as high, medium and low stages.

**4.4.3**　The occurrence frequency of discharge may be used for discharge gradation if a hydrometric station with small water quantity or whose stage is seriously affected by water-related projects, and the following requirements shall be complied with:

**1**　According to the measured maximum discharge $Q_M$ of a station each year, the frequency is calculated and the frequency distribution curve drawn. The discharge corresponding to the frequency $p$ of 90% is taken as a high discharge.

**2**　According to the mean annual discharge $\bar{Q}$ of a station each year, the frequency is calculated and the frequency curve drawn. The discharges corresponding to the frequency $p$ of 50% and 90% are taken as a medium discharge and low discharge, respectively.

**4.4.4**　According to the gradation results of stage (discharge), the hydrological characteristics period of a hydrometric station may be graded as four periods, i.e. high-flow period, medium-flow period, low-flow period and dry period.

**1**　Graded by stage:

When the stage is no lower than the high one, it is high-flow period.

When the stage is lower than the high one but no lower than the medium one, it is medium-flow period.

When the stage is lower than the medium one but no lower than the low one, it is low-flow period.

When the stage is lower than the low one, it is dry period.

2 Graded by discharge:

When the discharge is no less than the high one, it is high-flow period.

When the discharge is less than the high one but no less than the medium one, it is medium-flow period.

When the discharge is less than the medium one but no less than the low one, it is low-flow period.

When the discharge is less than the low one, it is dry period.

**4.4.5** If the results of stage (discharge) gradation graded by the occurrence frequency of stage or discharge are greatly different from the actual situation of a hydrometric station, graded stage (discharge) may be determined by analysis based on historical data and practical characteristics.

**4.4.6** Stage (discharge) gradation may be determined by the following methods for new hydrometric stations, and analyzed after a certain amount of data is collected:

**1** The gradation may be determined by interpolation with reference to the graded stages of upstream and downstream hydrometric stations.

**2** The gradation may be determined by the percentage of the highest flood stage investigated.

**3** The gradation may refer to that of hydrometric stations with similar hydrometric conditions.

## 4.5 Measurement of high flood discharge

**4.5.1** According to the principle of "safety, efficiency and speed", and the technical and water regime characteristics of a hydrometric station, various measurement schemes shall be formulated for high flood discharge measurement.

**4.5.2 Before the application of all kinds of high flood discharge measurement schemes, drills must be carried out to ensure measurement safety.**

**4.5.3** The high flood discharge measurement shall reach the highest accuracy of instruments or measuring methods. If measurement conditions permit, the measurement scheme with a higher accuracy should be selected.

**4.5.4** The following methods may be adopted for high flood discharge measurement:

**1** The current meter method.

**2** The float method.

**3** The slope-area method.

**4** The acoustic Doppler current profiler method.

**5** The electric wave current meter method.

**6** The hydraulic structure stream gauging method.

**4.5.5** According to the flow characteristics in the high flood period and the technical equipment of a hydrometric station, discharge measurement duration shall be shortened, and appropriate discharge measurement method selected, which shall be in accordance with the following requirements:

**1** When a discharge measurement scheme in the high flood period is deployed, the commonly used discharge measurement methods in the station shall be preferred.

**2** When the current meter method is adopted to measure discharge, representative verticals may be used to simplify discharge measurement for special water regimes such as the sharp rises and falls of stage, frequent stage changes due to fluctuating backwater, severe ice flow and dramatic changes in water regime in the icy period. The representative verticals shall be determined through a simplified analysis of historical data. The uncertainty of the velocity of representative verticals shall not exceed

8% and 10% for stations where discharge is measured by the multi-vertical and multi-point method and by the less-vertical and less-point method, respectively. Cross-section area may be referenced from recent measurement data.

**3** When it is difficult to adopt the current meter method, other commonly used discharge measurement methods may be selected according to the requirements of the discharge measurement necessity duration and accuracy in this code.

**4** For small and medium-sized rivers with sharp stage rises and falls and the large water surface slope of a measuring reach, the slope-area method may be used if the current meter method or the uniform float method cannot be used if the discharge measurement duration is not allowed.

**5** Floods with sharp stage rises and falls and a large amount of floating objects may be measured by the floating objects float method or the midstream floating objects float method. For small slope rivers in plain water network area, the midstream float method may be adopted.

**4.5.6** When special flow conditions caused by dam breach, flood diversion, debris flow, barrier lake, etc. occur, discharge measurement methods suitable for the measurement conditions and flow conditions at that time, such as electric wave current meter, may be adopted for emergency discharge measurement.

## 4.6 Discharge measurement in dry period

**4.6.1** The current meter method shall be prioritized for discharge measurement in the dry period. The small float method may be adopted when depth cannot meet the measuring requirements of the current meter. When some verticals meet the measuring requirements of the current meter method, the current meter method and the small float method may be mixed to complete the discharge measurement.

**4.6.2** When overgrown water plants in a river or accumulated rocks at the bottom of the river affect normal discharge measurement in the dry period, the water plants shall be removed and the river bottom flattened whenever necessary.

**4.6.3** When the depth in a cross-section is less than that required for velocity measurement by the one-point current meter method or flow velocity is lower than the normal operating range of measuring instrument, the following measures may be taken:

**1** A measuring reach shall be regulated with a regulated length of more than 5 times the width of water surface in the dry period.

**2** If the accuracy of discharge measurement cannot be guaranteed after regulation, the reach may be narrowed or backwater measures adopted.

**3** A measuring reach with large depth and low flow velocity may be narrowed. The length of the narrowed reach shall be greater than 1.0 times the river width. The gauging cross-section shall be arranged in the downstream of the narrowed measuring reach.

**4** If water is shallow but flow velocity is high enough, a narrowed reach may be canalized, and depth at most verticals shall be above 0.2m. The slope of the narrowed reach may be between 1:2 and 1:4, and the canalized length shall be more than 4 times the river width. The gauging cross-section shall be located downstream of the canalized reach, and the length from the intake should be 60% of the total length of the canalized reach.

**5** A distance should be kept from the regulated reach to the basic staff gauge cross-section. A temporary gauge may not be set up if the stage of the basic staff gauge and the discharge of the regulated cross-section are in good relation in the dry period. Otherwise, a temporary gauge shall be set up in the regulated cross-section.

**4.6.4** When depth in the cross-section is too small, flow velocity too low, or backwater has obvious influence in the dry period, and it is difficult to regulate a measuring reach or completely eliminate backwater influence by regulation, a measuring cross-section may be set up. A temporary gauge shall be set up in a measuring cross-section in the dry period if one of the following situations occurs:

**1** Flow in basic staff gauge cross-section is scattered or there are multiple streams of flow, backflows, etc.

**2** The stage and discharge are poorly correlated.

**3** The discharge of a measuring cross-section is frequently measured in the dry period.

**4** There is inflow or outflow between measuring cross-section and basic staff gauge cross-section in the dry period.

**4.6.5** If the cross-section depth is too small and/or flow velocity is too low in a short time within a year to use current meter or artificial regulation measures, a temporary measuring cross-section may be shifted to a reach without water inflow or outflow.

**4.6.6** For hydrometric stations serving the purpose of water resources management, discharge measurement accuracy should be tested in the dry period to determine discharge measurement scheme in the dry period. The permissible error of a single discharge measurement in the dry period shall be in accordance with Table 6.1.2 of this code and meet the requirements of water resources management. Flow velocity-measuring verticals in the dry period shall be selected according to the scheme given in Table B.12.12-1 to Table B.12.12-3 of this code if discharge measurement accuracy is not tested at a station in the dry period.

**4.6.7** If wading measurement is used, the personnel shall stand beside the current meter, facing the direction normal to the flow, and the distance between current meter and discharge measurer shall be kept more than 0.5m during flow velocity measurement.

## 4.7 Discharge measurement in icy period

**4.7.1** The current meter method or acoustic Doppler current profiler method may be adopted for discharge measurement in the icy period.

**4.7.2** If the current meter method is used, the following requirements shall be complied with:

**1** If ice holes are drilled for discharge measurement, brash ice or slush ice run shall be removed before measurement.

**2** If there is severely upwelling water on a gauging cross-section or the area of frazil slush under the ice in the cross-section exceeds 25% of wetted cross-section area, the gauging cross-section may be shifted to a cross-section without upwelling water over the ice or with less frazil slush.

**3** When ice layer is thick in the freeze-up period, special ice drill should be used to drill holes for discharge measurement.

**4** When the boundary of stagnant water under ice is measured, a measuring rod tied with red and white light fiber cloth or a long tube is injected with colored solution with similar specific gravity to water may be extended into an effective depth to observe whether water flows.

**5** Under severe cold weather, instrument surface may be coated with kerosene or covered by a thermal insulation and anti-freezing cover to prevent the surface from freezing after the instrument is withdrawn from water. If the instrument freezes, it shall be melted with hot water, shall not be twisted or knocked the instrument forcibly to remove the ice layer of its surface.

**6** If ice layer is not strong enough, discharge should be measured when the temperature is low in the morning.

**7** The following measures may be taken when ice cover with intercalated water layers occurs at a gauging cross-section:

**1**) A temporary cross-section for discharge measurement may be set up.

**2**) When a gauging cross-section is narrow, all the ice on the cross-section and a small section of the reach nearby may be removed, and discharge measurement is carried out according to the measurement method in the free flow period.

**3**) For large rivers, layered measurement may be carried out. If it is difficult to carry out layered measurement, long slot ice holes parallel to flow direction may be drilled on the gauging cross-section. The length of the ice slot is determined according to flow velocity and the thickness of immersed ice.

**4**) When the channel cross-section between various ice layers is not filled up with water, several ice holes penetrating through each ice layer may be drilled at a certain distance upstream of a gauging cross-section to concentrate flow through the ice layers to the lowest layer. After stage turns stable, discharge measurement may be carried out on the gauging cross-section according to normal methods.



### 4.8 Tidal discharge measurement

**4.8.1** According to the flow characteristics of a hydrometric station and existing technical equipment, tidal discharge shall be measured by current meter with multi-vertical simultaneous discharge measurement method, shipboard-type acoustic Doppler current profiler method, the ultrasonic transit time method, index and cross-section average velocity method, etc. When a tidal discharge measurement scheme is deployed, the common discharge measurement methods of the station shall be preferred.

**4.8.2** For a hydrometric station adopting one vertical for the index velocity method, cross-section area may be referenced from recent measured data, and the following requirements shall be complied with:

**1** During tidal discharge measurement, the correlation between original representative vertical and mean flow velocity at a cross-section shall be calibrated at least 15 times, and the t test shall be carried out.

**2** When the correlation between representative vertical and mean flow velocity at a cross-section is reestablished, the times of calibration shall not be less than 30, and the total random uncertainty of the error of the determination of relation curve shall not exceed 15%.

**3** For temporary tidal discharge measuring cross-section, the accuracy of determination of relation curve may be relaxed as appropriate.

**4.8.3** For hydrometric stations with the horizontal acoustic Doppler current profiler method, the accuracy requirements of determination of relation curve shall be the same as those in Article 4.8.2 of this code. Original correlation curve shall be calibrated every year, and the calibration times shall not be less than 15 in and against flow direction, respectively.

**4.8.4** Slack tide time shall be determined according to the following methods:

**1** The vertical and the location of the measuring points of the occurrence time of the slack tide of flood and ebb tides should be determined by test analysis. Before test, a current meter may be placed near the 0.4 times depth to measure the mean occurrence time of the slack tide at verticals. A current meter may be placed at a vertical between shore and midstream to measure the mean occurrence time of the slack tide of full cross-section if the multiple verticals by vertical measurement is adopted. If multiple verticals are used for simultaneous measurement, the mean occurrence time of slack tide shall be determined according to the arithmetic mean value of the slack tide times of each vertical. If there is no signal on a current meter for 180s, it may be regarded as slack tide. If measured slack tide lasts for a period, the mean value shall be taken.

**2** If a current meter is not used for measurement, the mean flow velocity hydrograph at a cross-section in the period before and after the turning of flood and ebb tides may be plotted and interpolated.

# 5 Check and analysis of discharge measurement results

## 5.1 Check items and methods

**5.1.1** The results of a single discharge measurement shall be checked and analyzed according to the principle of "computing, processing and analyzing the data once discharge measurement is done". If errors are found in measurement on site, causes shall be traced, and corresponding corrective and remedial measures shall be taken.

**5.1.2** The check of a single discharge measurement results shall include the following items:

**1** Standardization and completeness of on-site measurement process and records.

**2** Rationality of discharge measurement results.

**3** Rationality of discharge measurement times arrangement.

**5.1.3** The check of the measurement records of flow velocity, depth at a measuring point and distance from initial point shall be measured on-site on each measurement and calculation result, in combination with station characteristics, river regime and specific conditions at measuring sites, and shall be in accordance with the following requirements:

**1** The flow velocity distribution curve at verticals shall be plotted to check and analyze its rationality. If abnormalities are found, causes shall be investigated. If there are obvious measurement errors, re-measurement shall be done.

**2** The transverse distribution of the mean flow velocity at verticals or float flow velocity and a channel cross-section shall be plotted, and the rationality of the transverse distribution checked and analyzed. If abnormalities are found, causes shall be investigated. If there are measurement errors, re-measurement shall be done.

**3** When a representative vertical is used for measurement at a tidal current station, the hydrograph of index velocity shall be plotted, and the continuity, uniformity and rationality of flow velocity change process shall be checked and analyzed.

**4** For a station with flow velocity measurement by fixed verticals, when it is difficult to plot an analyzing diagram on site due to the constraint of the measurement conditions, or when the time for discharge measurement needs to be shortened due to the sharp fluctuation of stage, the measured results of vertical depth, flow velocity at measuring points and the mean flow velocity at verticals may be filled into the comparison checklist of velocity and sounding results made beforehand, which are checked against the measured results of adjacent verticals and previous measurement.

**5.1.4** The results of discharge measurement shall be computed and checked on the day when each discharge measurement ends, and the rationality shall be checked and analyzed according to the following requirements:

**1** The curves of correlation between stage or other hydraulic factors and discharge, stage and area, stage and velocity shall be plotted, and their change trend and the rationality of corresponding relations among the three curves shall be checked and analyzed.

**2** For stations adopting continuous measured discharge process line in data processing, stage, flow velocity, area and discharge hydrographs may be plotted, and the rationality of the change process of various elements checked by comparison.

**3** For discharge measurement in the icy period, a flow correction coefficient hydrograph or immersed ice thickness and temperature hydrograph in the icy period may be plotted to check the rationality of discharge in the icy period.

**4** When abnormal discharge measuring point is found, the causes shall be investigated and analyzed. For a controllable measurement which cannot be corrected, on-site investigation on the measuring reach should be conducted, and additional measurement shall be taken for verification.

**5.1.5** In the rationality check and analysis of discharge measurement arrangement, the discharge measuring points shall be plotted on the corresponding position of an hourly stage hydrograph after each discharge measurement. For stations adopting the fall method in hydrologic data processing and discharge computation, discharge measuring points shall be plotted on a drop hydrograph at the same time, and a comparative check shall be made according to the distribution of the discharge measuring points on the curve of the correlation between stage or hydraulic factors and discharge. If the arrangement of measurement times cannot satisfy the requirements of the determination of relation curve for data processing, measurement times shall be increased according to water regime, or the timing of the next measurement shall be adjusted.

## 5.2 Check and analysis



**5.2.1** The characteristics of a hydrometric station shall be regularly analyzed, mainly including the control characteristics of the station, stage-discharge relation, the changing tendency of the scouring and silting of a cross-section, velocity distribution pattern at verticals and the transverse distribution trend of flow vertical velocity at a cross-section.

**5.2.2** The analysis of the control characteristics of a hydrometric station shall be in accordance with the following requirements:

**1** To plot the curve of the relation between stage or hydraulic factors and discharge. The correlation curves of the current year and previous year shall be drawn on the same chart for comparison so as to understand the change and transfer of the station control from the deviation trend of the relation curve, and analyze the causes.

**2** To plot the curve of the relation between stage and percentage deviation curve of discharge measuring points so as to understand the transfer and change of the station control from the deviation and trend of the discharge measuring points, and analyze the causes.

**3** To plot the curve of the relation between the positive and negative deviation percentage of discharge measuring points and time so as to understand the change of the station control with time, and analyze the causes.

**4** To draw the curve of the specified discharge values according to the measured equivalent stage for many years so as to understand the change of the station control from the fall or rise trend of a stage curve corresponding to the specified discharge, and analyze the causes.

**5.2.3** For a station with unstable river bed, the relation between scouring and silting of the gauging cross-section of the station and hydraulic factors and that between scouring and silting and river regime shall be analyzed once every 3 to 5 years, and the scouring and silting trend and the change of the river bed shall be analyzed.

**5.2.4** The measured data of the multi-point method shall be used to analyze the flow velocity distribution pattern at a vertical. When various verticals at a cross-section are similar in velocity distribution pattern, a standard flow velocity distribution curve at a vertical may be plotted. When the flow velocity distribution patterns of verticals at each part of a cross-section are not fully identical, two or three distribution curves may be plotted, respectively. For hydrometric stations with large stage variation and different vertical velocity distribution patterns at different stages, the distribution curve of different stage points shall be drawn, and a flow velocity distribution formula obtained by curve fitting may be used to analyze the relation between the flow velocity at various relative depth measuring points and the mean flow velocity at a vertical.

**5.2.5** A hydrometric station shall adopt the data measured by the multi-vertical method at different stages to analyze the transverse distribution pattern and change of the mean flow velocity at a vertical.

# 6 Assessment of discharge measurement accuracy

## 6.1 General requirements

**6.1.1** The test of discharge measurement error or comparative gauging shall be made at a hydrometric station with certain representativeness and suitable measurement or comparison conditions, and the accuracy of the results may be assessed by analyzing the error test or comparative gauging data. For hydrometric stations with the same characteristics and measurement methods in the same region, the comprehensive results accuracy of the region may be used as assessment basis.

**6.1.2** The accuracy index of a single discharge measurement shall be determined according to data purpose or the needs of client. The permissible error of the current meter method shall comply with the requirements in Table 6.1.2, which may also be used as reference for other discharge measurement methods. For hydrometric stations with comprehensive functions, the highest accuracy index shall be adopted.

**Table 6.1.2 Permissible error of single discharge measurement by the current meter method**

| Station class | Stage gradation | Permissible error (%) | | | | |
|---|---|---|---|---|---|---|
| | | $X'_Q$ | | | | $\bar{\mu}_Q$ |
| | | Basic data collection | Hydrologic computation | Flood defense | Water resources management | |
| Class Ⅰ | High | 5 | 6 | 5 | 5 | −1.5~1 |
| | Medium | 6 | 7 | 6 | 6 | −2.0~1 |
| | Low | 9 | 9 | 8 | 7 | −2.5~1 |
| Class Ⅱ | High | 6 | 7 | 6 | 6 | −2.0~1 |
| | Medium | 7 | 8 | 7 | 7 | −2.5~1 |
| | Low | 10 | 10 | 9 | 8 | −3.0~1 |
| Class Ⅲ | High | 8 | 9 | 8 | 7 | −2.5~1 |
| | Medium | 9 | 10 | 9 | 8 | −3.0~1 |
| | Low | 12 | 12 | 11 | 10 | −3.5~1 |

Notes: 1 $X'_Q$—total random uncertainty at 95% of confidence level.

2 $\bar{\mu}_Q$—systematic error, a control index for different data purposes. The permissible error of a single discharge measurement data for other purposes may be determined by analysis as required.

**6.1.3** Appropriate measurement instruments and methods for hydrometric stations shall be selected according to the accuracy index determined in Table 6.1.2 of this code. If conventional instruments and methods fail to meet the specified accuracy requirements, the measurement methods shall be changed or a measuring reach or a measuring cross-section artificially regulated.

**6.1.4** The measurement accuracy of a hydrometric station for specific purpose may be determined by the purpose of setting-up the station according to Table 6.1.2 of this code.

**6.1.5** For hydrometric stations whose measurement conditions are seriously affected by human activities, if the accuracy of a single discharge measurement fails to meet the requirements in Table

6.1.2 of this code, the accuracy class may be lowered down or other discharge measurement methods with equivalent accuracy adopted.

**6.1.6** In the cases of special water regimes caused by dam breach, flood diversion, debris flow, barrier lake, etc., the accuracy of emergency discharge measurement may be determined according to the local measurement conditions and methods at that time.

**6.1.7** For rivers with a small water quantity, when the permissible error of discharge measurement in the low-flow period does not meet the requirements in Table 6.1.2 of this code, it may be expressed as absolute error, and its index shall be determined through the analysis of historical data of the station.

**6.1.8** In areas without error test data, representative stations with favorable conditions shall be selected to check the accuracy index specified in this code. If the measured results of the station and the accuracy index specified are inconsistent, data shall be analyzed and measurement scheme improved.

## 6.2 Error sources and control

**6.2.1** Discharge measurement errors may be divided into random error, undetermined systematic error, determined systematic error and spurious error. Random error shall be described with random uncertainty at a confidence level of 95% according to the normal distribution. Undetermined systematic error shall be described with system uncertainty at a confidence level of no less than 95%. Determined systematic error shall be corrected, and measurement results containing spurious errors eliminated.

**6.2.2** The error sources and control of the current meter method shall be in accordance with the following requirements:

**1** Error source analysis shall include the following:

**1**) Positioning error of distance from initial point.

**2**) Sounding error.

**3**) Positioning error of flow velocity measuring point.

**4**) Error caused by flow direction deflection angle.

**5**) Error caused by the non-parallel axis of current meter and streamline.

**6**) Error caused by the interference of an object entering the water measured.

**7**) Timing error.

**8**) Error of current meter calibration.

**9**) Error caused by the imperfection of a measurement scheme, mainly manifest in the error of flow velocity pulsation caused by the insufficient duration of the flow velocity measurement at measuring points, the error of the computation of the mean flow velocity at a vertical caused by the insufficient number of measuring points at the vertical, and error caused by the insufficient number of the flow velocity-measuring verticals on a cross-section.

**10**) Error caused by improper operation during measurement.

**11**) Error caused by measurement conditions beyond the proper use of measurement instrument.

**2** The following measures may be taken for error control:

**1**) To establish a regular inspection and registration system for main measurement instruments and tools and relevant measurement equipment and devices.

**2**) To timely verify, calibrate and maintain instruments according to relevant regulations.

**3**) To carry out width measurement and sounding according to the requirements stipulated in Section B.8 of this code.

**4**) To adopt effective measures for accurate positioning and the reduction of flow direction deflection angle and the hydraulic resistance of discharge measuring equipment.

**5**) During flow velocity measurement, the longitudinal axis of a hydrometric boat should be parallel to streamline, and the stability of the hydrometric boat maintained.

**6**) To regulate operation procedures.

**7**) To improve the measurement schemes.

**8**) Measurement conditions shall conform to the proper use of measurement instrument.

**6.2.3** The error sources and control of the float method shall be in accordance with the following requirements:

**1** Error source analysis shall include the following:

**1**) Float coefficient adoption error.

**2**) Cross-section borrowing or measuring error.

**3**) When the cross-section float method is used, float distribution is uneven or there are too few effective floats, resulting in error caused by the inaccurate velocity transverse distribution of floats.

**4**) In a reach where deep-water float or float is used to measure discharge, error may be caused by a considerable change of depth along the way.

**5**) Float observation error.

**6**) Timing error.

**7**) Float fabrication error.

**8**) Error caused by the influence of wind direction and wind speed on float operation.

**2** The following measures may be taken for error control:

**1**) To strengthen float coefficient test analysis.

**2**) If conditions permit, a measuring cross-section shall be adopted as much as possible, and cross-section measurement error shall be controlled according to relevant width measurement and sounding regulations.

**3**) When the cross-section float method is used, the number and transverse distribution position of the floats should be controlled to make the transverse distribution curve of float flow velocity more representative.

**4**) When the deep-water float or float rod method is used for discharge measurement, a measuring reach shall be selected according to Item 5 in Article C.1.1 of this code.

**5**) Measurement shall be carried out in accordance with the requirements for float flow velocity measurement in this code and the relevant requirements for the uniform design of floats shall be used for discharge measurement.

**6**) To time with a stopwatch with high accuracy and check frequently to eliminate timing systematic error.

**6.2.4** The error source and control of the acoustic Doppler current profiler method shall be in accordance with the following requirements:

**1** Error source analysis shall include the following:

**1**) Random error and systematic error caused by the noise of acoustic Doppler current profiler.

2) Sounding error.

3) The flow velocity measurement error of a hydrometric boat, including bottom tracking error or Global Positioning System (GPS) positioning error.

4) Measurement error of the distances from the start and end of the measurement to bank.

5) Error caused by a high ratio of hydrometric boat speed to flow velocity.

6) Error caused by a high ratio of the area of non-measured zone (surface layer, bottom layer, left and right bank area) to the area of measured zone.

7) The measurement error of a cross-section area.

8) Errors caused by factors around flow including pulsation or turbulence, surface waves, shear discharge, bed load at the bottom of a river, extremely slow velocity, etc.

9) Errors caused by human factors.

2 The following measures shall be taken for error control:

1) Differential GPS may be used instead of bottom tracking to measure hydrometric boat speed in a measuring reach affected by "moving bed".

2) For the gauging cross-section where water plants cannot be avoided, the fixed-point multiple verticals method should be adopted.

3) A transducer shall be installed firmly and its depth measured accurately to avoid input error.

4) Shore distance should be accurately measured by a laser range finder or tape, and the visual estimation method not be used.

5) Shore shape coefficient or bank discharge coefficient shall be correctly selected.

6) The flow velocity extension models of surface and bottom blanking distance shall be correctly selected. The 1/6 power function law may be used, and the power exponent or other flow velocity extension models should not be changed. Attention should be paid to the influence of bidirectional flow.

7) Blanking distance shall be set according to the frequency of a transducer, and the blanking distance value shall not be set too small.

8) The correct deflection angle correction value shall be input in discharge measuring software.

9) Appropriate working mode shall be selected.

10) A unit length value (MS) shall be set according to the frequency of a transducer, the maximum depth or the maximum number of units (MN).

11) The total duration of measurement shall not be less than 12 minutes, and at least two one-way measurements (one measurement cycle) shall be conducted.

**6.2.5** The error sources and control of other discharge measurement methods shall be in accordance with relevant codes and instrument instructions, or in accordance with the following requirements:

1 Error source analysis shall include the following:

1) Measurement conditions do not meet the use conditions of the instrument or method.

2) Instrument error.

3) Instrument verification and calibration error.

4) Positioning error.

5) Improper parameter setting.

2 The following measures may be taken for error control:

1) To select appropriate measurement instruments and methods according to the measurement

conditions.

**2**) To timely verify, calibrate and maintain instruments according to the relevant regulations.

**3**) If conditions permit, appropriate parameters are selected through comparative test.

**4**) To strictly abide by instrument operation procedures.

### 6.3 Assessment of discharge measurement accuracy

**6.3.1** The accuracy of discharge measurement results may be indicated by synthetic uncertainty. For hydrometric stations of all classes, the synthetic uncertainty of each station shall be computed once a year according to high, medium and low stages, and filled in a discharge record table as the basis for the accuracy assessment of measurement results.

**6.3.2** The relative standard deviation of each component of discharge shall be estimated in accordance with the following requirements:

**1** For the $n$ independent measurements of a certain component, the relative standard deviation of the component shall be estimated according to the following formulae:

$$\overline{Y}=\frac{1}{n}\sum_{i=1}^{n}Y_i \tag{6.3.2-1}$$

$$S_Y=\frac{1}{\overline{Y}}\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(Y_i-\overline{Y}\right)^2} \tag{6.3.2-2}$$

where $S_Y$ — relative standard deviation of discharge components (%);

$\overline{Y}$ — arithmetic mean value of $n$ measured values of discharge component;

$Y_i$ — the $i$th measurement value of discharge component.

**2** When the $n$ independent measurements mentioned above are conducted several times and their relative values may be used as sample observations of the same parent, the relative standard deviation of the component shall be estimated according to the following formulae:

$$\overline{\left(\frac{Y}{y}\right)}=\frac{1}{n}\sum_{i=1}^{n}\left(\frac{Y}{y}\right)_i \tag{6.3.2-3}$$

$$S_Y=\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left[\left(\frac{Y}{y}\right)_i-\overline{\left(\frac{Y}{y}\right)}\right]^2} \tag{6.3.2-4}$$

where $y$ — approximate true value of discharge component;

$\left(\frac{Y}{y}\right)_i$ — relative value obtained from the $i$th discharge measurement of a certain discharge component;

$\overline{\left(\frac{Y}{y}\right)}$ — arithmetic mean value of $n$ relative values of a certain discharge component.

**6.3.3** The random uncertainty of each independent component of discharge is taken at 95% of confidence level and shall be estimated according to the following requirements:

**1** When the sample size of measurement series is no less than 30, the random uncertainty shall be 2 times the relative standard deviation.

**2** When the sample size of measurement series is less than 30, the random uncertainty shall be calculated by multiplying the confidence factor [Student's (t) value] in Table 6.3.3 by the relative standard deviation.

**Table 6.3.3 Student's(t) value at 95% of confidence level**

| Sample size | Student's(t) value | Sample size | Student's(t) value | Sample size | Student's(t) value | Sample size | Student's(t) value |
|---|---|---|---|---|---|---|---|
| 2 | 12.706 | 9 | 2.306 | 16 | 2.131 | 23 | 2.074 |
| 3 | 4.303 | 10 | 2.262 | 17 | 2.120 | 24 | 2.069 |
| 4 | 3.182 | 11 | 2.228 | 18 | 2.110 | 25 | 2.064 |
| 5 | 2.776 | 12 | 2.201 | 19 | 2.101 | 26 | 2.060 |
| 6 | 2.571 | 13 | 2.179 | 20 | 2.093 | 27 | 2.056 |
| 7 | 2.447 | 14 | 2.160 | 21 | 2.086 | 28 | 2.052 |
| 8 | 2.365 | 15 | 2.145 | 22 | 2.080 | 29 | 2.048 |

**6.3.4** The uncertainty of a discharge measuring instrument may be determined according to the accuracy index given by manufacturer.

**6.3.5** If discharge can be expressed as a function of several components and each component is assumed to be independent, the total random uncertainty shall be calculated according to the following formula:

$$X_Q'^2 = \sum_{i=1}^{k} \left(\frac{\partial Q}{\partial Y_i}\right)^2 \left(\frac{Y_i}{Q}\right)^2 X_i'^2 \tag{6.3.5}$$

where $X_Q'$ — total random uncertainty of discharge(%);

$k$ — number of components;

$X_i'$ — random uncertainty of discharge components $Y_i$(%).

# Appendix A  Methods for accuracy classification of basic hydrometric stations

**A.0.1** The accuracy classification of basic hydrometric stations shall be divided into three classes according to Table A.0.1.

**Table A.0.1 Classification criteria for accuracy of hydrometric stations**

| Accuracy classification | Item | | | |
|---|---|---|---|---|
| | Accuracy requirements | Main tasks of hydrometric station | Drainage area ($km^2$) | |
| | | | Wet area | Arid and semiarid area |
| Class Ⅰ | Highest accuracy of existing operations and methods shall be achieved | To collect the long series of samples required to explore the variation pattern of hydrological characteristic values in time and along river and the data needed by economy and society | ≥3 000 | ≥5 000 |
| Class Ⅱ | Accuracy may be formulated according to measurement conditions | To collect the representative series of samples required to explore the variation patterns of hydrological characteristic values along river and in region and the data needed by economy and society | <10 000<br>≥200 | <10 000<br>≥500 |
| Class Ⅲ | Requirements on the accuracy of data purpose for station tasks shall be met | To collect data to explore the runoff yield, flow concentration law and runoff change rules of a small stream under various underlying surface conditions, as well as the hydrological analysis and calculation requirements for series representativeness, and the data needed by economy and society | <200 | <500 |

**A.0.2** Basin or provincial hydrological institutions may adjust the accuracy classification of stations according to the factors, such as importance of basic hydrometric stations, data purpose, service requirements and measuring difficulty, etc.

**A.0.3** If it is difficult for a hydrometric station to meet the original accuracy requirements due to the constraint of station control and measurement conditions, its accuracy may be reduced by one class, but shall not be lower than Class Ⅲ.

# Appendix B　Current meter method

## B.1　General requirements

**B.1.1**　The following work shall be done simultaneously whenever discharge is measured:

**1**　To observe the stage of basic staff gauge. When there is a gauge in a gauging cross-section, stage shall be observed at the same time. For a hydrometric station with slope observation requirement, stage of slope staff gauge shall be observed at the same time.

**2**　To measure channel cross-section. The measurement of channel cross-section shall comply with the relevant requirements stipulated in Section 3.2 and Section B.8 of this code.

**3**　To measure flow velocity at a measuring point or mean flow velocity at a vertical. When flow direction measurement is required, the deflection angle of flow direction shall be measured.

**4**　To observe weather phenomena and flow condition near a measuring cross-section.

**5**　To calculate, check and analyze discharge measurement data and calculation results.

**B.1.2**　A discharge measurement scheme may be selected according to that given in Table B.12.12-1 to Table B.12.12-3 of this code. When high measurement accuracy is required, the scheme of multiple verticals, multiple points and long duration may be selected.

**B.1.3**　The total random uncertainty of tidal discharge measurement shall be less than 15%, and systematic uncertainty less than 3%.

**B.1.4**　For a hydrometric station with little changes in river bed scouring and silting, the fluctuation difference of stage during one discharge measurement shall not exceed the requirements stipulated in Item 3 in Article 4.3.2 of this code. However, the continuous discharge measurement method may be adopted when sharp stage fluctuation makes the distribution of measurement times unable to meet the requirements.

**B.1.5**　For a hydrometric station where its river bed is relatively stable and the relation between stage and mean flow velocity at a vertical is stable, the segmental vertical discharge measurement method should be adopted when sharp stage fluctuation makes the stage fluctuation difference in one discharge measurement process likely exceed the requirements stipulated in Article B.11.4 of this code.

## B.2　Layout of flow velocity-measuring verticals

**B.2.1**　Flow velocity-measuring verticals shall be evenly distributed in general, capable of basically controlling the main turning points of cross-section terrain and velocity distribution along river width. The verticals in main channel shall be denser than those in river shore.

**B.2.2**　Flow velocity-measuring verticals shall be arranged for single-stream diversions and erosion ditches in a cross-section with a discharge greater than 1% of the cross-section discharge.

**B.2.3**　For a hydrometric station with obvious changes in cross-section shape or transverse distribution of flow velocity as stage grade changes, verticals shall be arranged according to high, medium and low stages.

**B.2.4**　The position of flow velocity-measuring verticals should be fixed. When one of the following situations occurs, the verticals shall be adjusted or supplemented anytime:

**1** Stage fluctuation or river bank scouring makes verticals near river bank too far away from or too close to the bank.

**2** There is stagnant water or backflow on a cross-section, and it is necessary to determine stagnant water or backflow boundary or backflow discharge.

**3** River bottom topography or the flow velocity distribution of measuring points along river width changes significantly.

**4** The distribution of frazil slush is uneven or a flow velocity-measuring vertical is frozen in the icy period.

**5** In the icy period, border ice appears near the boundary between border ice and exposed river surface.

**B.2.5** For a hydrometric station with cableway, sounding and width measurement instruments, tools and cable size signs shall be calibrated and checked according to Section B.8 of this code before using the cableway.

**B.2.6** The number of flow velocity-measuring verticals shall be determined according to a discharge measurement scheme selected in Section B.12 of this code. For a hydrometric station with a violent main flow swing or unstable river bed, and severe flood plain, a scheme with more flow velocity-measuring verticals should be selected.

**B.2.7** The number of flow velocity-measuring verticals in tidal rivers may be appropriately less than that in non-tidal rivers. 5 to 7 verticals should be used for the measurement by boat, and 7 to 9 verticals used for the measurement by hydrometric cableway. The number of verticals in especially wide or narrow rivers may be increased or decreased appropriately, but shall not be less than 3. When the water surface width and depth at high and low tide stages vary significantly, the number of flow velocity-measuring verticals and the position of flow velocity-measuring vertical on bank shall be adjusted according to the fluctuation of tide stage in each tidal period.

## B.3 Flow velocity measurement

**B.3.1** If the selected point method is used to measure mean flow velocity at a vertical, the distribution of flow velocity measuring points shall be in accordance with the following requirements:

**1** The minimum distance between two adjacent measuring points at a vertical should not be less than the diameter of the propeller or rotary cup of a current meter.

**2** When flow velocity on water surface is measured, the rotating part of instrument shall not be exposed to water surface.

**3** When flow velocity at river bottom is measured, a current meter shall be positioned below 0.9 times depth, and the edge of the rotating part of the instrument be 2cm to 5cm away from the river bottom. When ice bottom or frazil slush bottom is measured, the edge of the rotating part of the instrument shall be 5cm away from the ice bottom or frazil slush bottom.

**B.3.2** A current meter may be suspended by suspension rod or suspension cable. A suspended current meter shall be in a horizontal state underwater. If the depth or flow velocity of most verticals is small, a suspension rod should be used.

**B.3.3** The positioning of current meter measuring points shall be in accordance with the following requirements:

**1** The distance from current meter to the side of a boat shall not be less than 1.0m, and that to the side of a small boat not be less than 0.5m.

**2** If a suspension rod is adopted, the current meter shall be parallel to the flow direction of measuring point at that time, and the instrument installed on the suspension rod shall be able to rotate freely within a certain range of horizontal plane. When a suspension rod is fixed, one end of the rod shall be equipped with a chassis, under which there shall be a tip.

**3** If a suspension cable is adopted, the method of hanging elliptical type weight shall make a current meter parallel to the flow direction of measuring point at that time, and a single point suspension or a "splay" suspension with an adjustable center of gravity may be adopted. The method of deflection angle correction of suspension cable and measuring point positioning determination shall be selected according to Section B.9 of this code. If the actual depth cannot be measured by elliptical type weight, depth is looked up by borrowing the results of last cross-section measurement, and deflection angle of suspension cable is greater than 10°, the position of each measuring point below water surface shall be determined by the "trial and error method".

**B.3.4** The number of measuring point velocity values on flow velocity-measuring verticals shall be determined according to the discharge measurement scheme selected in Section B.12 of this code, and the location distribution of measuring point velocity shall comply with the requirements in Table B.3.4.

**Table B.3.4 Flow velocity position distribution of measuring points on vertical**

| Measuring point number | Relative depth position | |
|---|---|---|
| | Free flow period | Icy period |
| One | 0.6 or 0.5,0.0,0.2 | 0.5 |
| Two | 0.2,0.8 | 0.2,0.8 |
| Three | 0.2,0.6,0.8 | 0.15,0.5,0.85 |
| Five | 0.0,0.2,0.6,0.8,1.0 | – |
| Six | 0.0,0.2,0.4,0.6,0.8,1.0 | – |
| Eleven | 0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0 | – |

**B.3.5** The duration of flow velocity measurement at a measuring point shall be determined according to the discharge measurement scheme selected in Section B.12 of this code.

**B.3.6** When a stagnant water zone occurs in a gauging cross-section, the stagnant water boundary shall be determined by the analysis of previous test data or visual inspection. When the area of the stagnant water zone does not exceed 3% of the cross-section area, it may be treated as a flowing water zone. When the area of the stagnant water zone exceeds 3%, a low-speed current meter, deep-water float or other methods shall be used to measure the stagnant water boundary, and the area shall be treated as a stagnant water zone.

**B.3.7** When a backflow zone occurs in a gauging cross-section, the backflow of the cross-section does not exceed 1% of downstream flow of the cross-section, and the upstream and downstream flows are irregular at different times, flow velocity-measuring verticals may only be arranged on both sides of upstream and downstream flow junction to determine the boundary of backflow, and the backflow may be treated as stagnant water. When the backflow of the cross-section exceeds 1% of downstream flow of the cross-section, in addition to measuring its boundary, appropriate number of flow velocity-measuring verticals shall be arranged in the backflow area to measure the backflow quantity.

**B.3.8** Round-trip measurement should be adopted for flow velocity measurement at a vertical of tidal current station, and the number of measuring points may be determined by vertical depth according to following requirements:

**1** If the depth is less than 1.5m, the one-point method with 0.6 or 0.5 times depth may be adopted.

**2** If the depth is no less than 1.5m and less than 3.0m, the two-point method with 0.2 and 0.8 times depth may be adopted.

**3** If the depth is no less than 3.0m and less than 5.0m, the three-point method may be adopted.

**4** If the depth is no less than 5.0m, the six-point method should be adopted.

**B.3.9** The duration of flow velocity measurement at a single measuring point of tidal current station should be 60s to 100s. When velocity variability is large or there are many measuring points on a vertical, the measurement duration may be 30s to 60s.

**B.3.10** Flow velocity at a vertical of tidal current station may be measured simultaneously at various measuring points on the vertical with multiple current meters, or the flow velocity of various measuring points on a vertical may be measured successively with one current meter, and then corrected to simultaneous flow velocity.

**B.3.11** If a current meter is used to measure the tidal flow velocity of each measuring point in turn, the measurement and correction methods shall be in accordance with the following requirements:

**1** The revised graphic method. It is advisable to measure 5 to 6 points, and other measuring points except those on water surface shall be distributed at an equal distance, to keep the distance from river bottom fixed. When tide stage fluctuation causes the distance between water surface measuring points and adjacent measuring points to be too large or too small, measuring points shall be increased, decreased or adjusted according to the principle of uniformity and equal distance. A velocity hydrograph is drawn with measured velocities at each measuring point in time sequence (Figure B. 3.11). According to this set of curves, the simultaneous velocity of each measuring point on a vertical at any time in the measuring tidal current period may be found. Measuring sequence shall be from river bottom to water surface. The time interval of each measurement should be short, with more times of measurement.

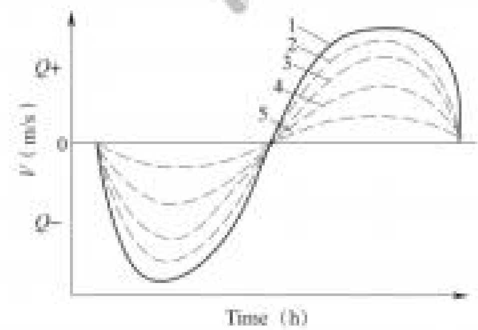



Figure B.3.11 Velocity hydrograph of each measuring point on the vertical of fluctuating tide

1–water surface measuring point; 2–d3 measuring point from river bottom; 3–d2 measuring point from river bottom; 4–d1 measuring point from river bottom; 5–river bottom measuring point

**2** The revised velocity-hydrograph method. The six-point method should be adopted, and measuring point position calculated according to relative depth. Measurement sequence shall be from river bottom to water surface, and the measurement time at each point shall be recorded. The time interval of each measurement should be short and the times of measurement more. The measurement and correction methods are the same as those in Item 1 of this article.

**3** The revised isobath-velocity method. The two-point to six-point method may be adopted.

Measurement sequence shall be from water surface down to the measuring point with a maximum depth, and then up to water surface point by point. Except for the measuring point with a maximum depth, the other measuring points shall be measured twice. The time interval of flow velocity measurement at each measuring point should be short and roughly equal. Except for river bottom flow velocity, the flow velocity of the other measuring points is the mean of two measurements. The measurement time of the maximum depth measuring point is taken as the mean time of flow velocity measurement at a vertical.

**4** The revised water surface flow velocity method. The three-point to six-point method may be adopted. Measurement sequence shall be from water surface down to river bottom, and the measurement starting time of water surface measuring points shall be recorded as the flow velocity measurement time of a vertical. The time interval of the measurement of each measuring point should be short and roughly equal. After a point at river bottom is measured, flow velocity on water surface shall be measured again immediately.

The correction value of flow velocity at each measuring point shall be calculated according to the following formula:

$$\Delta V_i = \frac{V'_{0.0} - V''_{0.0}}{V''_{0.0}} \times \frac{i-1}{n} \times V_i \qquad \text{(B.3.11)}$$

where $\Delta V_i$—correction value of flow velocity at the $i$th measuring point(m/s);

$V'_{0.0}$—flow velocity on water surface measured at the first time(m/s);

$V''_{0.0}$—flow velocity on water surface measured at the second time(m/s);

$i$—ordinal number of measuring points at a vertical;

$n$—total number of measuring points at a vertical;

$V_i$—flow velocity of measuring point to be corrected(m/s).

**B.3.12** The multi-boat simultaneous discharge measurement method, the one-boat and multi-vertical method or the multi-boat and multi-vertical method may be adopted to measure flow velocity at a cross-section of tidal current station, and shall be in accordance with the following requirements:

**1** For the multi-boat simultaneous discharge measurement method, one hydrometric boat may be fixed on each vertical of the cross-section to measure flow velocity at the same time.

**2** For the one-boat and multi-vertical method, when each vertical is measured by the two-point method or three-point method, it shall be measured from one bank to the other bank, and then measured from the other bank to the original bank. The mean flow velocity of the round-trip measurement of each measuring point shall be taken as the simultaneous velocity of last measuring point. When the number of measuring points on each vertical is more than six, measurement may be carried out from one bank to the other in turn without any return measurement. The simultaneous flow velocity of each vertical at the whole cross-section may be calculated by the method of plotting velocity process of measuring points (Figure B.3.12).

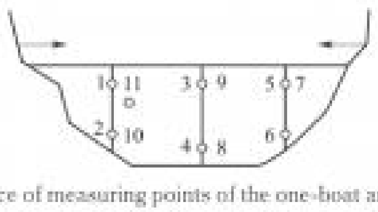



Figure B.3.12 Sequence of measuring points of the one-boat and multi-vertical method

1,2,3,...–the sequence of measurement at each measuring point. The sixth point is measured once, and the other points are measured twice

**3** For the multi-boat and multi-vertical method, 1 to 3 verticals may be measured by each hydrometric boat. The flow velocity measurement method of each vertical and measuring points is the same as that of the one-boat and multi-vertical method.

## B.4 Flow direction deflection angle measurement

**B.4.1** If the mean flow direction deflection angle of cross-section exceeds 10°, the flow direction deflection angle shall be measured. For a tidal current station with frequent changes in flow direction deflection angle, flow direction shall be measured at the same time as flow velocity of each measuring point on each vertical or part of the representative verticals. For a tidal current station with little changes in flow direction deflection angle, flow direction may only be measured at the verticals with flow direction deflection angle of more than 10°.

**B.4.2** For flow direction deflection angle measurement, flow-direction meter shall be used for a tidal current station, while flow-direction meter or mooring float for other hydrometric stations. And the following requirements shall be complied with:

**1** If a flow-direction meter is used to measure the magnetic azimuth of flow direction, and calculate the difference between the measured magnetic azimuth and magnetic azimuth of cross-section vertical, the meter shall be read continuously for 3 to 5 times, with the mean value taken when a direct reading flow velocity and flow direction meter is used and the reading value is not stable.

**2** When a flow-direction meter is used to measure flow direction near the water surface of low stage, the dial at the upper end of the rotating shaft of the flow-direction meter shall be perpendicular to the rotating shaft. When the compass reading is zero, its pointer shall be aligned with 0° or 90° of the dial of the flow-direction meter. The size of the flow-direction meter tail wing shall ensure that it may rotate freely with flow direction at low flow velocity.

**3** When a mooring float is used to measure flow direction, the float should be tied to a flexible thin line of 20m to 30m long and released from a vertical. After the thin line is tightened, a sextant or protractor may be used to measure flow direction deflection angle. When a protractor is used for measurement, it shall be drawn with a direction line, whose direction shall be controlled by a compass or collimator to make it coincide with or be perpendicular to gauging cross-section verticals.

**B.4.3** For cableway stations or hydrometric stations with difficulty in measuring flow direction deflection angle, the flow direction deflection angle may not be measured when it affects the total discharge of less than 1% through data analysis. But the flow plane map shall be checked once or twice a year for test.

## B.5 Other observation

**B.5.1** In each discharge measurement, basic staff gauge stage shall be observed or extracted. When an auxillary gauge is set in a gauging cross-section, stage shall be observed or extracted at the same time, and the following requirements shall be complied with:

**1** When stage changes mildly during discharge measurement, stage may be observed or extracted only once at the beginning and ending respectively of discharge measurement.

**2** For a hydrometric station with mean depth larger than 1m and cross-section area change larger than 5%, or mean depth of less than 1m and cross-section area change larger than 10%, the number of observations or extractions of stage shall be increased according to the requirements for controlling stage process and satisfying equivalent stage calculations when the great change of stage in discharge measurement process is likely to cause a great change in area of channel cross-section.

**3** When discharge measurement process is likely to cross the peak or bottom of stage hydrograph, the number of observations or extracts shall be increased.

**B.5.2** For a hydrometric station with a slope staff gauge, the stage of slope staff gauge shall be observed according to the purpose of the station. When stage changes steadily during discharge measurement, it may be observed only once at the beginning of discharge measurement. When stage changes greatly during discharge measurement, it shall be observed once at the beginning and once at the ending of discharge measurement.

**B.5.3** At the same time of each discharge measurement, wind direction and wind speed (force) as well as relevant conditions near a measuring reach affecting the measurement accuracy and stage-discharge relation, such as tributary jacking, backwater, flood plain, bank breach, ice dam backwater, etc., shall be observed and recorded on shore.

**B.5.4** When tidal current station is measured with a fixed hydrometric boat, the stage measurement of cross-section staff gauge at that time shall be added from the first measuring point on a vertical to the measuring point down to the maximum depth in each discharge measurement. When multiple verticals are measured with one boat, stage measurement shall be added to the first measuring point of each vertical. When round-trip measurement is adopted, stage measurement shall be added to the first measuring point of each vertical with two measurements. When slack tide is found, stage shall be observed at the same time.

## B.6 Check and maintenance of current meter

**B.6.1** Before each use of current meter, it is necessary to check whether the instrument is contaminated or deformed, the instrument rotates flexibly, and the contact wire and signal are normal.

**B.6.2** A commonly used current meter shall be comparatively gauged with standby current meter regularly in the use period, which shall be in accordance with the following requirements:

**1** The number of comparative gauging may be determined according to the performance of commonly used current meter, application duration, and the situation of flow velocity and sediment concentration in application period. When a current meter is actually used for 50h to 80h, it shall be comparatively gauged once.

**2** Comparative gauging should be carried out in the period of stable water regime and the location where flow velocity pulsation is small and flow direction consistent.

**3** Commonly used and standby current meters shall simultaneously measure flow velocity at a same measuring point depth at the same time, and the special U-shaped measuring frame may be used with the commonly used and standby current meters installed at both ends respectively. The net distance between two instruments shall not be less than 0.5m. During comparative gauging, the positions of the two instruments shall be exchanged.

**4** Comparative gauging point should not be close to river bottom, shore or location where the intensity of flow pulsation is large.

**5** Comparative gauging should not be carried out between propeller-type current meter and cup-type current meter.

**6** Each comparative gauging shall include more than 30 measuring points with large and small flow velocity and uniform distribution. If the relative deviation of comparative gauging is not more than 3% or not more than 5% with poor comparative gauging conditions, and a systematic error may be controlled within ± 1%, the commonly used current meter may continue to be used. The commonly used current meter exceeding the above-mentioned deviation value shall be stopped in use, cause identified and its impact on measured data analyzed.

**7** For stations without comparative gauging conditions, current meter shall be recalibrated after using for two years.

**8** If a current meter does not work properly or has other problems, it shall not be used. A current meter exceeding the verification period of more than two years shall also be sent for calibration even if it is not used.

**B.6.3** The maintenance of current meter shall be in accordance with the following requirements:

**1** After each use, current meter shall be cleaned immediately and lubricated according to the method specified in the instrument manual.

**2** When current meter is put into box, its rotor part shall be suspended.

**3** The parts of standby current meters in storage prone to rust shall be coated with butter.

**4** Instrument box shall be placed in a dry and ventilated place, kept away from high temperature and corrosive substances. Heavy objects shall not be stacked on instrument box.

**5** All parts and accessories of instrument and tools shall be returned to original place right after use.

**6** Instrument description, calibration charts and formulae shall be properly kept.

## B.7 Calculation of measured discharge

**B.7.1** The calculation of measured discharge in the free flow period shall meet the following requirements:

**1** The distance from initial point and depth of a vertical may be calculated according to calculation formula specified by measurement method.

**2** The flow velocity of a measuring point may be calculated by the number and duration of revolution, or looked up from current meter check list.

**3** If measured flow direction deflection angle is greater than 10° and those of all measuring points are recorded, the deflection angle shall be corrected before the calculation of mean flow velocity at a vertical, which shall be carried out according to the following formula:

$$V_N = V\cos\theta \tag{B.7.1-1}$$

where $V_N$ —flow velocity at a point normal to cross-section(m/s);

$V$ —measured flow velocity at a point(m/s);

$\theta$ —angle between flow direction and cross-section vertical.

**4** If there is no backflow on a vertical, mean flow velocity at a vertical shall be calculated according to the following formulae:

1) For the eleven-point method, mean flow velocity at a vertical shall be calculated according to the following formula:

$$V_m = \frac{1}{10}(0.5V_{0.0} + V_{0.1} + V_{0.2} + V_{0.3} + V_{0.4} + V_{0.5} + V_{0.6} + V_{0.7} + V_{0.8} + V_{0.9} + 0.5V_{1.0}) \tag{B.7.1-2}$$

2)For the five-point method, mean flow velocity at a vertical shall be calculated according to the following formula:

$$V_m=\frac{1}{10}(V_{0.0}+3V_{0.2}+3V_{0.6}+2V_{0.8}+V_{1.0}) \tag{B.7.1-3}$$

3)For the three-point method, mean flow velocity at a vertical may be calculated according to the following formulae:

$$V_m=\frac{1}{3}(V_{0.2}+V_{0.6}+V_{0.8}) \tag{B.7.1-4}$$

$$V_m=\frac{1}{4}(V_{0.2}+2V_{0.6}+V_{0.8}) \tag{B.7.1-5}$$

4)For the two-point method, mean flow velocity at a vertical shall be calculated according to the following formula:

$$V_m=\frac{1}{2}(V_{0.2}+V_{0.8}) \tag{B.7.1-6}$$

5)For the one-point method, mean flow velocity at a vertical may be calculated according to the following formulae:

$$V_m=V_{0.6} \tag{B.7.1-7}$$

$$V_m=KV_{0.5} \tag{B.7.1-8}$$

$$V_m=K_1V_{0.0} \tag{B.7.1-9}$$

$$V_m=K_2V_{0.2} \tag{B.7.1-10}$$

where $V_m$ — mean flow velocity at a vertical(m/s);

$V_{0.0}, V_{0.1}, V_{0.2}, \ldots, V_{1.0}$ — measured point flow velocity at 0.0, 0.1, 0.2, ..., 1.0 times depth, respectively (m/s);

$K, K_1, K_2$ — flow velocity coefficient at 0.5 times depth, water surface and 0.2 times depth, respectively(m/s).

**5** If there is backflow on a vertical, the backflow flow velocity shall be negative, and the graphical method may be used to measure mean flow velocity at a vertical. If there is backflow only on an individual vertical, the analysis method may be directly used to calculate mean flow velocity at a vertical.

**6** Segment area shall be delimited by the flow velocity-measuring vertical to divide wetted cross-section into several segments (Figure B. 7.1), which shall be calculated according to the following formula:

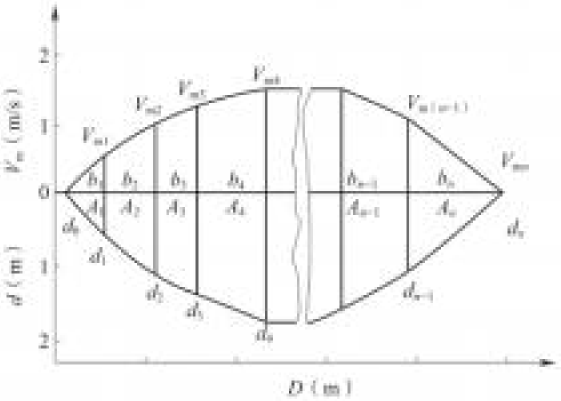



Figure B.7.1 Segment area calculation and division

$D$=distance from initial point(m)

$$A_i = \frac{d_{i-1} + d_i}{2} b_i \tag{B.7.1-11}$$

where $A_i$ — the $i$th segment area($m^2$);

$i$ — ordinal number of flow velocity-measuring verticals or sounding verticals, $i = 1, 2, \ldots, n$;

$d_i$ — actual depth of the $i$th vertical(m), if sounding and flow velocity measurement are not carried out simultaneously, application depth shall be calculated with adoption of river bottom elevation and stage during flow velocity measurement;

$b_i$ — cross-section width of the $i$th segment(m).

**7** The calculation of mean flow velocity at a segment shall be in accordance with the following requirements:

**1**) The mean flow velocity of the middle part of two flow velocity-measuring verticals shall be calculated according to the following formula:

$$\overline{V}_i = \frac{V_{m(i-1)} + V_{mi}}{2} \tag{B.7.1-12}$$

where $\overline{V}_i$ — mean flow velocity at a cross-section of the $i$th segment(m/s);

$V_{mi}$ — mean flow velocity at the $i$th vertical(m/s), where $i = 1, 2, \ldots, n-1$.

**2**) The mean flow velocity at a segment near shore or stagnant water shall be calculated according to the following formulae:

$$\overline{V}_1 = \alpha V_{m1} \tag{B.7.1-13}$$

$$\overline{V}_n = \alpha V_{m(n-1)} \tag{B.7.1-14}$$

where $\alpha$ — shoreside flow velocity coefficient.

**3**) The value of shoreside flow velocity coefficient $\alpha$ may be selected in Table B.7.1 according to shore conditions.

**Table B.7.1 Shoreside flow velocity coefficient $\alpha$**

| Shoreside condition | | $\alpha$ value |
|---|---|---|
| Water depth uniformly shallows to zero on sloping shore | | 0.67~0.75 |
| Steep shore | Uneven | 0.8 |
| | Smooth | 0.9 |
| Stagnant water edge at the junction of stagnant water and flowing water | | 0.6 |

Notes: 1 When calculating mean flow velocity of the bank or stagnant water edge, the above table may be used for the mean flow velocity at a vertical measured on the bank or stagnant water edge with a deep-water float or a combination of float and current meter.

2 If there is backflow on a cross-section, partial flow in backflow zone shall be negative.

**8** Segment discharge shall be calculated according to the following formula:

$$q_i = \overline{V}_i A_i \tag{B.7.1-15}$$

where $q_i$ — discharge of the $i$th segment($m^3$/s).

**9** Cross-section discharge shall be calculated according to the following formula:

$$Q = \sum_{i=1}^{n} q_i \tag{B.7.1-16}$$

where $Q$ — cross-section discharge($m^3$/s).

**B.7.2** If the continuous discharge measurement method is adopted, each cross-section discharge shall be calculated as follows:

**1** The first cross-section discharge may be calculated from the sounding and flow velocity-measuring records of the first vertical to the last vertical of the first measurement.

**2** The second cross-section discharge may be calculated from the sounding and flow velocity-measuring records of the second or third vertical to the last vertical of the first measurement and those of the first or second vertical of the second measurement. The ordinal number of measurement set is still the same as that of the previous set, but a semicolon is added in lower right corner according to the order of discharge calculation.

**3** The third and above cross-section discharges may be calculated by the above methods.

**4** The beginning and ending time of each discharge measurement shall be determined on the basis of the record time of the flow velocity measurement of selected verticals.

**B.7.3** When the partial vertical discharge measurement method is adopted, the cross-section discharge shall be calculated as follows:

**1** To calculate the mean flow velocity of the corresponding vertical according to the measured flow velocity of measuring points on some verticals at this time.

**2** According to the relation curve between stage and mean flow velocity at a vertical drawn with previous measured data, the mean flow velocity of remaining verticals on cross-section can be obtained with the stage observed this time.

**3** Segmental discharge and cross-section discharge are calculated according to the measured and checked mean flow velocity at a vertical.

**B.7.4** The calculation of measured discharge in the icy period shall be in accordance with the following requirements:

**1** The calculation of mean flow velocity at a vertical:

**1**) For the six-point method, it shall be calculated according to the following formula:

$$V_m = \frac{1}{10}(V_{0.0} + 2V_{0.2} + 2V_{0.4} + 2V_{0.6} + 2V_{0.8} + V_{1.0}) \tag{B.7.4-1}$$

**2**) For the three-point method, it shall be calculated according to the following formula:

$$V_m = \frac{1}{3}(V_{0.15} + V_{0.5} + V_{0.85}) \tag{B.7.4-2}$$

**3**) For the two-point method, it shall be calculated according to the following formula:

$$V_m = \frac{1}{2}(V_{0.2} + V_{0.8}) \tag{B.7.4-3}$$

**4**) For the one-point method, it shall be calculated according to the following formula:

$$V_m = K'V_{0.5} \tag{B.7.4-4}$$

where $V_{0.15}$, $V_{0.5}$, $V_{0.85}$ — flow velocity at effective times depth of 0.15, 0.5 and 0.85 (m/s);

$K'$ — half depth flow velocity coefficient in the icy period.

**2** Segment area shall be calculated according to Formula (B.7.1-11) of this code. The depth value $d$ in this formula shall be an effective depth on a vertical with immersed ice. If there is border ice or lead, depth on the same vertical at the junction of cover ice and free flow area is calculated by two kinds of values. When segment area below cover ice is calculated, an effective depth shall be used. When calculating the area of free flow is calculated, an actual depth shall be used. If the thickness of immersed ice on the vertical at the junction is less than 2% of effective depth, an actual depth may be used to calculate the two adjacent segment areas.

3 When discharge in the icy period is calculated, total cross-section area, immersed ice area, frazil slush area and area of channel cross-section shall be calculated separately. If there is an ice cover with intercalated water layers or there are several streams in a cross-section with inconsistent stages, the above-mentioned areas may not be calculated one by one. In the case of border ice or lead, they may be calculated in zones. Immersed ice area may be calculated according to the thickness of the immersed ice on each sounding vertical and the spacing of sounding verticals (Figure B.7.4), which shall be calculated according to the following formula:

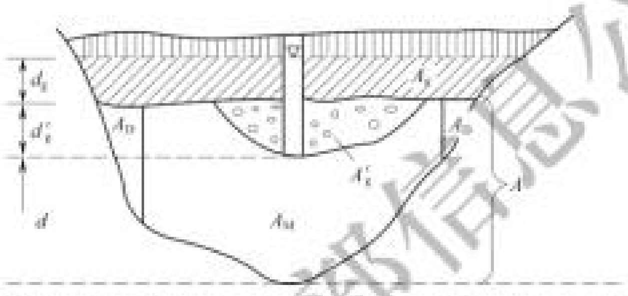


Figure B.7.4 Gauging cross-section during the freeze-up period

$A$–area of channel cross-section; $A_{St}$–cross-section area of flowing water; $A_D$–stagnant water area; $A_g$–immersed ice area; $A'_g$–frazil slush area; $d_g$–immersed ice thickness; $d'_g$–frazil slush thickness; $d$–effective depth

$$A_g = \frac{1}{2} d_{g0} b_0 + \frac{b_1}{2}(d_{g0} + d_{g1}) + \frac{b_2}{2}(d_{g1} + d_{g2}) + \cdots + \frac{b_n}{2}(d_{g(n-1)} + d_{gn}) + \frac{b_{n+1}}{2}(d_{gn} + d_{g(n+1)}) + \frac{1}{2} d_{g(n+1)} b_{n+2} \quad \text{(B.7.4-5)}$$

where $A_g$—immersed ice area ($m^2$);

$d_{g1}, d_{g2}, \ldots, d_{gn}$—immersed ice thickness on the first, second, ..., and $n$th sounding verticals measured from one bank to the other (m);

$d_{g0}, d_{g(n+1)}$—immersed ice thickness of ice base boundary (m), with the adoption of the measured value of ice base boundary, if it cannot be measured, the thickness of immersed ice in an ice hole nearest to ice base boundary may be used;

$b_1, b_2, \ldots, b_n, b_{n+1}$—distance from the bottom of border ice on the one side to the first sounding vertical, to the first and second sounding verticals, ..., to the last two sounding verticals, to the last sounding vertical and to the bottom of border ice on opposite bank (m);

$b_0, b_{n+2}$—distance from ice bottom to water surface on both banks. The position of water surface boundary may be found on a cross-section map according to stage.

4 The area of frazil slush may be calculated by Formula (B.7.4-5).

**B.7.5** When the acoustic Doppler current profiler method is used to measure discharge in the icy period, calculation shall be in accordance with the following requirements:

1 Mean flow velocity at each vertical may be measured by drilling frozen holes according to the full cross-section fixed vertical method in the free flow period.

2 A unit may be set and mean flow velocity at a vertical calculated according to depth. Vertical flow velocity test time shall not be less than 30s.

3 The flow velocity of blanking distance may be interpolated by the adoption of exponential flow velocity distribution, constant flow velocity distribution or other calibrated flow velocity distribution.

**4** Shoreside flow velocity coefficient may be selected for the calculation of bank discharge. It may be determined by comparative gauging or according to cross-section shape in Table B.7.5.

**Table B.7.5 Shoreside flow velocity coefficient $\alpha$**

| Shoreside condition | | $\alpha$ |
|---|---|---|
| Water depth uniformly shallows to zero on sloping shore | | 0.67–0.75 |
| Steep shore | Uneven | 0.8 |
| | Smooth | 0.9 |
| Stagnant water edge at the junction of stagnant water and flowing water | | 0.6 |

**B.7.6** The determination of flow velocity coefficients shall be in accordance with the following requirements:

**1** A half-depth flow velocity coefficient in the free flow period shall be calculated by a vertical flow velocity distribution curve, which is plotted with velocimetry data measured by the five-point method. The velocity of 0.5 times depth is interpolated. Compared with mean flow velocity at a vertical, it is determined after several analyses.

**2** A half-depth flow velocity coefficient in the freeze-up period shall be determined by the analysis of velocimetry data measured by the six-point or three-point method.

**3** The flow velocity coefficient of 0.2 times depth in the free flow period may be determined by the analysis of the velocimetry data of the hydrometric station measured by the two-point or multi-point method.

**4** The flow velocity coefficient on water surface in the free flow period shall be determined by the analysis of velocimetry data measured by the multi-point method or other flow velocity data of additional water surface measurement, or analyzed and calculated according to measured data such as surface slope, river bed roughness, etc.

**B.7.7** The calculation methods of measured tidal discharge shall be in accordance with the following requirements:

**1** For the selection of cross-section data, the results of each channel cross-section shall be plotted. If water surface width is less than 200m and the deviation of relation points of stage and area on relation curve is within ±3%, or if water surface width is more than 200m and the deviation of relation points of stage and area on relation curve is within ±5%, previous large cross-section results may still be used. If the above tolerance is exceeded, newly measured cross-section results shall be used. If one bank of measured channel cross-section is silted and the other bank scoured deeply, the cross-section shall be divided into the right and left parts for area calculation and comparison.

**2** The calculation of mean flow velocity at a vertical shall be in accordance with the following requirements:

**1)** The calculation formula of mean flow velocity at a vertical in tidal reach measured by the six-point, three-point or two-point method shall be the same as that in non-tidal reach.

**2)** When the revised isobath-velocity method is adopted for measurement, the velocity of each measuring point for round-trip measurement shall be arithmetic mean value.

**3)** When the flow direction of each measuring point at a vertical is inconsistent, the algebraic sum of velocity of each measuring point shall be taken to calculate mean flow velocity at a vertical.

**3** The calculation of mean flow velocity at a segment shall be in accordance with the following requirements:

**1**) When more than 3 verticals are measured in tidal reach, the mean flow velocity of a segment may be calculated by the calculation method of non-tidal reach.

**2**) When the flow directions of the verticals on the both sides of the same segment is inconsistent, the mean flow velocity at a segment shall be the mean value of the flow velocity algebraic sum of two verticals.

**3**) Shoreside flow velocity coefficient shall be determined by test. If the shapes of left and right banks are different, the coefficient shall be determined separately. If there is no test data, shoreside flow velocity coefficient $a$ may be selected from Table B.7.5 of this code according to the shape and flatness of shoreside.

**4** The segment area of tidal reach should be divided into several parts according to large cross-section calculation table, the corresponding segment areas of stages at all gradation calculated and drawn into a relational chart with stage, and then directly checked and calculated on the chart according to discharge measurement stage.

**5** The calculation method of segment discharge and cross-section discharge shall be in accordance with the following requirements:

**1**) The segment discharge of tidal reach shall be the product of mean flow velocity at a segment and the segment area.

**2**) If more than 3 verticals are measured in tidal reach, cross-section discharge may be determined by multiplying the mean flow velocity at a cross-section by the cross-section area when the mean flow velocity at a cross-section is converted by correlation.

**6** The calculation method of the tidal volume of flood and ebb tides and the net outflow or inflow:

**1**) The calculation of tidal discharge shall be delimited by the occurrence time of slack tide (Figure B.7.7). The volumes of flood tidal and ebb tidal shall be calculated according to the following formulae:

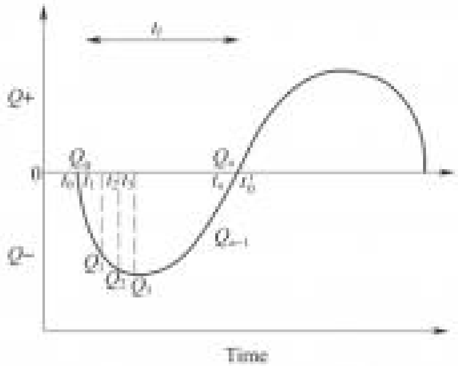



Figure B.7.7 Tidal volume calculation of flood and ebb tides

$t_0$-time at slack tide of ebb tide; $t_0'$-time at slack tide of flood tide; $t_f = t_1 + t_2 + t_3 + \cdots + t_n$

$$W' = \frac{1}{2}Q_1 t_1 + \frac{Q_1 + Q_2}{2} t_2 + \cdots + \frac{1}{2} Q_{n-1} t_n \tag{B.7.7-1}$$

$$W'' = \frac{1}{2}Q'_1 t_1 + \frac{Q'_1 + Q'_2}{2} t_2 + \cdots + \frac{1}{2} Q'_{n-1} t_n \tag{B.7.7-2}$$

where $W'$ — flood tidal volume($m^3$);

$W''$ — ebb tidal volume($m^3$);

$Q_1, Q_2, \ldots, Q_{n-1}$ — flood tidal volume measured successively from the slack tide of ebb tide to that flood tide, respectively($m^3/s$);

$Q'_1, Q'_2, \ldots, Q'_{n-1}$ — ebb tidal volume measured successively from the slack tide of flood tide to that ebb tide, respectively($m^3/s$);

$t_1, t_2, \ldots, t_n$ — time interval between measurements(s).

**2**) The net outflow(inflow)discharge volume of the same tidal current period shall be calculated according to the following formula:

$$W = W'' - W' \tag{B.7.7-3}$$

where $W$—net outflow (inflow) discharge volume ($m^3$); if the calculation result is positive, it is net outflow discharge volume; if the calculation result is negative, it is net inflow discharge volume.

**B.7.8** The equivalent stage calculation of measured discharge shall be in accordance with the following requirements:

**1** Arithmetic mean method. The change in area of channel cross-section caused by the change of stage during discharge measurement shall not exceed 5% when mean depth is greater than 1m, or not exceed 10% when mean depth is less than 1m. The arithmetic mean value of two stages at the beginning and ending of discharge measurement may be taken as an equivalent stage. When flow measurement process crosses the peak or bottom of stage, the arithmetic mean value of measured or extracted stages of several times shall be taken as an equivalent stage.

**2** Weighted mean method. When the change in area of channel cross-section during discharge measurement exceeds the range of Item 1 of this article, equivalent stage shall be calculated according to the following formula:

$$Z_m = \frac{b'_1 V_{m1} Z_1 + b'_2 V_{m2} Z_2 + \cdots + b'_n V_{mn} Z_n}{b'_1 V_{m1} + b'_2 V_{m2} + \cdots + b'_n V_{mn}} = \frac{\sum_1^n b'_i V_{mi} Z_i}{\sum_1^n b'_i V_{mi}} \tag{B.7.8}$$

where $Z_m$—equivalent stage(m);

$b'_i$—width of water surface represented by flow velocity-measuring vertical(m), which should adopt the mean width of the two segments on the both sides of the vertical, or the sum of the distance from water edge to the vertical plus a half of the distance from the vertical to next vertical for shoreside vertical;

$V_{mi}$—mean flow velocity at the $i$th vertical(m/s);

$Z_i$—measured or interpolated basic staff gauge stage at the time of flow velocity measurement at the $i$th vertical (m).

**3** Other methods. If the difference of equivalent stages calculated by other methods and by the weighted mean method is less than 1cm, other methods may be used.

**B.7.9** The calculation of stage fluctuation rate and surface slope in the free flow period shall be in accordance with the following requirements:

**1** Stage fluctuation rate shall be the mean fluctuation rate in discharge measurement period, and may be calculated by dividing the difference of stages at the ending and beginning of discharge measurement by the total duration of discharge measurement. Positive value shall be taken when flooding and negative value taken when ebbing. When discharge measurement process crosses the peak and bottom of stage, it may not be calculated.

**2** Surface slope shall be calculated by dividing the mean stage difference between upstream and downstream slope staff gauges by the distance between two slope cross-sections.

### B.8 Width measurement and sounding methods of cross-section

**B.8.1** The following methods may be used for cross-section width measurement:

**1** The direct ranging method. The distance from initial point of each vertical is directly measured by electronic total station, laser distance gauge, satellite positioning system and other ranging instruments.

**2** The building sign method. Signs shall be set up on river-crossing structures and comply with the following requirements:

**1**) Equidistant scale signs should be adopted. If river width is greater than 50m, the minimum spacing of signs may be 1m. If river width is less than 50m, the minimum spacing may be 0.5m. At an integral multiple of every 5m, the signs of different colors shall be used to distinguish.

**2**) For hydrometric stations with a fixed sounding and flow velocity-measuring vertical, a sign may be set only at the fixed vertical. The ordinal number of the sign must be consistent with that of the vertical, and marked in different colors or numbers.

**3**) The first sign shall face the starting point of a cross-section stake, and its reading is zero. If it is impossible to face the starting point of the cross-section stake, the first sign may be adjusted to the position with a distance of an integral multiple of each meter away from the starting point of the cross-section stake, and the reading is the distance from initial point of the position.

**4**) The theodolite angular intersection method shall be used for inspection once or twice a year under the conditions that meet the requirements of field application. When cable expansion or sag changes, original sign shall be reset, or its distance from initial point corrected.

**5**) For river-crossing cables with unfixed span and sag (lifting type), signs should not be set on the cables.

**3** The ground sign method. It may adopt the radiation line method, the directional line method, the similar triangle intersection method, the floats type sign method in river, the fixed sign method on river shore, etc., which shall be in accordance with the following requirements:

**1**) The top of the fixed sign on river shore shall be higher than the highest flood stage over the years.

**2**) At the time of the determination of the distance from initial point of sounding and flow velocity-measuring vertical, the positioning point on a hydrometric boat shall be located on gauging cross-section vertical.

**3**) Signs shall be inspected once a year. If the signs are damaged, they shall be corrected or supplemented in time.

**4** The counter ranging method. The application of the counter ranging method shall be in accordance with the following requirements:

**1**) A counter shall be calibrated and compared with the distance from initial point measured by the theodolite angular intersection method. The number of comparison points shall not be less than 30 and be evenly distributed on the cross-section. The positioning error of a vertical shall not exceed 0.5% of river width, and absolute error not exceed 1m. If it exceeds the above error range, it shall be calibrated again.

**2**) After each measurement, overhead crane shall be driven back to the zero point of the distance from initial point of cross-section and check whether the counter returns to zero. If zeroing error exceeds 1% of river width, causes shall be found and ranging result corrected.

**3**) A comparative gauging test shall be carried out to counter once a year. When the sag of main cable is adjusted and elliptical type weight, circulating cable, lifting cable, sensing wheel and signal devices replaced, calibration shall be carried out in time with comparative gauging.

**5** The instrument intersection methods. The instrument intersection methods include the horizontal intersection method of theodolite angle measurement, the polar coordinate method, the flat panel meter intersection method, the sextant intersection method, etc. The instrument intersection methods shall be in accordance with the following requirements:

**1**) When the distance from initial point of vertical and stake is measured with theodolite and flat panel meter, the instrument shall be calibrated once with alignment to the original rear view point after the last vertical or stake is observed. Measurement may be ended when it is determined that the instrument has not changed.

**2**) When a sextant is used to measure the distance from initial point of a vertical, two signs on one bank of a gauging cross-section shall be first aligned, so that the positioning point on a hydrometric boat is located on cross-section vertical.

**3**) Measuring signs shall be inspected once a year. If a sign is damaged, it shall be corrected or reset in time.

**6** The direct measurement method. When distance is measured, attention shall be paid to keeping a steel ruler or leather tape horizontal between two verticals or stakes.

**B.8.2** The following methods may be used for sounding:

**1** Ultrasonic sounding. The application of ultrasonic sounder for sounding shall be in accordance with the following requirements:

**1**) An ultrasonic sounder shall be calibrated on site before use. The calibration points should not be less than 3 and shall be distributed at different positions of depth.

**2**) When sounding transducer is at a distance from water surface, the measured or recorded depth shall be corrected for the depth of the transducer into water. When a large horizontal distance between transmitting transducer and receiving transducer makes the difference between ultrasonic propagation distance and vertical distance exceed 2% of the vertical distance, slant distance correction shall be made.

**3**) Before sounding, water temperature shall be observed at a depth of not less than 1m in flowing water, and acoustic velocity shall be corrected according to water temperature.

When a digital display sounder without data processing function is used, more than 5 consecutive readings shall be taken for each sounding with the mean value taken.

**2** Elliptical type weight sounding. The use of elliptical type weight sounding shall be in accordance with the following requirements:

1) When elliptical type weight is used for sounding on a cableway, water surface and river bottom annunciators shall be installed on the elliptical type weight. When elliptical type weight is used for sounding on a boat, only river bottom annunciator may be installed.

2) The size of wire rope for suspending elliptical type weight shall be determined according to depth, flow velocity, the weight of elliptical type weight and the load capacity of river crossing and lifting equipment.

3) The direct reading method, vernier reading method, counter counting method, etc. may be used to measure water depth. When a counter is used to measure the depth, the calibration of sounding counter, sounding correction number, and depth comparative gauging shall be carried out. For the permissible error of depth comparative gauging, relative random uncertainty shall not exceed 2% if river bottom is relatively flat or depth greater than 3m, and relative random uncertainty shall not exceed 4% if river bottom is uneven or depth less than 3m. Relative systematic error shall be controlled within ±1%. If depth is less than 1m, absolute error shall not exceed 0.05m. The number of comparative gauging verticals at different depth, which shall be evenly distributed, shall not be less than that of sounding verticals at a same stage. If comparative gauging results exceed the above tolerance range, causes shall be identified and corrected. When multiple types of elliptical type weight sounding are used, they shall be calibrated separately.

4) Before each sounding, suspension cableway (lifting rope), elliptical type weight suspension, wire, annunciator, etc. shall be carefully checked. If problems are found, they shall be eliminated in time. The deflection angle of suspension cableway shall be read and recorded during sounding, and the deflection angle of sounding results corrected according to Section B.9 of this code.

5) The times of measurement and the permissible error range of each vertical depth shall comply with Section B.8 of this code for sounding weight.

6) An inspection shall be conducted for the signs or counters on the suspension cableway by comparative gauging once a year. When the sag of main cable is adjusted and elliptical type weight, circulating cable, lifting cable, sensing wheel and signal devices replaced, the counter shall be calibrated and compared in time.

**3** Sounding of sounding rod. The use of sounding rod shall be in accordance with the following requirements:

1) Scale on sounding rod shall be accurate to 1% of the depth at different depth readings.

2) For cross-sections with relatively flat river bottom, the depth of each vertical shall be continuously measured twice. If the difference between two measured depths does not exceed 2% of the minimum depth value, the mean value of two depth readings shall be taken. If the difference between two measured depths exceeds 2%, measurement shall be added, and the mean value of two sounding results that meet the tolerance of 2% shall be taken. If multiple measurements fail to meet the requirement of tolerance of 2%, the mean value of multiple sounding results may be taken.

3) For cross-sections with uneven river bottom or large waves and verticals at a depth of less than 1m, tolerance is controlled by 3%. For a cross-section of river bottom composed of ripraps or large pebbles and gravels, five points shall be measured at a sounding vertical,

upstream and downstream of the vertical, and at the left and right sides of the vertical. The distance between surrounding measuring points and center point should be 0.2m for small rivers and 0.5m for large rivers, and the mean value of the depth readings of the five points shall be taken as the measuring point depth.

**4** Sounding of sounding weight. The application of sounding weight shall be in accordance with the following requirements:

**1**) Scale on measuring line shall be set when the measuring line is immersed in water and naturally straightened by the sounding weight.

**2**) The depth of each vertical shall be continuously measured twice. The difference between the two measured depths does not exceed 3% and 5% of the minimum depth value for a cross-section with relatively flat river bottom and uneven river bottom, respectively. The mean value of two depth readings shall be taken. If the depth difference between two measurements exceeds the above tolerance, measurement shall be added, and the mean value of two sounding results within the tolerance shall be taken. If multiple measurements fail to meet the tolerance requirements, the mean value of multiple sounding results may be taken.

**3**) A hydrometric station shall have 1 or 2 standby sounding weights with measuring rope. When a sounding weight is easy to be stuck and lost at a cross-section composed of ripraps, standby sounding weights with measuring rope should not be less than 2.

**4**) Before and after the flood season every year, the scale of measuring line shall be checked. When the scale of measuring rope is inconsistent with the length of checking ruler, measured depth shall be corrected according to actual situation. If measuring rope is worn out or with unclear scale, it shall be replaced or replenished in time.

### B.9 Correction method of deflection angle of suspension cable

**B.9.1** For the measurement of the deflection angle of suspension cable, a sector protractor may be used to directly measure and read the deflection angle when elliptical type weight sounding is used on hydrometric boat, bridge and cable car. When elliptical type weight on cableway is used for sounding, theodolite, telescope or other measures shall be used to measure and record deflection angle value.

**B.9.2** If the deflection angle of suspension cable is greater than 10°, deflection angle shall be corrected. The correction of wet line length shall be calculated according to the following formulae:

$$L_H = H\int_0^1 \sqrt{1+(\varphi_1 \tan\theta)^2}\, d\eta \tag{B.9.2-1}$$

$$K_H = \frac{\Delta L}{L_H} = \frac{L_H - H}{L_H} = 1 - \frac{1}{\int_0^1 \sqrt{1+(\varphi_1 \tan\theta)^2}\, d\eta} \tag{B.9.2-2}$$

$$\varphi_1 = 1 - \frac{\eta\left(1 - \frac{P}{3}\eta^2\right)}{\left(1 - \frac{P}{3}\right) + \frac{\beta}{H}(1-P)} \tag{B.9.2-3}$$

where $L_H$ — wet line length (m);

$H$ — water depth (m);

$\theta$ — deflection angle of the suspension cableway (°), which refers to the included angle between suspension cable fulcrum along suspended tangent and plumb line;

$\eta$—relative depth;

$K_H$—correction coefficient;

$\Delta L$—value of wet line correction(m);

$P$—flow velocity distribution parameter;

$\beta$—impulse parameter.

**B.9.3** Impulse parameter $\beta$ shall be calculated in accordance with the following requirements:

**1** If there is a wire, it shall be calculated according to the following formula:

$$\beta=0.3\frac{G^{\frac{2}{3}}}{d'} \tag{B.9.3-1}$$

**2** If there is no wire, it shall be calculated according to the following formula:

$$\beta=0.4\frac{G^{\frac{2}{3}}}{d'} \tag{B.9.3-2}$$

**3** If elliptical type weight is cast from iron, it shall be calculated according to the following formula:

$$\beta=0.5\frac{G^{\frac{2}{3}}}{d'} \tag{B.9.3-3}$$

where $G$—weight of elliptical type weight(kg);

$d'$—diameter of suspension cable actually used during sounding(mm).

**B.9.4** Sounding deflection angle correction shall be in accordance with the following requirements:

**1** For the direct observation of the length of wet line, the correction value of wet line length shall be checked and calculated according to Appendix E of this code if deflection angle is greater than 10°.

**2** The length of wet line observed with counter or by the vernier counting method shall be corrected according to the following requirements:

**1)** When deflection angle is greater than 10° and the ratio of elevation difference ($Z_\Delta$) between suspended fulcrum and water surface to measured depth is less than the value of air line length correction conditions specified in Table B.9.4, air line length may not be corrected, but wet line length shall be corrected.

**Table B.9.4 Correction conditions of air line length**

| Deflection angle of suspension cable with elliptical type weight at river bottom | 10° | 15° | 20° | 25° | 30° | 35° | 40° |
|---|---|---|---|---|---|---|---|
| Ratio of elevation difference between suspended fulcrum and water surface to measured depth | 0.64 | 0.28 | 0.16 | 0.10 | 0.06 | 0.04 | 0.03 |

**2)** When deflection angle is greater than 10° and the ratio of elevation difference between suspended fulcrum and water surface to measured depth is greater than the value of air line length specified in Table B.9.4, air line length and wet line length shall be corrected.

**3)** When deflection angle is less than 10° and the correction value of air line length exceeds 1% to 2% of depth, wet line length may not be corrected, but air line length shall be corrected.

**4)** The corrected value of air line length shall be calculated according to the following formula:

$$\Delta_a=Z_\Delta(\sec\theta-1) \tag{B.9.4-1}$$

where $Z_{\Delta}$—elevation difference between suspended fulcrum and water surface(m);

$\Delta_d$—corrected value of air line length(m);

$\theta$—deflection angle of suspension cable when elliptical type weight is lowered to river bottom.

**3** Corrected depth shall be calculated according to the following formula:

$$d = L_x - \Delta_d - \Delta_w \tag{B.9.4-2}$$

where $d$— corrected depth(m);

$L_x$— depth measured and recorded by counter when elliptical type weight is lowered from water surface to river bottom(m);

$\Delta_w$— corrected value of wet line length(m).

**B.9.5** The deflection angle correction of cableway gauging shall be in accordance with the following requirements:

**1** The corrected value of displacement caused by suspension cableway deflection and fulcrum displacement shall be calculated according to the following formulae:

$$\Delta_t = \frac{1}{2} m_0 f_x (\tan^2\theta - \tan^2\theta_0) \tag{B.9.5-1}$$

$$m_0 = \left(1 + 4\frac{f_m}{L}\right) k^2 \tag{B.9.5-2}$$

$$k = \frac{G}{\frac{qL}{2} + p_x} \tag{B.9.5-3}$$

$$p_x = F + \frac{q'L}{2} + G\left(1 - 4\frac{f_m}{L}\right) \tag{B.9.5-4}$$

where $\Delta_t$— displacement correction value(m);

$\theta_0$— deflection angle of suspension cable (°) when elliptical type weight is lowered to water surface;

$f_x$— loading sag at the end point of main cable $x$(m);

$m_0$— cableway parameter;

$f_m$— maximum loading sag of main cable(m);

$L$— span length of main cable(m);

$p_x$— concentrated load(kg);

$q$— weight per unit length of main cable(kg/m);

$k$— deflection angle coefficient;

$q'$— weight per unit length of working cable(kg/m);

$F$— weight of overhead crane and accessories(kg).

**2** When deflection angle at water surface is greater than 5°, the air line of cableway sounding shall be corrected according to the following formula:

$$\Delta'_d = Z_{\Delta}(\sec\theta - \sec\theta_0) \tag{B.9.5-5}$$

where $\Delta'_d$—corrected value of air line for cableway gauging(m).

**3** The total correction value of cableway gauging depth shall be corrected according to the following formula:

$$d = L_x - \Delta'_d - \Delta_w - \Delta_t \tag{B.9.5-6}$$

where $d$—corrected value of air line of cableway gauging(m).

4 Under difficult conditions such as large depth, rapid flow and many floating objects, secondary cable shall be used for deflection correction. The position of the secondary cable shall be appropriate. The lowest point of the secondary cable should not be too high above design flood level, and the horizontal distance between main cable and secondary cable not be too close. In addition, the weight of elliptical type weight should not be too small. It shall be ensured that the sag of lifting cable and circulating cable does not exceed the requirements specified in the current professional standard SL 443 *Specification for Hydrometric Cableway Surveying*, and the deflection angle may be controlled within permissible range of accuracy under the action of pulling force.

**B.9.6** The deflection angle correction of the location of flow velocity measuring point shall be in accordance with the following requirements:

1 The length of wet line at water surface and river bottom measuring points may be directly observed, while that at other measuring points shall be equal to the product of relative depth of point and total length of the wet line. The length of wet line at the measuring points of ice bottom, frazil slush bottom and river bottom in the icy period may be directly observed. The length of wet line at other measuring points shall be equal to the product of relative depth calculated from the ice bottom or frazil slush bottom of the point and total length of effective wet line, plus the sum of total thickness of immersed ice and frazil slush.

2 When reading is indicated by a counter or vernier, and the deflection angle of suspension cable is less than 10° or the ratio of elevation difference between suspended fulcrum and water surface to measured depth is less than the value specified in Table B.9.4 of this code, the positioning method of measuring point is the same as that in Item 1 of this article.

3 When reading is indicated by a counter or vernier, the deflection angle of suspension cable is greater than 10° and the ratio of suspended fulcrum and water surface to measured depth is greater than the value specified in Table B.9.4 of this code, the "trial and error method" may be used to position measuring point. When the flow velocity measurement sequence is raised from river bottom to water surface, counter or vernier reading for transferring the position of measuring point shall be initially determined according to the difference of wet line length at each adjacent measuring point, and the instrument transferred to predetermined measuring point. Then the deflection angle of suspension cable is re-measured and compared with previous measuring point. When the comparison difference exceeds the permissible range of accuracy, air line correction difference corresponding to two deflection angles shall be checked and the instrument position adjusted. The above procedure shall be repeated several times until the requirements of full accuracy are met.

4 The "one time positioning method" may be used for the flow velocity measurement positioning of hydrometric cableway. When the counter depth of measuring point is determined, possible changes of deflection angle at measuring point and possible vertical offset distance shall be pre-corrected.

**B.9.7** The values related to deflection angle correction may be found in the table of deflection angle correction in Appendix E of this code.

## B.10 Method of determining gauging cross-section direction

**B.10.1** For flow velocity and flow direction measurement, 5 to 15 verticals shall be uniformly arranged on selected cross-section according to river width. Current meter is used to measure the mean flow velocity at each vertical, and flow-direction meter, flow-direction instrument or mooring float used to measure the water surface flow direction of each vertical instead of vertical flow direction. For conditional tidal current station, velocity and flow direction meter may be used to measure the flow velocity and direction of measuring point at each vertical in rapidly falling period, and the mean flow velocity and flow direction at a vertical calculated with vector method.

**B.10.2** Flow direction measurement shall be in accordance with the following requirements:

**1** Flow direction shall be measured by flow direction meter according to its manual. When direct reading instantaneous flow direction meter is used, reading shall be observed continuously for 3 times at equal time interval if the reading is unstable, and mean value shall be taken.

**2** If flow direction is measured by flow direction instrument, rotating shaft may be installed on suspension rods or suspension frames in parallel. The dial at the upper end of the rotating shaft shall be perpendicular to the rotating shaft, and lower tail wing able to rotate freely with flow direction. The mean value of three consecutive observations shall be taken.

**3** If flow direction is measure by a mooring float, the float shall be tied on a soft thin line of 20m to 30m long and released from flow velocity-measuring vertical. After the thin line is tightened, a sextant or protractor is used to measure flow direction deflection angle. The mean value of three consecutive measurements shall be taken.

**B.10.3** If the cross-section control method is used to measure flow plane map, the following requirements shall be complied with:

**1** Before measurement, 1 or 2 cross-sections shall be arranged parallel to a cross-section to be set up or checked at the upstream and downstream with equidistance, and the spacing among cross-sections shall not be less than 20 times mean flow velocity at a cross-section. If current meter gauging cross-section coincides with the medium cross-section of float, the upstream and downstream cross-sections of float may be adopted or another two upstream and downstream parallel cross-sections may be arranged with equidistance from medium cross-section.

**2** During measurement, 5 to 15 water surface floats shall be evenly placed at the upstream of measuring cross-section according to river width. A theodolite or a flat plane meter is used to measure the distance from initial point of each float flowing through each cross-section, and the corresponding time is recorded. Basic staff gauge stage is observed once at the beginning and ending of measurement respectively. When measurement process possibly cross flood peak or bottom, the times of observation shall be increased.

**3** The production of water surface float shall comply with the requirements stipulated in Article C.2.1 of this code.

**B.10.4** If the time control method is used to measure flow plane map, the following requirements shall be complied with:

**1** On the gauging cross-section to be set up or checked, 5 to 15 water surface floats shall be evenly dropped from the upstream according to river width, two theodolites or flat plane meters used to simultaneously intersect the position of each float floating in a reach after a certain time interval, and the corresponding time shall be recorded.

**2** The production of water surface float and the determination of times of stage observation shall be in accordance with Article B.10.3 of this code for the measurement of flow plane map by the cross-section control method.

**B.10.5** The calculation method for determining cross-section direction by measuring flow velocity and flow direction shall be in accordance with the following requirements:

**1** The distance from initial point of each flow velocity-measuring vertical shall be drawn on the initially selected gauging cross-section (AC), and measured flow direction drawn with a dotted line (Figure B.10.5).

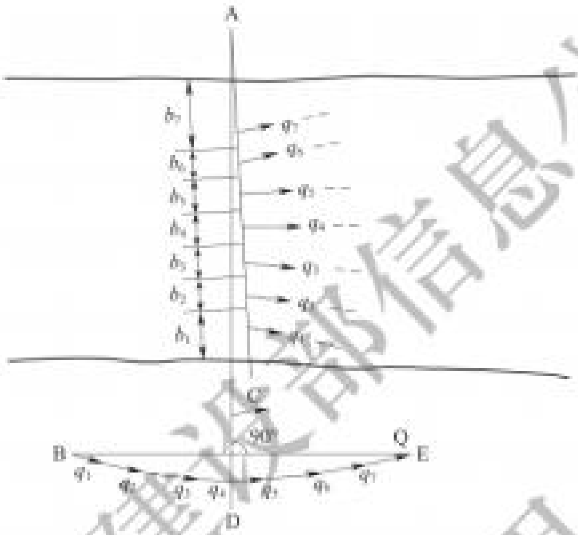



Figure B.10.5 Determination of gauging cross-section direction by measuring flow velocity and flow direction

**2** The mean value of depth on each two adjacent boundaries is calculated and taken as the distance from initial point of segment area boundary.

**3** The mean value of depth on two adjacent boundaries is adopted as the segmental mean depth of flow velocity-measuring vertical. The difference between the distances from initial point of two boundaries is taken as the corresponding segment width, and segment area is obtained by multiplying segment width $b_1, b_2, \ldots, b_7$ with the corresponding mean depth.

**4** Each segmental discharge $q_1, q_2, \ldots, q_7$ is obtained by multiplying each mean flow velocity at a vertical with the corresponding segment area, and the flow direction of same flow velocity-measuring vertical expressed as a vector value, which is drawn on the plane map at a certain scale.

**5** At the bottom of the map, the vector values of each segmental discharge are connected into vector polygon by the method of pushing parallel lines, and the resultant vector line BE is the mean flow direction of the cross-section.

**6** Line AD perpendicular to the resultant vector line BE is the gauging cross-section vertical.

**B.10.6** If the vector method is adopted, mean flow velocity and flow direction at a vertical shall be calculated according to the following methods:

**1** The flow velocity of measuring point is decomposed into the velocity component $V_{EW}$ in east-west direction and the velocity component $V_{NS}$ in north-south direction, which are calculated according to the following formulae:

$$V_{iEW} = V_i \sin\alpha_i \qquad \text{(B.10.6-1)}$$

$$V_{iNS} = V_i \sin\alpha_i \qquad \text{(B.10.6-2)}$$

where $V_i$— layered measured flow velocity;

$\alpha_i$— layered true north azimuth;

$V_{iEW}$—layered flow velocity in east-west direction;

$V_{iNS}$—layered flow velocity in south-north direction.

**2** The mean flow velocity at a vertical is decomposed into mean flow velocity at a vertical $V_{Em}$ in east-west direction and mean flow velocity at a vertical $V_{Nm}$ in north-south direction, which are calculated according to the following requirements:

**1**) For the six-point method, they shall be calculated according to the following formulae:

$$V_{Em}=\frac{1}{10}(V_{E0.0}+2V_{E0.2}+2V_{E0.4}+2V_{E0.6}+2V_{E0.8}+V_{E1.0}) \quad (B.10.6\text{-}3)$$

$$V_{Nm}=\frac{1}{10}(V_{N0.0}+2V_{N0.2}+2V_{N0.4}+2V_{N0.6}+2V_{N0.8}+V_{N1.0}) \quad (B.10.6\text{-}4)$$

**2**) For the three-point method, they shall be calculated according to the following formulae:

$$V_{Em}=\frac{1}{3}(V_{E0.2}+V_{E0.6}+V_{E0.8}) \quad (B.10.6\text{-}5)$$

$$V_{Nm}=\frac{1}{3}(V_{N0.2}+V_{N0.6}+V_{N0.8}) \quad (B.10.6\text{-}6)$$

**3**) For the two-point method, they shall be calculated according to the following formulae:

$$V_{Em}=\frac{1}{2}(V_{E0.2}+V_{E0.8}) \quad (B.10.6\text{-}7)$$

$$V_{Nm}=\frac{1}{2}(V_{N0.2}+V_{N0.8}) \quad (B.10.6\text{-}8)$$

**4**) For the one-point method, they shall be calculated according to the following formulae:

$$V_{Em}=V_{E0.6} \quad (B.10.6\text{-}9)$$

$$V_{Nm}=V_{N0.6} \quad (B.10.6\text{-}10)$$

**3** Mean flow velocity and flow direction at a vertical shall be calculated according to the following formulae:

$$V_m=\sqrt{V_{Em}^2+V_{Nm}^2} \quad (B.10.6\text{-}11)$$

$$\alpha_m=\arctan\frac{V_{Em}}{V_{Nm}} \quad (B.10.6\text{-}12)$$

where $V_{Nm}$—mean flow velocity at a vertical in south-north direction;

$V_{Em}$—mean flow velocity at a vertical in east-west direction;

$V_m$—mean flow velocity at a vertical;

$\alpha_m$—mean flow direction at a vertical (determined according to specific quadrants).

**B.10.7** The calculation method for determining the cross-section direction by measuring flow plane map with the cross-section control method shall be in accordance with the following requirements:

**1** On the plane map of hydrometric station, connect the intersection points of each float and each cross-section shall be connected into broken lines with dotted lines in sequence (Figure B.10.7). If there are small longitudinal variation and uniform transverse variation of flow velocity and flow direction in a cross-section to be set up or checked and its vicinity, the cross-section may be selected as a gauging cross-section. If there are large longitudinal variation and non-uniform transverse variation of flow velocity and flow direction in a cross-section to be set up or checked and its vicinity, other appropriate cross-sections shall be selected on the map.

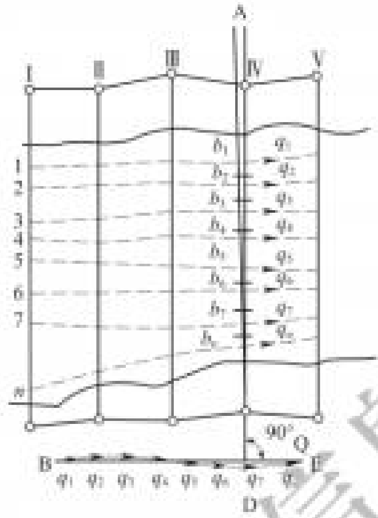



Figure B.10.7 Cross-section control method

**2** For the cross-section control method, the segment area and segment virtual discharge of a gauging cross-section to be set up are calculated according to the calculation method of determining the cross-section direction by measuring flow velocity and flow direction. Float flow velocity may be calculated by dividing the linear distance between two intersection points of the upstream and downstream adjacent cross-sections of float by operation duration, and the vector line of segment virtual discharge drawn according to appropriate proportion. The direction of the vector line is parallel to the line connecting the two intersection points of the float at the upstream and downstream adjacent cross-sections.

**3** The vector values of each segment virtual discharge are connected into a vector polygon by pushing parallel lines, and resultant vector line BE determined. Line AD which is perpendicular to Line BE is selected as cross-section vertical.

**B.10.8** The calculation method for determining the cross-section direction by measuring flow plane map with the time control method shall be in accordance with the following requirements:

**1** The operation route of each float is drawn on the plane map of hydrometric station, and the time of intersection indicated (Figure B.10.8).

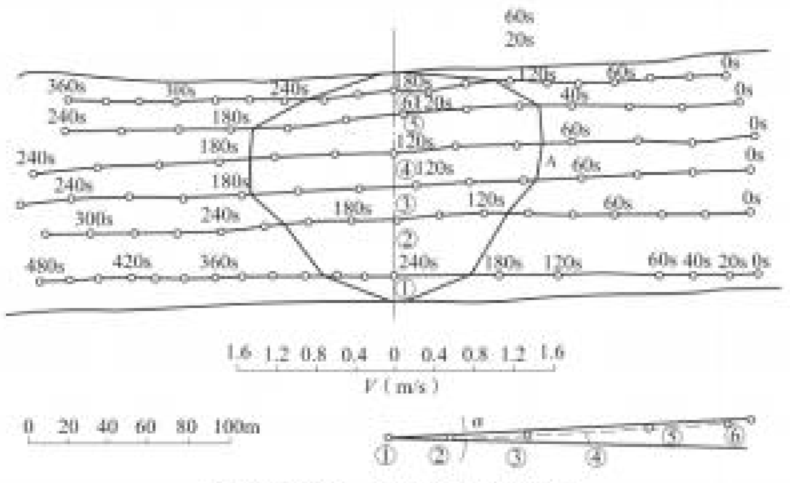



Figure B.10.8 Time control method

**2** On the preliminary flow plane map, a gauging cross-section with uniform transverse variation and small longitudinal variation of flow velocity and flow direction is selected, and the time of each float passing through the cross-section calculated by interpolation indicated.

**3** On the operation route of each float, the points of a certain time interval from the upstream of selected gauging cross-section vertical is intercepted(the equal time interval of the time control method is 50s)and connected to draw the isochron A. From the downstream of selected gauging cross-section vertical, intercept points with same time interval on the operation route of each float is intercepted and connected to draw the isochron B. The distance intercepted by the above two isochrones on each float operation route represents the vector of flow velocity on water surface.

**4** The corresponding segment width of each float operation route on the cross-section after boundary is drawn in Figure B.10.8 is measured, and the mean depth value of two adjacent boundaries taken as mean depth. Segment area and segment virtual discharge may be calculated according to method in Article B.10.5 of this code.

**5** At the intersection of each float operation route and gauging cross-section, segment virtual discharge vector line is drawn proportionally. The direction of the connection between float operation route and intersection of the upstream and downstream isochrones A and B at cross-section is the direction of vector. Resultant vector line is determined by pushing parallel lines. The cross-section perpendicular to the resultant vector line is gauging cross-section vertical.

## B.11 Error test and uncertainty estimation

**B.11.1** The error test of discharge measurement shall be carried out at a hydrometric station with representativeness and suitable conditions for test in each measuring area. The component error of discharge measurement error shall be determined through test data analysis.

**B.11.2** Preparation for error test shall include the following:

**1** To collect the channel topographic map of a measuring reach, the possible maximum cross-section of a gauging cross-section, existing transverse and longitudinal distributions of flow velocity, the characteristic values of stage and discharge, and other basic data.

**2** To allocate measuring instruments.

**3** To formulate testing scheme for discharge measurement error of the current meter method, including the test and layout schemes of the sounding and width measurement error of a single discharge measurement, error caused by limited flow velocity measuring points and insufficient duration of measurement(Type Ⅰ error), the calculation error of mean flow velocity at a vertical caused by an insufficient number of measuring points on vertical(Type Ⅱ error), and the components of error(Type Ⅲ error)caused by an insufficient number of flow velocity-measuring verticals.

**4** To prepare original test record sheet and other relevant test data record sheets.

**B.11.3** The error test of discharge measurement shall be conducted at high, medium and low stages, with test times uniformly arranged on rising and falling water surface, and shall be conducted under the condition of relatively stable flow.

**B.11.4** Stage variation in a single discharge component error test period shall be in accordance with the following requirements:

**1** For hydrometric stations with Class Ⅰ accuracy, stage variation shall not exceed 0.10m.

**2** For hydrometric stations with Class Ⅱ and Class Ⅲ accuracy, stage variation shall not exceed 0.30m.

**B.11.5** If sharp water regime change in a single discharge component error test period makes it difficult to meet the requirements stipulated in Article B.11.4 of this code, the number of flow velocity-measuring verticals and the times of repeated measurements and the number of measuring points of a same vertical may be appropriately reduced. Under the condition that geometric and hydraulic characteristics of a measuring reach are basically stable, testing samples with different test time but the same or close stage may be combined into the same series and treated as repeated testing samples at the same time and stage.

**B.11.6** Instruments shall be checked before and after each testing. During error test process, abnormal conditions of natural environment, instrument conditions and human factors or other conditions affecting testing shall be observed and recorded for reference when error is analyzed.

**B.11.7** Type Ⅰ error test shall be in accordance with the following requirements:

**1** More than 3 verticals including the deepest point and the depth of 60% and 30% of the maximum depth in gauging cross-section shall be selected as test verticals.

**2** Long-duration continuous flow velocity measurement is conducted at each high, medium and low stages, and an isochronous flow velocity observed every 10s to 20s or at a short interval, so that the number of measured hourly mean flow velocity is not less than 100.

**3** Single vertical test shall comply with the requirements in Table B.11.7.

**Table B.11.7 Type Ⅰ error test**

| Station type | Number of testing per stage (times) | Relative depth of measuring point at a vertical | | Duration of flow velocity measurement at measuring point(s) |
|---|---|---|---|---|
| | | Two-point method | Three-point method | |
| Class Ⅰ accuracy station | >3 | 0.2<br>0.8 | 0.2 | ≥2 000 |
| Class Ⅱ accuracy station | | | 0.6 | ≥1 000 |
| Class Ⅲ accuracy station | | | 0.8 | ≥1 000 |

**B.11.8** The collation and calculation of Type Ⅰ error test data shall be in accordance with the following requirements:

**1** Isochronous flow velocity points with big or spurious error in original measurement series are eliminated.

**2** The mean flow velocity of a single measurement(measuring point)shall be calculated according to the following formula:

$$\overline{V}=\frac{1}{N}\sum_{i=1}^{N}V_i \tag{B.11.8-1}$$

where $\overline{V}$ — mean flow velocity of original measurement series ($N$) (i. e. mean flow velocity in $Nt_0$ period, which may also be directly calculated from the total duration and total revolutions);

$V_i$ — mean flow velocity observed in $i$th $t_0$ period of the original measurement series;

$N$ — total number of observation periods in original measurement series(i.e.sample size);

$i$ — mean number of $t_0$ periods observed in original measurement series (i. e. the ordinal number of $t_0$), and $i=1,2,3,\ldots,N$.

**3** The standard deviation of original measurement period shall be calculated according to the following formula:

$$S(t_0)=\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(\frac{V_i-\overline{V}}{\overline{V}}\right)^2} \tag{B.11.8-2}$$

where $t_0$ —original measurement period (10s may be taken generally);

$S(t_0)$ —(relative) standard deviation of mean flow velocity in original measurement period, that is the relative standard deviation of flow velocity pulsation(Type Ⅰ error)(%).

**4** The calculation of (relative) standard deviation of mean flow velocity in $nt_0$ period:

The measurement period $t_0$ of original test series of flow velocity is very short (such as 10s), and the relative standard deviation of measured flow velocity is relatively large, while the length of period usually used in actual flow velocity measurement is $nt_0$ (such as 60s, 100s, etc. where $n$ is 6 or 10). Therefore, it is necessary to analyze and calculate the (relative) standard deviation of flow velocity in $nt_0$ period according to experimental data. The Type Ⅰ relative standard deviation of measuring point shall be estimated according to the following methods:

**1**)Method 1:

$$S^2(nt_0)=\frac{S^2(t_0)}{n}\left[1+2\sum_{i=1}^{n-1}\left(1-\frac{i}{n}\right)\hat{\rho}(i)\right] \quad \text{(B.11.8-3)}$$

$$\hat{\rho}(i)=\frac{N-1}{N-i}\frac{\sum_{j=1}^{N-i}(V_j-\overline{V})(V_{i+j}-\overline{V})}{\sum_{j=1}^{N}(V_j-\overline{V})^2} \quad \text{(B.11.8-4)}$$

where $t_0$—original measurement period(s);

$n$—multiple of original measurement period;

$S(nt_0)$— Type Ⅰ relative standard deviation of measuring point with a flow velocity measurement duration of $nt_0$(%);

$S(t_0)$—relative standard deviation of original measurement series(%);

$\hat{\rho}(i)$—autocorrelation function of original measurement series with time interval displacement $i$;

$V_j$—flow velocity value of $j$th measuring point in original measurement series(m/s);

$V_{i+j}$—flow velocity value of $(i+j)$ th measuring point in original measurement series(m/s);

$\overline{V}$—arithmetic mean value of flow velocity at a measuring point in original measurement series(m/s);

$N$—sample size of original measurement series.

**2**)Method 2:

Mean flow velocity in $nt_0$ period is calculated first, and then standard deviation calculated directly from mean flow velocity of total period ($Nt_0$), which shall be calculated according to the following formulae:

$$\overline{V}_{nt_0,j}=\frac{1}{n}\sum_{i=1}^{n}V_{(j-1)n+i} \quad \text{(B.11.8-5)}$$

$$S(nt_0)=\sqrt{\frac{1}{M-1}\sum_{j=1}^{M}\left(\frac{\overline{V}_{nt_0,j}-\overline{V}}{\overline{V}}\right)^2} \quad \text{(B.11.8-6)}$$

where $\overline{V}_{nt_0,j}$—the $j$th mean flow velocity in $nt_0$ period;

$j$—ordinal number of periods in mean flow velocity series of $nt_0$ period, which is 1, 2, 3, ..., $M$;

$nt_0$—newly synthesized mean flow velocity period(such as 60s, 100s, etc.);

$i$ —ordinal number when mean flow velocity in $nt_0$ period is calculated, which is 1, 2, 3, …, $n$;

$S(nt_0)$ —(relative) standard deviation of mean flow velocity in $nt_0$ period, i. e. the relative standard deviation of mean flow velocity fluctuation (Type Ⅰ error) in $nt_0$ period(%);

$M$ —total number of periods in mean flow velocity series of $nt_0$ period (i.e. the sample size of mean discharge), which shall be calculated according to the following formula:

$$M=\text{int}\left(\frac{N}{n}\right) \tag{B.11.8-7}$$

where int—integer is taken.

**5** The Type Ⅰ relative standard deviation of vertical shall be estimated according to the following formula:

$$S_v^2(nt_0)=\sum_{k=1}^{p} d_k^2 S_k^2(nt_0) \tag{B.11.8-8}$$

where $S_v(nt_0)$ —Type Ⅰ relative standard deviation of the $i$th vertical in the flow velocity measurement duration of $nt_0$(%);

$p$ —number of measuring points on a vertical used to determine mean flow velocity at a vertical;

$d_k$ —weight coefficient of measuring point flow velocity when mean flow velocity at a vertical is determined;

$S_k(nt_0)$ —Type Ⅰ relative standard deviation of measuring point $k$ in the flow velocity measurement period of $nt_0$(%).

**B.11.9** Type Ⅱ error test shall be in accordance with the following requirements:

**1** More than 5 verticals located at the midstream and different depths shall be selected as testing verticals of gauging cross-section.

**2** Tests shall be carried out at high, medium and low stages.

**3** Single vertical test shall comply with the requirements in Table B.11.9.

**Table B.11.9 Type Ⅱ error test**

| Station type | Number of testing per stage (times) | Fluctuation range of stage in one test(m) | Number of measuring points on a vertical(point) | Number of repeated flow velocity measurement(times) | Flow velocity duration of measuring point(s) |
|---|---|---|---|---|---|
| Class Ⅰ accuracy station<br>Class Ⅱ, Class Ⅲ accuracy stations | >2 | ≤0.1<br>≤0.3 | 11 | 10 | 100~60 |

**4** If hydrometric stations with Class Ⅱ or Class Ⅲ accuracy cannot meet the requirements stipulated in Table B.11.9, the number of measuring points on a single vertical, the number of repeated flow velocity measurement and the flow velocity duration of measuring point may be reduced to 5 points, 6 times and 30s to 50s, respectively.

**B.11.10** The collation and calculation of Type Ⅱ error test data shall be in accordance with the following requirements:

**1** The approximate true value of mean flow velocity at a vertical is the value of vertical measuring points calculated by the multi-point ($n$=11 or 5) method according to Article B.7.1 of this code.

**2** Relative mean flow velocity at a vertical is the mean flow velocity at a vertical calculated by the less-point ($p$=1,2,3 or 5) method divided by the approximate true value.

**3** Type Ⅱ error shall be calculated according to the following formulae:

$$\hat{S}_i=\frac{1}{J}\sum_{j=1}^{J}\frac{\overline{v}_{pij}-\overline{v}_{mij}}{\overline{v}_{mij}} \tag{B.11.10-1}$$

$$\hat{\mu}_s=\frac{1}{I}\sum_{i=1}^{I}\hat{S}_i \tag{B.11.10-2}$$

$$S_p=\sqrt{\frac{1}{I-1}\sum_{i=1}^{I}(\hat{S}_i-\hat{\mu}_s)^2} \tag{B.11.10-3}$$

where $\hat{S}_i$— sampling relative error of mean flow velocity at a vertical of the $i$th group series caused by calculation rules (%);

$\overline{v}_{pij}$— mean vertical flow velocity of the $J$ measuring times in the $i$th group calculated by the less-point ($p$=1,2,3 or 5) method (m/s);

$\overline{v}_{mij}$— mean vertical flow velocity of the $J$ measuring times in the $i$th group calculated by the multi-point ($n$=11 or 5) method (m/s);

$J$— repeated measurement number of the multi-point method in $i$th group measurement (times);

$\hat{\mu}_s$— sampling relative systematic error caused by using the less-point method to calculate mean flow velocity at a vertical (%);

$S_p$— sampling relative standard deviation caused by using the less-point method to calculate mean flow velocity at a vertical(%);

$I$— number of total groups (verticals) of Type Ⅱ error test.

**B.11.11** Type Ⅲ error test shall be in accordance with the following requirements:

**1** The layout of flow velocity-measuring verticals shall be in accordance with Section B.2 of this code.

**2** The times of measurement shall be uniformly arranged at high, medium and low stages, with tests of no less than 20 times. Due to the long duration of each testing, it is difficult to carry out tests in high flood period. Testing shall be carried out in the period of stable discharge.

**3** Error test may be carried out for hydrometric stations with different water surface width according to Table B.11.11.

**Table B.11.11 Type Ⅲ error test**

| Test requirements | | Measuring method of mean flow velocity at a vertical | | Flow velocity measurement duration of a single measuring point(s) | |
|---|---|---|---|---|---|
| Water surface width (m) | Minimum number of flow velocity-measuring verticals | Two-point method | Three-point method | Class Ⅰ accuracy station | Class Ⅱ, Class Ⅲ accuracy stations |
| 50≤$B$≤1 200 | 50~60 | 0.2,0.8 | 0.2,0.6,0.8 | 100~60 | 60~30 |
| 25≤$B$≤50 | 30~50 | | | | |
| $B$<25 | >25 | | | | |

Note: When water surface width $B$ is greater than 1 200m, the number of flow velocity-measuring verticals laid at measuring cross-section should be greater than 60.

**B.11.12** The collation and calculation of Type Ⅲ error test data shall be in accordance with the following requirements:

**1** The approximate true value of a single discharge is cross-section discharge calculated by the mean division method for multiple flow velocity-measuring verticals.

**2** When the multi-vertical cross-section discharge is simplified, the flow velocity-measuring verticals controlling cross-section shape and locating at the turning point of transverse flow velocity distribution shall be retained, and then less-vertical cross-section discharge shall be calculated according to the principle of uniform extraction of verticals.

**3** The Type Ⅲ error of the current meter method shall be estimated according to following formulae:

$$\bar{\mu}_m = \frac{1}{I}\sum_{i=1}^{I}\left(\frac{Q_{mi}}{Q_i} - 1\right) \tag{B.11.12-1}$$

$$S_m = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left[\left(\frac{Q_{mi}}{Q_i} - 1\right) - \bar{\mu}_m\right]^2} \tag{B.11.12-2}$$

where $\bar{\mu}_m$ — relative systematic error caused by reducing the number of flow velocity-measuring verticals to $m$ (%);

$S_m$ — relative standard deviation caused by reducing the number of flow velocity-measuring verticals to $m$(%);

$Q_{mi}$ — cross-section discharge value calculated when the number of flow velocity-measuring verticals in the $i$th testing is reduced to $m$($m^3/s$);

$Q_i$ — cross-section discharge calculated when flow velocity-measuring verticals of the $i$th testing are multiple, which is the approximate true value($m^3/s$);

$N$ — total measurement number of Type Ⅲ error test(times).

**B.11.13** The relative standard deviation of sounding and width measurement shall be estimated according to Formula(6.3.2-2) of this code.

**B.11.14** The synthetic uncertainty of a single discharge measurement by the current meter method consists of total random uncertainty and total systematic uncertainty of the discharge measurement. The estimation formula is as follows:

**1** The total random uncertainty shall be calculated according to the following formula:

$$X'_Q = \left[X'^2_m + \frac{1}{m+1}\left(X'^2_e + X'^2_p + X'^2_b + X'^2_d + X'^2_c\right)\right]^{1/2} \tag{B.11.14-1}$$

where $X'_Q$—total random uncertainty of a single discharge measurement(%);

$X'_m$—random uncertainty of Type Ⅲ cross-section(%);

$X'_e$—random uncertainty of Type Ⅰ cross-section(%);

$X'_p$—random uncertainty of Type Ⅱ cross-section(%);

$X'_b$—random uncertainty of cross-section width measurement(%);

$X'_d$—random uncertainty of cross-section sounding(%);

$X'_c$—random uncertainty of current meter calibration of cross-section(%);

$m$—number of flow velocity-measuring verticals laid out in a single discharge measuring cross-section.

**2** The total systematic uncertainty shall be calculated according to the following formula:

$$X_Q''=(X_b''^2+X_d''^2+X_c''^2)^{1/2} \tag{B.11.14-2}$$

where $X_Q''$—total systematic uncertainty of a single discharge measurement(%);

$X_b''$—systematic uncertainty of width measurement(%);

$X_d''$—systematic uncertainty of sounding(%);

$X_c''$—systematic uncertainty of current meter verification(%).

**3** Synthetic uncertainty $X_Q$ may be estimated according to the following formula:

$$X_Q=(X_Q'^2+X_Q''^2)^{1/2} \tag{B.11.14-3}$$

where $X_Q'$—total random uncertainty of a single discharge measurement(%);

$X_Q''$—total systematic uncertainty of a single discharge measurement(%).

## B.12 Permissible error of discharge measurement and selection of discharge measurement scheme

**B.12.1** The permissible error of a single discharge measurement component is the maximum control index, and accuracy assessment shall be controlled within the permissible error range.

**B.12.2** The random uncertainty of width measurement shall not be greater than 2%, and the systematic uncertainty of width measurement not be greater than 0.5%.

**B.12.3** Sounding error shall comply with the values in Table B.12.3.

**Table B.12.3 Sounding permissible error**

| Depth(m) | $X_d'$(%) | | | $X_d''$(%) |
|---|---|---|---|---|
| | Suspension cable | Sounding rod | Ultrasonic sounder | |
| <0.8 | – | 3 | – | 0.5 |
| 0.8–6 | 2 | 2 | 1.5 | |
| >6 | 1 | 1 | 1.1 | |

Note: $X_d'$ and $X_d''$ are random uncertainty and systematic uncertainty at 95% of confidence level, respectively.

**B.12.4** Current meter shall be accurately calibrated in a calibration tank. When flow velocity is not less than 0.5m/s, the random uncertainty and systematic uncertainty of current meter verification shall not be greater than 1% and 0.5%, respectively, within the applicable range of the current meter.

**B.12.5** Type Ⅰ error caused by insufficient limited flow velocity measurement duration of measuring point shall not exceed the values specified in Table B.12.5.

**Table B.12.5 Type Ⅰ permissible error**

| Station type | Calculation method | High stage | | | Medium stage | | | Low stage | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Duration(s) | | | | | | | | |
| | | 100 | 60 | 30 | 100 | 60 | 30 | 100 | 60 | 30 |
| | | $X_e'$(%) | | | | | | | | |
| Class Ⅰ, Class Ⅱ, Class Ⅲ accuracy hydrometric stations | One-point method | 7 | 8 | 9 | 8 | 9 | 12 | 10 | 12 | 16 |
| | Two-point method | 5 | 6 | 7 | 6 | 7 | 9 | 7.5 | 9 | 11 |
| | Three-point method | 4 | 5 | 6 | 4.5 | 5.5 | 8 | 6 | 7 | 10 |

Note: $X_e'$ is Type Ⅰ random uncertainty at 95% of confidence level. Duration is in seconds(s).

**B.12.6** Type Ⅱ error caused by insufficient number of measuring points at flow velocity-measuring vertical shall not exceed the values specified in Table B.12.6.

**Table B.12.6 Type Ⅱ permissible error**

| Station type | Calculation method | High stage | | Medium stage | | Low stage | |
|---|---|---|---|---|---|---|---|
| | | $X'_p$ | $\hat{\mu}_e$ | $X'_p$ | $\hat{\mu}_e$ | $X'_p$ | $\hat{\mu}_e$ |
| Class Ⅰ accuracy hydrometric station | One-point method | 4.2 | 0.9~−1.0 | 4.5 | 1.0~−1.0 | 4.8 | 1.0~−1.0 |
| | Two-point method | 3.2 | 0.7~−1.0 | 3.5 | 0.9~−1.0 | 3.6 | 1.0~−1.0 |
| | Three-point method | 2.4 | 0.5~−0.5 | 2.8 | 0.7~−0.7 | [illegible] | 0.8~−1.0 |
| Class Ⅱ, Class Ⅲ accuracy hydrometric stations | One-point method | 5.9 | 1.0~−1.0 | 6.1 | 1.0~−1.0 | 6.2 | 1.0~−1.0 |
| | Two-point method | 4.7 | 0.7~−1.0 | 4.8 | 1.0~−1.0 | 4.9 | 1.0~−1.0 |
| | Three-point method | 4.0 | 0.5~−0.7 | 4.3 | 0.9~−0.8 | 4.4 | 1.0~−1.0 |

Notes: 1 $X'_p$ is Type Ⅱ random uncertainty at 95% of confidence level.

2 $\hat{\mu}_e$ is Type Ⅱ systematic error. According to the analysis of testing data, $\hat{\mu}_e$ has positive and negative variations due to different flow velocity distribution forms at a vertical, which cannot be treated as a constant systematic error. Therefore, the variation range of Type Ⅱ systematic error $\hat{\mu}_e$ is shown in attached table. According to error statistics theory, the maximum negative value of 30% to 50% of different calculation method may be used for estimation according to specific situation.

**B.12.7** Type Ⅲ error caused by insufficient number flow velocity-measuring verticals shall not exceed the values specified in Table B.12.7.

**Table B.12.7 Type Ⅲ permissible error**

| Station type | Number of flow velocity-measuring verticals $m$ | Permissible error(%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | High stage | | Medium stage | | Low stage | |
| | | $X'_m$ | $\hat{\mu}_m$ | $X'_m$ | $\hat{\mu}_m$ | $X'_m$ | $\hat{\mu}_m$ |
| Class Ⅰ accuracy hydrometric station | 5 | 5.2 | −2.1 | [illegible] | −2.4 | 8.8 | −3.5 |
| | 10 | 3.3 | [illegible] | [illegible] | −1.7 | 5.6 | −2.2 |
| | 15 | 2.5 | [illegible] | 3.5 | −1.4 | 4.3 | −1.7 |
| | 20 | 2.1 | [illegible] | 3.0 | −1.2 | 3.6 | −1.4 |
| Class Ⅱ accuracy hydrometric station | 5 | [illegible] | −2.4 | 7.0 | −2.8 | 9.0 | −3.6 |
| | 10 | 3.6 | −1.5 | 4.9 | −2.0 | 5.7 | −2.3 |
| | 15 | 2.9 | −1.2 | 4.0 | −1.6 | 4.4 | −1.8 |
| | 20 | 2.4 | −1.0 | 3.5 | −1.4 | 3.7 | −1.5 |
| Class Ⅲ accuracy hydrometric station | 5 | 7.0 | −2.8 | 8.5 | −3.4 | 10.3 | −4.1 |
| | 10 | 4.4 | −1.8 | 5.6 | −2.2 | 6.5 | −2.6 |
| | 15 | 3.4 | −1.4 | 4.4 | −1.8 | 5.0 | −2.0 |
| | 20 | 2.8 | −1.1 | 3.7 | −1.5 | 4.1 | −1.6 |

Notes: 1 $X'_m$ is Type Ⅲ random uncertainty at 95% of confidence level.

2 $\hat{\mu}_m$ is Type Ⅲ systematic error.

**B.12.8** For the selection of discharge measurement scheme, the number of verticals at a cross-section $m$, the number of measuring points at a vertical $p$ and the duration of flow velocity measurement at measuring points $t$ shall be analyzed and determined according to the accuracy grade of hydrometric station, different stage, data purposes, etc.

**B.12.9** The determination of vertical number $m$ shall be in accordance with the following requirements:

**1** For hydrometric station with conditions for simplified analysis, the measured data of the multi-vertical method shall be collected for simplified analysis to determine vertical number.

**2** In order to avoid too large impacts of the random error and systematic error caused by the number of flow velocity-measuring verticals on discharge measurement, spacing between any two adjacent flow velocity-measuring verticals on cross-section should not be too large, and the ratio of vertical spacing to total water surface width at high, medium and low stages shall comply with the following requirements: 7%-10% for Class Ⅰ accuracy stations, 8%-11% for Class Ⅱ accuracy stations, and 9%-12% for Class Ⅲ accuracy stations.

**3** If the following situations occur, the number of flow velocity-measuring verticals shall be appropriately increased:

**1**) The ratio of water surface width to depth is especially large or flood plain is large.

**2**) River bed is composed of boulders and ripraps, or there are many diversion flows and erosion ditches.

**3**) For special service requirements, the accuracy requirement of discharge data is high.

**4** When water regime changes rapidly as well as the less-vertical and less-point method cannot be used due to the lack of simplified analysis, the number of flow velocity-measuring verticals may be appropriately reduced. However, if water surface width is less than 50m, it should not be less than 5, and the accuracy of discharge measurement shall not be lower than that with the float method.

**5** For the number and layout location of index velocity-measuring verticals, multiple sets of schemes (multi-vertical and less-vertical) should be prepared according to various water regime variations, so as to be selected according to measuring conditions. And the following situations shall be complied with:

**1**) Verticals should not be too few in a period and a hydrometric station with violently main stream swing or unstable river bed.

**2**) If there are small verticals, it shall be avoided to arrange them at locations with high flow velocity pulsation.

**3**) Verticals shall be arranged at main stream preferentially.

**6** The number and layout location of flow velocity-measuring verticals of tidal current station should be analyzed according to river width, depth, channel terrain, transverse distribution of flow velocity and stability of river bed, and appropriately reduced according to the requirements stipulated in Item 2 of this article.

**B.12.10** The determination of the number of measuring points at a vertical $p$ shall be in accordance with the following requirements:

**1** Hydrometric stations with conditions for simplified analysis shall collect the measured data of the multi-vertical method to conduct simplified analysis, and determine the number of measuring points at a vertical.

**2** For hydrometric stations without conditions for simplified analysis and newly deployed gauging cross-sections, the two-point method (for the free flow period) or three-point method (for the icy period) should be adopted in order to avoid the large impact of random error of the less-point method on cross-section discharge. At a vertical with very irregular flow velocity distribution, the five-point method (for the free flow period) or six-point method (for icy period) should be used as long as depth is sufficient.

**3** In order to shorten the duration of discharge measurement and improve the accuracy of discharge measurement results, the one-point method may be used for flow velocity measurement in the following situations:

**1**) The difference of sharp stage fluctuation in discharge measurement process exceeds the corresponding value specified in this code when flow velocity is measured with the normal number of measuring points.

**2**) It is difficult to accurately locate the instrument due to strong wind, waves and other reasons.

**3**) Instrument is damaged when measuring point near river bed with pebbles or ripraps is measured.

**4**) The safety of discharge measurement is affected by serious drift ice in the icy period.

**4** If the one-point method is used to measure flow velocity, the measuring point shall first be located at 0.6 times depth. If the deflection angle of suspension cable is too large and it is difficult to measure flow velocity at 0.6 times depth, it may be deployed on water surface or at 0.2 times depth.

**B.12.11** The determination of the flow velocity measurement duration $t$ of measuring points shall be in accordance with the following requirements:

**1** For hydrometric stations with conditions for simplified analysis, the duration of flow velocity measurement at measuring points at a vertical should be determined through simplified analysis. For hydrometric stations and newly deployed gauging cross-sections without conditions for simplified analysis, the duration shall not be less than 100s.

**2** If small verticals and small measuring points are used and a shorter duration of flow velocity measurement meet the accuracy requirements, the flow velocity measurement duration may be shortened to 60s.

**3** If stage rises and falls sharply or water plants, floating objects and drift ice are serious, and it is still difficult to use the flow velocity measurement duration of 60s, the duration may be shortened to 30s.

**4** For tidal current stations, when flow velocity variation rate is large or there are many measuring points at a vertical, the flow velocity measurement duration may be 30s to 60s.

**B.12.12** For various accuracy hydrometric stations without comparative test, the discharge measurement scheme of the current meter method may be selected and determined according to service objects and accuracy requirements in Table B.12.12-1 to Table B.12.12-3. When high accuracy is required, a measurement scheme with multiple verticals, multiple points and long duration may be selected.

**Table B.12.12-1 Discharge measurement scheme and accuracy selection of Class Ⅰ accuracy hydrometric station**

| Discharge measurement scheme | | | Measurement error(%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of verticals | Number of measuring points for flow velocity | Duration of discharge measurement at measuring points(s) | High stage | | Medium stage | | Low stage | |
| $m$ | $p$ | $t$ | $X'_Q$ | $\bar{\mu}_Q$ | $X'_Q$ | $\bar{\mu}_Q$ | $X'_Q$ | $\bar{\mu}_Q$ |
| 20 | 3 | 100 | 2.4 | −1.0 | 3.3 | −1.3 | 3.9 | −1.6 |
| 20 | 3 | 60 | 2.5 | −1.0 | 3.3 | −1.3 | 4.0 | −1.6 |
| 20 | 3 | 30 | 2.6 | −1.0 | 3.6 | −1.4 | 4.2 | −1.6 |
| 20 | 2 | 100 | 2.5 | −1.0 | 3.4 | −1.4 | 4.1 | −1.6 |
| 20 | 2 | 60 | 2.6 | −1.0 | 3.5 | −1.4 | 4.2 | −1.7 |
| 20 | 2 | 30 | 2.8 | −1.1 | 3.7 | −1.5 | 4.4 | −1.8 |
| 20 | 1 | 100 | 2.8 | −1.1 | 3.7 | −1.5 | 4.4 | −1.8 |
| 20 | 1 | 60 | 2.9 | −1.2 | 3.8 | −1.5 | 4.6 | −1.8 |
| 20 | 1 | 30 | 3.1 | −1.2 | 4.1 | −1.6 | 5.2 | −2.0 |
| 15 | 3 | 100 | 2.8 | −1.1 | 3.8 | −1.5 | 4.7 | −1.9 |
| 15 | 3 | 60 | 2.9 | −1.2 | 3.9 | −1.6 | 4.8 | −1.9 |
| 15 | 3 | 30 | 3.1 | −1.2 | 4.1 | −1.6 | 5.1 | −2.0 |
| 15 | 2 | 100 | 3.0 | −1.2 | 4.0 | −1.6 | 4.8 | −1.9 |

**Table B.12.12-1 (continued)**

| Discharge measurement scheme | | | Measurement error(%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of verticals | Number of measuring points for flow velocity | Duration of discharge measurement at measuring points(s) | High stage | | Medium stage | | Low stage | |
| $m$ | $p$ | $t$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ |
| 15 | 2 | 60 | 3.1 | −1.2 | 4.1 | −1.6 | 5.0 | −2.0 |
| 15 | 2 | 30 | 3.2 | −1.3 | 4.3 | −1.7 | 5.0 | −2.0 |
| 15 | 1 | 100 | 3.3 | −1.3 | 4.2 | −1.7 | 5.2 | −2.1 |
| 15 | 1 | 60 | 3.4 | −1.4 | 4.4 | −1.8 | 5.4 | −2.2 |
| 15 | 1 | 30 | 3.6 | −1.4 | 4.8 | −1.9 | 6.0 | −2.4 |
| 10 | 3 | 100 | 3.7 | −1.5 | 4.7 | −1.9 | 6.0 | −2.4 |
| 10 | 3 | 60 | 3.8 | −1.5 | 4.8 | −1.9 | 6.1 | −2.4 |
| 10 | 3 | 30 | 3.9 | −1.5 | 5.1 | −2.0 | 6.5 | −2.5 |
| 10 | 2 | 100 | 3.8 | −1.5 | 4.9 | −2.0 | 6.2 | −2.5 |
| 10 | 2 | 60 | 4.0 | −1.6 | 5.0 | −2.0 | 6.4 | −2.5 |
| 10 | 2 | 30 | 4.1 | −1.6 | 5.3 | −2.1 | 6.6 | −2.5 |
| 10 | 1 | 100 | 4.2 | −1.7 | 5.2 | −2.1 | 6.6 | −2.6 |
| 10 | 1 | 60 | 4.4 | −1.8 | 5.3 | −2.1 | 6.9 | −2.8 |
| 10 | 1 | 30 | 4.5 | −1.8 | 5.8 | −2.3 | 7.6 | −3.0 |
| Insertion control scheme | | | | | | | | |
| 5 | 3 | 100 | 5.6 | −2.2 | 6.6 | −2.6 | 9.3 | −3.7 |
| 5 | 3 | 60 | 5.8 | −2.3 | 6.7 | −2.7 | 9.4 | −3.8 |
| 5 | 3 | 30 | 5.9 | −2.4 | 7.1 | −2.8 | 9.8 | −3.9 |
| 5 | 2 | 100 | 5.8 | −2.3 | 6.8 | −2.7 | 9.5 | −3.8 |
| 5 | 2 | 60 | 6.0 | −2.4 | 7.0 | −2.8 | 9.7 | −3.9 |
| 5 | 2 | 30 | 6.2 | −2.5 | 7.3 | −2.9 | 10.0 | −4.0 |
| 5 | 1 | 100 | 6.3 | −2.5 | 7.2 | −2.9 | 10.0 | −4.0 |
| 5 | 1 | 60 | 6.5 | −2.6 | 7.4 | −3.0 | 10.3 | −4.1 |
| 5 | 1 | 30 | 6.7 | −2.7 | 8.1 | −3.2 | 11.2 | −4.5 |

**Table B.12.12-2 Discharge measurement scheme and accuracy selection of Class Ⅱ accuracy hydrometric station**

| Discharge measurement scheme | | | Measurement error(%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of verticals | Number of measuring points for flow velocity | Duration of discharge measurement at measuring points(s) | High stage | | Medium stage | | Low stage | |
| $m$ | $p$ | $t$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ |
| 20 | 3 | 100 | 2.8 | −1.1 | 3.8 | −1.5 | 4.0 | −1.6 |
| 20 | 3 | 60 | 2.8 | −1.1 | 3.9 | −1.6 | 4.1 | −1.6 |
| 20 | 3 | 30 | 2.9 | −1.2 | 4.1 | −1.6 | 4.2 | −1.7 |
| 20 | 2 | 100 | 2.9 | −1.2 | 3.9 | −1.6 | 4.2 | −1.7 |
| 20 | 2 | 60 | 3.0 | −1.2 | 4.0 | −1.6 | 4.4 | −1.8 |
| 20 | 2 | 30 | 3.1 | −1.2 | 4.2 | −1.7 | 4.6 | −1.8 |
| 20 | 1 | 100 | 3.2 | −1.3 | 4.2 | −1.7 | 4.5 | −1.8 |
| 20 | 1 | 60 | 3.3 | −1.3 | 4.3 | −1.7 | 4.8 | −1.9 |
| 20 | 1 | 30 | 3.4 | −1.4 | 4.6 | −1.8 | 5.3 | −2.0 |
| 15 | 3 | 100 | 3.3 | −1.3 | 4.3 | −1.7 | 4.8 | −1.9 |

**Table B.12.12-2 ( continued )**

| Discharge measurement scheme | | | Measurement error(%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of verticals | Number of measuring points for flow velocity | Duration of discharge measurement at measuring points(s) | High stage | | Medium stage | | Low stage | |
| $m$ | $p$ | $t$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ |
| 15 | 3 | 60 | 3.4 | −1.4 | 4.4 | −1.8 | 4.9 | −2.0 |
| 15 | 3 | 30 | 3.5 | −1.4 | 4.6 | −1.8 | 5.2 | −2.1 |
| 15 | 2 | 100 | 3.4 | −1.4 | 4.5 | −1.8 | 5.0 | −2.0 |
| 15 | 2 | 60 | 3.5 | −1.4 | 4.6 | −1.8 | 5.1 | −2.0 |
| 15 | 2 | 30 | 3.6 | −1.4 | 4.8 | −1.9 | 5.4 | −2.2 |
| 15 | 1 | 100 | 3.8 | −1.5 | 4.8 | −1.9 | 5.3 | −2.1 |
| 15 | 1 | 60 | 3.9 | −1.6 | 4.9 | −2.0 | 5.6 | −2.2 |
| 15 | 1 | 30 | 4.0 | −1.6 | 5.3 | −2.1 | 6.2 | −2.5 |
| 10 | 3 | 100 | 4.2 | −1.7 | 5.3 | −2.1 | 6.2 | −2.5 |
| 10 | 3 | 60 | 4.3 | −1.7 | 5.4 | −2.2 | 6.3 | −2.5 |
| 10 | 3 | 30 | 4.5 | −1.8 | 5.7 | −2.3 | 6.6 | −2.6 |
| 10 | 2 | 100 | 4.4 | −1.8 | 5.5 | −2.2 | 6.4 | −2.6 |
| 10 | 2 | 60 | 4.5 | −1.8 | 5.6 | −2.2 | 6.5 | −2.6 |
| 10 | 2 | 30 | 4.6 | −1.8 | 5.8 | −2.3 | 6.8 | −2.7 |
| 10 | 1 | 100 | 4.8 | −1.9 | 5.8 | −2.3 | 6.8 | −2.7 |
| 10 | 1 | 60 | 4.9 | −2.0 | 6.0 | −2.4 | 7.1 | −2.8 |
| 10 | 1 | 30 | 5.1 | −2.0 | 6.4 | −2.5 | 7.7 | −3.0 |
| Insertion control scheme | | | | | | | | |
| 5 | 3 | 100 | 6.5 | −2.6 | 7.5 | −3.0 | 9.5 | −3.8 |
| 5 | 3 | 60 | 6.6 | −2.6 | 7.6 | −3.0 | 9.6 | −3.8 |
| 5 | 3 | 30 | 6.8 | −2.7 | 8.0 | −3.2 | 10.0 | −4.0 |
| 5 | 2 | 100 | 6.7 | −2.7 | 7.7 | −3.1 | 9.7 | −3.9 |
| 5 | 2 | 60 | 6.8 | −2.7 | 7.9 | −3.2 | 9.9 | −4.0 |
| 5 | 2 | 30 | 7.0 | −2.8 | 8.2 | −3.3 | 10.2 | −4.1 |
| 5 | 1 | 100 | 7.2 | −2.9 | 8.2 | −3.3 | 10.2 | −4.1 |
| 5 | 1 | 60 | 7.3 | −2.9 | 8.4 | −3.4 | 10.5 | −4.2 |
| 5 | 1 | 30 | 7.5 | −3.0 | 9.0 | −3.6 | 11.4 | −4.6 |

**Table B.12.12-3 Discharge measurement scheme and accuracy selection of Class Ⅲ accuracy hydrometric station**

| Discharge measurement scheme | | | Measurement error(%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of verticals | Number of measuring points for flow velocity | Duration of discharge measurement at measuring points(s) | High stage | | Medium stage | | Low stage | |
| $m$ | $p$ | $t$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ |
| 20 | 3 | 100 | 3.1 | −1.2 | 4.0 | −1.6 | 4.4 | −1.8 |
| 20 | 3 | 60 | 3.2 | −1.3 | 4.0 | −1.6 | 4.5 | −1.8 |
| 20 | 3 | 30 | 3.3 | −1.3 | 4.2 | −1.7 | 4.8 | −1.9 |
| 20 | 2 | 100 | 3.2 | −1.3 | 4.1 | −1.6 | 4.6 | −1.8 |
| 20 | 2 | 60 | 3.3 | −1.3 | 4.2 | −1.7 | 4.7 | −1.9 |
| 20 | 2 | 30 | 3.4 | −1.4 | 4.4 | −1.8 | 4.9 | −2.0 |
| 20 | 1 | 100 | 3.5 | −1.4 | 4.3 | −1.7 | 4.9 | −2.0 |
| 20 | 1 | 60 | 3.6 | −1.4 | 4.4 | −1.8 | 5.1 | −2.0 |

**Table B.12.12-3 ( continued )**

| Discharge measurement scheme | | | Measurement error(%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of verticals | Number of measuring points for flow velocity | Duration of discharge measurement at measuring points(s) | High stage | | Medium stage | | Low stage | |
| $m$ | $p$ | $t$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ | $X'_Q$ | $\hat{\mu}_Q$ |
| 20 | 1 | 30 | 3.7 | −1.5 | 4.8 | −1.9 | 5.6 | −2.2 |
| 15 | 3 | 100 | 3.7 | −1.5 | 4.7 | −1.9 | 5.4 | −2.2 |
| 15 | 3 | 60 | 3.8 | −1.5 | 4.8 | −1.9 | 5.4 | −2.2 |
| 15 | 3 | 30 | 3.9 | −1.6 | 5.0 | −2.0 | 5.7 | −2.3 |
| 15 | 2 | 100 | 3.9 | −1.6 | 4.8 | −1.9 | 5.5 | −2.2 |
| 15 | 2 | 60 | 4.0 | −1.6 | 4.9 | −2.0 | 5.7 | −2.3 |
| 15 | 2 | 30 | 4.1 | −1.6 | 5.1 | −2.0 | 5.9 | −2.4 |
| 15 | 1 | 100 | 4.2 | −1.7 | 5.1 | −2.0 | 5.8 | −2.3 |
| 15 | 1 | 60 | 4.3 | −1.7 | 5.2 | −2.1 | 6.1 | −2.4 |
| 15 | 1 | 30 | 4.4 | −1.8 | 5.6 | −2.2 | 6.6 | −2.6 |
| 10 | 3 | 100 | 4.8 | −1.9 | 6.0 | −2.4 | 6.9 | −2.8 |
| 10 | 3 | 60 | 4.9 | −2.0 | 6.0 | −2.4 | 7.0 | −2.8 |
| 10 | 3 | 30 | 5.0 | −2.0 | 6.3 | −2.5 | 7.3 | −2.9 |
| 10 | 2 | 100 | 4.9 | −2.0 | 6.1 | −2.4 | 7.1 | −2.8 |
| 10 | 2 | 60 | 5.0 | −2.0 | 6.2 | −2.5 | 7.2 | −2.9 |
| 10 | 2 | 30 | 5.1 | −2.0 | 6.4 | −2.6 | 7.5 | −3.0 |
| 10 | 1 | 100 | 5.3 | −2.1 | 6.4 | −2.6 | 7.4 | −3.0 |
| 10 | 1 | 60 | 5.4 | −2.2 | 6.5 | −2.6 | 7.7 | −3.1 |
| 10 | 1 | 30 | 5.7 | −2.2 | 7.0 | −2.8 | 8.3 | −3.3 |
| Insertion control scheme | | | | | | | | |
| 5 | 3 | 100 | 7.5 | −3.0 | 8.9 | −3.6 | 10.8 | −4.3 |
| 5 | 3 | 60 | 7.6 | −3.0 | 9.0 | −3.6 | 10.9 | −4.4 |
| 5 | 3 | 30 | 7.7 | −3.1 | 9.3 | −3.7 | 11.3 | −4.5 |
| 5 | 2 | 100 | 7.6 | −3.0 | 9.1 | −3.6 | 11.0 | −4.4 |
| 5 | 2 | 60 | 7.7 | −3.1 | 9.2 | −3.7 | 11.2 | −4.5 |
| 5 | 2 | 30 | 7.9 | −3.2 | 9.5 | −3.8 | 11.5 | −4.6 |
| 5 | 1 | 100 | 8.0 | −3.2 | 9.5 | −3.8 | 11.4 | −4.6 |
| 5 | 1 | 60 | 8.2 | −3.3 | 9.7 | −3.9 | 11.7 | −4.7 |
| 5 | 1 | 30 | 8.3 | −3.3 | 10.2 | −4.1 | 12.5 | −5.0 |

Notes: 1 $X'_Q$ is the total random uncertainty of a single discharge measurement at 95% of confidence level.

2 $\hat{\mu}_Q$ is single discharge systematic error composed of Type Ⅲ and Type Ⅱ systematic errors extracted from single discharge of the multi-vertical and multi-point method( calculated by the mean split method). According to the statistics of a large number of error test data, its value is basically negative.

3 The measurement permissible error in scheme is the measurement accuracy control index corresponding to optional scheme.

4 A hydrometric station shall select discharge measurement scheme according to the accuracy classification of hydrometric station, different stage and data purpose, etc. The total random uncertainty and systematic error of a single discharge measurement shall comply with Article 6.1.2 of this code.

5 The systematic error of insertion control scheme($m$=5, $p$=1–3, $t$=30–100) is too large to meet the accuracy requirements. It is only used as discharge measurement scheme of the control interpolation alternative scheme, which should not be adopted by various accuracy hydrometric stations under normal measurement environment conditions.

# Appendix C　Float method

## C.1　General requirements

**C.1.1**　The float methods for discharge measurement stipulated in this code including the surface float method, deep-water float method, float rod method and small float method, which are respectively applicable to the conditions that it is difficult to measure flow velocity with current meter or the discharge measurement of high flow velocity, low flow velocity, small depth and other situations is beyond the range of current meter. According to the hydrologic regime characteristics of a river where a hydrometric station is located, discharge measurement method shall be selected and discharge measurement scheme formulated according to the following requirements:

**1**　If stage fluctuation difference between the beginning and ending of a discharge measurement complies with the requirements of Item 3 in Article 4.3.2 of this code, the uniform float method shall be used for discharge measurement. In discharge measurement scheme by the uniform float method, the control part of effective float transverse distribution shall be determined according to the number of flow velocity-measuring verticals and current meter location in discharge measurement scheme by the current meter method. The control part of effective float transverse distribution in the multi-float discharge measurement scheme shall include the control part of effective floats in the less-float discharge measurement scheme.

**2**　If flood level rises and falls sharply, the flood peak lasts for a short time, and the uniform float method cannot be used to measure discharge, the midstream float method may be used to measure discharge.

**3**　If float dropping equipment is damaged or temporarily failed, or dropped floats cannot be identified due to too many floating objects on a river, the floating objects may be used as floats to measure discharge.

**4**　If a part of gauging cross-section cannot be measured with current meter while the other part can be measured with current meter, the float method and current meter method may be combined to measure discharge.

**5**　The deep-water float method and float rod method are suitable for discharge measurement at low flow velocity. The measuring reach of discharge measurement shall be set in a straight reach without water plants growth or riprap protruding, and with flat river bottom and uniform longitudinal bottom slope.

**6**　The small float method is suitable for discharge measurement if flow velocity exceeds the low flow velocity range of current meter. If small depth only occurs in parts of a gauging cross-section, the small float method and current meter method may be combined to measure discharge.

**7**　If too large wind speed seriously impacts the operation of float, the float method should not be used to measure discharge.

**C.1.2**　For hydrometric station using the float method to measure discharge, the material, form, depth under water and other specifications of float must be unified in this station. Float coefficient shall be tested and analyzed, and the equivalent test float coefficients used for different discharge measurement schemes. If other types of floats are used for flow velocity measurement due to some reason, the float coefficient shall be tested and analyzed separately.

**C.1.3** The determination and selection of float coefficient shall be in accordance with the following requirements:

**1** Float coefficient determined by test data shall be corrected by corrective gauging according to the requirements stipulated in Section C.6 of this code. The times of corrective gauging shall not be less than 10. The result of corrective gauging should be tested by the Student's(t) test method. If there is a significant difference between original float coefficient and corrective gauging sample, float coefficient test shall be conducted again and a new float coefficient adopted.

**2** Float coefficient determined by experience shall be tested by the requirements of Article C.1.6 of this code, and then the float coefficient of the station determined.

**3** For new hydrometric stations that need to use the float method to measure discharge, float coefficient shall be tested at the same time with discharge measurement. The float coefficient of the station should be tested and determined within 2 or 3 years. Before the float coefficient test data is obtained, the float coefficient of a hydrometric station with similar cross-section shape, flow conditions and the same float type in the local area may be referred or selected in the following range according to the cross-section shape and flow conditions of a measuring reach:

**1)** In general, 0.85 to 0.90 and 0.75 to 0.85 may be taken for large and medium rivers and small rivers in humid areas, respectively, and 0.80 to 0.85 and 0.70 to 0.80 for large and medium rivers and small rivers in arid areas, respectively.

**2)** Under special situations, 0.90 to 1.00 may be taken in humid areas and 0.65 to 0.70 in arid areas.

**3)** For a measuring reach with small flow velocity gradient or large depth at a vertical, a larger value should be taken. For a measuring reach with large flow velocity gradient or small depth at a vertical, a smaller value should be taken.

**4** If there are significant changes in a measuring reach or the control of hydrometric station, float coefficient test shall be conducted again and a new float coefficient adopted.

**C.1.4** For hydrometric station with relatively stable cross-section and test float coefficient, the permissible error of a single discharge measurement by the uniform float method shall not exceed the values specified in Table C.1.4.

**Table C.1.4 Permissible error of a single discharge measurement by the uniform float method**

| Station type | Error index(%) | |
|---|---|---|
| | Synthetic uncertainty | Systematic uncertainty |
| Class Ⅰ accuracy station | 10 | −2~1 |
| Class Ⅱ accuracy station | 11 | −2~1 |
| Class Ⅲ accuracy station | 12 | −2.5~1 |

Note: For hydrometric stations with large change of scouring and silting of a cross-section or empirical float coefficient, the permissible error of a single discharge measurement by the float method shall be determined according to the actual situation.

**C.1.5** The selection of the discharge measurement scheme of the uniform float method shall adopt the permissible error range in Table C.1.4 of this code as control accuracy, and analyze and determine the number of effective floats according to the total random uncertainty estimation of the uniform float method which is based on each component random uncertainty of the uniform float method in Section

C.8 of this code. The control part of each float shall comply with Item 1 in Article C.1.1 of this code.

**C.1.6** Discharge measurement by the float method shall include the following:

**1** To observe the stages of basic staff gauge, gauging cross-section gauge and slope gauge.

**2** To drop floats, observe the operation duration of each float floating through upstream and downstream cross-sections, and determine the position of each float through medium cross-section.

**3** To observe wind direction, wind force (speed) and items that shall be observed during the operation of each float.

**4** To measure the medium cross-section area of float.

**5** To calculate measured discharge and other relevant statistical values.

**6** To check and analyze discharge measurement results.

## C.2 Surface float method

**C.2.1** The fabrication of water surface floats shall be in accordance with the following requirements:

**1** The part of a float under water surface shall be rough and not be streamlined. The float shall be attached with weights to keep it drifting stably in water. The depth of float under water surface shall not be larger than 1/10 of water depth. Float should be put into water for test after fabrication.

**2** The part of a float exposed on water surface shall have obvious marks which are easy to identify.

**C.2.2** For hydrometric stations that use water surface floats to measure discharge, float dropping equipment should be set up. It shall be composed of running cableway and dropping device, and comply with the following requirements:

**1** The plane position of running cableway shall be set at a certain distance upstream of the upstream cross-section of a float, and the distance shall be such that the float may be put into normal operation before reaching the upstream cross-section. The spatial height of the cableway shall be above the highest flood level of investigation.

**2** Float dropping equipment shall be simple and firm in structure and flexible and labor-saving in operation, and convenient for continuous dropping and maintenance.

**3** For hydrometric stations without conditions for setting up float dropping equipment, floats may be dropped by boat or by the utilization of upstream bridges and other river-crossing facilities.

**C.2.3** The dropping method of water surface floats shall be in accordance with the following requirements:

**1** For discharge measurement with the uniform float method, floats shall be placed uniformly on the whole cross-section. The control part of effective floats should be consistent with the position determined in discharge measurement scheme. There shall be 1 or 2 floats near each determined control part and near bank. The floats shall be dropped from one bank to the other in sequence. When the hydrometric regime in river changes sharply, floats may be dropped in the midstream of channel first and then on both sides. If there is a single stream in a measuring reach, 3 to 5 effective floats shall be placed on each stream.

**2** If the float method and current meter method are combined to measure discharge, floats shall be placed within the discharge measurement boundary of current meter to make the two flow velocity measurement zone overlap.

**3** For discharge measurement with the midstream float method, 3 to 5 floats shall be placed on the midstream part. There shall be 2 or 3 floats with adjacent positions and normal operation, and the difference between the longest and shortest operation duration shall not exceed 10% of the shortest duration.

**4** When the floating object method is used to measure discharge, 3 or 5 conspicuous floating objects in the midstream and similar to the floating objects selected in the float coefficient test should be selected to measure flow velocity. The technical requirements for flow velocity measurement shall comply with the relevant requirements of the midstream float method. The type, size, estimated freeboard and submerged depth of floating objects shall be noted in detail.

**C.2.4** If the cross-section float method is used, the measurement record of float operation duration and the measurement of float position shall be in accordance with the following requirements:

**1** Cross-section monitoring personnel shall send a signal in time when each float reaches the cross-section.

**2** Timekeeper shall timely open and close the stopwatch when receiving the signal that a float reaches upstream and downstream cross-sections, correctly read and record the operation duration of the float. The time reading shall be accurate to 0.1s. If operation duration is more than 100s, it may be accurate to 1s.

**3** Instrument rendezvous personnel shall correctly measure the position of a float, record the ordinal number of the float and measurement angle, and calculate the equivalent distance from initial point when receiving the signal of the float reaching medium cross-section. The observation of float position shall be measured by the theodolite or flat panel goniometer intersection method, and the instrument shall be checked once according to the original rear view point after the last float is intersected by each current measurement. The measurement may be completed only when it is identified that the instrument position has not changed.

**C.2.5** If the polar coordinate float method is adopted, the following requirements shall be complied with:

**1** Instrument rendezvous personnel must send a signal in time when a float passes through the predetermined position on the upstream and downstream cross-sections, and observe and read the vertical and horizontal angles of the float position. Timekeeper shall open and close the stopwatch in time, correctly read and record the operation duration of the float. The time reading shall be accurate to 0.1s. If operation duration is more than 100s, it may be accurate to 1s.

**2** Polar coordinate points shall be set at a high place with good visibility near a gauging cross-section. If the terrain of banks is high, a ground-type elevation base point may be set up at a high terrain. If the elevation of banks is low, a platform elevation base point may be set up by using fixed building platforms such as roof. Polar coordinate points shall meet the requirement of sight line depression angle greater than or equal to 4° when each float above and below a cross-section at the highest flood stage is observed. They should be set as fixed elevation points, and plane coordinates and elevation measured.

**C.2.6** If the surface float method is used to measure discharge, channel cross-section should be measured at the same time. The width measurement and sounding methods shall comply with the requirements stipulated in Section B.8 of this code. If the manpower and equipment are insufficient, or water regime changes rapidly, and it is really difficult to measure channel cross-section at the same time, a cross-section may be selected according to the following requirements:

**1** For hydrometric stations with stable cross-sections, adjacent measured cross-sections may be directly referred.

**2** For hydrometric stations with large changes in scouring and silting of a cross-section, only the depth of several verticals with relatively larger changes in scouring and silting of the cross-section may be measured, and analyzed and determined in combination with the existing measured cross-section data.

### C.3 Deep-water float method and float rod method

**C.3.1** The fabrication of deep-water floats and float rods shall be in accordance with the following requirements:

**1** A deep-water float shall be composed of an upper float and a lower float. The diameter of the upper float shall be 1/4 to 1/5 of the lower float diameter. The specific gravity of the lower float shall be greater than that of water, and make the upper float often float on water surface during operation.

**2** A float rod shall be made of two parts connected to each other and able to slide up and down. The length of the float rod may be adjusted according to the depth of flow velocity-measuring verticals. The exposed part of the float rod shall be 1cm to 2cm, and the float rod shall be able to stand upright stably in water when drifting in water.

**3** After deep-water float and float rod are made, they shall be put into water for test. If they are not qualified, the weight of a heavy object attached to the lower float and the lower part of float rod may be increased or decreased until they comply with requirements.

**C.3.2** The flow velocity measurement method and technical requirements of the deep-water float method and float rod method shall be in accordance with the following requirements:

**1** The upstream and downstream sign cross-sections with equal spacing shall be set up at the upstream and downstream gauging cross-sections with a sign ruler. Sign cross-sections shall be parallel to each other and normal to mean flow direction. The distance between the upstream and downstream sign cross-sections may be taken as 2m to 3m.

**2** The number of flow velocity-measuring verticals shall be the same as the number of fixed flow velocity-measuring verticals at the same stage for the current meter method. If transverse velocity changes greatly or fluctuates greatly, and the fixed flow velocity-measuring verticals cannot control the change of transverse flow velocity, flow velocity-measuring verticals shall be appropriately increased. The depth shall be measured before flow velocity measurement at each flow velocity-measuring vertical.

**3** If water depth is greater than 0.5m, flow velocity may be measured at 0.2 and 0.8 times depth by deep-water float. If water depth is less than 0.5m, flow velocity may be measured at 0.6 times depth. The depth of measuring point shall be calculated as the one from water surface to the center of lower float. If a float rod is used for flow velocity measurement, the submerged depth of the float rod shall be 90% to 95% of depth at flow velocity-measuring verticals, and the float rod shall not touch river bottom.

**4** For flow velocity measurement with deep-water float or float rod, each measuring point or each vertical shall be measured repeatedly for 3 times, and the following requirements shall be complied with:

1) Total operation duration shall not be less than 20s. For an individual point or vertical with high flow velocity, the duration shall not be less than 10s. If it is less than 10s, the vertical shall be measured with a current meter.

2) The difference between the longest duration and the shortest duration shall not exceed 10% of the shortest duration for the results of three repeated flow velocity measurements. If it exceeds 10%, the times of measurement shall be increased, and the three flow velocity-measuring records complying with the above requirements shall be selected as official results.

## C.4 Small float method

**C.4.1** A small float should be made into a small round float with a diameter of 3cm to 5cm with rough wood with a thickness of 1cm to 1.5cm.

**C.4.2** For the layout of gauging cross-section, two equally spaced secondary cross-sections may be set up at the upstream and downstream gauging cross-sections. The distance between the upstream and downstream cross-sections shall not be less than 2.0m. The upstream and downstream cross-sections shall be parallel to medium cross-section with equal distance. If the river reach of original gauging cross-section is not suitable for discharge measurement with the small float method, temporary gauging cross-section shall be set up. There shall be no internal water outflow or external water inflow between the temporary gauging cross-section and the original gauging cross-section, and the temporary gauging cross-section shall be normal to mean flow direction.

**C.4.3** Discharge measurement with small floats shall be in accordance with the following requirements:

**1** Gauging cross-section shall be measured at the same time of discharge measurement.

**2** The effective number of floats shall be equal to or more than the number of flow velocity-measuring verticals at the same stage for a current meter, and the transverse distribution of floats may control the transverse change of flow velocity at a cross-section.

**3** The position of float passing through a gauging cross-section may be directly measured and read by a temporary cross-section cable or tape.

**4** The operation duration of each float shall be more than 20s, and shall not be less than 10s if the flow velocity of individual flow lines is large. If the operation duration of most floats is less than 10s and flow velocity cannot be measured by a current meter due to the constraint of water depth, the spacing between the upstream and downstream secondary cross-sections shall be appropriately increased to make the operation duration of floats not less than 10s.

**5** Each flow line of flow velocity measurement shall be measured twice. The difference between two operation durations shall not exceed 10% of the shortest duration. If the difference exceeds 10%, the times of measurement shall be increased, and those measurement of the difference between the two floats operation duration not exceeding 10% shall be selected as official result.

## C.5 Other observation

**C.5.1** The stage of basic staff gauge and gauging cross-section gauge may be observed once at the beginning and ending of discharge measurement. If discharge measurement process possibly crossed flood peak or valley, additional stage shall be measured at the flood peak or valley, and the times of measurement shall be appropriately increased according to the principle of uniform distribution to control the flood change process. The observation of slope stage shall comply with the requirements stipulated in Article B.5.2 of this code.

**C.5.2** Wind direction and wind force (speed) shall be observed during the operation of each float. If wind direction and wind force(speed) change slightly, their mean values may be measured and recorded. If the change is large, the change range shall be recorded. When an instrument is used to observe wind direction and wind speed, the instrument shall be placed at a place that may represent the wind direction and wind speed near the water surface of a measuring reach. Wind direction shall be measured from right to left according to flow direction. The direction of downwind parallel to the flow direction is recorded as 0°, that of upwind as 180°, that of wind normal to the flow direction from right bank as 90°, and that of wind from left bank as 270°. If wind force and direction are measured visually, they may be recorded according to the current national standard GB/T 50138 *Standard for Stage Observation*.

**C.5.3** Weather phenomena, floating objects, wind waves, flow direction, stagnant water area and flood plain, diversion, river bank breach, ice dam blockage, tributaries and floods near the upstream and downstream of a measuring reach all shall be observed and recorded.

## C.6 Test and determination of float coefficient

**C.6.1** For the hydrometric station with conditions for comparative gauging test, water surface float coefficient shall be comparatively tested with the current meter method and the float method. For stations without conditions for comparative gauging test, float coefficient may be determined by the stage-discharge relation curve method and the surface flow velocity coefficient method. Float coefficient shall be obtained by dividing cross-section discharge by cross-section virtual discharge, or dividing mean flow velocity at a cross-section by mean virtual flow velocity at a cross-section, or dividing mean flow velocity at a cross-section by the flow velocity measured with the midstream float method or floating object float method.

**C.6.2** For the test of water surface float coefficient, relation curve shall not be extended too much. Data shall be accumulated year by year, and the fluctuation range of stage increased in comparative test. The test data of a high stage segment shall include those of different stages, wind directions, wind forces (speeds) and other conditions, and the numbers of tests shall be more than 20.

**C.6.3** The comparative test of water surface float coefficient shall be in accordance with the following requirements:

**1** The float coefficients of various discharge measurement schemes by the float method shall be tested and analyzed separately.

**2** The measuring time of the float method shall be placed in the middle of gauging time by the current meter method. If it cannot be placed in the middle period due to conditions constraint, the order of discharge measurement by the current meter method and by the float method shall be exchanged between the rising and falling water surfaces in multiple measurements, and the numbers of exchange should be equal.

**3** For the comparative test of cross-section float coefficient, the control part of each effective float in transverse direction shall correspond to the layout position of each flow velocity-measuring vertical of current meter. If the float coefficients of various test schemes are calculated by extracting the test results of various limited floats and corresponding limited flow velocity-measuring verticals from the comparative test data of multiple floats and multiple flow velocity-measuring verticals, the transverse distribution curve of float flow velocity shall be drawn separately according to the number of limited floats selected for various test schemes to look up for virtual flow velocity, the transverse distribution curve of multiple float flow velocity shall not be drawn only once, and the virtual flow velocity of different sampling schemes shall be looked up repeatedly. The test data of a high stage segment shall include those of different stages, wind directions, wind forces and other conditions, and the numbers of tests shall be more than 20.

**4** For the test of midstream float coefficient and floating object float coefficient, a comparative test should be carried out according to one of the discharge measurement schemes selected by the current meter method in the high-flow period, and may be carried out in combination with the test of cross-section float coefficient. If the current meter method is used to measure discharge at other time, flow velocity may be measured in time in the case of optional floating objects for the analysis of floating object float coefficient.

**5** If it is difficult to carry out the comparative test of float coefficient in the high-flow period, representative verticals may be used for the test analysis of float coefficient. The test method and technical requirements shall comply with the following requirements:

**1**) According to the measured discharge data of current meter, the relation curves of the mean value of mean flow velocity at 1 to 3 representative verticals and the mean flow velocity at a cross-section may be established, and the best one of relation curves may be selected to determine a representative vertical. For the float coefficients of different discharge measurement schemes, representative verticals shall be determined respectively.

**2**) On a selected representative vertical, a current meter shall be used to measure the mean flow velocity at a vertical, and the mean flow velocity at a cross-section converted through an established relation curve. Float flow velocity shall be measured according to the relevant requirements of the uniform float method, midstream float method and floating object float method. Mean virtual flow velocity at a cross-section shall be calculated by dividing virtual discharge at a cross-section by the cross-section area. The arithmetic mean method shall be used to calculate the midstream float flow velocity and floating objects float flow velocity, and the float coefficient of the representative vertical method shall be calculated according to Item 3 in Article C.6.6 of this code.

**3**) Float coefficient obtained from tests with the representative vertical method shall be comprehensively analyzed together with the test results of cross-section float coefficient or with midstream float coefficient and floating object float coefficient. When change trend is consistent with the characteristics of a hydrometric station, it may be used as official test data.

**4**) For stations with frequent changes in the position of representative verticals with stage in the high-flow period, the representative vertical method should not be used to test float coefficient.

**C.6.4** Float coefficient shall be determined within the measured discharge range of current meter if stage-discharge relation curve is used to analyze the float coefficient. Measured value shall be adopted for the virtual discharge of float, and the cross-section discharge looked up on the relation curve of the stage and the measuring point of current meter with the equivalent stage measured by the float method. The following requirements shall be complied with:

**1** For the analysis of cross-section float coefficient, the discharge measuring points by the current meter method corresponding to the flow velocity-measurement vertical distribution according to the control part of effective float for float discharge measuring points by the float method shall be selected to plot a stage-discharge curve for looking up the cross-section discharge.

**2** For the analysis of the midstream and floating objects float coefficients, cross-section discharge should be looked up on the stage-discharge relation curve drawn with the discharge measuring points of a discharge measurement scheme of the current meter method in the high-flow period.

**3** For different types of stage-discharge relation curves, the cross-section discharge shall be read according to the following requirements:

1) For hydrometric stations with a single curve of stage-discharge relation, the discharge shall be directly looked up on the curve.

2) For hydrometric stations with multiple single curves of stage-discharge relation, the discharge shall be looked up on the curve of float measuring points in the same period.

3) For hydrometric stations with the stage-discharge relation of compound loop curve, the discharge shall be looked up on the loop curve of the same flood process as float measuring points.

**C.6.5** The data of float coefficient test analysis shall be sorted out by classification, and the influence of air resistance on float coefficient considered. The relationship between float coefficient and relevant factors shall be established, and then the relation diagram and table drawn for reference. The selection of relevant factors shall be determined by hydrometric station according to actual situation.

**C.6.6** The following requirements shall be complied with for float coefficient determined indirectly by the test data of the flow velocity coefficient on water surface:

**1** For the test of the mean flow velocity coefficient of a cross-section on water surface, the layout of flow velocity-measuring verticals shall be determined in combination with the control part of effective float transverse distribution in the discharge measurement scheme of the float method.

**2** The test of the midstream water surface velocity coefficient should be compared and analyzed according to a discharge measurement scheme selected in the high-flow period.

**3** If it is difficult to measure cross-section velocity with current meter in the high-flow period, the test method of water surface flow velocity coefficient at a representative vertical may be used to determine the flow velocity coefficient on water surface. The test methods and requirements shall be in accordance with the following requirements:

1) The relation curves of the mean value of water surface flow velocity coefficient of 1 to 3 verticals and the mean value of water surface flow velocity coefficient at a cross-section and the relation curves of the mean flow velocity at 1 to 3 verticals and the mean flow velocity at a cross-section shall be established by the adoption of the discharge measurement data of current meter with water surface velocity measurement, and one best relation curve shall be selected from the above two kinds of curves respectively to determine its representative vertical. For different discharge measurement schemes, their representative verticals shall be determined respectively.

2) For the test of mean flow velocity coefficient at a cross-section on water surface, mean flow velocity coefficient at a cross-section on water surface shall be obtained by the mean flow velocity at a vertical and the water surface flow velocity at the selected representative vertical measured with a current meter. And the mean flow velocity coefficient of a cross-section on water surface is obtained through the conversion of relation curve.

3) For the test of the midstream water surface flow velocity coefficient, current meter shall be used to measure the mean flow velocity at a selected representative vertical and the midstream

flow velocity on water surface. Mean flow velocity at a vertical shall be first converted into mean flow velocity at a cross-section through relation curve, and then midstream water surface flow velocity coefficient calculated.

**4**) Water surface flow velocity coefficient obtained from the representative vertical method test shall be comprehensively analyzed together with the test results of mean water surface flow velocity coefficient at a cross-section or midstream water surface flow velocity coefficient. If the change trend characteristics are consistent, it may be used as official test data.

**5**) The representative vertical method should not be used to test water surface flow velocity coefficient for the stations with frequent changes in the position of representative vertical with stage in the high-flow period.

**C.6.7** The discharge calculation of the float method with water surface flow velocity coefficient shall be converted into equivalent float coefficient through channel correction coefficient $K_W$ according to the following requirements:

**1** Channel correction coefficient shall be calculated according to the following formulae:

$$K_W=\frac{\overline{A_f}}{A_c} \quad \text{(C.6.7-1)}$$

$$\overline{A_f}=\frac{1}{6}(A_u+4A_m+A_l) \quad \text{(C.6.7-2)}$$

where $K_W$—channel correction coefficient;

$\overline{A_f}$—mean cross-section area of a float measuring reach($m^2$);

$A_c$—gauging cross-section area of current meter($m^2$);

$A_u$—upstream cross-section area of float($m^2$);

$A_m$—medium cross-section area of float($m^2$);

$A_l$—downstream cross-section area of float($m^2$).

**2** Cross-section float coefficient $K_f$ shall be calculated according to the following formulae:

**1**) If the influence of air resistance on float coefficient is not considered, it shall be calculated according to the following formula:

$$K_f=K_W\overline{K_0} \quad \text{(C.6.7-3)}$$

where $\overline{K_0}$—mean flow velocity coefficient at a cross-section on water surface, which is a look-up value on the relation curve of stage and mean flow velocity coefficient at a cross-section on water surface.

**2**) If the influence of air resistance on float coefficient is considered, it shall be calculated according to the following formula:

$$K_f=K_W\overline{K_0}\left(1+A\overline{K_c}\right) \quad \text{(C.6.7-4)}$$

where $\overline{K_c}$—mean air resistance parameter at a cross-section;

$A$—float resistance distribution coefficient, which may be referred to the test data of similar float types.

**3** The midstream float coefficient $K_{mf}$ shall be calculated according to the following formulae:

**1**) If the influence of air resistance on float coefficient is not considered, it shall be calculated according to the following formula:

$$K_{mf}=K_W\overline{K_{m0}} \quad \text{(C.6.7-5)}$$

where $\overline{K_{m0}}$—midstream water surface flow velocity coefficient, which is a look-up value of the relation between stage and midstream water surface flow velocity coefficient.

**2**) If the influence of air resistance on float coefficient is considered, it shall be calculated according to the following formula:

$$K_{mf} = K_W \overline{K_{m0}} (1 + A \overline{K_{mr}}) \tag{C.6.7-6}$$

where $\overline{K_{mr}}$—midstream mean air resistance parameter.

**C.6.8** For the test of float coefficient in sediment-laden stream, single sample sediment concentration shall be measured at the same time. Float coefficient is selected according to the relation among sediment concentration, float flow velocity and float coefficient. Or the relation among sediment concentration, flow velocity on water surface and flow velocity coefficient on water surface is established, and float coefficient shall be indirectly determined according to Article C.6.6 of this code.

**C.6.9** The test of small float coefficient shall be carried out at the minimum depth or the critical stage of the minimum flow velocity allowed by current meter in the weather of no wind or light wind. Mean flow velocity at each vertical and float flow velocity shall be measured respectively with current meter and small floats at the same time, and the measurement repeated for 10 times. The arithmetic mean value of the ratio of the mean flow velocity at a vertical to the float flow velocity measured 10 times simultaneously for each vertical shall be the mean small float coefficient of the vertical, and the arithmetic mean value of the mean small float coefficient at all the verticals shall be adopted as cross-section small float coefficient.

**C.6.10** The extension of float coefficient on water surface shall be in accordance with the following requirements:

**1** If the float coefficient of a high stage segment is basically stable, it may be looked up by extending 20% of the stage-discharge relation curve. Otherwise, it may be looked up by extended 10% of the relation curve.

**2** If stage measured by the float method exceeds the allowable extension range of float coefficient by 10%–20%, float coefficient shall be determined by comprehensive comparison and analysis according to the characteristics of a hydrometric station.

### C.7 Measured discharge calculation

**C.7.1** The calculation of measured discharge by the uniform float method shall be in accordance with the following requirements:

**1** The flow velocity of each float shall be calculated according to the following formula:

$$V_{fi} = \frac{L_f}{t_i} \tag{C.7.1-1}$$

where $V_{fi}$ — measured float flow velocity of the $i$th float (m/s);

$L_f$ — vertical distance between the upstream and downstream cross-sections of float (m);

$t_i$ — operation duration of the $i$th float (s).

**2** The distance from initial point of a sounding vertical and float point position may be calculated according to the relevant requirements of the theodolite and flat panel meter intersection method.

**3** Float flow velocity transverse distribution curve and cross-section map (Figure C.7.1) shall be drawn. The point position of each float shall be plotted above water surface line with the ordinate as the float flow velocity and the abscissa as distance from initial point. The cause of individual protruding points shall be found, the point shall be discarded and noted if it is a test error. If wind direction and wind force (speed) change slightly during discharge measurement, a float flow velocity transverse distribution curve may be drawn through the center of gravity of the point group. If wind direction and wind force (speed) change greatly during discharge measurement, the distribution curve of floats shall be drawn with consideration of each float point position. When the distribution curve is drawn, water edge or stagnant water boundary shall be used as a starting point and ending point.

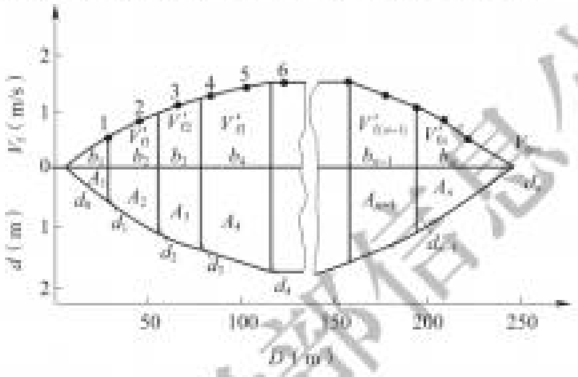



Figure C.7.1 Graphical analysis and calculation of discharge

$V_f$–virtual flow velocity at a vertical, which is a look-up value on the distribution curve(m/s);

$d$–vertical depth(m); $b$–segment water surface width(m); $A$–segment area($m^2$); $D$–distance from initial point(m)

**4** Virtual flow velocity at the boundary of each segment area is looked up on the float flow velocity transverse distribution curve.

**5** The calculation methods of mean virtual flow velocity at a segment, segment area, segment virtual discharge and virtual discharge at a cross-section are the same as that for discharge measurement of the current meter method.

**6** The cross-section discharge shall be calculated according to the following formula:

$$Q = K_f Q_f \quad \text{(C.7.1-2)}$$

where $Q$ — cross-section discharge($m^3/s$);

$Q_f$ — virtual discharge at a cross-section($m^3/s$).

**C.7.2** The calculation of the measured discharge of the midstream float method and the floating object float method shall be in accordance with the following requirements:

**1** The discharge measured by the midstream float method shall be calculated according to the following formula:

$$Q = K_{mf} A_m V_{mf} \quad \text{(C.7.2-1)}$$

where $V_{mf}$—arithmetic mean value of a midstream float flow velocity.

**2** The discharge measured by the floating object float method shall be calculated according to the following formula:

$$Q = K_{ff} A_m \overline{V_{ff}} \quad \text{(C.7.2-2)}$$

where $K_{ff}$— floating object float coefficient;

$\overline{V_{ff}}$— arithmetic mean value of a floating object float flow velocity.

**C.7.3** The calculation of discharge jointly measured by the float method and current meter method shall be in accordance with the following requirements:

**1** The transverse distribution curves of mean flow velocity at a vertical of river shore and the float flow velocity of main channel, or those of the float flow velocity of river shore and mean flow velocity at a vertical of main channel shall be drawn, respectively. For the overlapped part of the transverse distribution curves of float flow velocity and mean flow velocity at a vertical at the boundary of river shore and main channel, velocity ratio looked up on the two curves of a same distance from initial point shall be close to the float coefficient of test. If the difference between the velocity ratio and float coefficient exceeds 10%, causes shall be found. If the current measurement results of current meter are judged as reliable, the transverse distribution curve of the float flow velocity of the corresponding part may be appropriately modified according to the transverse distribution curve of the mean flow velocity at a vertical of the overlapped part to make discharge measurement results with two methods connected with each other.

**2** The measured discharge of main channel and river shore shall be calculated according to the calculation method of the measured discharge of the current meter method and float method, respectively. The sum of the discharges of the main channel and river shore is the measured discharge of a whole cross-section.

**C.7.4** For the calculation of the measured discharge of the deep-water float method, the mean flow velocity at a measuring point shall be calculated by dividing the distance between the upstream and downstream cross-sections of each measuring point by mean duration, and then the cross-section discharge calculated according to Article C.7.1 of this code.

**C.7.5** The cross-section discharge of the float rod method may be calculated according to Article C.7.1 of this code, and mean flow velocity at a vertical shall be calculated according to the following formulae:

$$V_m = K_h V_h \qquad (C.7.5\text{-}1)$$

$$K_h = 1 - 0.116\left(\sqrt{1 - \frac{h}{d}} - 0.10\right) \qquad (C.7.5\text{-}2)$$

where $K_h$ — flow velocity correction coefficient of float rod;

$V_h$ — measured flow velocity of float rod(m/s);

$h$ — submerged depth of float rod(m).

**C.7.6** The cross-section discharge measured by small floats may be calculated by multiplying the virtual discharge at a cross-section by the small float coefficient of a cross-section. The mean flow velocity of small floats at each vertical may be calculated by dividing the distance between the upstream and downstream cross-sections by mean duration. The virtual discharge at a cross-section may be calculated according to Article C.7.1 of this code.

**C.7.7** The calculation of measured discharge by the polar coordinate float method (Figure C.7.7) shall be carried out according to the following requirements:

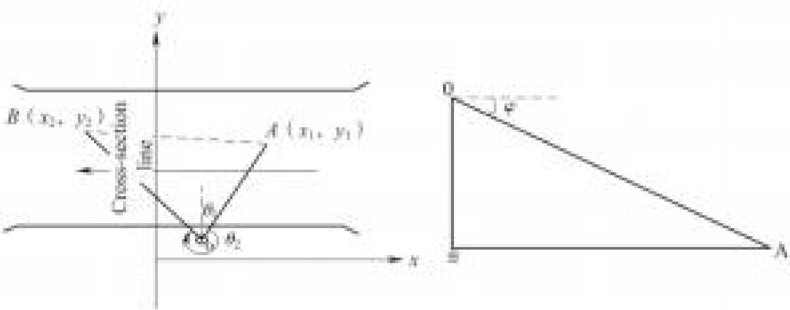



Figure C.7.7 Schematic diagram of discharge measurement by the polar coordinate float method

**1** The flow velocity of each float shall be calculated according to the following formulae:

$$V_{fi}=\frac{L_i}{t_i} \tag{C.7.7-1}$$

$$L_i=\cot\theta_1\sin\varphi_1(Z+i-G)-\cot\theta_2\sin\varphi_2(Z+i-G) \tag{C.7.7-2}$$

where $V_{fi}$— measured float flow velocity of the $i$th float(m/s);

$L_i$— vertical distance of float operation(m);

$t_i$— operation duration of the $i$th float(s);

$\theta_1$, $\theta_2$— measured depression angles of a float on the predetermined position of the upstream and downstream cross-section, respectively;

$\varphi_1$, $\varphi_2$— differences between the azimuth angle of intersection sight line and cross-section line when a float is on the predetermined position of the upstream and downstream cross-section, respectively;

$Z$— elevation of elevation base point(m);

$i$— height of instrument(m);

$G$— stage(m).

**2** The distance from initial point for each float passing over a cross-section shall be calculated according to the following formulae:

$$D=y_1-\frac{y_1-y_2}{x_1-x_2}x_1 \tag{C.7.7-3}$$

$$x_1=x_0+\cot\theta_1\sin\varphi_1(Z+i-G),\ x_2=x_0+\cot\theta_2\sin\varphi_2(Z+i-G) \tag{C.7.7-4}$$

$$y_1=y_0+\cot\theta_1\cos\varphi_1(Z+i-G),\ y_2=y_0+\cot\theta_2\cos\varphi_2(Z+i-G) \tag{C.7.7-5}$$

where $D$— distance from initial point(m);

$x_0$, $x_1$, $x_2$— distances between a cross-section and the position of polar coordinate point and float at upstream and downstream cross-section, respectively, if polar coordinate point and float are at the upstream of the cross-section, the value is positive, otherwise, negative;

$y_0$, $y_1$, $y_2$— distancs from initial point of polar coordinate point and float at upstream and downstream cross-section respectively.

**C.7.8** The equivalent stage of the measured discharge of the float method may be calculated according to Article B.7.8 of this code.

## C.8 Uncertainty estimation

**C.8.1** The uncertainty of the float method shall mainly consists of the following components:

**1** Width measurement uncertainty.

**2** Sounding uncertainty.

**3** Float flow velocity uncertainty.

**4** Float coefficient uncertainty.

**5** Uncertainty caused by the limitation of cross-section segment number.

**6** Uncertainty caused by the non-synchronization of cross-section measurement and float discharge measurement.

**C.8.2** The uncertainty of each component shall be determined according to the following requirements:

**1** The requirements stipulated in Article B.12.2 and Article B.12.3 of this code shall be adopted for the uncertainty of width measurement and sounding.

**2** Float flow velocity uncertainty consists of two parts:

**1**) The uncertainty of float route through the upstream and downstream cross-sections. The permissible uncertainty of distance between the upstream and downstream cross-sections of an observation float is 1.5%.

**2**) The uncertainty of the time when a float passes through the upstream and downstream cross-sections. The permissible uncertainty of a float operation duration is 1.5%.

**3** Float coefficient uncertainty may be estimated by the mathematical statistics method on the basis of the collection of a large number of float coefficient test data as required. The permissible random uncertainty of float coefficient shall be in accordance with Table C.8.2.

**Table C.8.2 Permissible random uncertainty of float coefficient**

| Number of cross-section segments | 5 | 10 | 15 | 20 |
|---|---|---|---|---|
| Random uncertainty of float coefficient(%) | 7 | 6 | 5 | 4.6 |

**4** The analysis method of uncertainty caused by the constraint of vertical number is the same as the current meter method.

**5** The uncertainty caused by the non-synchronization of cross-section measurement and float discharge measurement may be estimated by statistical analysis based on a large number of measured data at a station. For hydrometric stations with relatively stable river bed, 4% to 6% may be preferred.

**C.8.3** Total random uncertainty shall be calculated according to the following formula:

$$X'_Q = \pm\left[X'^2_m + X'^2_{kf} + X'^2_{nf} + \left(\frac{1}{m+1}\right)(X'^2_b + X'^2_d) + (X'^2_L + X'^2_T)\right]^{\frac{1}{2}} \tag{C.8.3}$$

where $X'_Q$ — total random uncertainty of float discharge measurement;

$X'_m$ — uncertainty caused by the constraint of vertical number;

$X'_{kf}$ — uncertainty of float coefficient;

$X'_{nf}$ — uncertainty caused by non-synchronization of cross-section measurement and float discharge measurement;

$X'_b$, $X'_d$ — width measurement uncertainty and sounding uncertainty;

$X'_L$ — uncertainty of float route through the upstream and downstream cross-sections;

$X'_T$ — uncertainty of the time when a float passes through the upstream and downstream cross-sections;

$m$ — number of cross-section segments.

**C.8.4** Total systematic uncertainty shall be calculated according to the following formula:

$$X''_Q = \pm[(X''^2_b + X''^2_d)/2]^{\frac{1}{2}} \tag{C.8.4}$$

where $X''_b$, $X''_d$ — systematic uncertainties of width measurement and sounding, respectively.

**C.8.5** The synthetic uncertainty of a single discharge measurement shall be calculated according to the following formula:

$$X_Q = \pm(X'^2_Q + X''^2_Q)^{\frac{1}{2}} \tag{C.8.5}$$

# Appendix D  Format of discharge measurement table and filling instructions

## D.1 Table preparation

**D.1.1** The format of various tables in this code may be adjusted appropriately according to the situation, but the format of tables used by the institutions in a same river basin, provinces (autonomous regions or municipalities directly under the Central Government) and departments shall be unified.

**D.1.2** The columns specified in a table may be added as needed, but should not be reduced.

**D.1.3** The original records of each measurement shall be recorded in Arabic numerals and in hard pencil on the spot with the requirements of being true, accurate and clear. If there is any error in measurement records, it shall be slashed out to make the original number recognizable, and the number to be re-filled in on the upper right of the slashed-out number shall not be erased, altered or replicated.

**D.1.4** Various measurement tables and sheets shall be sorted, calculated and checked at any time, bound into volumes on a monthly or yearly basis, and kept properly without any loss or damage.

**D.1.5** The units and significant figures of each measurement quantity shall comply with the requirements in Table D.1.5.

**Table D.1.5 Units and significant figures of each measurement quantity**

| Item | Unit name | Unit of measurement | Number of digit place |
|---|---|---|---|
| Stage and draft reading | meter | m | Record to 0.01m, and to 0.005m when reading is required to three decimal places |
| Zero elevation | meter | m | Record to 0.001m |
| Depth | meter | m | In the case of no less than 100m, record to 1m.<br>In the case of less than 100m and no less than 5m, record to 0.1m.<br>In the case of less than 5m, record to 0.01m |
| River bed elevation and hydraulic radius | meter | m | Record to 0.01m |
| Ice thickness, thickness of immersed ice, thickness of frazil slush and snow depth on ice | meter | m | All record to 0.01m |
| Flow velocity | meter per second | m/s | In the case of no less than 1m/s, take three significant digits.<br>In the case of less than 1m/s, take two significant digits, up to three decimals |
| Velocity measurement duration | second | s | In the case of no less than 100s, record to an integer.<br>In the case of less than 100s, record to 0.1s or 0.5s |
| Flow velocity coefficient and float coefficient | | | In the case of discharge calculation, record to two decimals.<br>Take three significant figures when float coefficient and flow velocity coefficient are analyzed and studied |
| Deflection angle of suspension cable and deflection angle of flow direction | degree | (°) | Record to an integer |

**Table D.1.5 ( continued )**

| Item | Unit name | Unit of measurement | Number of digit place |
|---|---|---|---|
| Distance from initial point | meter | m | In the case of no less than 100m, record to an integer.<br>In the case of less than 100m and no less than 5m, record to 0.1m.<br>In the case of less than 5m, record to 0.01m |
| Water surface width | meter | m | Take three significant digits.<br>In the case of no less than 5m, record up to one decimal.<br>In the case of less than 5m, record up to two decimals |
| Cross-section area | square meter | $m^2$ | Take three significant digits, up to two decimal |
| Discharge | cubic meter per second | $m^3/s$ | Take three significant digits, up to two decimal |
| Surface slope | permyriad | $10^{-4}$ | Take three significant digits |
| River bed roughness | | | Take to 0.001 |
| Stage rise rate | meter per hour | m/h | Take three significant digits, up to two decimal |
| Wind speed | meter per second | m/s | Take three significant digits, up to two decimal |
| Tidal volume | $10^4$ cubic meters | $10^4 m^3$ | Take four significant digits, up to two decimal |
| Net discharge(inflow)volume | $10^4$ cubic meters | $10^4 m^3$ | The number of digits of the last digit taken shall be the same as that of the last digit of a smaller tidal volume of the rising and falling tidal volume |
| Uncertainty | | % | Take one decimal |

Notes: 1 Significant digit is rounded according to the rule of "round-to-even, look at the five odd or even". If the number after significant digit less than five is rounded to zero, and that greater than five is rounded to one. If the last number is five, there are two cases: it is rounded to one when the penultimate number is odd, and rounded to zero when the penultimate number is even.

2 When a significant digit is taken, it is not necessary to consider uniform decimal places.

**D.1.6** Due to the application of different calculation tools, relevant columns may be left blank if there is no need to reflect the values of some intermediate calculation processes in various measurement tables, but they shall be explained in remark column.

**D.1.7** The format of various tables shall be in accordance with the following requirements:

**1** The ordinal number and specifications of tables shall comply with the requirements in Table D.1.7-1.

**2** The cover of discharge measurement record book and the format of each table therein shall satisfy the requirements in Table D.1.7-2 to Table D.1.7-12, respectively.

**3** The cover of tidal discharge measurement record book and the format of each table therein shall satisfy the requirements in Table D.1.7-13 to Table D.1.7-20, respectively.

**Table D.1.7-1 Ordinal number and specifications of various tables**

| Table name | Ordinal number | Specifications |
|---|---|---|
| A.Discharge measurement record book | | Sixteenmo |
| 1.Cover | Table D.1.7-2 | Sixteenmo |
| 2.Sounding and flow velocity-measuring records and discharge calculation table( Ⅰ )(current meter method in free flow period) | Table D.1.7-3 | Sixteenmo |
| 3.Sounding and flow velocity-measuring records and discharge calculation table( Ⅱ )(current meter method in free flow period) | Table D.1.7-4 | Sixteenmo |
| 4.Sounding and flow velocity-measuring records and discharge calculation table( Ⅰ )(current meter method in free flow period of cableway) | Table D.1.7-5 | Sixteenmo |
| 5.Sounding and flow velocity-measuring records and discharge calculation table( Ⅱ )(current meter method in free flow period of cableway) | Table D.1.7-6 | Sixteenmo |
| 6.Sounding and flow velocity-measuring records and discharge calculation table( Ⅰ )(current meter method in icy period) | Table D.1.7-7 | Sixteenmo |
| 7.Sounding and flow velocity-measuring records and discharge calculation table( Ⅱ )(current meter method in icy period) | Table D.1.7-8 | Sixteenmo |
| 8.Equivalent stage calculation table(current meter method) | Table D.1.7-9 | Sixteenmo |
| 9.Flow velocity-measuring record table(surface float method) | Table D.1.7-10 | Sixteenmo |
| 10.Sounding record and discharge calculation table(surface float method) | Table D.1.7-11 | Sixteenmo |
| 11.Float flow velocity distribution curve and cross-section profile | Table D.1.7-12 | Sixteenmo |
| B.Tidal discharge measurement record book | | Sixteenmo |
| 1.Cover | Table D.1.7-13 | Sixteenmo |
| 2.Description of tidal discharge measurement | Table D.1.7-14 | Sixteenmo |
| 3.Statistical table of calculation results of tidal discharge measurement | Table D.1.7-15 | Sixteenmo |
| 4.Tidal discharge measurement and flow velocity-measuring record table | Table D.1.7-16 | Sixteenmo |
| 5.Record table of tidal discharge measurement of shipboard-type ADCP | Table D.1.7-17 | Sixteenmo |
| 6.Tidal discharge calculation table | Table D.1.7-18 | Sixteenmo |
| 7.Tidal volume calculation table | Table D.1.7-19 | Sixteenmo |
| 8.Tidal volume calculation table(representative vertical discharge measurement) | Table D.1.7-20 | Sixteenmo |

**Table D.1.7-2 Cover of discharge measurement record book**

Discharge measurement record book of ___________ Station(Cross-section)

Station code ___________

Management unit ___________

Watershed _____________ River system ___________ River name ___________

__________ Province(autonomous region or municipality directly under the Central Government)

_______County(city,district)______Township(town,street)________Village

Ordinal number of measurements from __________ to __________

Measuring date from ____ year ____ month ____ day to ____ year ____ month ____ day

Checker__________(____ month ____ day)

Station manager ___________(____ month ____ day)

______ pages in total

**Table D.1.7-3 Sounding and flow velocity-measuring records and discharge**

Measuring time: From year month day hour minute to day hour minute (mean: day hour minute)

Current meter brand and formula: Service hours after verification or comparative gauging:

| Ordinal number of vertical | | Angle or reading (°) | Distance from initial point (m) | Time | | Stage of gauging cross-section (m) | Measured depth (m) | Total length of wet line (m) | Deflection angle of suspension cable (°) | Corrected length (m) | | Depth or applied depth (m) | River bed elevation (m) | Current meter position | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sounding | Velocity measurement | | | Sounding | Velocity measurement | Stage of basic staff gauge cross-section (m) | | | | Air line | Wet line | | | Relative depth | Measuring point depth or wet line length (m) |
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**calculation table (Ⅰ) of ____Station(current meter method in free flow period)**



Weather: Wind direction and wind force: Flow direction:

Calculation formula of distance from initial point: Stopwatch No.:

| Flow velocity-measuring record | | Deflection angle of flow direction (°) | Flow velocity(m/s) | | | | | Between sounding verticals | | Area of channel cross-section | | Segment discharge ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total rotor revolutions | Total duration (s) | | Measuring point | After flow direction correction | Coefficient | Mean value at a vertical | Mean value of a segment | Mean depth (m) | Spacing (m) | Between sounding verticals ($m^2$) | Segment ($m^2$) | |
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Ordinal number of measurement: ____________

**Table D.1.7-4 Sounding and flow velocity-measuring records and discharge**

Measuring time: From year month day hour minute to day hour minute (mean: day hour minute)

Current meter brand and formula: Service hours after verification or comparative gauging:

| Ordinal number of vertical | | Angle or reading (°) | Distance from initial point (m) | Time | | Stage of gauging cross-section (m) | Measured depth (m) | Total length of wet line (m) | Deflection angle of suspension cable (°) | Corrected length (m) | | Depth or applied depth (m) | River bed elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sounding | Velocity measurement | | | Sounding | Velocity measurement | Stage of basic staff gauge cross-section (m) | | | | Air line | Wet line | | |
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|---|---|---|---|---|---|
| Cross-section discharge | m³/s | Water surface width | m | Roughness | |
| Area of channel cross-section | m² | Mean depth | m | Rising rate of stage | m/h |
| Stagnant water area | m² | Maximum depth | m | Equivalent stage | m |
| Mean flow velocity | m/s | Stage difference between upstream and downstream slopes | m | Spacing between upstream and downstream slope measuring staff gauges | m |
| Maximum flow velocity at a point | m/s | Surface slope | $\times 10^{-4}$ | Number of verticals | |
| | | | | Total number of measuring points | |
| Explanation | Method of crossing river: | Ranging method: | Sounding method: | Height difference between suspension fulcrum and water surface(m): | Current meter suspension mode: |
| Note: | | | | | |

Measurer ______ Calculator ______( month day) Checker ______( month day) Re-checker ______( month day)

**calculation table (Ⅱ) of __Station(current meter method in free flow period)**

Page   of

| Weather: | Wind direction and wind force: | Flow direction: |
|---|---|---|
| Calculation formula of distance from initial point: | Stopwatch No.: | |

| Current meter position | | Flow velocity-measuring record | | Deflection angle of flow direction (°) | Flow velocity (m/s) | | | | | Between sounding verticals | | Area of channel cross-section | | Segment discharge ($m^3$/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relative depth | Measuring point depth or wet line length (m) | Total rotor revolutions | Total duration (s) | | Measuring point | After flow direction correction | Coefficient | Mean value at a vertical | Mean value at a segment | Mean depth (m) | Spacing (m) | Between sounding verticals ($m^2$) | Segment ($m^2$) | |
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| Stage record | Name of gauge | Ordinal number | Gauge reading (m) | Zero elevation (m) | Stage (m) |
|---|---|---|---|---|---|
| | Basic staff gauge | | Beginning: Ending: Mean: | | |
| | Discharge measurement gauge | | Beginning: Ending: Mean: | | |
| | Upper slope gauge (secondary) | | Beginning: Ending: Mean: | | |
| | Lower slope gauge (secondary) | | Beginning: Ending: Mean: | | |

| Explanation | Weight of elliptical type weight(kg): Suspension cable diameter(mm): | Distance from the center of instrument shaft to the bottom of elliptical type weight(cm): | Ordinal number of gauging cross-section used for discharge calculation: | Zeroing error: | Synthetic uncertainty: | Determined system uncertainty: |
|---|---|---|---|---|---|---|
| | | | | | | |

Ordinal number of measurement: ____________

### Table D.1.7-5 Sounding and flow velocity-measuring records and discharge

Measuring time: From year month day hour minute to day hour minute (mean: day hour minute)

Current meter brand and formula: Service hours after verification or comparative gauging: Prospecting instrument No.:

| Ordinal number of vertical | | Distance from initial point (m) | Time | | Stage of gauging cross-section (m) | Depth counter (m) | | Deflection angle of suspension cableway (°) | Sag of main cable (m) | Height difference between overhead cable and water surface (m) | Corrected value (m) | | | Wet line length (m) | Depth or applied depth (m) | River bed elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sounding | Velocity measurement | | Sounding | Velocity measurement | Stage of basic staff gauge cross-section (m) | Reading | Correction | Water surface / River bottom | | | Air line | Displacement | Wet line | | | |
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calculation table(Ⅰ)of ____Station(current meter method in free flow period of cableway)

Page　　of

Weather:　　Wind direction and wind force:　　Flow direction:

Calculation formula of distance from initial point:　　Stopwatch No.:

| Current meter position | | Flow velocity-measuring record | | Flow velocity (m/s) | | | | Between sounding verticals | | Area of channel cross-section | | Segment discharge ($m^3$/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relative depth | Measuring point depth (m) | Total rotor revolutions | Total duration (s) | Measuring point | Coefficient | Mean value at a vertical | Mean value at a segment | Mean depth (m) | Spacing (m) | Between sounding verticals ($m^2$) | Segment ($m^2$) | |
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Ordinal number of measurement:________

**Table D.1.7-6 Sounding and flow velocity-measuring records and discharge**

Measuring time: From year month day hour minute to day hour minute (mean: day hour minute)

Current meter brand and formula: Service hours after verification or comparative gauging: Prospecting instrument No.:

| Ordinal number of vertical | | Distance from initial point (m) | Time | | Stage of gauging cross-section | Depth counter (m) | | Deflection angle of suspension cable (°) | Sag of main cable (m) | Height difference between overhead cable and water surface (m) | Corrected value (m) | | | Wet line length (m) | Depth or applied depth (m) | River bed elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sounding | Velocity measurement | | Sounding | Velocity measurement | Stage of basic staff gauge cross-section (m) | Reading | Correction | Water surface / River bottom | | | Air line | Displacement | wet line | | | |
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|---|---|---|---|---|---|
| Cross-section discharge | $m^3/s$ | Water surface width | m | Roughness | |
| Area of channel cross-section | $m^2$ | Mean depth | m | Rising rate of stage | m/h |
| Stagnant water area | $m^2$ | Maximum depth | m | Equivalent stage | m |
| Mean flow velocity | m/s | Stage difference between upstream and downstream slopes | m | Distance between upstream and downstream slope measuring staff gauges | m |
| Maximum flow velocity at a point | m/s | Surface slope | $\times 10^{-4}$ | Number of verticals | |
| | | | | Total number of measuring points | |
| Explanation | Method of crossing river: | Ranging method: | Sounding method: | Height difference between suspension fulcrum and water surface(m): | Current meter suspension mode: |
| Note: | | | | | |

**calculation table( Ⅱ )of ____Station (current meter method in free flow period of cableway)**



| | | |
|---|---|---|
| Weather: | Wind direction and wind force: | Flow direction: |
| Calculation formula of distance from initial point: | | Stopwatch No.: |

| Current meter position | | Flow velocity-measuring record | | Flow velocity(m/s) | | | | Between sounding verticals | | Area of channel cross-section | | Segment discharge ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relative depth | Measuring point depth (m) | Total rotor revolutions | Total duration (s) | Measuring point | Coefficient | Mean value at a vertical | Mean in segment | Mean depth (m) | Spacing (m) | Between sounding verticals ($m^2$) | Segment ($m^2$) | |
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| | Name of gauge | Ordinal number | Gauge reading (m) | Zero elevation(m) | Stage (m) |
|---|---|---|---|---|---|
| Stage record | Basic staff gauge | | Beginning: Ending: Mean: | | |
| | Discharge measurement gauge | | Beginning: Ending: Mean: | | |
| | Upper slope gauge(secondary) | | Beginning: Ending: Mean: | | |
| | Lower slope gauge(secondary) | | Beginning: Ending: Mean: | | |
| Explanation | Weight of elliptical type weight(kg): Suspension cable diameter(mm): | Distance from center of instrument shaft to the bottom of elliptical type weight (cm): | Ordinal number of cross-sections used for discharge calculation: | Synthetic uncertainty: | Determined system uncertainty: |
| | | | | | |

Ordinal number of measurement: ____________

**Table D.1.7-7 Sounding and flow velocity-measuring records and**

| Measuring time: From year month day hour minute to day hour minute (mean: day hour minute) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current meter brand and formula: | | | | | | Service hours after verification or comparative gauging: | | | | | | | |
| Ordinal number of vertical | | Angle or reading (°) | Distance from initial point (m) | Depth (m) | Thickness of ice (m) | Thickness of immersed ice (m) | Thickness of frazil slush (m) | Spacing between sounding verticals (m) | Area of immersed ice | | Area of (frazil) slush | | Effective or applied depth (m) | River bed elevation (m) |
| Sounding | Velocity measurement | | | | | | | | Mean thickness between verticals (m) | Area between verticals ($m^2$) | Mean thickness between verticals (m) | Area between verticals ($m^2$) | | |
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**discharge calculation table( Ⅰ )of ____ Station(current meter method in icy period)**

Page　　of

| Weather: | Wind direction and wind force: | Flow direction: | Ice condition: |
|---|---|---|---|
| Calculation formula of distance from initial point: | | Stopwatch No.: | |

| Area of channel cross-section | | | Current meter position | | Flow velocity-measuring record | | Deflection angle of flow direction (°) | Flow velocity($m/s$) | | | | | Segment discharge ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Between sounding verticals | | Segment area ($m^2$) | Relative depth | Measuring point depth (m) | Total rotor revolutions | Total duration (s) | | Measuring point | Corrected flow direction | Coefficient | Mean value at a vertical | Mean value at a segment | |
| Mean depth (m) | Area ($m^2$) | | | | | | | | | | | | |
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Ordinal number of measurement:____________________

**Table D.1.7-8 Sounding and flow velocity-measuring records and discharge**

Measuring time: From  year  month  day  hour  minute to  day  hour  minute (mean:  day  hour  minute)

Current meter brand and formula:  Service hours after verification or comparative gauging:

| Ordinal number of vertical | | Angle or reading (°) | Distance from initial point (m) | Depth (m) | Thickness of ice (m) | Thickness of immersed ice (m) | Thickness of frazil slush (m) | Spacing between sounding verticals (m) | Area of immersed ice | | Area of frazil slush | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sounding | Velocity measurement | | | | | | | | Mean thickness between verticals (m) | Area between verticals (m²) | Mean thickness between verticals (m) | Area between verticals (m²) |
| | | | | | | | | | | | | |
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|---|---|---|---|---|---|
| Cross-section discharge | m³/s | Area of immersed ice | m² | Mean effective depth | m |
| Area of channel cross-section | m² | Area of frazil slush | m² | Maximum depth | m |
| Stagnant water area | m² | Total area of cross-section | m² | Maximum effective depth | m |
| Mean flow velocity | m/s | Water surface width | m | Number of verticals | |
| | | | | Total number of measuring points | |
| Maximum flow velocity at a point | m/s | Width of ice bottom | m | Ordinal number of measuring cross-section used for discharge calculation | |
| Equivalent stage | m | Mean depth | m | | |

Note:

Measurer ______ Calculator ______ ( month day) Checker ______ ( month day) Re-checker ______ ( month day)

**calculation table(Ⅱ)of ____ Station (current meter method in icy period)**



Weather: Wind direction and wind force: Flow direction: Ice condition:

Calculation formula of distance from initial point: Stopwatch No.:

| Effective or applied depth (m) | River bed elevation (m) | Area of channel cross-section | | | Current meter position | | Flow velocity-measuring record | | Deflection angle of flow direction (°) | Flow velocity (m/s) | | | | Segment discharge ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Between sounding verticals | | Segment area ($m^2$) | Relative depth | Measuring point depth (m) | Total rotor revolutions | Total duration (s) | | Measuring point | Corrected flow direction | Coefficient | Mean value at a segment | |
| | | Mean depth (m) | Area ($m^2$) | | | | | | | | | | | |
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| Stage record | Name of gauge | Ordinal number | Gauge reading (m) | Zero elevation (m) | Stage (m) |
|---|---|---|---|---|---|
| | Basic staff gauge | | Beginning: Ending: Mean: | | |
| | Discharge measurement gauge | | Beginning: Ending: Mean: | | |

| Explanation | | |
|---|---|---|
| | Method of crossing river: | Ranging method: |
| | Sounding method: | Current meter suspension mode: |
| | Weight of elliptical type weight(kg):<br>Suspension cable diameter(mm): | Distance from center of instrument shaft to the bottom of elliptical type weight(cm): |

Ordinal number of measurement: ____________

**Table D.1.7-9 Equivalent stage calculation table of ______ Station (current meter method)**

Page of

Measuring time: From year month day hour minute to day hour minute (mean: day hour minute)

| Ordinal number of sounding vertical | Distance from initial point (m) | Segment width of channel cross-section $b$ (m) | Width of flow velocity-measuring vertical $b'$ (m) | Mean flow velocity at a vertical $V_m$ (m/s) | Stage $Z$ (m) | $b'V_m$ | $b'V_mZ$ | Number of flow velocity-measuring verticals | Distance from initial point (m) | Segment width of channel cross-section $b$ (m) | Width of flow velocity-measuring vertical $b'$ (m) | Mean flow velocity at a vertical $V_m$ (m/s) | Stage $Z$ (m) | $b'V_m$ | $b'V_mZ$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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$\sum b'V_m=$ $\sum b'V_mZ=$ Equivalent stage $=\frac{\sum b'V_mZ}{\sum b'V_m}=$ ______ (m)

Calculator: ______ ( month day) Preliminary checker: ______ ( month day) Re-checker: ______ ( month day) Ordinal number of measurement: ______

**Table D.1.7-10 Flow velocity-measuring record table of ______ Station (surface float method)**

Page of

Measuring time: From year month day hour minute to day hour minute (mean: day hour minute)
Weather:

Flow direction: Water surface condition: Stopwatch No.:
Distance between upstream and downstream cross-sections: m

Type of surface floats: Submerged depth (dm): Freeboard (dm): Float dropping method:

| Float | | Passing through gauging cross-section | | Reading of stopwatch | | | | Duration (s) | Float flow velocity (m/s) | Wind force (speed) | Wind direction | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Upstream cross-section | | Downstream cross-section | | | | | | |
| Ordinal number | Characteristics | Angle (°) | Distance from initial point (m) | (min) | (s) | (min) | (s) | | | | | |
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Measurer: ____________ Ordinal number of measurement: ____________

**Table D.1.7-11 Sounding record and discharge calculation table of ______Station(surface float method)**

Page of

Sounding date: From year month day Ordinal number of measuring cross-section: Sounding method:

Calculation formula of distance from initial point: Ranging method: Spacing between upstream and downstream cross-sections in gradient:

| Ordinal number of vertical | Angle or reading (°) | Distance from initial point (m) | Depth (m) | Sounding time | Stage of zero flow cross-section (m) | River bed elevation (m) | Applied depth (m) | Between sounding verticals (m) | | Segment area (m²) | Virtual flow velocity (m/s) | | Segment virtual discharge (m³/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Mean depth | Spacing | | Vertical | Mean value at a segment | |
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|---|---|---|---|---|---|---|---|
| Virtual discharge at a cross-section | m³/s | Mean flow velocity | m/s | Equivalent stage | m | Method for float coefficient determination | |
| Float coefficient | | Maximum flow velocity at a point | m/s | Stages of upstream and downstream slopes | m | | |
| Cross-section discharge | m³/s | Water surface width | m | Surface slope | $\times 10^{-4}$ | Synthetic uncertainty | |
| Area of channel cross-section | m² | Mean depth | m | Roughness | | Determined system uncertainty | |
| Stagnant water area | m² | Maximum depth | m | Rising rate of stage | m/h | | |

| | Name of gauge | Ordinal number | Gauge reading (m) | Zero elevation (m) | Stage (m) | Remarks |
|---|---|---|---|---|---|---|
| Stage record | Basic staff gauge | | Beginning: Ending: Mean: | | | |
| | Discharge measurement gauge | | Beginning: Ending: Mean: | | | |
| | Upper slope gauge (secondary) | | Beginning: Ending: Mean: | | | |
| | Lower slope gauge (secondary) | | Beginning: Ending: Mean: | | | |

Note:

Measurer______ Calculator ______ ( month day) Checker______ ( month day) Re-checker ______ ( month day) Ordinal number of measurement:______________

**Table D.1.7-12 Float flow velocity distribution curve and cross-section profile of ______ Station**

Page    of

| Scale: Flow velocity/Depth | Longitudinal profile: | Transverse profile: |
|---|---|---|
| | | |

Drafter: ________ Checker: ________ Ordinal number of measurement: ________



**Table D.1.7-13 Cover format of tidal discharge measurement record book**

Tidal discharge measurement record book of ________________ Station(Cross-section)

Station code ________________

Management unit ____________

Watershed ________________ River system ________________ River name ________________

________ Province(autonomous region or municipality directly under the Central Government)

________ County(city, district) Township(town, street) ________ Village

Ordinal number of measurement ____________

Measuring time from ______ year ______ month ______ day(Lunar calendar ______ month ______ day) ______ hour ______ minute to ______ month ______ day(Lunar calendar ______ month ______ day) ______ hour ______ minute

Measurer: ____________

Calculator: ____________ ( ____ month ____ day)

Checker: ____________ ( ____ month ____ day)

Re-checker: ____________ ( ____ month ____ day)

Station manager: _______ ( ____ month ____ day)

______ pages in total

**Table D.1.7-14 Description of tidal discharge measurement of ______ Station**

Page of

| | |
|---|---|
| Cross-section position: | |
| Vertical arrangement method: | |
| Measuring line $\frac{\text{Distance from initial point}}{\text{River bottom elevation}}$ (m): I —— II —— III —— IV —— V —— VI —— VII | |
| Method of measurement: Hydrometric boat fixation: | |
| Ranging method: Sounding method: | |
| Ordinal number of gauging cross-section used for discharge calculation: | |
| During flood tidal and ebb tidal: Weather________ Dominant wind direction______ Mean wind force(speed)______ | |
| Note | |

Ordinal number of measurement: ____________________

**Table D.1.7-15 Statistical table of calculation results of tidal discharge measurement of ______ Station**

Page of

| Period of measurement | | Tidal stage (m) | | Cross-section area($m^2$) | | | Tidal volume | Tidal current duration (h) | Mean discharge ($m^3/s$) | Mean flow velocity (m/s) | Maximum instantaneous discharge ($m^3/s$) | Maximum discharge at a measuring point ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Highest | Lowest | Maximum | Minimum | Mean | $10^4 m^3$ | | | | | |
| to | Tidal current period | | | | | | | | | | | |
| | Flood tidal current | | | | | | | | | | | |
| | Ebb tidal current | | | | | | | | | | | |
| Note | 1. The stage of the adjacent low tide before a tidal current period is measured: m<br>2. Slack tide stage: (1) m (2) m (3) m<br>3. Shoreside flow velocity coefficient: Left bank: Right bank: | | | | | | | | | | | |

Filling staff:________( year month day) Preliminary checker:________( year month day)
Re-checker:________( year month day) Ordinal number of measurement:________________

**Table D.1.7-16 Tidal discharge measurement and flow velocity-measuring record table of ________ Station**

Page    of

Measuring time: From    year    month    day    hour    minute to    day    hour    minute    Current meter brand and formula:    Usage hours after verification or comparative gauging:

Suspension mode of current meter:    Weight of elliptical type weight:    kg    Suspension cable diameter:    mm

Distance from center of instrument shaft to the bottom of elliptical type weight:    cm    Distance from instrument to side of boat:    m    Stopwatch No.:

| Ordinal number of vertical | Measuring time | | Stage (m) | Distance from initial point (m) | Tidal depth (m) | Ordinal number of measuring point | Measuring point depth (m) | Flow velocity measuring record | | Flow velocity (m/s) | | | | | | Wind direction | Wind force (speed) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hour | Minute | | | | | | Total rotor revolutions | Total duration | Measuring point | Deflection angle of flow direction (°) | Correction value | Measuring point correction | Mean value at a measuring point | Mean value at a vertical | | | |
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Measurer:________ Calculator:________ (    month    day) Preliminary checker:________ (    month    day) Re-checker:________ (    month    day)

Ordinal number of measurement:________________

**Table D.1.7-17 Tidal discharge measurement record**

| Number of tidal current: | Date: year month day (Lunar calendar: month day) | |
|---|---|---|
| Weather: | Wind force and wind direction: | Sea conditions/Waves: |
| Submerged depth of transducer: m | Depth unit size: m | Number of depth units: |
| Projection angle: | Calculation method of cross-section area: | |

| Number of measurement | Measurement cycle | Data file name | Crossing course | Beginning | | | Ending | | | Water surface width (m) | Maximum depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Time | Depth (m) | Shoreside distance (m) | Time | Depth (m) | Shoreside distance (m) | | |
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Note:

Observer: Preliminary checker: Second checker:

**table of ______ Station on ______ River(shipboard-type ADCP)**

Page of

| | | | |
|---|---|---|---|
| Position of gauging cross-section: | | Instrument model: | Hydrometric boat material: |
| Installation method: | | Ground speed mode: | Sounding method: |
| The number of pings in water tracking: | The number of pings in bottom tracking: | Edge-vertical epoch number: | Magnetic declination: |
| Special instruction settings: | | Salinity: | Acoustic velocity: |

| Shipboard discharge | | Left bank discharge | | | Right bank discharge | | | Top discharge | | | Bottom discharge | | | Total discharge of cross-section (m³/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured discharge (m³/s) | Proportion of total discharge (%) | Estimation method | Estimated discharge (m³/s) | Proportion of total discharge (%) | Estimation method | Estimated discharge (m³/s) | Proportion of total discharge (%) | Estimation method | Estimated discharge (m³/s) | Proportion of total discharge (%) | Estimation method | Estimated discharge (m³/s) | Proportion of total discharge (%) | |
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Re-checker: Page of

**Table D.1.7-18 Tidal discharge calculation table of ______ Station**

Page of

| Hour | Minute | Ordinal number of vertical | Distance from initial point (m) | Tidal stage (m) | Mean flow velocity at a vertical (m/s) | Mean flow velocity at a segment (m/s) | Segment area ($m^2$) | Segment discharge ($m^3/s$) | Cross-section discharge ($m^3/s$) | Area of channel cross-section ($m^2$) | Mean flow velocity at a cross-section (m/s) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
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Calculator: ______ ( month day) Preliminary checker: ______ ( month day) Re-checker: ______ ( month day) Ordinal number of measurement: ______

**Table D.1.7-19 Tidal volume calculation table of __________ Station**

Page  of

| Flood tidal current | | | | | | Ebb tidal current | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hour | Minute | Discharge ($m^3/s$) | Mean discharge ($m^3/s$) | Duration (s) | Tidal volume ($10^4m^3$) | Hour | Minute | Discharge ($m^3/s$) | Mean discharge ($m^3/s$) | Duration (s) | Tidal volume ($10^4m^3$) |
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Calculator: ________ ( month day) Preliminary checker: ________ ( month day) Re-checker: ________ ( month day)

Ordinal number of measurement: ________________

**Table D.1.7-20 Tidal volume calculation table of ______ Station**

**(representative vertical discharge measurement)**

Page  of

| Hour | Minute | Tidal stage (m) | Representative vertical flow velocity (m/s) | Mean flow velocity at a cross-section (m/s) | Cross-section area ($m^2$) | Discharge ($m^3/s$) | Mean discharge ($m^3/s$) | Tidal current duration (s) | Tidal volume ($10^4m^3$) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Flood tidal current | Ebb tidal current | |
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Calculator: ________ ( month day) Preliminary checker: ________ ( month day) Re-checker: ________ ( month day)

Ordinal number of measurement: ________________

## D.2 Filling instructions

**D.2.1** The filling of the cover of discharge measurement record book(Table D.1.7-2 of this code)shall be in accordance with the following requirements:

**1** Station name: Fill in the full name of a hydrometric station.

**2** Station code: Fill in the existing station code. New hydrometric stations(or cross-sections and special hydrometric stations without code) may prepare a temporary code according to hydrometric station coding rules.

**3** Management unit: Fill in the full name of basin or provincial hydrological agency.

**4** Watershed, river system and river name: Fill in the names uniformly defined by river basin authorities, or data collection and publishing agencies.

**5** Province(autonomous region or municipality directly under the Central Government), county (city, district), township(town, street), village: Fill in the name of administrative division of the bank where the basic staff gauge cross-section of a hydrometric station is located.

**6** Ordinal number of measurement: Fill in the ordinal number of measurements from the first to the last discharge measurement to be included in the record book.

**7** Measuring time: Fill in the first and last measuring time to be included in the record book. Month and day shall be filled in two digits. If less than two digits, add "0" in front of the single digit.

**D.2.2** The filling of Table D.1.7-3 and Table D.1.7-4 of this code for sounding and flow velocity-measuring records and discharge calculation by the current meter method in the free flow period shall be in accordance with the following requirements:

**1** If the number of sounding and flow velocity-measuring verticals is small, Table D.1.7-4 of this code may only be used separately.

**2** Wind direction and wind force: Fill in according to the national standard GB/T 50138-2010 *Standard for Stage Observation*.

**3** Flow direction: Flow direction refers to the direction of main stream, while local backflow is not considered. Downstream flow is denoted as "Λ", upstream flow as "V", and stagnation as "×".

**4** Current meter brand and formula: Fill in the type, ordinal number and calibration formula of a current meter. If more than two instruments are used in discharge measurement, they shall be listed one by one, and the ordinal number of verticals measured by each instrument shall be indicated in the note column.

**5** Service hours after verification or comparative gauging: Fill in accumulated hours from verification or comparative gauging up to the time of current measurement(counting to one decimal place). If an instrument does not undergo comparative gauging after verification, cross off the words "or comparative gauging". Otherwise, cross off the words "verification or".

**6** Calculation formula of distance from initial point: Fill in the formula used for calculating distance from initial point or zero point correction value. Direct distance measurement does not require zero point correction, so this column may be left blank.

**7** Ordinal number of vertical: Fill in according to the ordinal number of vertical distance from initial point. Water edge points are not numbered, and only fill in the words "left water edge" or "right water edge" in the corresponding column.

**8** Angle or reading: Fill in the intersection angle of instruments or the reading of a distance counter.

**9** Distance from initial point: Fill in the distance from initial point at a vertical calculated by the intersection angle or distance counter.

**10** Sounding and flow velocity-measuring time: Fill in the time when measurement begins at each vertical. The column shall be filled in with hour and minute in two digits. If less than two digits, add "0" in front of the single digit.

**11** Stage of gauging cross-section or basic staff gauge cross-section: Fill in the observed stage at the beginning of measurement or periodically observed stage record at each vertical.

**12** Measured depth, total length of wet line:

**1**) If sounding with elliptical type weight and reading by depth counter or vernier, fill in by fraction. Fill in the difference between the readings when elliptical type weight contact water surface and river bottom as a numerator and the length of the wet line after the length correction of air line as a denominator. If the deflection angle of suspension cable or the height difference between suspension fulcrum and water surface is small so that there is no need of correction, the numerator and denominator are filled in with the same value.

**2**) Fill in the total length of the wet line directly with the direct reading of the suspension cable sign.

**3**) If sounding with a sounding rod, suspension rod or sounder, fill in the measured depth.

**4**) If a cross-section is borrowed for discharge calculation, this column may be left blank.

**13** Deflection angle of suspension cable: If suspension cable is used to suspend an elliptical type weight for sounding, fill in the deflection angle of suspension cable when the elliptical type weight touches river bottom. If suspension cable is used to suspend a current meter for measuring flow velocity, fill in the deflection angle of suspension cable when the current meter is located at a measuring point. If the deflection angle of suspension cable is less than 10° and a suspension rod is used to suspend an elliptical type weight for sounding and flow velocity measurement, this column is left blank.

**14** Corrected length of air line and wet line: The corrected length of air line and wet line is filled in respectively by looking up Table E.0.1 and Table E.0.2 of this code. If a suspension rod is used to suspend an elliptical type weight for sounding, this column is left blank.

**15** Depth or applied depth: Fill in the depth measured by a sounding rod, sounding weight or suspension rod, or the actual depth measured by an elliptical type weight suspended by suspension cable and corrected by air and wet lines correction, and cross out the words "or applied depth". If a cross-section is borrowed for discharge calculation, fill in the stage of the gauging cross-section measured at the vertical or the applied depth obtained by subtracting the river bed elevation at the corresponding vertical position of the borrowed cross-section from the mean stage measured on the same cross-section, and cross out the words "Depth or".

**16** River bed elevation: Obtain by subtracting the depth at a vertical from the stage of a gauging cross-section. If a cross-section is borrowed for discharge calculation, its elevation is directly filled as that of river bed. For hydrometric stations without fixed verticals, it may be obtained by the straight line interpolation of the river bed elevation of the borrowed cross-section.

**17** Current meter position:

**1**) Relative depth: Fill the ratio of measuring point depth or length of wet line to actual depth or total length of wet line with current meter.

2) Measuring point depth or length of wet line: If a current meter is suspended by a suspension rod, fill in the vertical depth from the measuring point to water surface, which is the product of relative depth and depth. If a current meter is suspended by a suspension cable, fill in the length of wet line at the measuring point, which is the product of relative depth and the total length of wet line.

**18** Flow velocity-measuring record:

1) Total rotor revolutions: Expressed by fraction. Fill in the number of current meter contacting signals as a numerator and the product of the number of contacting signals and the rotor revolution number of each signal as a denominator.

2) Total duration: Fill in the equivalent duration of the total number of times the current meter contacts the signals in seconds when flow velocity is measured.

**19** Deflection angle of flow direction: Fill in the deflection angle between flow direction at the measuring point (or flow direction near water surface) and a vertical at gauging cross-section. The column may be left blank if it is less than 10°.

**20** Flow velocity at a measuring point: Fill in by looking up current meter verification chart according to total duration and total rotor revolutions. Or directly fill in the flow velocity value shown on the flow velocity direct reader.

**21** Flow velocity after flow direction correction: This column is left blank if flow direction correction is not required. If flow velocity at a measuring point is consistent with that at a point near water surface, this column is left blank. Calculated mean flow velocity at a vertical after unified correction is directly filled into the column of mean flow velocity at a vertical.

**22** Coefficient: If the one-point method is adopted to measure flow velocity and the measuring point is not at 0.6 times depth, fill in flow velocity coefficient at a vertical.

**23** Mean flow velocity at a vertical: If the one-point method with a measuring point at 0.6 times depth or other selected point method is adopted to measure flow velocity, fill in the measured mean flow velocity at a verticals.

**24** Mean flow velocity at a segment: Fill in the calculated value according to the formula specified in Item 7 in Article B.7.1 of this code.

**25** Mean depth between sounding verticals: Fill in the arithmetic mean value of two adjacent vertical depths or applied depths.

**26** Spacing between sounding verticals: Fill in the difference between the distances from initial point of two adjacent verticals.

**27** Area of channel cross-section between sounding verticals: Fill in the product of the spacing between two adjacent sounding verticals and mean depth.

**28** Segment area of channel cross-section: Fill in the segment area between two adjacent flow velocity-measuring verticals.

**29** Segment discharge: Fill in the product of the segment area of channel cross-section and mean flow velocity at a segment. The discharge of upstream flow is negative, so a negative sign "—" shall be added prior to the discharge value.

**30** Cross-section discharge: Fill in the algebraic sum of each segment discharge. If there is diversion flow or erosion ditches, they shall be filled in according to the following requirements:

1) In main stream record table, main stream discharge is filled in this column. In diversion flow

record table, diversion flow discharge is filled in this column. Indicate main stream or diversion flow in brackets. If there is only one set of basic staff gauges of main stream in the whole cross-section and the discharge of several streams is measured at the same time, the sum of the discharge of each stream measured at this time shall be indicated in the "Note" column of each table. If there are several sets of basic staff gauges in the cross-section, the sum of the discharge of each stream measured at the same time and controlled by the same set of staff gauges shall be indicated in the "Note" column of the discharge measurement record table.

**2**) If there is only one set of basic staff gauges, the sum of main stream discharge and diversion flow discharge measured at the same time is filled in this column in the combined record table of main stream discharge and diversion discharge, but the discharge of each flow stream or main stream and diversion flow shall be indicated in the "Note" column.

**31** Area of channel cross-section: Fill in the sum of all the "Segment area of channel cross-section".

**32** Stagnant water area: Fill in the segment area of channel cross-section in a stagnant water zone with zero flow velocity.

**33** Mean flow velocity: Fill in the quotient of cross-section discharge and the area of channel cross-section.

**34** Maximum flow velocity at a point: Fill in the maximum measured value of flow velocity at a measuring point.

**35** Water surface width: Fill in the difference between the distances from initial point of water edge on left and right banks. If there is a shoal in of a river, the width of the shoal shall be subtracted.

**36** Mean depth: Fill in the quotient of area of channel cross-section and water surface width.

**37** Maximum depth: Fill in the maximum value of each depth or applied depth.

**38** Stage difference between upstream and downstream slopes: Fill in stage difference between upstream and downstream slope gauges (secondary).

**39** Surface slope: Fill in the quotient of stage difference between upstream and downstream slopes and distance between upstream and downstream cross-sections.

**40** Roughness: Calculate and fill in according to the requirements of relevant codes.

**41** Equivalent stage: Fill in after the calculation of the stage observation records of basic staff gauge in the process of discharge measurement according to the method stipulated in Article B.7.8. of this code. If there are diversion flows, erosion ditched and several sets of basic staff gauges, the equivalent stage of main stream is filled in the main stream record table and the equivalent stage of the diversion flow in respective diversion flow record table.

**42** Rising rate of stage: Obtain by dividing the difference between the stages measured at the ending and beginning by the total duration of discharge measurement. Take a positive value when flow rises and negative value when flow falls. This column is only filled in if discharge measurement process does not cross the peak and valley of stages and when objectively necessary.

**43** Number of verticals: Fill in the total number of flow velocity-measuring verticals or the number of effective floats when a current meter or deep-water float is used for gauging. When the current meter method and surface float method (or float rod method) are used for flow discharge measurement at the same time, the total number of flow velocity-measuring verticals and effective floats are filled in two items connected with "+". The first item represents the total number of flow velocity-measuring verticals with the current meter method, and the second item the number of effective surface floats(or the number of flow velocity-measuring verticals measured by the float rod method).

**44** Total number of measuring points: Fill in the total number of flow velocity-measuring points at all the verticals for the current meter method.

**45** Method of crossing river: Fill in the river crossing method of the current meter method.

**46** Ranging method: Fill in the method of measuring distance from initial point at a vertical.

**47** Sounding method: Fill in the method used to measure depth.

**48** Height difference between suspension fulcrum and water surface: Fill in the reading on a counter or vernier only if an elliptical type weight suspended by a suspension cable is used for sounding.

**49** Current meter suspension mode: Fill in "suspension rod" or "suspension cable".

**50** Zeroing error: Fill in the zeroing error value of a ranging counter, with the accuracy of 0.1m.

**51** Weight of elliptical type weight, suspension cable diameter: Fill in the weight of elliptical type weight used for discharge measurement and the diameter of suspension cable. If elliptical type weights of more than two kinds of weights or suspension cables of more than two kinds of diameters are used in one time of discharge measurement, they shall be filled in one by one and explained in the "Note" column.

**52** Distance from center of instrument shaft to the bottom of elliptical type weight: Fill in the distance from the horizontal shaft of current meter or the center line of yoke to the bottom of elliptical type weight.

**53** Ordinal number of gauging cross-section used for discharge calculation: Fill in the ordinal number of discharge measurement or channel cross-section measurement before and after flow velocity measurement. If a discharge calculated from measured channel cross-section at other times is borrowed for discharge measurement without channel cross-section measured, the ordinal number of the borrowed cross-section shall be filled in. If a part of the gauging cross-section is borrowed, all the ordinal numbers of various cross-section measurements shall be filled in with explanation.

**54** Synthetic uncertainty and determined system uncertainty: Fill in according to the relevant requirements stipulated in Section B.11 of this code.

**55** Ordinal number of measurement: Fill in the ordinal number arranged uniformly according to the chronological order of discharge measurement by various methods, which shall be in accordance with the following requirements:

**1**) Only on ordinal number is arranged if there are diversion flows, erosion ditched, artificial water diversion and so on, there is only one set of basic staff gauges in the main channel, and the discharge of each flow in main stream, diversion flow or erosion ditch is measured at the same time. If the discharge of each flow in main stream, diversion flow or erosion ditch is not measured at the same time, the ordinal number of measurements is arranged chronologically, no matter whether the ordinal number of measurement in the main stream, diversion flow or erosion ditch is same or not, the actual discharge of the main stream, diversion flow or erosion ditch must be indicated by text code. When basic staff gauges are respectively set on the main stream and diversion flow, the ordinal number of measurements shall be arranged according to the requirements of ordinal number for only one set of basic staff gauges available, and each set of basic staff gauges shall be regarded as a system for ordinal number arrangement. If there is a discharge measurement of artificial water diversion near a hydrometric station, the ordinal number of measurements shall be arranged according to an independent system. When there are several discharge measurements of artificial water diversion, their ordinal numbers shall be arranged as for respective independent systems.

2) If the cross-section discharge is calculated by the record of the same discharge measurement with the continuous discharge measurement method is numbered as an independent number. If the cross-section discharge is calculated by the record of two discharge measurements, the ordinal number of previous measurement is used, and a sub-number is added to the lower right corner of the ordinal number.

**56** Note: Fill in the location of temporary gauging cross-section and the information or items that discharge measurement personnel deem necessary to record.

**D.2.3** The filling of Table D.1.7-5 and Table D.1.7-6 of this code for sounding and flow velocity-measuring records and discharge calculation by the current meter method in free flow period of cableway shall be in accordance with the following requirements:

**1** If less verticals are used for sounding and flow velocity measurement, only Table D.1.7-6 of this code may be used independently.

**2** Depth counter reading: Fill in the reading shown on a depth counter and add the word "lift" or "lower" to the lower right corner of the reading to indicate the reading of lifting up or lowering down the counter.

**3** Depth counter correction: Fill in the corrected value of sounding determined by the comparison measurement of a hydrometric station. If the value is negative, a negative sign "−" shall be added prior to the value.

**4** Deflection angle of suspension cable $\frac{\text{Water surface}}{\text{River bottom}}$: The deflection angle of suspension cable is filled in as a numerator when an elliptical type weight contacts water surface, and is filled in the deflection angle of suspension cable filled in as a denominator when the elliptical type weight contacts river bottom.

**5** Sag of main cable: Fill in sag of main cable at the position of sounding and flow velocity-measuring verticals.

**6** Height difference between overhead crane and water surface: Fill in the height difference between an overhead crane at the sounding and flow velocity-measuring verticals and water surface, with the accuracy of 0.1m.

**7** Corrected value of air line, displacement and wet line: Fill in the looking-up value separately.

**8** Wet line length ($L_H$): If the length of wet line is directly measured, fill in the directly measured length of wet line. If a depth counter is used, fill in the value calculated according to the following formula:

$$L_H = H_c + \Delta h - \Delta_w - \Delta_d - \Delta_t \quad \text{(D.2.3)}$$

where $H_c$ —depth counter reading;

$\Delta h$ —height difference between overhead crane and water surface;

$\Delta_w$ —wet line corrected value;

$\Delta_d$ —air line corrected value;

$\Delta_t$ —displacement corrected value.

**9** The filling of other columns is the same as that of Table D.1.7-3 and Table D.1.7-4 of this code.

**D.2.4** The filling Table D.1.7-7 and Table D.1.7-8 of this code for sounding and flow velocity-measuring records and discharge calculation by the current meter method in icy period shall be in accordance with the following requirements:

**1** If there are less verticals for sounding and flow velocity measurement, only Table D.1.7-8 of this code may be used independently.

**2** Ice condition: Fill in main ice conditions during discharge measurement, such as the whole river freeze-up, border ice, lead, ice jam, etc. If there is not enough space in this column, supplementary explanation may be added in the "Note" column.

**3** Depth: Fill in the mean depth of the actual depths measured from free water surface in an ice hole several times. If verticals are on ice surface, water surface edge and ice base boundary or borrowed from other sounding measurements, this column is not filled. But the position of the ice surface boundary, water surface edge and ice base boundary shall be shown in the column of distance from initial point, without numbering verticals.

**4** Thickness of ice: Fill in the mean value of several consecutive readings of ice ruler intercepted on the ice surface. For the ice surface boundary of an inclined river bank, fill in "0" in in this column. If verticals for other sounding records are borrowed, this column is not filled.

**5** Thickness of immersed ice:

**1**) Fill in the mean value of the several consecutive readings of ice ruler at a vertical intercepted on the water surface.

**2**) Fill in "0" for the water surface boundary of an inclined river bank.

**3**) Fill in "0" for ice suspended above water surface.

**4**) Fill in the measured thickness of immersed ice on ice base boundary. If it is impossible to determine the position of ice base boundary, the thickness of immersed ice in an ice hole nearest to ice base boundary may be filled in with brackets.

**6** Thickness of frazil slush:

**1**) Fill in the difference between the mean value of the several consecutive readings of a frazil slush ruler (plate) at a suspension cable (rod) measured at water surface and the thickness of immersed ice.

**2**) Fill in "0" for the junction of ice base and frazil slush bottom. The position of frazil slush bottom junction shall be shown in the column of distance from initial point, without numbering verticals.

**3**) For the vertical of an ice cover hanging on water surface, the filling of this column is the same as that of the column of thickness of immersed ice.

**7** Spacing between sounding verticals: The filling is the same as that of the table in free flow period. Fill in two values for the part close to bank, that is, one is the distance between water surface boundary and ice base boundary, and the other is the distance between ice base boundary and nearshore vertical.

**8** Area of immersed ice and frazil slush:

**1**) Mean thickness between verticals: Fill in the arithmetic mean value of the thickness of immersed ice or frazil slush between two adjacent verticals. Fill in two values for the part close to the ice base boundary of an inclined river bank, that is, one is the arithmetic mean value of the thicknesses of immersed ice at nearshore vertical and ice base boundary, and the other is a half of thickness of immersed ice at ice base boundary, which are filled in between water surface boundary and ice base boundary.

2) Area between verticals: Fill in the product of the spacing between verticals and the mean thickness between the verticals of immersed ice (or frazil slush). For the part between nearshore vertical and bank, fill in two values of immersed ice area, that is, one is the area between nearshore vertical to ice base boundary, and the other is the area between ice base boundary and water surface boundary.

**9** Effective or applied depth:

1) If depth is measured, fill in the difference of the measured depth minus the sum of thicknesses of immersed ice and frazil slush, and cross out the words "or applied".

2) For the edge of ice surface and water surface, this column is left blank. Fill in "0" in this column for ice base boundary.

3) If the verticals of sounding record is borrowed, fill in applied depth, that is, the difference between the mean stage of gauging cross-section minus the sum of river bed elevation, the thickness of immersed ice and the thickness of frazil slush, and cross out the words "Effective or";

**10** Segment area of channel cross-section: Calculated and filled according to the relevant requirements stipulated in Article B.7.4 of this code.

**11** Current meter position:

1) Relative depth: Fill in the ratio of the depth of measuring point below ice bottom or frazil slush bottom to effective depth or applied depth.

2) Measuring point depth: Fill in the vertical depth from measuring point to water surface, that is, the product of relative depth and effective depth or applied depth plus the thicknesses of immersed ice and frazil slush. For a vertical without immersed ice, the filling of above two columns are the same as that in free-flow period.

**12** Area of immersed ice and area of frazil slush: Fill in the respective sum of the water surface areas of immersed ice and frazil slush between verticals from left bank to right bank.

**13** Total area of cross-section: Fill in the sum of the areas of channel cross-section, immersed ice and frazil slush.

**14** Width of ice bottom: Fill in the width of the ice base boundary on both banks.

**15** Mean depth: Fill in the ratio of total area of channel cross-section to water surface width.

**16** Mean effective depth: Fill in the ratio of the area of channel cross-section to the width of ice bottom. If an ice cover is suspended above water surface, fill in the ratio of the total area of cross-section to the width of water surface.

**17** Maximum effective depth: Fill in the maximum value selected from various effective depths. If there is border ice or lead, fill in the maximum value selected from various depths and effective depths.

**18** Note: Fill in snow depth on ice, water depth on ice and other relevant items that sounding and discharge measurement personnel deem necessary to record.

**19** The filling of other columns is the same as that of Table D.1.7-3 and Table D.1.7-4 of this code.

**D.2.5** The filling of equivalent stage calculation table by the current meter method (Table D.1.7-9 of this code) shall be in accordance with the following requirements:

**1** Ordinal number of sounding verticals, distance from initial point and mean flow velocity at a vertical: Copy into this table from the sounding and flow velocity-measuring records and discharge calculation table by the current meter method in free flow period.

**2** Segment width of channel cross-section:

**1**)For a part near bank, fill in the difference between a sounding vertical near bank and the distance from initial point of water edge.

**2**)For other parts, fill in the difference between the distances from initial point of two adjacent flow velocity-measuring verticals.

**3** Width of flow velocity-measuring verticals:

**1**)For a part near bank, take a half of the sum of segment width of channel cross-section near the bank and the adjacent segment width of channel cross-section.

**2**)For other parts, take the arithmetic mean of the channel cross-section width of two adjacent segments.

**4** Stage: Fill in the stage of basic staff gauge when the flow velocity at each vertical is measured. It may be copied from the stage observation records of each vertical or interpolated according to the flow velocity-measuring time and the timed stage observation records of each vertical.

**5** $b'V_m$: Fill in the product of the width of flow velocity-measuring vertical and the mean flow velocity at the same vertical.

**6** $b'V_mZ$: Fill in the product of the value of Item 5 in this article and the stage measured at the same vertical.

**7** $\sum b'V_m$, $\sum b'V_mZ$: Fill in the sum of the values in the columns in Item 5 and Item 6 of this article, respectively.

**8** Equivalent stage: Fill in the quotient of $\sum b'V_mZ$ and $\sum b'V_m$.

**9** The filling of other columns is the same as that in sounding and flow velocity-measuring records and discharge calculation table of current meter method.

**D.2.6** The filling of flow velocity-measuring record table by the surface float method (Table D.1.7-10 of this code) shall be in accordance with the following requirements:

**1** Water surface condition: Fill in water surface conditions during measurement in words of calm, slightly wavy, wavy and with floating debris.

**2** Distance between upstream and downstream cross-sections: Fill in the straight line distance between the upstream and downstream cross-sections of a float.

**3** Type of surface floats, submerged depth and freeboard: Fill in the material and type of surface float, the actual depth of water immersion and the height of the floats exposed out of water surface.

**4** Float dropping method: Fill in the dropping method of floats, such as dropping by a thrower, from a bridge, from a boat, etc.

**5** Ordinal number of float: Fill in the column with the ordinal number of each float in turn according to dropping order. Invalid floats shall still be numbered for reference.

**6** Float characteristics: Fill in the basic characteristics by which each float is identified, such as red, black, white, etc.

**7** Angle of float passing through gauging cross-section: Fill in the reading of a theodolite intersected with the gauging cross-section for angle observation.

**8** Distance from initial point: Fill in the calculated or measurement distance from initial point.

**9** Float flow velocity: Fill in the quotient of the float operation duration and the distance between upstream and downstream cross-sections of a float.

**10** Wind force(speed):

**1**)If an anemometer is used for observation, fill in the mean value of measured wind speeds of each float running in a measuring reach in several observations.

**2**)If wind force is observed visually, fill in the mean wind force during the operation of each float according to the wind level table stipulated in the current national standard GB/T 50138 *Standard for Stage Observation*. In addition, wind speed converted from wind force shall be indicated in brackets.

**11** Wind direction:

**1**)If an anemometer is used for observation, fill in the angle between wind direction and mean flow direction, with the accuracy of 10°.

**2**)If wind direction is observed visually or with simple wind direction indicator, in this column, the relation between wind direction and flow direction is indicated by an arrow according to the current national standard GB/T 50138 *Standard for Stage Observation*.

**12** Note: Fill in the reasons for obsolete floats and other relevant information and items that an observer deem necessary to record.

**D.2.7** The filling of sounding record and discharge calculation table by the surface float method (Table D.1.7-11 of this code) shall be in accordance with the following requirements:

**1** Sounding date and ordinal number of measuring cross-section: Fill in the measurement date and ordinal number of water depth or borrowed cross-section for the discharge measurement.

**2** Sounding time: Fill in the time of measurement at the first vertical. If a cross-section is borrowed for sounding, this column is left blank.

**3** Virtual flow velocity at a vertical: Fill in an equivalent flow velocity value at a vertical dividing segment, which is looked up from the curve of float flow velocity distribution.

**4** Mean virtual flow velocity at a segment: Calculated and filled in according to the relevant requirements stipulated in Article C.7.1 of this code.

**5** Segment virtual discharge: Fill in the product of the area and mean virtual flow velocity at a segment.

**6** Virtual discharge at a cross-section: Fill in the sum of each segment virtual discharge.

**7** Float coefficient and method for float coefficient determination: Respectively fill in float coefficient used in the calculation of a cross-section discharge and its determination method, such as "test analysis", "borrowing from similar stations" or "experience", etc.

**8** Cross-section discharge: Fill in the product of the virtual discharge at a cross-section and float coefficient.

**9** The filling of other columns is the same as that of Table D.1.7-4 of this code.

**D.2.8** Float flow velocity distribution curve and cross-section profile (Table D.1.7-12 of this code) shall be drawn according to the requirements stipulated in Article C.7.1 of this code.

**D.2.9** If the cross-section discharge is jointly measured with the current meter method and surface float method in free flow period, the filling shall be in accordance with the following requirements:

**1** Zoning record of a whole cross-section. In the gauging zone of current meter, discharge measurement results are recorded in sounding and flow velocity-measuring records and discharge calculation table by the current meter method in free flow period. In the gauging zone of floats on water surface, the results of discharge measurement are recorded in the discharge measurement record table of floats on water surface. The vertical of flood plain boundary shall be used as zoning boundary.

**2** Only the measured discharge and its equivalent results in each measurement zone are filled in the statistical column of calculation results in the flow velocity-measuring record table by the current meter method and float method, which are explained in the "Note" column. Fill in the total discharge measured by the two methods in different measurement zones and other equivalent results in the statistical column of additional page of Table D.1.7-4 of this code, which are explained in the "Note" column.

**D.2.10** The filling of the cover format of tidal discharge measurement record book (Table D.1.7-13 of this code) shall be in accordance with the following requirements:

**1** Ordinal number of measurement: Fill in the ordinal number of the measurement of tidal discharge. Bounded by the year, ordinal number is numbered successively from the first measurement each year, and each tidal current period is taken as a measurement time. Records of each measurement time are bound into a single book.

**2** Measuring time: Fill in the beginning and ending time of each tidal current period. If slack tide in ebb tide lasts, fill in the mean occurrence time of the slack tide in the whole cross-section. The extended measurement time of early start and delayed end is excluded.

**3** The filling of other columns is the same as that of the cover of discharge measurement record book.

**D.2.11** The filling of the description of tidal discharge measurement (Table D.1.7-14 of this code) shall be in accordance with the following requirements:

**1** Cross-section position: Fill in the position of each gauging cross-section, which is expressed as its relationship with the position of basic staff gauge.

**2** Vertical arrangement method: Fill in the method of determining the position of flow velocity-measuring vertical at a cross-section.

**3** Measuring line $\frac{\text{Distance from initial point}}{\text{River bottom elevation}}$: Expressed by fraction, with the distance from initial point of each vertical filled in successively as a numerator, and the river bed elevation of corresponding measuring line filled in as a denominator.

**4** Method of measurement: Fill in the number of hydrometric boats or the type of cableways used in the measurement and the measurement methods of flow velocity at a vertical and at a cross-section.

**5** Hydrometric boat fixation: Fill in the fixing method of a hydrometric boat and the stability situation of the hydrometric boat position.

**6** Weather, dominant wind direction, mean wind force (speed): Expressed by fraction according to flood tidal current and ebb tidal current. Mean wind force (speed) refers to the mean value of the wind force (speed) of each measurement of flood (ebb) tidal current, instead of the mean value of the wind force (speed) of dominant wind direction.

**7** The filling of other columns is the same as that of Table D.1.7-4 of this code in discharge measurement record book.

**D.2.12** The filling of the statistical table of calculation results of tidal discharge measurement (Table D.1.7-15 of this code) shall be in accordance with the following requirements:

**1** Period of measurement (from ×× to ××): Fill in the boundaries of the measuring tidal current period, i.e. from a slack tide of ebb tide to a slack tide of another ebb tide or from × hour(s) after low tide to × hour(s)after another low tide.

**2** Tidal stage:Fill in the highest and lowest tidal stages of flood tidal current, ebb tidal current and the whole tidal current period, respectively. The highest tidal stage of flood tidal current is the one in measuring tidal current period, and the lowest tidal stage is generally the one of the mean slack tide of ebb tide at a cross-section at the beginning of measurement. The highest tidal stage of ebb tidal current is generally the one at the time of mean slack tide of flood tide at a cross-section. The lowest tidal stage is the one in measuring tidal current period.

**3** Cross-section area:Fill in the equivalent maximum and minimum section areas of each highest and lowest tidal stages according to the chart of relation between tidal stage and area, and the arithmetic mean value into the "Mean" column.

**4** Tidal volume shall be filled in as the following requirements:

**1)** The tidal volume of flood and ebb tidal currents shall be filled in according to the cumulative value of the tidal volume in the calculation table(Table D.1.7-19 or Table D.1.7-20 of this cod). No sign of "+" or "−" shall be added before the digit. The measured tidal volume of a tidal current period shall be the net discharge or net inflow after the ebb tidal volume minus the flood tidal volume, and a sign of "+" or "−" shall be added before the digit.

**2)** If the flow direction of the measuring tidal current period is all that of ebb tidal current or flood tidal current, tidal volume and other results are filled in only one line of ebb tidal current or flood tidal current. The remaining two lines are left blank.

**5** Tidal current duration: Fill in the time interval of dividing the tidal current period and the beginning and ending time of flood and ebb tide, respectively.

**6** Mean discharge: Obtain by dividing each value in the tidal volume column by the equivalent tidal current duration. Mean discharge in a tidal current period shall be preceded by a sign of "+" or "−".

**7** Mean flow velocity: Obtain by dividing mean discharge by equivalent mean cross-section area. Mean flow velocity in a tidal current period shall be preceded by a sign of "+" or "−".

**8** Maximum instantaneous discharge: Fill in selected discharge with the largest absolute value from the tidal volume calculation table(Table D.1.7-19 or Table D.1.7-20 of this code) for flood and ebb tide current.

**9** Maximum discharge at a measuring point: Fill in the selected maximum absolute value of flood and ebb tide current from the column of flow velocity at a measuring point or flow velocity of measuring point correction in the flow velocity-measuring record table(Table D.1.7-16 of this code), respectively.

**10** Note: Fill in the equivalent values in the table, and record other situations that need to be noted.

**D.2.13** The filling of tidal discharge measurement and flow velocity-measuring record table(Table D.1.7-16 of this code)shall be in accordance with the following requirements:

**1** Measuring time: Fill in the beginning and ending time of flow velocity measurement.

**2** The filling of measuring time and stage shall be in accordance with the following requirements:

**1)** If a fixed hydrometric boat is used for measurement, fill in the measuring time of the first measuring point and the point with the maximum depth at a vertical and the stage of gauge on gauging cross-section.

**2)** If multiple verticals are measured with one hydrometric boat, fill in the measuring time at the first measuring point of each vertical and the stage of gauge on gauging cross-section. If the round-trip measurement method is used, fill in the measuring time at the first measuring point of each vertical for round-trip measurement and the stage of gauge on gauging cross-section.

**3**) If a current meter is used to measure slack tide, the beginning and ending time and stage of slack tide shall be filled in. If there is a continuous slack tide phenomenon, the mean time of flood (ebb) slack tide and the equivalent tidal stage shall also be filled in in the next spaces below the columns of ending time of slack tide and tidal stage.

**3** Distance from initial point: Fill the distance from initial point of each sounding vertical.

**4** Tidal depth: Obtain by subtracting river bed elevation of a vertical from tide level at the measuring time. It may be looked up from a prepared table of tidal stage–depth–measuring point depth, and filled in the same line of measuring time and tidal stage.

**5** Ordinal number of measuring point: Fill in the flow velocity measurement ordinal number of each measuring point at a vertical, such as 1, 2, 3, etc. If the round-trip measurement method is adopted, one more grid shall be left behind the record of the forward measurement of each measuring point for its backward measurement, which shall be numbered in turn.

**6** Measuring point depth: Fill in the depth of the measurement position of each flow velocity measuring point at a vertical, which is expressed by a relative depth (the ratio of the depth of measuring point of a current meter to actual depth), except that an absolute value of water depth (a relative depth adopted for a point on water surface) is used for the revised graphical method. If the flow velocity of each measuring point at each vertical is measured from top to bottom with round-trip measurement, the measuring point depth is checked and calculated according to the depth of the first measuring point. If the flow velocity of each measuring point is measured from bottom to top with round-trip measurement, the measuring point depth is checked and calculated according to the depth of the last measuring point in the backward measurement. If the water depth or the measuring point depth of the upper and lower grids are the same, they shall still be filled in, and shall not be expressed with the sign " " or left blank.

**7** Flow velocity at a measuring point: Generally, "+" and "−" signs are not added to the flow velocity at measuring points. But if flow direction of each measuring point is different within a measurement, a sign of "+" or "−" shall be added to the left side of the flow velocity at a measuring point. "−" stands for flood tidal current, and "+" for ebb tidal current.

**8** Deflection angle of flow direction: Expressed by fraction if the flow direction meter method is adopted, with the measured magnetic azimuth angle as a numerator and the calculated deflection angle of flow direction as a denominator. If other methods are adopted to measure the deflection angle of flow direction, it is not expressed by fraction, but only the measured deflection angle of flow direction.

**9** Correction value: If the revised water surface flow velocity method is adopted, the correction value of flow velocity at each measuring point shall be calculated and then filled in in this column in turn.

**10** Flow velocity of measuring point correction: If the deflection angle of flow direction exceeds 10°, fill in the product of flow velocity at a measuring point and the cosine of the deflection angle of flow direction. If the surface flow velocity correction method is adopted, fill in the algebraic sum of the flow velocity of each measuring point and its correction value.

**11** Mean flow velocity at a measuring point: If the flow velocity of each measuring point at a vertical is measured with the round-trip symmetry method, fill in the arithmetic mean value of the flow velocity at a measuring point measured twice or the flow velocity of measuring point correction. For one-way flow velocity measurement, this column is left blank. If there is a sign of "+" and "−" in front of the value of the flow velocity at a measuring point, the mean flow velocity at a measuring point is the mean of its algebraic sum of flow velocity.

**12** Mean flow velocity at a vertical: Calculate and fill in according to the method stipulated in Article B.7.7 of this code, with a sign of "+" or "−" before the value. If a fixed hydrometric boat is used to measure at the same time, it is recorded in the same line of the measuring time of the last measuring point at a vertical for backward measurement. If one or more hydrometric boats are used to measure eligible verticals, it is recorded in the same line of distance from initial point of each vertical. If the slack tide of the flood(ebb) tide lasts, fill in "0" only in the same line of the mean time of slack tide.

**13** Wind direction and wind force(speed): Fill in the wind direction and wind force(speed) at the first measuring point at a vertical in the beginning of each measurement.

**14** The filling of other columns is the same as that of Table D.1.7-4 of this code in the discharge measurement record book.

**D.2.14** The filling of tidal discharge calculation table (Table D.1.7-18 of this code) shall be in accordance with the following requirements:

**1** All the hydrometric stations measuring flow velocity at three or more verticals shall fill in this table.

**2** Hour and minute:

**1)** Fill the hour and minute for calculating cross-section discharge of each measurement in the top grid of each measurement.

**2)** If various verticals are measured at the same time with the round-trip measurement method, the measuring hour and minute of the last measuring point at a vertical for backward measurement is taken as the calculation time.

**3)** If a hydrometric boat is used to measure multiple verticals for round-trip measurement, the measuring hour and minute of the last measuring point at the last vertical in the backward measurement is used as the calculation time. If one hydrometric boat is used to measure multiple verticals in a single way with the revised flow velocity hydrograph method, the time for calculating the flow velocity shall be determined according to the turning point of the hydrograph.

**3** Ordinal number of vertical and distance from initial point: Fill in the ordinal number of vertical and distance from initial point of each flow velocity-measuring vertical of the whole cross-section in turn.

**4** Tidal stage: Fill in the tidal stage equivalent to the hour and minute column, which may be checked from the flow velocity-measuring record table or the tidal stage self-recording paper.

**5** Mean flow velocity at a vertical:

**1)** Copy in the mean flow velocity at each vertical on the whole cross-section at each measurement from the flow velocity record table. If the flow velocity at each vertical is not measured at the same time for individual measurements near the slack tide, the flow velocity hydrograph of each vertical shall be drawn first, and then filled in after the interpolation of simultaneous velocity.

**2)** After each measurement, a grid shall be left below, and the parallel columns of hour and minute, distance from initial point and tide stage shall also be left blank, and then mean flow velocity at a vertical of the next measurement shall be filled in.

**6** Mean flow velocity at a segment: Fill in the calculated result according to the method specified in Item 7 in Article B.7.1 of this code, with "+" or "−" before the value.

**7** Segment area: Fill in each segment area of each measurement looked up from a prepared chart of the relation between tidal stage and segment area after calculation.

**8** Segment discharge: Fill in the product of the mean flow velocity at a segment and segment area. The value shall be preceded by a sign of "+" or "−".

**9** Cross-section discharge: Add the each segment discharge of each measurement and fill it in the same line of hour and minute, and add a sign of "+" or "−" before the value. A horizontal line shall be drawn on the line of the last segment discharge in each measurement, and the filling position and a horizontal line drawing of the area of channel cross-section and the mean flow velocity at a cross-section are the same as those of the discharge at a cross-section.

**10** Area of channel cross-section: Fill in the sum of the area of each segment in the measurement.

**11** Mean flow velocity at a cross-section: Obtain by dividing the cross-section discharge of each measurement by the cross-section area. The value shall be preceded by a sign of "+" or "−". For the slack tide of flood (ebb) tide, only the mean slack tide time of the cross-section needs to be filled in, "0" shall be filled in the two columns of equivalent cross-section discharge and mean flow velocity at a cross-section, and other columns left blank.

**12** Note: Fill in the special problems in calculation and situations needed to be explained.

**D.2.15** The filling of the tidal volume calculation table (Table D.1.7-19 of this code) shall be in accordance with the following requirements:

**1** Hour, minute and discharge: Copy in from the equivalent column of the tidal discharge calculation table, and the discharge value are not required to be preceded by a sign of "+" or "−".

**2** Mean discharge: Fill in the arithmetic mean of two adjacent discharges.

**3** Duration: Fill in the duration of two adjacent time intervals.

**4** Tidal volume: Obtain by multiplying mean discharge and duration.

**D.2.16** The filling of tidal volume calculation table (representative vertical discharge measurement) (Table D.1.7-20 of this code) (for one or two representative verticals) shall be in accordance with the following requirements:

**1** Hour, minute and tide stage: The filling is the same as that in Table D.1.7-18 of this code.

**2** Mean discharge, tidal current duration and tidal volume: The filling is the same as that in Table D.1.7-19 of this code.

**3** Representative vertical flow velocity: Fill in the mean flow velocity at a vertical if one representative vertical is used. If there are two representative verticals, fill in the arithmetic mean value of the mean flow velocity at the two representative verticals, and add a sign of "+" or "−" before the value. If there are three or more representative verticals, the tidal discharge calculation table (Table D.1.7-18 of this code) and tidal volume calculation table (Table D.1.7-19 of this code) are still used to calculate the cross-section discharge and tidal volume.

**4** Mean flow velocity at a cross-section: Fill in the result either looked up from the chart of the relation between the flow velocity of representative vertical and the mean flow velocity at a cross-section or calculated according to relevant formula. A sign of "+" or "−" shall be added before the flow velocity value.

**5** Cross-section area: Fill in the looked-up value from a relation curve between tidal stage and cross-section area drawn in advance.

**6** Discharge: It is the product of the mean flow velocity at a cross-section and the cross-section area. The value shall be preceded by a sign of "+" or "−".

**7** Note: Fill in the equation of the mean flow velocity at a representative vertical and other special problems in calculation and situations needed to be explained.

## Appendix E Table of deflection angle correction of suspension cable

**E.0.1** The correction value of air line may be found in Table E.0.1.

**E.0.2** The correction value of wet line may be found in Table E.0.2-1 to Table E.0.2-5.

**E.0.3** The correction coefficient $K_{\mathrm{H}}$(%) of wet line may be found in Table E.0.3-1 or Table E.0.3-2.

**Table E.0.1 Correction value of air line(Unit:m)**

| Height difference between suspension point and water surface (m) | Deflection angle of suspension cable (θ°) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4° | 6° | 8° | 10° | 12° | 14° | 16° | 18° | 20° | 22° | 24° | 26° | 28° | 30° | 32° | 34° | 36° | 38° | 40° |
| 1 | 0 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.09 | 0.11 | 0.13 | 0.15 | 0.18 | 0.21 | 0.24 | 0.27 | 0.31 |
| 2 | 0 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.08 | 0.10 | 0.13 | 0.16 | 0.19 | 0.23 | 0.27 | 0.31 | 0.36 | 0.41 | 0.47 | 0.54 | 0.61 |
| 3 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.09 | 0.12 | 0.15 | 0.19 | 0.24 | 0.28 | 0.34 | 0.40 | 0.46 | 0.54 | 0.62 | 0.71 | 0.81 | 0.92 |
| 4 | 0.01 | 0.02 | 0.04 | 0.06 | 0.09 | 0.12 | 0.16 | 0.21 | 0.26 | 0.31 | 0.38 | 0.45 | 0.53 | 0.62 | 0.72 | 0.82 | 0.94 | 1.08 | 1.22 |
| 5 | 0.01 | 0.03 | 0.05 | 0.08 | 0.11 | 0.15 | 0.20 | 0.26 | 0.32 | 0.39 | 0.47 | 0.56 | 0.66 | 0.77 | 0.90 | 1.03 | 1.18 | 1.35 | 1.53 |
| 6 | 0.01 | 0.03 | 0.06 | 0.09 | 0.13 | 0.18 | 0.24 | 0.31 | 0.39 | 0.47 | 0.57 | 0.68 | 0.80 | 0.93 | 1.08 | 1.24 | 1.42 | 1.61 | 1.83 |
| 7 | 0.02 | 0.04 | 0.07 | 0.11 | 0.16 | 0.21 | 0.28 | 0.36 | 0.45 | 0.55 | 0.66 | 0.79 | 0.93 | 1.08 | 1.25 | 1.44 | 1.65 | 1.88 | 2.14 |
| 8 | 0.02 | 0.04 | 0.08 | 0.12 | 0.18 | 0.24 | 0.32 | 0.41 | 0.51 | 0.64 | 0.76 | 0.90 | 1.06 | 1.24 | 1.43 | 1.65 | 1.89 | 2.15 | 2.44 |
| 9 | 0.02 | 0.05 | 0.09 | 0.14 | 0.20 | 0.28 | 0.36 | 0.46 | 0.58 | 0.71 | 0.85 | 1.01 | 1.19 | 1.39 | 1.61 | 1.86 | 2.12 | 2.42 | 2.75 |
| 10 | 0.02 | 0.05 | 0.10 | 0.15 | 0.22 | 0.31 | 0.40 | 0.51 | 0.64 | 0.79 | 0.95 | 1.13 | 1.33 | 1.55 | 1.79 | 2.06 | 2.26 | 2.69 | 3.05 |
| 11 | 0.03 | 0.06 | 0.11 | 0.17 | 0.25 | 0.34 | 0.44 | 0.57 | 0.71 | 0.88 | 1.04 | 1.24 | 1.46 | 1.70 | 1.97 | 2.27 | 2.60 | 2.96 | 3.36 |
| 12 | 0.03 | 0.07 | 0.12 | 0.19 | 0.27 | 0.37 | 0.48 | 0.62 | 0.77 | 0.94 | 1.14 | 1.35 | 1.59 | 1.86 | 2.15 | 2.47 | 2.83 | 3.23 | 3.66 |
| 13 | 0.03 | 0.07 | 0.13 | 0.20 | 0.29 | 0.40 | 0.52 | 0.67 | 0.83 | 1.02 | 1.23 | 1.46 | 1.72 | 2.01 | 2.33 | 2.68 | 3.07 | 3.50 | 3.97 |
| 14 | 0.03 | 0.08 | 0.14 | 0.22 | 0.31 | 0.43 | 0.56 | 0.72 | 0.90 | 1.10 | 1.32 | 1.58 | 1.86 | 2.17 | 2.51 | 2.89 | 3.30 | 3.77 | 4.28 |
| 15 | 0.04 | 0.08 | 0.15 | 0.23 | 0.34 | 0.46 | 0.60 | 0.77 | 0.96 | 1.18 | 1.42 | 1.69 | 1.99 | 2.32 | 2.69 | 3.09 | 3.54 | 4.04 | 4.58 |
| 16 | 0.04 | 0.09 | 0.16 | 0.25 | 0.36 | 0.49 | 0.64 | 0.82 | 1.03 | 1.26 | 1.51 | 1.80 | 2.12 | 2.48 | 2.87 | 3.30 | 3.78 | 4.30 | 4.89 |
| 17 | 0.04 | 0.09 | 0.17 | 0.26 | 0.38 | 0.52 | 0.69 | 0.87 | 1.09 | 1.34 | 1.61 | 1.91 | 2.25 | 2.63 | 3.05 | 3.51 | 4.01 | 4.57 | 5.19 |
| 18 | 0.04 | 0.10 | 0.18 | 0.28 | 0.40 | 0.55 | 0.73 | 0.93 | 1.16 | 1.41 | 1.70 | 2.03 | 2.39 | 2.78 | 3.23 | 3.71 | 4.25 | 4.84 | 5.50 |
| 19 | 0.05 | 0.10 | 0.19 | 0.29 | 0.42 | 0.58 | 0.77 | 0.98 | 1.22 | 1.49 | 1.80 | 2.14 | 2.52 | 2.94 | 3.40 | 3.92 | 4.49 | 5.11 | 5.80 |
| 20 | 0.05 | 0.11 | 0.20 | 0.31 | 0.45 | 0.61 | 0.81 | 1.03 | 1.28 | 1.57 | 1.89 | 2.25 | 2.65 | 3.09 | 3.58 | 4.12 | 4.72 | 5.38 | 6.11 |
| 21 | 0.05 | 0.12 | 0.21 | 0.32 | 0.47 | 0.64 | 0.85 | 1.08 | 1.35 | 1.65 | 1.99 | 2.36 | 2.78 | 3.25 | 3.76 | 4.33 | 4.96 | 5.65 | 6.41 |
| 22 | 0.05 | 0.12 | 0.22 | 0.34 | 0.49 | 0.67 | 0.89 | 1.13 | 1.41 | 1.73 | 2.08 | 2.48 | 2.92 | 3.40 | 3.94 | 4.54 | 5.19 | 5.92 | 6.72 |
| 23 | 0.06 | 0.13 | 0.23 | 0.35 | 0.51 | 0.70 | 0.93 | 1.18 | 1.48 | 1.81 | 2.18 | 2.59 | 3.05 | 3.56 | 4.12 | 4.74 | 5.43 | 6.19 | 7.02 |
| 24 | 0.06 | 0.13 | 0.24 | 0.37 | 0.54 | 0.73 | 0.97 | 1.24 | 1.54 | 1.88 | 2.27 | 2.70 | 3.18 | 3.71 | 4.30 | 4.95 | 5.67 | 6.46 | 7.33 |
| 25 | 0.06 | 0.14 | 0.25 | 0.39 | 0.56 | 0.77 | 1.01 | 1.29 | 1.60 | 1.96 | 2.37 | 2.82 | 3.31 | 3.87 | 4.48 | 5.16 | 5.90 | 6.73 | 7.64 |
| 26 | 0.06 | 0.14 | 0.26 | 0.40 | 0.58 | 0.80 | 1.05 | 1.34 | 1.67 | 2.04 | 2.46 | 2.93 | 3.45 | 4.02 | 4.66 | 5.36 | 6.14 | 6.99 | 7.94 |
| 27 | 0.07 | 0.15 | 0.27 | 0.42 | 0.60 | 0.83 | 1.09 | 1.39 | 1.73 | 2.12 | 2.56 | 3.04 | 3.58 | 4.18 | 4.84 | 5.57 | 6.37 | 7.26 | 8.25 |
| 28 | 0.07 | 0.15 | 0.28 | 0.43 | 0.63 | 0.86 | 1.13 | 1.41 | 1.80 | 2.20 | 2.65 | 3.15 | 3.71 | 4.33 | 5.02 | 5.77 | 6.61 | 7.53 | 8.55 |
| 29 | 0.07 | 0.16 | 0.28 | 0.45 | 0.65 | 0.80 | 1.17 | 1.49 | 1.86 | 2.28 | 2.74 | 3.27 | 3.84 | 4.49 | 5.20 | 5.98 | 6.85 | 7.80 | 8.86 |
| 30 | 0.07 | 0.17 | 0.29 | 0.46 | 0.67 | 0.92 | 1.21 | 1.54 | 1.93 | 2.36 | 2.84 | 3.38 | 3.98 | 4.64 | 5.38 | 6.19 | 7.08 | 8.07 | 9.16 |

**Table E.0.2-1 Correction value of wet line (Unit: m) $\beta$=1~2**

| Wet line length (m) | Deflection angle of suspension cable $\theta$(°) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4° | 6° | 8° | 10° | 12° | 14° | 16° | 18° | 20° | 22° | 24° | 26° | 28° | 30° | 32° | 34° | 36° | 38° | 40° |
| 1 | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 | 0.10 | 0.11 | 0.12 | 0.14 |
| 2 | 0 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 | 0.10 | 0.12 | 0.14 | 0.16 | 0.18 | 0.21 | 0.23 |
| 3 | 0 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.06 | 0.07 | 0.08 | 0.10 | 0.12 | 0.14 | 0.16 | 0.19 | 0.22 | 0.20 | 028 | 0.32 |
| 4 | 0 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.07 | 0.09 | 0.10 | 0.13 | 0.15 | 0.18 | 0.21 | 0.24 | 0.27 | 0.31 | 0.36 | 0.40 |
| 5 | 0 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 | 0.10 | 0.13 | 0.15 | 0.18 | 0.21 | 0.25 | 0.29 | 0.33 | 0.38 | 0.43 | 0.49 |
| 6 | 0 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.08 | 0.10 | 0.13 | 0.15 | 0.18 | 0.21 | 0.25 | 0.29 | 0.34 | 0.39 | 0.44 | 0.50 | 0.57 |
| 7 | 0.01 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.09 | 0.11 | 0.14 | 0.17 | 0.21 | 0.25 | 0.29 | 0.34 | 0.39 | 0.44 | 0.51 | 0.58 | 0.65 |
| 8 | 0.01 | 0.02 | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.13 | 0.16 | 0.19 | 0.23 | 0.28 | 0.32 | 0.38 | 0.44 | 0.50 | 0.57 | 0.65 | 0.73 |
| 9 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.08 | 0.11 | 0.14 | 0.18 | 0.22 | 0.26 | 0.31 | 0.36 | 0.42 | 0.49 | 0.56 | 0.64 | 0.72 | 0.82 |
| 10 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.09 | 0.12 | 0.16 | 0.19 | 0.24 | 0.29 | 0.34 | 0.40 | 0.46 | 0.54 | 0.61 | 0.70 | 0.80 | 0.90 |
| 11 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.10 | 0.13 | 0.17 | 0.21 | 0.26 | 0.30 | 0.37 | 0.44 | 0.51 | 0.59 | 0.67 | 0.77 | 0.87 | 0.98 |
| 12 | 0.01 | 0.02 | 0.04 | 0.06 | 0.08 | 0.11 | 0.14 | 0.18 | 0.23 | 0.28 | 0.34 | 0.40 | 0.47 | 0.54 | 0.63 | 0.73 | 0.83 | 0.94 | 1.07 |
| 13 | 0.01 | 0.02 | 0.04 | 0.06 | [illegible] | 0.12 | 0.16 | 0.20 | 0.25 | 0.30 | 0.36 | 0.43 | 0.51 | 0.59 | 0.68 | 0.78 | 0.89 | 1.02 | 1.15 |
| 14 | 0.01 | 0.02 | 0.04 | [illegible] | 0.09 | 0.13 | 0.17 | 0.21 | 0.27 | [illegible] | 0.39 | 0.46 | 0.54 | 0.63 | 0.73 | 0.84 | 0.96 | 1.09 | 1.23 |
| 15 | 0.01 | 0.02 | 0.04 | 0.07 | 0.10 | 0.14 | 0.18 | 0.23 | 0.28 | [illegible] | 0.42 | 0.50 | 0.58 | 0.68 | 0.78 | 0.90 | 1.02 | 1.16 | 1.31 |
| 16 | 0.01 | [illegible] | [illegible] | 0.07 | 0.10 | 0.14 | 0.19 | 0.24 | [illegible] | 0.37 | 0.44 | 0.53 | 0.62 | 0.72 | 0.83 | 0.95 | 1.09 | 1.23 | 1.40 |
| 17 | 0.01 | 0.03 | 0.05 | 0.08 | 0.11 | 0.15 | 0.20 | 0.26 | 0.32 | 0.39 | 0.47 | 0.56 | 0.65 | 0.76 | 0.88 | 1.01 | 1.15 | 1.31 | 1.48 |
| 18 | 0.01 | 0.03 | 0.05 | 0.08 | 0.12 | 0.16 | 0.21 | 0.27 | 0.34 | 0.41 | 0.50 | 0.59 | 0.69 | 0.81 | 0.93 | 1.07 | 1.22 | 1.38 | 1.56 |
| 19 | 0.01 | 0.03 | 0.05 | 0.09 | 0.12 | 0.17 | 0.22 | 0.29 | 0.35 | 0.43 | 0.52 | 0.62 | 0.73 | 0.85 | 0.98 | 1.12 | 1.28 | 1.45 | 1.64 |
| 20 | 0.02 | 0.03 | 0.06 | 0.09 | 0.13 | 0.18 | 0.23 | 0.30 | 0.37 | 0.46 | 0.55 | 0.65 | 0.76 | 0.89 | 1.03 | 1.18 | 1.35 | 1.53 | 1.73 |
| 21 | 0.02 | 0.03 | 0.06 | 0.09 | 0.14 | 0.19 | 0.25 | 0.31 | 0.39 | 0.48 | 0.57 | 0.68 | 0.80 | 0.94 | 1.08 | 1.24 | 1.41 | 1.60 | 1.81 |
| 22 | 0.02 | 0.04 | 0.06 | 0.10 | 0.14 | 0.20 | 0.26 | 0.33 | 0.41 | 0.50 | 0.60 | 0.71 | 0.84 | 0.98 | 1.13 | 1.29 | 1.48 | 1.67 | 1.89 |
| 23 | 0.02 | 0.04 | 0.07 | 0.10 | 0.15 | 0.20 | 0.27 | 0.34 | 0.43 | 0.52 | 0.63 | 0.74 | 0.85 | 1.02 | 1.18 | 1.35 | 1.54 | 1.75 | 1.98 |
| 24 | 0.02 | 0.04 | 0.07 | 0.11 | 0.15 | 0.21 | 0.28 | 0.36 | 0.44 | 0.54 | 0.65 | 0.78 | 0.91 | 1.06 | 1.23 | 1.41 | 1.60 | 1.82 | 2.06 |
| 25 | 0.02 | 0.04 | 0.07 | 0.11 | 0.16 | 0.22 | 0.29 | 0.37 | 0.46 | 0.56 | 0.68 | 0.81 | 0.95 | 1.10 | 1.28 | 1.46 | 1.67 | 1.89 | 2.14 |
| 26 | 0.02 | 0.04 | 0.07 | 0.12 | 0.17 | 0.23 | 0.30 | 0.38 | 0.48 | 0.59 | 0.71 | 0.84 | 0.98 | 1.15 | 1.32 | 1.52 | 1.73 | 1.97 | 2.22 |
| 27 | 0.02 | 0.04 | 0.08 | 0.12 | 0.17 | 0.24 | 0.31 | 0.40 | 0.58 | 0.61 | 0.73 | 0.87 | 1.02 | 1.19 | 1.37 | 1.58 | 1.80 | 2.04 | 2.31 |
| 28 | 0.02 | 0.04 | 0.08 | 0.12 | 0.18 | 0.25 | 0.32 | 0.41 | 0.52 | 0.63 | 0.76 | 0.90 | 1.06 | 1.23 | 1.42 | 1.63 | 1.86 | 2.12 | 2.39 |
| 29 | 0.02 | 0.05 | 0.08 | 0.13 | 0.19 | 0.26 | 0.34 | 0.43 | 0.53 | 0.65 | 0.78 | 0.93 | 1.09 | 1.28 | 1.48 | 1.69 | 1.93 | 2.19 | 2.47 |
| 30 | 0.02 | 0.05 | 0.08 | 0.13 | 0.19 | 0.26 | 0.35 | 0.44 | 0.55 | 0.67 | 0.81 | 0.96 | 1.13 | 1.32 | 1.52 | 1.75 | 1.99 | 2.26 | 2.55 |

**Table E.0.2-2 Correction value of wet line (Unit: m) $\beta$=3~4**

| Wet line length (m) | Deflection angle of suspension cableway θ(°) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4° | 6° | 8° | 10° | 12° | 14° | 16° | 18° | 20° | 22° | 24° | 26° | 28° | 30° | 32° | 34° | 36° | 38° | 40° |
| 1 | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.14 | 0.16 | 0.18 |
| 2 | 0 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 | 0.10 | 0.11 | 0.14 | 0.16 | 0.18 | 0.20 | 0.23 | 0.26 | 0.30 |
| 3 | 0 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.07 | 0.08 | 0.11 | 0.13 | 0.15 | 0.18 | 0.20 | 0.24 | 0.27 | 0.31 | 0.35 | 0.40 |
| 4 | 0 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 | 0.11 | 0.13 | 0.15 | 0.19 | 0.22 | 0.25 | 0.29 | 0.33 | 0.38 | 0.43 | 0.49 |
| 5 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.15 | 0.18 | 0.22 | 0.26 | 0.30 | 0.34 | 0.39 | 0.45 | 0.51 | 0.57 |
| 6 | 0.01 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.09 | 0.11 | 0.14 | 0.17 | 0.21 | 0.25 | 0.29 | 0.34 | 0.39 | 0.45 | 0.51 | 0.58 | 0.66 |
| 7 | 0.01 | 0.01 | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.13 | 0.16 | 0.20 | 0.24 | 0.28 | 0.33 | 0.39 | 0.44 | 0.51 | 0.58 | 0.66 | 0.74 |
| 8 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.09 | 0.11 | 0.14 | 0.18 | 0.22 | 0.26 | 0.31 | 0.37 | 0.43 | 0.49 | 0.57 | 0.64 | 0.73 | 0.83 |
| 9 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.09 | 0.12 | 0.16 | 0.20 | 0.24 | 0.29 | 0.34 | 0.40 | 0.47 | 0.54 | 0.62 | 0.71 | 0.81 | 0.91 |
| 10 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.10 | 0.14 | 0.17 | 0.21 | 0.26 | 0.32 | 0.37 | 0.44 | 0.51 | 0.59 | 0.68 | 0.77 | 0.88 | 0.99 |
| 11 | 0.01 | 0.02 | 0.04 | 0.06 | 0.08 | 0.11 | 0.15 | 0.19 | 0.23 | 0.28 | 0.34 | 0.41 | 0.48 | 0.56 | 0.64 | 0.74 | 0.84 | 0.95 | 1.08 |
| 12 | 0.01 | 0.02 | 0.04 | 0.06 | 0.09 | 0.12 | 0.16 | 0.20 | 0.25 | 0.31 | 0.37 | 0.45 | 0.51 | 0.60 | 0.69 | 0.79 | 0.90 | 1.03 | 1.16 |
| 13 | 0.01 | 0.02 | 0.04 | 0.06 | 0.09 | 0.13 | 0.17 | 0.22 | 0.27 | 0.33 | 0.40 | 0.47 | 0.55 | 0.64 | 0.74 | 0.85 | 0.97 | 1.10 | 1.24 |
| 14 | 0.01 | 0.03 | 0.04 | 0.07 | 0.10 | 0.14 | 0.18 | 0.23 | 0.29 | 0.35 | 0.42 | 0.50 | 0.59 | 0.68 | 0.79 | 0.91 | 1.03 | 1.17 | 1.33 |
| 15 | 0.01 | 0.03 | 0.05 | 0.07 | 0.11 | 0.15 | 0.19 | 0.24 | 0.30 | 0.37 | 0.45 | 0.53 | 0.62 | 0.73 | 0.84 | 0.96 | 1.10 | 1.25 | 1.41 |
| 16 | 0.01 | 0.03 | 0.05 | 0.08 | 0.11 | 0.15 | 0.20 | 0.26 | 0.32 | 0.39 | 0.47 | 0.56 | 0.66 | 0.77 | 0.89 | 1.02 | 1.16 | 1.32 | 1.49 |
| 17 | 0.01 | 0.03 | 0.05 | 0.08 | 0.12 | 0.16 | 0.21 | 0.27 | 0.34 | 0.42 | 0.50 | 0.59 | 0.70 | 0.81 | 0.94 | 1.08 | 1.23 | 1.39 | 1.57 |
| 18 | 0.01 | 0.03 | 0.05 | 0.09 | 0.12 | 0.17 | 0.23 | 0.29 | 0.36 | 0.44 | 0.53 | 0.63 | 0.73 | 0.85 | 0.99 | 1.13 | 1.29 | 1.47 | 1.66 |
| 19 | 0.01 | 0.03 | 0.06 | 0.09 | 0.13 | 0.18 | 0.24 | 0.30 | 0.38 | 0.46 | 0.55 | 0.66 | 0.77 | 0.90 | 1.04 | 1.19 | 1.36 | 1.54 | 1.74 |
| 20 | 0.02 | 0.03 | 0.06 | 0.10 | 0.14 | 0.19 | 0.25 | 0.31 | 0.39 | 0.48 | 0.58 | 0.69 | 0.81 | 0.91 | 1.09 | 1.25 | 1.42 | 1.61 | 1.82 |
| 21 | 0.02 | 0.04 | 0.06 | 0.10 | 0.14 | 0.20 | 0.26 | 0.33 | 0.42 | 0.50 | 0.60 | 0.72 | 0.84 | 0.98 | 1.13 | 1.30 | 1.49 | 1.69 | 1.91 |
| 22 | 0.02 | 0.04 | 0.07 | 0.10 | 0.15 | 0.20 | 0.27 | 0.34 | 0.43 | 0.52 | 0.63 | 0.75 | 0.88 | 1.03 | 1.18 | 1.36 | 1.55 | 1.76 | 1.99 |
| 23 | 0.02 | 0.04 | 0.07 | 0.11 | 0.16 | 0.21 | 0.28 | 0.36 | 0.45 | 0.55 | 0.66 | 0.78 | 0.92 | 1.07 | 1.23 | 1.42 | 1.62 | 1.83 | 2.07 |
| 24 | 0.02 | 0.04 | 0.07 | 0.11 | 0.16 | 0.22 | 0.29 | 0.37 | 0.46 | 0.57 | 0.68 | 0.81 | 0.95 | 1.11 | 1.28 | 1.47 | 1.68 | 1.91 | 2.15 |
| 25 | 0.02 | 0.04 | 0.07 | 0.12 | 0.17 | 0.23 | 0.30 | 0.39 | 0.48 | 0.59 | 0.71 | 0.84 | 0.99 | 1.15 | 1.33 | 1.53 | 1.74 | 1.98 | 2.24 |
| 26 | 0.02 | 0.04 | 0.08 | 0.12 | 0.17 | 0.24 | 0.32 | 0.40 | 0.50 | 0.61 | 0.74 | 0.87 | 1.03 | 1.20 | 1.38 | 1.59 | 1.81 | 2.05 | 2.32 |
| 27 | 0.02 | 0.05 | 0.08 | 0.12 | 0.18 | 0.25 | 0.33 | 0.42 | 0.52 | 0.63 | 0.76 | 0.91 | 1.06 | 1.24 | 1.43 | 1.64 | 1.87 | 2.13 | 2.40 |
| 28 | 0.02 | 0.05 | 0.08 | 0.13 | 0.19 | 0.26 | 0.34 | 0.43 | 0.54 | 0.65 | 0.79 | 0.94 | 1.10 | 1.28 | 1.48 | 1.70 | 1.94 | 2.20 | 2.49 |
| 29 | 0.02 | 0.05 | 0.09 | 0.13 | 0.19 | 0.26 | 0.35 | 0.44 | 0.55 | 0.68 | 0.81 | 0.97 | 1.14 | 1.32 | 1.53 | 1.75 | 2.00 | 2.27 | 2.57 |
| 30 | 0.02 | 0.05 | 0.09 | 0.14 | 0.20 | 0.27 | 0.36 | 0.46 | 0.57 | 0.70 | 0.84 | 1.00 | 1.17 | 1.37 | 1.58 | 1.81 | 2.07 | 2.34 | 2.65 |

**Table E.0.2-3 Correction value of wet line (Unit: m) $\beta$=5**

| Wet line length (m) | Deflection angle of suspension cableway $\theta$(°) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4° | 6° | 8° | 10° | 12° | 14° | 16° | 18° | 20° | 22° | 24° | 26° | 28° | 30° | 32° | 34° | 36° | 38° | 40° |
| 1 | 0 | 0 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.05 | 0.07 | 0.08 | 0.09 | 0.10 | 0.12 | 0.13 | 0.15 | 0.17 | 0.19 |
| 2 | 0 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 | 0.11 | 0.13 | 0.15 | 0.17 | 0.20 | 0.23 | 0.26 | 0.29 | 0.33 |
| 3 | 0 | 0.01 | 0.02 | 0.02 | 0.03 | 0.05 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.17 | 0.20 | 0.23 | 0.27 | 0.30 | 0.34 | 0.39 | 0.44 |
| 4 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.17 | 0.21 | 0.24 | 0.28 | 0.32 | 0.37 | 0.42 | 0.48 | 0.54 |
| 5 | 0.01 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.09 | 0.11 | 0.14 | 0.17 | 0.20 | 0.24 | 0.28 | 0.33 | 0.38 | 0.43 | 0.49 | 0.56 | 0.63 |
| 6 | 0.01 | 0.01 | 0.02 | 0.04 | 0.05 | 0.07 | 0.10 | 0.13 | 0.16 | 0.19 | 0.23 | 0.27 | 0.32 | 0.37 | 0.43 | 0.49 | 0.56 | 0.64 | 0.72 |
| 7 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.08 | 0.11 | 0.14 | 0.18 | 0.21 | 0.26 | 0.31 | 0.36 | 0.42 | 0.48 | 0.55 | 0.63 | 0.72 | 0.81 |
| 8 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.09 | 0.12 | 0.16 | 0.19 | 0.24 | 0.28 | 0.34 | 0.40 | 0.46 | 0.53 | 0.61 | 0.70 | 0.79 | 0.89 |
| 9 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.10 | 0.13 | 0.17 | 0.21 | 0.26 | 0.31 | 0.37 | 0.43 | 0.51 | 0.58 | 0.67 | 0.76 | 0.87 | 0.98 |
| 10 | 0.01 | 0.02 | 0.04 | 0.06 | 0.08 | 0.11 | 0.15 | 0.18 | 0.23 | 0.28 | 0.34 | 0.40 | 0.47 | 0.55 | 0.63 | 0.73 | 0.83 | 0.94 | 1.06 |
| 11 | 0.01 | 0.02 | 0.04 | 0.06 | 0.09 | 0.12 | 0.16 | 0.20 | 0.25 | 0.30 | 0.36 | 0.43 | 0.51 | 0.59 | 0.68 | 0.78 | 0.89 | 1.01 | 1.15 |
| 12 | 0.01 | 0.02 | 0.04 | 0.07 | 0.09 | 0.13 | 0.17 | 0.21 | 0.27 | 0.32 | 0.39 | 0.46 | 0.54 | 0.64 | 0.73 | 0.84 | 0.96 | 1.09 | 1.23 |
| 13 | 0.01 | 0.03 | 0.04 | 0.07 | 0.10 | 0.14 | 0.18 | 0.23 | 0.28 | 0.35 | 0.42 | 0.50 | 0.58 | 0.68 | 0.78 | 0.90 | 1.02 | 1.16 | 1.31 |
| 14 | 0.01 | 0.03 | 0.05 | 0.07 | 0.11 | 0.14 | 0.19 | 0.24 | 0.30 | 0.37 | 0.44 | 0.53 | 0.62 | 0.72 | 0.83 | 0.96 | 1.09 | 1.24 | 1.40 |
| 15 | 0.01 | 0.03 | 0.05 | 0.08 | 0.11 | 0.15 | 0.20 | 0.26 | 0.32 | 0.39 | 0.47 | 0.56 | 0.66 | 0.76 | 0.88 | 1.01 | 1.15 | 1.31 | 1.48 |
| 16 | 0.01 | 0.03 | 0.05 | 0.08 | 0.12 | 0.16 | 0.21 | 0.27 | 0.34 | 0.41 | 0.50 | 0.59 | 0.69 | 0.81 | 0.93 | 1.07 | 1.22 | 1.38 | 1.56 |
| 17 | 0.01 | 0.03 | 0.05 | 0.09 | 0.12 | 0.17 | 0.22 | [illegible] | [illegible] | 0.43 | 0.52 | 0.62 | 0.73 | 0.85 | 0.98 | 1.13 | 1.28 | 1.46 | 1.65 |
| 18 | 0.01 | 0.03 | 0.06 | 0.09 | 0.13 | 0.18 | 0.23 | 0.30 | 0.37 | 0.46 | 0.55 | 0.65 | 0.77 | 0.89 | 1.03 | 1.18 | 1.35 | 1.53 | 1.73 |
| 19 | 0.02 | 0.03 | 0.06 | 0.09 | 0.14 | 0.19 | 0.25 | 0.31 | 0.39 | 0.48 | 0.57 | 0.68 | 0.80 | 0.93 | 1.08 | 1.24 | 1.41 | 1.60 | 1.81 |
| 20 | 0.02 | 0.04 | 0.06 | 0.10 | 0.14 | 0.20 | 0.26 | 0.33 | 0.41 | 0.50 | 0.60 | 0.71 | 0.84 | 0.98 | 1.13 | 1.30 | 1.48 | 1.68 | 1.89 |
| 21 | 0.02 | 0.04 | 0.07 | 0.10 | 0.15 | 0.20 | 0.27 | 0.34 | 0.43 | 0.52 | 0.63 | 0.75 | 0.88 | 1.02 | 1.18 | 1.35 | 1.54 | 1.75 | 1.98 |
| 22 | 0.02 | 0.04 | 0.07 | 0.11 | 0.16 | 0.21 | 0.28 | 0.36 | 0.45 | 0.54 | 0.65 | 0.78 | 0.91 | 1.06 | 1.23 | 1.41 | 1.61 | 1.82 | 2.06 |
| 23 | 0.02 | 0.04 | 0.07 | 0.11 | 0.16 | 0.22 | 0.29 | 0.37 | 0.46 | 0.56 | 0.68 | 0.81 | 0.95 | 1.11 | 1.28 | 1.46 | 1.67 | 1.90 | 2.14 |
| 24 | 0.02 | 0.04 | 0.07 | 0.12 | 0.17 | 0.23 | 0.30 | 0.39 | 0.48 | 0.59 | 0.71 | 0.84 | 0.98 | 1.15 | 1.32 | 1.52 | 1.73 | 1.97 | 2.23 |
| 25 | 0.02 | 0.04 | 0.08 | 0.12 | 0.18 | 0.24 | 0.31 | 0.40 | 0.50 | 0.61 | 0.73 | 0.87 | 1.02 | 1.19 | 1.37 | 1.58 | 1.80 | 2.04 | 2.31 |
| 26 | 0.02 | 0.05 | 0.08 | 0.12 | 0.18 | 0.25 | 0.32 | 0.41 | 0.52 | 0.63 | 0.76 | 0.90 | 1.06 | 1.23 | 1.42 | 1.63 | 1.86 | 2.12 | 2.39 |
| 27 | 0.02 | 0.05 | 0.08 | 0.13 | 0.19 | 0.26 | 0.34 | 0.43 | 0.53 | 0.65 | 0.78 | 0.93 | 1.10 | 1.28 | 1.47 | 1.69 | 1.93 | 2.19 | 2.47 |
| 28 | 0.02 | 0.05 | 0.09 | 0.13 | 0.19 | 0.26 | 0.35 | 0.44 | 0.55 | 0.67 | 0.81 | 0.96 | 1.13 | 1.32 | 1.52 | 1.75 | 1.99 | 2.26 | 2.56 |
| 29 | 0.02 | 0.05 | 0.09 | 0.14 | 0.20 | 0.27 | 0.36 | 0.46 | 0.57 | 0.70 | 0.84 | 0.99 | 1.17 | 1.36 | 1.57 | 1.80 | 2.06 | 2.33 | 2.64 |
| 30 | 0.02 | 0.05 | 0.09 | 0.14 | 0.21 | 0.28 | 0.37 | 0.47 | 0.59 | 0.72 | 0.86 | 1.03 | 1.21 | 1.40 | 1.62 | 1.86 | 2.12 | 2.41 | 2.72 |

**Table E.0.2-4 Correction value of wet line (Unit: m)**

| Wet line length (m) | β=2.0 | | | | | | | | | | β=3.0 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Deflection angle of suspension cable θ(°) | | | | | | | | | | | | | | | | | | | |
| | 42° | 44° | 46° | 48° | 50° | 52° | 54° | 56° | 58° | 60° | 42° | 44° | 46° | 48° | 50° | 52° | 54° | 56° | 58° | 60° |
| 11 | 1.1 | 1.3 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.7 | 3.0 | 1.2 | 1.3 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.8 | 3.1 |
| 12 | 1.2 | 1.4 | 1.5 | 1.7 | 1.9 | 2.1 | 2.4 | 2.6 | 2.9 | 3.2 | 1.3 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 | 3.0 | 3.3 |
| 13 | 1.3 | 1.5 | 1.7 | 1.8 | 2.1 | 2.3 | 2.6 | 2.8 | 3.1 | 3.4 | 1.4 | 1.5 | 1.7 | 1.9 | 2.1 | 2.4 | 2.6 | 2.9 | 3.2 | 3.6 |
| 14 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 | 3.0 | 3.3 | 3.7 | 1.5 | 1.6 | 1.9 | 2.1 | 2.3 | 2.5 | 2.8 | 3.1 | 3.5 | 3.8 |
| 15 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.6 | 3.9 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.7 | 3.0 | 3.3 | 3.7 | 4.1 |
| 16 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.8 | 3.1 | 3.4 | 3.8 | 4.2 | 1.7 | 1.9 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.5 | 3.9 | 4.3 |
| 17 | 1.7 | 1.9 | 2.1 | 2.4 | 2.6 | 2.9 | 3.3 | 3.6 | 4.0 | 4.4 | 1.7 | 2.0 | 2.2 | 2.4 | 2.7 | 3.0 | 3.4 | 3.7 | 4.1 | 4.6 |
| 18 | 1.8 | 2.0 | 2.2 | 2.5 | 2.8 | 3.1 | 3.4 | 3.8 | 4.2 | 4.7 | 1.8 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.5 | 3.9 | 4.3 | 4.8 |
| 19 | 1.9 | 2.1 | 2.4 | 2.6 | 2.9 | 3.3 | 3.6 | 4.0 | 4.4 | 4.9 | 1.9 | 2.2 | 2.4 | 2.7 | 3.0 | 3.4 | 3.7 | 4.1 | 4.6 | 5.0 |
| 20 | 2.0 | 2.2 | 2.5 | 2.8 | 3.1 | 3.1 | 3.8 | 4.2 | 4.7 | 5.1 | 2.0 | 2.3 | 2.5 | 2.8 | 3.2 | 3.5 | 3.9 | 4.3 | 4.8 | 5.3 |
| 21 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.6 | 4.0 | 4.4 | 4.9 | 5.4 | 2.1 | 2.4 | 2.7 | 3.0 | 3.3 | 3.7 | 4.1 | 4.5 | 5.0 | 5.5 |
| 22 | 2.2 | 2.4 | 2.7 | 3.0 | 3.4 | 3.7 | 4.2 | 4.6 | 5.1 | 5.6 | 2.2 | 2.5 | 2.8 | 3.1 | 3.5 | 3.8 | 4.3 | 4.7 | 5.2 | 5.8 |
| 23 | 2.3 | 2.5 | 2.8 | 3.2 | 3.5 | 3.9 | 4.3 | 4.8 | 5.3 | 5.9 | 2.3 | 2.6 | 2.9 | 3.2 | 3.6 | 4.0 | 4.4 | 4.9 | 5.4 | 6.0 |
| 24 | 2.3 | 2.6 | 2.9 | 3.3 | 3.7 | 4.1 | 4.5 | 5.0 | 5.5 | 6.1 | 2.4 | 2.7 | 3.0 | 3.4 | 3.7 | 4.2 | 4.6 | 5.1 | 5.7 | 6.3 |
| 25 | 2.4 | 2.7 | 3.1 | 3.4 | 3.8 | 4.2 | 4.7 | 5.2 | 5.8 | 6.4 | 2.5 | 2.8 | 3.1 | 3.5 | 3.9 | 4.3 | 4.8 | 5.3 | 5.9 | 6.5 |
| 26 | 2.5 | 2.8 | 3.2 | 3.5 | 3.9 | 4.4 | 4.9 | 5.4 | 6.0 | 6.6 | 2.6 | 2.9 | 3.2 | 3.6 | 4.0 | 4.5 | 5.0 | 5.5 | 6.1 | 6.7 |
| 27 | 2.6 | 2.9 | 3.3 | 3.7 | 4.1 | 4.5 | 5.0 | 5.6 | 6.2 | 6.8 | 2.7 | 3.0 | 3.4 | 3.8 | 4.2 | 4.6 | 5.2 | 5.7 | 6.3 | 7.0 |
| 28 | 2.7 | 3.0 | 3.4 | 3.8 | 4.2 | 4.7 | 5.2 | 5.8 | 6.4 | 7.1 | 2.8 | 3.1 | 3.5 | 3.9 | 4.3 | 4.8 | 5.3 | 5.9 | 6.5 | 7.2 |
| 29 | 2.8 | 3.2 | 3.5 | 3.9 | 4.4 | 4.9 | 5.4 | 6.0 | 6.6 | 7.3 | 2.9 | 3.2 | 3.6 | 4.0 | 4.5 | 5.0 | 5.5 | 6.1 | 6.8 | 7.5 |
| 30 | 2.9 | 3.3 | 3.6 | 4.1 | 4.5 | 5.0 | 5.6 | 6.2 | 6.9 | 7.6 | 3.0 | 3.3 | 3.7 | 4.1 | 4.6 | 5.1 | 5.7 | 6.3 | 7.0 | 7.7 |
| 31 | 3.0 | 3.4 | 3.8 | 4.2 | 4.7 | 5.2 | 5.8 | 6.4 | 7.1 | 7.8 | 3.1 | 3.4 | 3.8 | 4.3 | 4.7 | 5.3 | 5.9 | 6.5 | 7.2 | 8.0 |
| 32 | 3.1 | 3.5 | 3.9 | 4.3 | 4.8 | 5.4 | 6.0 | 6.6 | 7.3 | 8.1 | 3.1 | 3.5 | 3.9 | 4.4 | 4.9 | 5.5 | 6.1 | 6.7 | 7.4 | 8.2 |
| 33 | 3.2 | 3.6 | 4.0 | 4.5 | 5.0 | 5.5 | 6.1 | 6.8 | 7.5 | 8.3 | 3.2 | 3.6 | 4.1 | 4.5 | 5.1 | 5.6 | 6.2 | 6.9 | 7.6 | 8.4 |
| 34 | 3.3 | 3.7 | 4.1 | 4.6 | 5.1 | 5.7 | 6.3 | 7.0 | 7.7 | 8.5 | 3.3 | 3.7 | 4.2 | 4.7 | 5.2 | 5.8 | 6.4 | 7.1 | 7.9 | 8.7 |
| 35 | 3.4 | 3.8 | 4.2 | 4.7 | 5.2 | 5.8 | 6.5 | 7.2 | 8.0 | 8.8 | 3.4 | 3.8 | 4.3 | 4.8 | 5.3 | 5.9 | 6.6 | 7.3 | 8.1 | 8.9 |
| 36 | 3.5 | 3.9 | 4.3 | 4.9 | 5.4 | 6.0 | 6.7 | 7.4 | 8.2 | 9.0 | 3.5 | 3.9 | 4.4 | 4.9 | 5.5 | 6.1 | 6.8 | 7.5 | 8.3 | 9.2 |
| 37 | 3.6 | 4.0 | 4.5 | 5.0 | 5.5 | 6.2 | 6.8 | 7.6 | 8.4 | 9.3 | 3.6 | 4.0 | 4.5 | 5.1 | 5.6 | 6.3 | 6.9 | 7.7 | 8.5 | 9.4 |
| 38 | 3.6 | 4.1 | 4.6 | 5.1 | 5.7 | 6.3 | 7.0 | 7.8 | 8.6 | 9.5 | 3.7 | 4.2 | 4.6 | 5.2 | 5.8 | 6.4 | 7.1 | 7.9 | 8.7 | 9.7 |
| 39 | 3.7 | 4.2 | 4.7 | 5.2 | 5.8 | 6.5 | 7.2 | 8.0 | 8.8 | 9.8 | 3.8 | 4.3 | 4.8 | 5.3 | 5.9 | 6.6 | 7.3 | 8.1 | 9.0 | 9.9 |
| 40 | 3.8 | 4.3 | 4.8 | 5.4 | 6.0 | 6.7 | 7.4 | 8.2 | 9.1 | 10.0 | 3.9 | 4.4 | 4.9 | 5.4 | 6.1 | 6.7 | 7.5 | 8.3 | 9.2 | 10.1 |
| 41 | 3.9 | 4.4 | 4.9 | 5.5 | 6.1 | 6.8 | 7.6 | 8.4 | 9.3 | 10.3 | 4.0 | 4.5 | 5.0 | 5.6 | 6.2 | 6.9 | 7.7 | 8.5 | 9.4 | 10.4 |
| 42 | 4.0 | 4.5 | 5.0 | 5.6 | 6.3 | 7.0 | 7.7 | 8.6 | 9.5 | 10.5 | 4.1 | 4.6 | 5.1 | 5.7 | 6.4 | 7.1 | 7.8 | 8.7 | 9.6 | 10.6 |
| 43 | 4.1 | 4.6 | 5.2 | 5.8 | 6.4 | 7.1 | 7.9 | 8.8 | 9.7 | 10.7 | 4.2 | 4.7 | 5.2 | 5.8 | 6.5 | 7.2 | 8.0 | 8.9 | 9.8 | 10.9 |
| 44 | 4.2 | 4.7 | 5.3 | 5.9 | 6.6 | 7.3 | 8.1 | 9.0 | 9.9 | 11.0 | 4.3 | 4.8 | 5.3 | 6.0 | 6.6 | 7.4 | 8.2 | 9.1 | 10.1 | 11.1 |
| 45 | 4.3 | 4.8 | 5.4 | 6.0 | 6.7 | 7.5 | 8.3 | 9.2 | 10.2 | 11.2 | 4.4 | 4.9 | 5.5 | 6.1 | 6.8 | 7.6 | 8.4 | 9.3 | 10.3 | 11.4 |
| 46 | 4.4 | 4.9 | 5.5 | 6.2 | 6.9 | 7.6 | 8.5 | 9.4 | 10.4 | 11.5 | 4.4 | 5.0 | 5.6 | 6.2 | 6.9 | 7.7 | 8.6 | 9.5 | 10.5 | 11.6 |
| 47 | 4.5 | 5.0 | 5.6 | 6.3 | 7.0 | 7.8 | 8.6 | 9.6 | 10.6 | 11.7 | 4.5 | 5.1 | 5.7 | 6.4 | 7.1 | 7.9 | 8.7 | 9.7 | 10.7 | 11.9 |
| 48 | 4.6 | 5.1 | 5.8 | 6.4 | 7.1 | 7.9 | 8.8 | 9.8 | 10.8 | 12.0 | 4.6 | 5.2 | 5.8 | 6.5 | 7.2 | 8.0 | 8.9 | 9.9 | 10.9 | 12.1 |
| 49 | 4.7 | 5.2 | 5.9 | 6.5 | 7.3 | 8.1 | 9.0 | 10.0 | 11.0 | 12.2 | 4.7 | 5.3 | 5.9 | 6.6 | 7.4 | 8.2 | 9.1 | 10.1 | 11.2 | 12.3 |
| 50 | 4.8 | 5.3 | 6.0 | 6.7 | 7.4 | 8.3 | 9.2 | 10.2 | 11.2 | 12.4 | 4.8 | 5.4 | 6.1 | 6.8 | 7.5 | 8.4 | 9.3 | 10.3 | 11.4 | 12.6 |

**Table E.0.2-5 Correction value of wet line (Unit: m)**

| Wet line length (m) | β=4.0 | | | | | | | | | | β=5.0 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Deflection angle of suspension cableway θ(°) | | | | | | | | | | | | | | | | | | | |
| | 42° | 44° | 46° | 48° | 50° | 52° | 54° | 56° | 58° | 60° | 42° | 44° | 46° | 48° | 50° | 52° | 54° | 56° | 58° | 60° |
| 11 | 1.2 | 1.4 | 1.6 | 1.7 | 1.9 | 2.2 | 2.4 | 2.6 | 2.9 | 3.2 | 1.3 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 | 3.0 | 3.4 |
| 12 | 1.3 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.6 | 2.8 | 3.1 | 3.5 | 1.4 | 1.6 | 1.7 | 1.9 | 2.2 | 2.4 | 2.7 | 2.9 | 3.3 | 3.6 |
| 13 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 | 3.0 | 3.4 | 3.7 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.6 | 2.8 | 3.2 | 3.5 | 3.9 |
| 14 | 1.5 | 1.7 | 1.9 | 2.1 | 2.4 | 2.6 | 2.9 | 3.2 | 3.6 | 4.0 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 | 3.0 | 3.4 | 3.7 | 4.1 |
| 15 | 1.6 | 1.8 | 2.0 | 2.3 | 2.5 | 2.8 | 3.1 | 3.4 | 3.3 | 4.2 | 1.7 | 1.9 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.5 | 3.9 | 4.3 |
| 16 | 1.7 | 1.9 | 2.1 | 2.4 | 2.7 | 3.0 | 3.3 | 3.6 | 4.0 | 4.5 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 | 3.1 | 3.4 | 3.8 | 4.2 | 4.6 |
| 17 | 1.8 | 2.0 | 2.3 | 2.5 | 2.8 | 3.1 | 3.5 | 3.8 | 4.2 | 4.7 | 1.9 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.6 | 4.0 | 4.4 | 4.8 |
| 18 | 1.9 | 2.1 | 2.4 | 2.7 | 3.0 | 3.3 | 3.6 | 4.0 | 4.5 | 4.9 | 1.9 | 2.2 | 2.4 | 2.7 | 3.0 | 3.4 | 3.7 | 4.2 | 4.6 | 5.1 |
| 19 | 2.0 | 2.2 | 2.5 | 2.8 | 3.1 | 3.4 | 3.8 | 4.2 | 4.7 | 5.2 | 2.0 | 2.3 | 2.6 | 2.9 | 3.2 | 3.5 | 3.9 | 4.4 | 4.8 | 5.3 |
| 20 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.6 | 4.0 | 4.4 | 4.9 | 5.4 | 2.1 | 2.4 | 2.7 | 3.0 | 3.3 | 3.7 | 4.1 | 4.6 | 5.0 | 5.6 |
| 21 | 2.2 | 2.4 | 2.7 | 3.0 | 3.4 | 3.8 | 4.2 | 4.6 | 5.1 | 5.7 | 2.2 | 2.5 | 2.8 | 3.1 | 3.5 | 3.9 | 4.3 | 4.8 | 5.3 | 5.8 |
| 22 | 2.3 | 2.5 | 2.8 | 3.2 | 3.5 | 3.9 | 4.4 | 4.8 | 5.3 | 5.9 | 2.3 | 2.6 | 2.9 | 3.3 | 3.6 | 4.0 | 4.5 | 4.9 | 5.5 | 6.1 |
| 23 | 2.4 | 2.7 | 3.0 | 3.3 | 3.7 | 4.1 | 4.5 | 5.0 | 5.6 | 6.2 | 2.4 | 2.7 | 3.0 | 3.4 | 3.8 | 4.2 | 4.6 | 5.1 | 5.7 | 6.3 |
| 24 | 2.5 | 2.8 | 3.1 | 3.4 | 3.8 | 4.3 | 4.7 | 5.2 | 5.8 | 6.4 | 2.5 | 2.8 | 3.1 | 3.5 | 3.9 | 4.3 | 4.8 | 5.3 | 5.9 | 6.5 |
| 25 | 2.5 | 2.9 | 3.2 | 3.6 | 4.0 | 4.4 | 4.9 | 5.4 | 6.0 | 6.6 | 2.6 | 2.9 | 3.3 | 3.6 | 4.1 | 4.5 | 5.0 | 5.5 | 6.1 | 6.8 |
| 26 | 2.6 | 3.0 | 3.3 | 3.7 | 4.1 | 4.6 | 5.1 | 5.6 | 6.2 | 6.9 | 2.7 | 3.0 | 3.4 | 3.8 | 4.2 | 4.7 | 5.2 | 5.7 | 6.4 | 7.0 |
| 27 | 2.7 | 3.1 | 3.4 | 3.8 | 4.3 | 4.7 | 5.3 | 5.8 | 6.5 | 7.1 | 2.8 | 3.1 | 3.5 | 3.9 | 4.3 | 4.8 | 5.4 | 5.9 | 6.6 | 7.3 |
| 28 | 2.8 | 3.2 | 3.5 | 4.0 | 4.4 | 4.9 | 5.4 | 6.0 | 6.7 | 7.4 | 2.9 | 3.2 | 3.6 | 4.0 | 4.5 | 5.0 | 5.5 | 6.1 | 6.8 | 7.5 |
| 29 | 2.9 | 3.3 | 3.7 | 4.1 | 4.6 | 5.1 | 5.6 | 6.2 | 6.9 | 7.6 | 3.0 | 3.3 | 3.7 | 4.2 | 4.6 | 5.2 | 5.7 | 6.3 | 7.0 | 7.8 |
| 30 | 3.0 | 3.4 | 3.8 | 4.2 | 4.7 | 5.2 | 5.8 | 6.4 | 7.1 | 7.9 | 3.1 | 3.4 | 3.8 | 4.3 | 4.8 | 5.3 | 5.9 | 6.5 | 7.2 | 8.0 |
| 31 | 3.1 | 3.5 | 3.9 | 4.4 | 4.8 | 5.4 | 6.0 | 6.6 | 7.3 | 8.1 | 3.2 | 3.5 | 4.0 | 4.4 | 4.9 | 5.5 | 6.1 | 6.7 | 7.5 | 8.2 |
| 32 | 3.2 | 3.6 | 4.0 | 4.5 | 5.0 | 5.5 | 6.2 | 6.8 | 7.5 | 8.3 | 3.3 | 3.6 | 4.1 | 4.6 | 5.1 | 5.6 | 6.3 | 6.9 | 7.7 | 8.5 |
| 33 | 3.3 | 3.7 | 4.1 | 4.6 | 5.1 | 5.7 | 6.3 | 7.0 | 7.8 | 8.6 | 3.3 | 3.8 | 4.2 | 4.7 | 5.2 | 5.8 | 6.4 | 7.1 | 7.9 | 8.7 |
| 34 | 3.4 | 3.8 | 4.2 | 4.7 | 5.3 | 5.9 | 6.5 | 7.2 | 8.0 | 8.8 | 3.4 | 3.9 | 4.3 | 4.8 | 5.4 | 6.0 | 6.6 | 7.3 | 8.1 | 9.0 |
| 35 | 3.5 | 3.9 | 4.4 | 4.9 | 5.4 | 6.0 | 6.7 | 7.4 | 8.2 | 9.1 | 3.5 | 4.0 | 4.4 | 4.9 | 5.5 | 6.1 | 6.8 | 7.5 | 8.3 | 9.2 |
| 36 | 3.6 | 4.0 | 4.5 | 5.0 | 5.6 | 6.2 | 6.9 | 7.6 | 8.4 | 9.3 | 3.6 | 4.1 | 4.5 | 5.1 | 5.7 | 6.3 | 7.0 | 7.7 | 8.6 | 9.5 |
| 37 | 3.7 | 4.1 | 4.6 | 5.1 | 5.7 | 6.4 | 7.1 | 7.8 | 8.6 | 9.6 | 3.7 | 4.2 | 4.7 | 5.2 | 5.8 | 6.4 | 7.2 | 7.9 | 8.8 | 9.7 |
| 38 | 3.8 | 4.2 | 4.7 | 5.3 | 5.9 | 6.5 | 7.2 | 8.0 | 8.9 | 9.8 | 3.8 | 4.3 | 4.8 | 5.3 | 6.0 | 6.6 | 7.3 | 8.1 | 9.0 | 9.9 |
| 39 | 3.8 | 4.3 | 4.8 | 5.4 | 6.0 | 6.7 | 7.4 | 8.2 | 9.1 | 10.1 | 3.9 | 4.4 | 4.9 | 5.5 | 6.1 | 6.8 | 7.5 | 8.3 | 9.2 | 10.2 |
| 40 | 3.9 | 4.4 | 5.0 | 5.5 | 6.2 | 6.8 | 7.6 | 8.4 | 9.3 | 10.3 | 4.0 | 4.5 | 5.0 | 5.6 | 6.2 | 6.9 | 7.7 | 8.5 | 9.4 | 10.4 |
| 41 | 4.0 | 4.5 | 5.1 | 5.7 | 6.3 | 7.0 | 7.8 | 8.6 | 9.5 | 10.5 | 4.1 | 4.6 | 5.1 | 5.7 | 6.4 | 7.1 | 7.9 | 8.7 | 9.7 | 10.7 |
| 42 | 4.1 | 4.6 | 5.2 | 5.8 | 6.4 | 7.2 | 7.9 | 8.8 | 9.7 | 10.8 | 4.2 | 4.7 | 5.3 | 5.9 | 6.5 | 7.3 | 8.1 | 8.9 | 9.9 | 10.9 |
| 43 | 4.2 | 4.7 | 5.3 | 5.9 | 6.6 | 7.3 | 8.1 | 9.0 | 10.0 | 11.0 | 4.3 | 4.8 | 5.4 | 6.0 | 6.7 | 7.4 | 8.2 | 9.1 | 10.1 | 11.2 |
| 44 | 4.3 | 4.8 | 5.4 | 6.0 | 6.8 | 7.5 | 8.3 | 8.2 | 10.2 | 11.3 | 4.4 | 4.9 | 5.5 | 6.1 | 6.8 | 7.6 | 8.4 | 9.3 | 10.3 | 11.4 |
| 45 | 4.4 | 4.9 | 5.5 | 6.2 | 6.9 | 7.6 | 8.5 | 9.4 | 10.4 | 11.5 | 4.5 | 5.0 | 5.6 | 6.3 | 7.0 | 7.7 | 8.6 | 9.5 | 10.5 | 11.7 |
| 46 | 4.5 | 5.1 | 5.7 | 6.3 | 7.0 | 7.8 | 8.7 | 9.6 | 10.6 | 11.8 | 4.6 | 5.1 | 5.7 | 6.4 | 7.1 | 7.9 | 8.8 | 9.7 | 10.8 | 11.9 |
| 47 | 4.6 | 5.2 | 5.8 | 6.4 | 7.2 | 8.0 | 8.8 | 9.8 | 10.8 | 12.0 | 4.6 | 5.2 | 5.8 | 6.5 | 7.3 | 8.1 | 8.9 | 9.9 | 11.0 | 12.1 |
| 48 | 4.7 | 5.3 | 5.9 | 6.6 | 7.3 | 8.2 | 9.0 | 10.0 | 11.1 | 12.2 | 4.7 | 5.3 | 6.0 | 6.6 | 7.4 | 8.2 | 9.1 | 10.1 | 11.2 | 12.4 |
| 49 | 4.8 | 5.4 | 6.0 | 6.7 | 7.5 | 8.3 | 9.2 | 10.2 | 11.3 | 12.5 | 4.8 | 5.4 | 6.1 | 6.8 | 7.5 | 8.4 | 9.3 | 10.3 | 11.4 | 12.6 |
| 50 | 4.9 | 5.5 | 6.1 | 6.8 | 7.6 | 8.5 | 9.4 | 10.4 | 11.5 | 12.7 | 4.9 | 5.5 | 6.2 | 6.9 | 7.7 | 8.5 | 9.5 | 10.5 | 11.6 | 12.9 |

**Table E.0.3-1 Correction coefficient $K_w$ ( % ) of wet line table( Ⅰ )**

| β/d | 4° | 6° | 8° | 10° | 12° | 14° | 16° | 18° | 20° | 22° | 24° | 26° | 28° | 30° | 32° | 34° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 0.070 | 0.158 | 0.282 | 0.443 | 0.611 | 0.878 | 1.155 | 1.474 | 1.836 | 2.244 | 2.699 | 3.206 | 3.767 | 4.385 | 5.064 | 5.810 |
| 0.06 | 0.071 | 0.159 | 0.284 | 0.446 | 0.645 | 0.883 | 1.162 | 1.482 | 1.846 | 2.256 | 2.714 | 3.223 | 3.787 | 4.408 | 5.091 | 5.840 |
| 0.07 | 0.071 | 0.160 | 0.285 | 0.448 | 0.648 | 0.888 | 1.168 | 1.490 | 1.856 | 2.268 | 2.729 | 3.240 | 3.807 | 4.431 | 5.118 | 5.871 |
| 0.08 | 0.071 | 0.161 | 0.287 | 0.450 | 0.652 | 0.893 | 1.174 | 1.498 | 1.866 | 2.280 | 2.743 | 3.258 | 3.827 | 4.455 | 5.145 | 5.901 |
| 0.09 | 0.072 | 0.162 | 0.289 | 0.453 | 0.656 | 0.898 | 1.181 | 1.506 | 1.876 | 2.292 | 2.758 | 3.275 | 3.847 | 4.478 | 5.171 | 5.932 |
| 0.10 | 0.072 | 0.163 | 0.290 | 0.455 | 0.659 | 0.903 | 1.187 | 1.514 | 1.886 | 2.305 | 2.773 | 3.292 | 3.868 | 4.502 | 5.198 | 5.963 |
| 0.20 | 0.076 | 0.172 | 0.306 | 0.480 | 0.695 | 0.951 | 1.251 | 1.595 | 1.987 | 2.427 | 2.919 | 3.466 | 4.070 | 4.736 | 5.467 | 6.268 |
| 0.30 | 0.080 | 0.180 | 0.322 | 0.505 | 0.730 | 1.000 | 1.314 | 1.676 | 2.087 | 2.549 | 3.065 | 3.638 | 4.270 | 4.967 | 5.732 | 6.570 |
| 0.40 | 0.084 | 0.189 | 0.337 | 0.529 | 0.765 | 1.047 | 1.377 | 1.756 | 2.185 | 2.668 | 3.208 | 3.806 | 4.467 | 5.194 | 5.992 | 6.865 |
| 0.50 | 0.087 | 0.197 | 0.352 | 0.552 | 0.799 | 1.094 | 1.438 | 1.835 | 2.281 | 2.785 | 3.347 | 3.971 | 4.659 | 5.415 | 6.245 | 7.151 |
| 0.60 | 0.091 | 0.206 | 0.367 | 0.576 | 0.833 | 1.139 | 1.497 | 1.909 | 2.373 | 2.899 | 3.483 | 4.130 | 4.845 | 5.630 | 6.489 | 7.429 |
| 0.70 | 0.095 | 0.214 | 0.381 | 0.592 | 0.865 | 1.183 | 1.537 | 1.982 | 2.465 | 3.009 | 3.614 | 4.285 | 5.024 | 5.836 | 6.725 | 7.696 |
| 0.80 | 0.098 | 0.222 | 0.395 | 0.620 | 0.896 | 1.225 | 1.611 | 2.052 | 2.553 | 3.115 | 3.741 | 4.434 | 5.197 | 6.036 | 6.952 | 7.953 |
| 0.90 | 0.102 | 0.229 | 0.409 | 0.641 | 0.926 | 1.267 | 1.665 | 2.121 | 2.637 | 3.217 | 3.862 | 4.577 | 5.364 | 6.227 | 7.171 | 8.199 |
| 1.00 | 0.105 | 0.236 | 0.421 | 0.661 | 0.955 | 1.307 | 1.717 | 2.186 | 2.718 | 3.315 | 3.980 | 4.715 | 5.524 | 6.411 | 7.380 | 8.435 |
| 1.10 | 0.108 | 0.243 | 0.434 | 0.680 | 0.984 | 1.345 | 1.767 | 2.250 | 2.797 | 3.410 | 4.093 | 4.847 | 5.677 | 6.587 | 7.580 | 8.662 |
| 1.20 | 0.111 | 0.250 | 0.446 | 0.699 | 1.011 | 1.382 | 1.815 | 2.311 | 2.872 | 3.501 | 4.201 | 4.974 | 5.825 | 6.756 | 7.772 | 8.878 |
| 1.30 | 0.114 | 0.257 | 0.457 | 0.717 | 1.037 | 1.417 | 1.861 | 2.369 | 2.941 | 3.589 | 4.305 | 5.096 | 5.966 | 6.918 | 7.956 | 9.085 |
| 1.40 | 0.117 | 0.263 | 0.469 | 0.735 | 1.062 | 1.451 | 1.906 | 2.426 | 3.014 | 3.673 | 4.405 | 5.214 | 6.102 | 7.047 | 8.133 | 9.283 |
| 1.50 | 0.119 | 0.269 | 0.479 | 0.751 | 1.086 | 1.484 | 1.948 | 2.483 | 3.081 | 3.754 | 4.501 | 5.326 | 6.232 | 7.223 | 8.302 | 9.473 |
| 1.60 | 0.122 | 0.275 | 0.490 | 0.767 | 1.109 | 1.516 | 1.990 | 2.532 | 3.145 | 3.831 | 4.593 | 5.434 | 6.357 | 7.366 | 8.463 | 9.655 |
| 1.70 | 0.124 | 0.280 | 0.500 | 0.783 | 1.131 | 1.546 | 2.029 | 2.582 | 3.207 | 3.906 | 4.682 | 5.538 | 6.477 | 7.502 | 8.619 | 9.829 |
| 1.80 | 0.127 | 0.286 | 0.509 | 0.798 | 1.153 | 1.576 | 2.068 | 2.631 | 3.266 | 3.978 | 4.767 | 5.638 | 6.592 | 7.634 | 8.767 | 9.996 |
| 1.90 | 0.129 | 0.291 | 0.519 | 0.812 | 1.174 | 1.604 | 2.104 | 2.677 | 3.324 | 4.047 | 4.849 | 5.733 | 6.703 | 7.760 | 8.910 | 10.156 |
| 2.00 | 0.131 | 0.296 | 0.527 | 0.826 | 1.194 | 1.631 | 2.140 | 2.722 | 3.379 | 4.113 | 4.928 | 5.825 | 6.809 | 7.882 | 9.047 | 10.310 |

**Table E.0.3-2 Correction coefficient $K_w$ ( % ) of wet line table( Ⅱ )**

| β/d | 36° | 38° | 40° | 42° | 44° | 46° | 48° | 50° | 52° | 54° | 56° | 58° | 60° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 6.626 | 7.520 | 8.496 | 9.562 | 10.725 | 11.995 | 13.382 | 14.895 | 16.548 | 18.353 | 20.326 | 22.483 | 24.843 |
| 0.06 | 6.661 | 7.558 | 8.539 | 9.610 | 10.779 | 12.055 | 13.447 | 14.966 | 16.625 | 18.437 | 20.417 | 22.582 | 24.949 |
| 0.07 | 6.695 | 7.567 | 8.583 | 9.658 | 10.832 | 12.114 | 13.512 | 15.037 | 16.703 | 18.522 | 20.508 | 22.680 | 25.054 |
| 0.08 | 6.730 | 7.636 | 8.626 | 9.707 | 10.886 | 12.173 | 13.577 | 15.108 | 16.780 | 18.606 | 20.599 | 22.778 | 25.159 |
| 0.09 | 6.765 | 7.675 | 8.670 | 9.755 | 10.940 | 12.232 | 13.642 | 15.180 | 16.858 | 18.690 | 20.690 | 22.876 | 25.264 |
| 0.10 | 6.799 | 7.714 | 8.713 | 9.804 | 10.993 | 12.291 | 13.707 | 15.251 | 16.935 | 18.774 | 20.781 | 22.974 | 25.369 |
| 0.20 | 7.144 | 8.102 | 9.146 | 10.285 | 11.529 | 12.879 | 14.351 | 15.955 | 17.702 | 19.606 | 21.679 | 23.939 | 26.403 |

Table E.0.3-2 (continued)

| $\beta/d$ | 36° | 38° | 40° | 42° | 44° | 46° | 48° | 50° | 52° | 54° | 56° | 58° | 60° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.30 | 7.485 | 8.484 | 9.573 | 10.795 | 12.050 | 13.455 | 14.982 | 16.643 | 18.450 | 20.414 | 22.550 | 24.873 | 27.390 |
| 0.40 | 7.818 | 8.857 | 9.989 | 11.220 | 12.559 | 14.013 | 15.593 | 17.308 | 19.171 | 21.192 | 23.380 | 25.766 | 28.348 |
| 0.50 | 8.141 | 9.219 | 10.392 | 11.666 | 13.050 | 14.552 | 16.131 | 17.947 | 19.861 | 21.934 | 24.187 | 26.613 | 29.246 |
| 0.60 | 8.456 | 9.568 | 10.779 | 12.095 | 13.522 | 15.068 | 16.743 | 18.556 | 20.518 | 22.640 | 24.934 | 27.414 | 30.091 |
| 0.70 | 8.754 | 9.903 | 11.152 | 12.506 | 13.973 | 15.561 | 17.279 | 19.136 | 21.142 | 23.308 | 25.646 | 28.168 | 30.885 |
| 0.80 | 9.042 | 10.225 | 11.508 | 12.899 | 14.404 | 16.031 | 17.789 | 19.686 | 21.733 | 23.949 | 26.318 | 28.877 | 31.630 |
| 0.90 | 9.318 | 10.533 | 11.849 | 12.274 | 14.815 | 16.478 | 18.273 | 20.208 | 22.298 | 24.537 | 26.950 | 29.543 | 32.327 |
| 1.00 | 9.583 | 10.827 | 12.175 | 13.632 | 15.206 | 16.904 | 18.733 | 20.703 | 22.822 | 25.100 | 27.045 | 30.169 | 32.980 |
| 1.10 | 9.836 | 11.109 | 12.486 | 13.973 | 15.578 | 17.308 | 19.170 | 21.172 | 23.323 | 25.631 | 28.106 | 30.757 | 33.592 |
| 1.20 | 10.078 | 11.378 | 12.782 | 14.299 | 15.933 | 17.692 | 19.584 | 21.618 | 23.796 | 26.132 | 28.634 | 31.309 | 34.166 |
| 1.30 | 10.310 | 11.634 | 13.065 | 14.600 | 16.271 | 18.058 | 19.977 | 22.037 | 24.244 | 26.606 | 29.132 | 31.829 | 34.705 |
| 1.40 | 10.531 | 11.880 | 13.336 | 14.904 | 16.592 | 18.405 | 20.351 | 22.436 | 24.668 | 27.054 | 29.601 | 32.318 | 35.211 |
| 1.50 | 10.743 | 12.114 | 13.593 | 15.186 | 16.898 | 18.738 | 20.705 | 22.814 | 25.069 | 27.477 | 30.045 | 32.779 | 35.687 |
| 1.60 | 10.945 | 12.338 | 13.840 | 15.455 | 17.191 | 19.050 | 21.043 | 23.174 | 25.470 | 27.877 | 30.463 | 33.214 | 36.135 |
| 1.70 | 11.139 | 12.553 | 14.075 | 15.711 | 17.466 | 19.350 | 21.363 | 23.515 | 25.811 | 28.257 | 30.860 | 33.625 | 36.558 |
| 1.80 | 11.325 | 12.758 | 14.300 | 15.950 | 17.733 | 19.635 | 21.569 | 23.840 | 26.154 | 28.617 | 31.235 | 34.013 | 36.957 |
| 1.90 | 11.503 | 12.954 | 14.515 | 16.191 | 17.986 | 19.907 | 21.960 | 24.148 | 26.479 | 28.958 | 31.590 | 34.381 | 37.334 |
| 2.00 | 11.673 | 13.142 | 14.721 | 16.414 | 18.228 | 20.167 | 22.237 | 24.443 | 26.789 | 29.283 | 31.928 | 34.729 | 37.691 |

## Explanation of wording in this code

**1** Words used for different degrees of strictness are explained as follows in order to mark the differences in implementing the requirements of this code.

**1**)Words denoting a very strict or mandatory requirement:

"Must" is used for affirmation, "must not" for negation.

**2**)Words denoting a strict requirement under normal conditions:

"Shall" is used for affirmation, "shall not" for negation.

**3**)Words denoting a permission of a slight choice or an indication of the most suitable choice when conditions permit:

"Should" is used for affirmation, "should not" for negation.

**4**)"May" is used to express the option available, sometimes with the conditional permit.

**2** "Shall meet the requirements of ..." or "shall comply with ..." is used in this code to indicate that it is necessary to comply with the requirements stipulated in other relative standards and codes.

## List of quoted standards

GB/T 50138 *Standard for Stage Observation*

SL 443 *Specification for Hydrometric Cableway Surveying*