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National Standard of the People's Republic of China

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Replace GB17502-1998

Specifications for submarine cable and pipeline route investigation

海底电缆管道路由勘察规范

（*English Translation*）

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Contents

Foreword

SAC/TC 283 is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

This standard replaces the GB 17502-1998 *Specifications for Submarine Cable and Pipeline route Investigation* in whole.

The main revisions are as followings:

— The terms and definitions of landing section, inshore section, shallow sea section, deep sea section, remotely operated vehicle (ROV), cone penetration test (CPT) have been added as 3.2, 3.3, 3.4, 3.5, 3.6 and 3.7;
— Generals has been added as Clause 4;
— The time-limit requirements for hydrological and meteorological data collection in route pre-selection have been raised (see 5.3);
— The surveyed scope, contents and technical requirements of route corridor zone in landing section have been revised and the 9.2, 9.3 and 9.4 in 1998 edition have now changed to 6.1, 6.2 and 6.3 in this edition;
— The contents of horizontal and vertical control survey, microwave range-based positioning, long and short baseline acoustic positioning are deleted;
— The technical requirements of navigating and positioning for sailing geophysical survey and fixed-point survey have been revised and the 5.3.1.1 and 5.3.1.2 in 1998 edition have now changed to 7.4 and 7.5 in this edition;
— Multi-beam bathymetry has been added as 8.4, and the requirements for performance, implementation on the sea, data acquisition and processing of all involved survey apparatus have been modified, and the 6.2, 6.3, 6.4 and 6.5 in 1998 edition have changed to 8.3, 8.5, 8.6 and 8.7 in this edition;
— The title of the Clause of Seabed Sediment Sampling and Geotechnical Test in 1998 edition was changed to Seabed Sediment Sampling(see Clause 9), and sample packaging and storage have been added as 9.3.3 and 9.3.4, and the lithology description has been refined in 7.4 of 1998 edition and which has changed to 9.3.2 in this edition;
— The drilling vessel and drilling methods have been added as 10.1.2 and 10.2, and the content of lithology description has been refined in 8.3.1a of 1998 edition and which has changed to 10.4.3 in this edition;
— In-situ Test has been added as Clause 11;
— Geotechnical Test has been added as Clause 12,it encompassed the geotechnical test introduced in 7.5, 7.6, 7.7 and 7.8 in 1998 edition, which has changed to 12.2 in this edition;
— The title of the Clause of Seismic Risk Analysis in 1998 edition was changed to Evaluation of Seismic Safety, and revised contents and requirements of analysis and evaluation (see 12.1, 12.2 and 12.3 in 1998 edition and 14.1, 14.2, 14.3 and 14.4 in this edition);
— The title of the Clause of Observation of Marine Hydrological Meteorological Elements in 1998 edition was changed to Collection and Observation of Marine Hydrological and Meteorological Data (see Clause 15), and removed the content of humidity;
— Submarine Cable and Pipeline Post-lay Survey has been added as Clause 16;
— The title of the Clause of Evaluation of Route Conditions and Compilation of Report in 1998 edition was changed to Route Conditions Evaluation and Compilation of Result Report (see Clause 17), removed the content of recommended route and provided details about content, name of drawings and annexes (see 13.3 in 1998 edition and 17.2 in this edition;
— Data Filing has been added as Clause 18;
— Annex A has added the Compilation Guideline for Submarine Cable and Pipeline Route

Pre-selection Report;

— B1 and B2 in Annex B have added the content of classification and designation of soils;

— Annex C has added the Pattern of Alignment Charts.

Annex B in this standard is normative, and Annex A, C are informative.

This standard was proposed by the State Oceanic Administration, People's Republic of China.

This standard was prepared by SAC/TC 283 National Technical Committee on Ocean Standardization Administration of China.

The first edition was issued in 1998 as GB 17502-1998 *Specifications for submarine cable and pipeline route investigation*.

Specifications for Submarine Cable and Pipeline Route Investigation

1 Scope

This standard specifies the contents, methods and technical requirements, report compilation and data filing of submarine cable and pipeline route investigation,

This standard is applicable to the site selection and survey of submarine cable and pipeline engineering. Other linear and shallow foundation structures on the sea floor can be used for reference.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments (excluding corrections), or revisions, of any of these publications do not apply to this standard. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

GB/T 12327-1998 *Specifications for hydrographic survey*
GB/T 12763.2-2007 *Specifications for oceanographic survey- Part 2: Marine hydrographic observation*
GB/T 12763.3-2007 *Specifications for oceanographic survey- Part 3: Marine meteorological observation*
GB/T 12763.6-2007 *Specifications for oceanographic survey- Part 6: Marine biological survey*
GB/T 17424-1998 *Technical requirements of differential global positioning system*
GB 17501-1998 *Specification for marine engineering topographic surveying*
GB 17741-2005 *Evaluation of seismic safety for engineering sites*
GB 50011-2001 *Code for seismic design of buildings*
GB 50021-2001 *Code for investigation of geotechnical engineering*
GB/T 50123-1999 *Standard for soil test method*
GB/T 50269-1997 *Code for measurement method of dynamic properties of subsoil*
ASTM D2487-2006 *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*
ASTM D5778-1995(2000) *Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils* Terms and Definitions

3 Terms and Definitions

For the purposes of this standard, the following terms and definitions apply.

3.1 Submarine cable and pipeline

The submarine cable and pipeline are included. Submarine cable refers to cables laid on the

seabed for communication and power transmission, including submarine optical cables and submarine power cables, etc. The submarine pipeline refers to the pipeline facilities laid on the seabed for the purpose of transmission of water, gas, oil or other materials.

3.2 Landing section

The route corridor with a water depth of less than 5m near the landing point of submarine cable and pipeline.

Note: The corridor usually extends 100m from coastline to land, and extends to 5m water depth.

3.3 Inshore section

The route corridor from the coastline to 20 m water depth

3.4 Shallow sea section

The route corridor with water depth of 20 m to 1000 m

3.5 Deep sea section

The route corridor with water depth deeper than 1000 m

3.6 Remotely operated vehicle (ROV)

The underwater vehicle operated remotely with power and operated according to instructions

3.7 Cone penetration test (CPT)

The process measuring the penetration resistance (cone tip resistance, side wall friction)and other parameters by pressing a conical probe into the soil at a constant speed.

4 Generals

4.1 Purpose and task of the survey

4.1.1 The purpose of the survey is to provide basic information, scientific and technological basis for the site selection, design, construction and maintenance of submarine cable and pipeline engineering.

4.1.2 The task of the survey is to ascertain the engineering geological conditions, marine meteorological and hydrographic environments, corrosive environmental parameters and marine planning and development activities in the submarine cable and pipeline route area.

4.2 Contents of the survey

The survey mainly includes the following contents:

a) Water depth and seabed topography;

b) Seabed conditions and natural or man-made obstacles;

c) Structural characteristics, spatial distribution, physical and mechanical properties of

submarine shallow strata;
d) Seabed hazard geology and seismic factors;
e) Marine hydrographic and meteorological dynamic environments;
f) Corrosive environmental parameters;
g) Marine planning and development activities.

4.3 Procedures of the survey

The survey shall be carried out in accordance with the procedures of preliminary data collection, implementation plan formulation, marine survey, laboratory test and analysis, data processing and interpretation, drawing and report compilation, acceptance of results, and data filing, etc.

4.4 Methods of the survey

The main survey methods are as follows:
a) Bathymetric and topographic survey;
b) Side scan sonar detection;
c) Sub-bottom profiling;
d) Magnetic detection;
e) Sampling of seabed sediments and bottom water;
f) Engineering geological drilling;
g) In-situ test;
h) Geotechnical test and corrosive environment parameter determination;
i) Observation of marine hydrographic and meteorological elements.

4.5 Scope of the survey

Scope of the survey shall be in accordance with the following requirements:
a) Route survey is carried out in the corridor with certain width along both sides of route center line. The width of survey corridor is generally 500 m in landing section, 500 m in inshore section, 500 m-1000 m in shallow sea section, and 2-3 times of water depth in deep sea section;
b) Site survey of the branch unit is carried out within a certain range of its center. The survey area in shallow sea section is generally 1000 m×1000 m, and in deep sea section is usually carried out in a square area with a width of 3 times of water depth;
c) Survey of crossing points between routes and existing submarine cables or pipelines is conducted within 500 m centered on crossing points;
d) The overlaps between survey regions by different vessels are generally 500 m in shallow sea section and 1000 m in deep sea section.

4.6 General requirements

4.6.1 The offshore survey vessel shall be able to operate under the sea conditions of class 2 or class 3 of Beaufort scale, and the open sea survey vessel shall be able to operate under the sea conditions of class 4 or class 5 of Beaufort scale. It can maintain the speed of less than 5 kn. and comply with the requirements of navigation, positioning, safety, firefighting and lifesaving, communication, power supply, equipment installation, release and recovery,

laboratory, etc.

4.6.2 The technical indicators of survey apparatuses shall comply with the requirements of survey project, and shall be used within validity period of the certificate of verification and calibration, and shall be in normal working condition. Apparatuses which cannot be calibrated indoors shall be compared with traditional apparatuses on the spot to examine their effectiveness. The transportation, installation, distribution, operation and maintenance of apparatuses shall be carried out according to the provisions of their instructions.

4.6.3 The survey technician shall obtain the qualification certificate issued by the legitimate qualified organization which is in conformity with survey project and is competent for the work.

4.6.4 The person on duty shall abide by the duty and shift system, and make good records. The records shall be unified and standardized. The records shall be completed by the person on duty and verified by successor during the shift to ensure integrity and reliability of the contents.

4.6.5 When several geophysical survey methods are used for synchronous operation, positioning time, number of survey lines and points shall be unified. If the survey is interrupted or same surveying line is divided, supplementary survey is required to carry out according to the same method and at least three positioning points shall be overlapped.

4.6.6 Maritime traffic, fishing and other activities related to route survey shall be recorded in time.

4.6.7 All kinds of raw data, records, samples collected and observed at sea shall be given unique identification.

4.6.8 Implementing quality control throughout the whole process, conduct on-site quality inspection and acceptance of samples and raw materials obtained at sea, the survey work that fails to meet the technical requirements shall be supplemented or re-surveyed. Quality inspection shall be carried out on the results of sample analysis, testing and data processing.

5 Route Pre-selection

5.1 The purpose is to select the landing point and the location of the sea route according to the general layout of cables and pipelines. More than two route schemes shall be proposed and compared.

5.2 Route pre-selection shall follow the principle of selecting a relatively safe, reliable, economical and reasonable route for submarine cable and pipeline, and it is also convenient for their construction and maintenance.

5.3 When route pre-selecting, the natural environment data such as topography, geology, earthquake, hydrography and meteorology of route area shall be collected (for inshore section, shall contain hydrographic and meteorological data within 5 years), especially the hazard geological factors, such as bare bedrock, steep cliff, trench, paleo-channel, shallow gas,

turbidity current, active sand wave, active faults, etc. Pre-selected route shall avoid the above hazard geological factors as much as possible.

5.4 When route pre-selecting, the corrosive environmental parameters shall be collected as much as possible, and their corrosiveness to the cable and pipeline shall be evaluated.

5.5 When route pre-selecting, the data of marine planning and development activities in route area shall be collected as much as possible, mainly including:

a) Fishery: including the number of fishing boats in route area, the way of fishing, season of fishing operations, closed fishing area, closed fishing period, cultivation area in shallow sea and beach;
b) Mineral resources exploration: including the distribution of offshore oil and gas fields and placer mining areas, resource development, planning and exploitation status, offshore platform and oil and gas pipeline location etc.;
c) Transportation: including the main shipping line, ship type, anchor type, navigation density, channel dredging and mud dumping, etc.;
d) Communication: submarine optical cable;
e) Electric power: submarine power cable;
f) Water conservancy: seawall, coastal reclamation, and reclamation project, etc.;
g) Municipal: sewage pipes, etc.;
h) Marine nature reserve: distribution of marine natural reserves;
i) Seabed artificial wastes: such as shipwrecks, containers, anchors, etc.;
j) Others: such as tourism area, dumping area, scientific research area, military activity area, etc.

5.6 Collect failure records of existing submarine cables and pipelines, analyze the cause of failures, and provide useful experience for design, construction and maintenance of new cables and pipelines.

5.7 Pre-selection route should avoid offshore oil and gas fields, petroleum bearing structures, placer mining areas, oil and gas pipelines, wharfs, anchorages, nature reserves, military sea areas, man-made waste and others. The route should be crossed vertically with navigation line, and avoiding crossing with submarine cable and pipeline, and crossing vertically when crossing is really necessary.

5.8 When route pre-selecting, on-site survey shall be carried out to investigate the distribution of villages and towns near landing point, land use, nature and utilization of the coast, beach (tidal flat) topography, scouring and silting characteristics, the distance between landing point and landing station, and marine activities near landing point. The selected landing point shall be in line with marine functional zonation, close to landing station, less interference with other marine planning and activities, and be conducive to cable and pipeline landing construction and maintenance.

5.9 For the outline of route pre-selection report, see Annex A.

6 Landing Section Survey

6.1 Scope of the survey

The survey area of landing section includes land area near coast line of landing point, the intertidal zone and coastal area with water depth less than 5 m. The width of survey corridor is generally 500 m, extending from coastline to water depth of 5 m, and the distance from coastline to land of 100 m.

6.2 Contents and technical requirements of the survey

The contents and technical requirements are as followings:
a) The plane position measurement accuracy of landing point shall meet the requirements of GPS-E grade, and the elevation measurement accuracy shall reach the requirements of fourth grade;
b) Surveying the landform and artificial features of landing section, and photographing important objects. The landform and artificial features outside the survey corridor can be transferred from existing large scale map;
c) Three to five profiles which are vertical to coastline shall be planned to survey the topography, geomorphology as well as sediment sampling in tidal flats. The types and distribution of sediments shall be described in detail, and the dynamics of beach erosion and deposition shall be analyzed;
d) Measurement of the water depth and topography of landing section shall be carried out according to the requirements given in Clause 10 of GB 17501-1998. Seabed sediment sampling shall be carried out according to the requirements given in Clause 9. Sub-bottom profiling shall be carried out according to the requirements given in 8.5. , Diving survey, underwater photography and bar probing shall be carried out when necessary.

6.3 Result maps

The result maps shall include:
a) Bathymetric and seabed topographic maps are generally compiled in scale of 1:1000-1:5000;
b) Seabed sediment type maps are generally compiled in scale of 1:1000-1:5000;
c) Alignment charts are generally compiled in scale of 1:5000.

7 Navigating and Positioning

7.1 Root mean square error in positioning

The root mean square error in positioning shall comply with the following requirements:
a) When the mapping scale is larger than 1: 5000, the root mean square error in positioning on the sea shall not be larger than 1.5 mm on map;
b) When the mapping scale is not larger than 1: 5000, the root mean square error in positioning on the sea shall not be larger than 1.0 mm on map.

7.2 Coordinate system and projection

The coordinate system and projection method shall comply with the following requirements:
a) The plane coordinate system adopts WGS-84 geodetic coordinate system or 1954 Beijing

coordinate system, or other coordinate systems as required by **the** entrusting party;
b) Use Gauss Kruger projection, other projection methods can also be used according to the requirements of the entrusting party.

7.3 Navigating and positioning methods

7.3.1 Navigating and positioning methods shall comply with the following requirements:

a) Meet the requirements concerning error in navigation and positioning operations;
b) Positioning range can cover the operation area;
c) Be able to continuous, stable and reliable operation;
d) Update rate of positioning data is not less than 1 time/sec.

7.3.2 DGPS navigating and positioning shall comply with the requirements as specified in GB/T 17424-1998, Clause 4 and 9, and the error comparison test in positioning shall be carried out before operation. Navigation and positioning shall have differential signals, the number of effective observation satellites shall not be less than 4, the satellite angle of elevation shall not be less than 5 degrees, the position dilution of precision (PDOP) shall not be more than 6, and the difference signal update rate shall not be more than 30 s.

7.3.3 Ultra-short baseline underwater acoustic positioning system is mainly used for the positioning of the geophysical underwater towing probe. The underwater acoustic transponder is installed in the probe, and the probe is positioned according to the position relationship between the positioning equipment of survey ship and underwater acoustic transponder. Before starting work, the installation attitude of positioning system shall be calibrated.

7.4 Navigating and positioning for sailing geophysical survey

Navigating and positioning for sailing geophysical survey shall comply with the following requirements:
a) The survey ship shall be moved ahead and delayed on the extension of survey line. The length of extension line shall be no less than 2 times the length of towing cable when there is a towing body;
b) The surveying speed of ship shall not exceed 5 kn. for the survey of side-scan sonar, sub-bottom profiler and magnetic detection. For the single operation of bathymetric sounding, the working speed shall not exceed 10 kn.;
c) The offset between the track and design line shall not be greater than 20% of distance between the lines. When multi beam bathymetric operation is carried out, the maximum deviation value of survey line shall not be greater than 10% of measured coverage width;
d) The distance between positioning points shall not be greater than 1 cm on the map;
e) The report shall record line number, first and last point number, date and time, quality index of satellite signal, interruption situation and handling opinions in detail;
f) The horizontal position of antenna of positioning instrument on survey ship and the probe of survey equipment shall be overlapped as much as possible. When the horizontal distance between antenna and probe of survey equipment exceeds 1 mm on the map, the eccentricity of points shall be corrected.

7.5 Navigating and positioning for fix-point survey

Navigating and positioning for fixed-point survey shall comply with the following requirements:
a) Record the positioning data when sampling or testing devices enter the water. The maximum deviation between actual borehole location and designed borehole location shall be less than 20 m in inshore section and less than 50 m in shallow sea section;
b) When sampling, the shipboard of sampling operation should be adjusted to the windward side.

7.6 Collation of positioning data

Data collation shall comply with the following requirements:
a) Field survey data shall be collated in accordance with the requirements given in 9.4.2 of GB 17501-1998;
b) Track chart shall be plotted on the basis of positioning data in accordance with requirements given in 9.8.2 of GB 17501-1998.

8 Engineering Geophysical Survey

8.1 Content of the survey

Engineering geophysical survey includes bathymetry, side scan sonar detection, sub-bottom profiling and magnetic detection. Among them, whether magnetic detection is carried out may be determined according to actual needs. For the deep sea area where does not require pipeline and cable embedment, only full coverage of multi-beam bathymetry is needed.

8.2 Mapping scale and survey line layout

8.2.1 Mapping scale

The mapping scale shall be determined according to the actual needs and the complexity of the shallow seabed geology and geomorphology. The general provisions are:
a) Inshore section, the mapping scale is not less than 1: 5000;
b) Shallow sea section, with mapping scale 1: 5000-1: 25000;
c) Deep sea section, with mapping scale 1: 50000-1: 100000.

8.2.2 Map division

Free framing is used in the map division. It is a principle to cover the whole survey area with fewer maps. There shall be a certain overlap between the adjacent maps and between route alter courses. The overlap shall not be less than 3 cm on the map.

8.2.3 Sheet dimension

Standard sheet dimensions are 50 cm×70 cm, 70 cm×100 cm, 80 cm×110 cm, and other sheet sizes can be used under the necessity.

8.2.4 Layout of survey line

a) Main survey lines shall be laid in parallel with the pre-selected route in inshore and shallow sea section, but the total number shall be kept no less than 3, one of which is to be laid along the pre-selected route and the other two shall be laid on either side of the route. The space between survey lines shall be 1 cm to 2 cm on the map. The check line shall be perpendicular to the main line, and the space between them is not more than 10 times that of the main line;
b) When conducting survey in deep-sea section that does not involve burial construction, it is acceptable to use less than 3 main survey lines, on the premise that multi-beam sounding is adopted with full coverage;
c) Whenever a multi-beam bathymetric system is employed, full-coverage sounding shall be carried out in the route corridor zone. The laying of main survey lines shall enable any two adjacent survey lines to be 20% overlapped. Check lines are to be laid as required, with a space of generally no greater than 10 km.

8.3 Single beam bathymetric sounding

8.3.1 The sounder selected shall have both analog and digital recording modes, and its main technical indicators shall comply with the requirements given in 6.3.4 of GB12327-1998.

8.3.2 Single beam bathymetric sounding shall comply with the following technical requirements:

a) Root mean square error in bathymetric sounding: In waters with depth less than 20 m, the error is not greater than 0.2 m; in waters with depth more than 20 m, the error is not greater than 1% of the water depth;
b) The tolerance of water depth inconsistency between coincidence points (within 1 mm on the map): In waters with depth less than 20 m, the tolerance is not greater than 0.4 m. In waters with depth greater than 20 m, the tolerance is not greater than 2% of water depth. The number of points exceeding the limit must not exceed 15% of total comparison points;
c) The in-situ measured water level data shall be used in the inshore section for water level correction. The root mean square error of water level observation in tide gauge stations shall not be larger than 5 cm. When tidal station along coast or other means cannot control the change of water level in sounding area, forecast water level may be used to correct the water level;
d) When dynamic draft change is greater than 5 cm, dynamic draft correction shall be carried out.

8.3.3 Bathymetric sounding on the sea shall be carried out in accordance with the requirements given in 9.2.6 of GB 17501-1998.

8.3.4 Supplementary measurement or resounding shall be performed in the following situations:

a) Root mean square error in positioning cannot meet the requirement given in 7.1;
b) The deviation of sounding line from design line is more than 50% of the space between designed lines or the missed sounding exceeds 5 mm on the map;
c) Depth error cannot meet the requirements as specified in 8.3.2 a) and 8.3.2 b);
d) Result of deep stitching comparison of different time and different systems cannot meet the requirements of 8.3.2 b);
e) Data of water level and sound velocity cannot meet the requirements of depth correction.

8.3.5 Water depth data collation shall comply with the following requirements:

a) Depth value shall be taken according to the requirements given in 9.5.4 of GB 17501-1998;
b) Depth correction shall be in accordance with the requirements given in 9.5.5 of GB 17501-1998.

8.3.6 Compilation of result maps shall be in accordance with the following requirements:

a) Datum level of bathymetric maps and seabed topographic maps shall be the lowest theoretical tidal level, mean sea level or 1985 National Elevation Datum. When other datum levels are used, their relationship with theoretical lowest tidal level, mean sea level or 1985 National Elevation Datum shall be indicated;
b) Basic isobaths interval of bathymetric maps and seabed topographic maps shall be selected according to Table 1, and the isobaths are divided into head curves and metering curves;
c) Other requirements for bathymetric map and seabed topographic map shall be in accordance with the provisions given in 9.6 of GB17501-1998.

Table 1 Basic equal depth interval of bathymetric map in meters

Seabed inclination	Mapping scale		
	1∶1000	1∶2000	1∶5000
$\alpha < 3°$	0.5	1	2
$3° \leq \alpha < 10°$	1	2	5
$10° \leq \alpha < 25°$	1	2	5
$\alpha \geq 25°$	2	2	5

8.4 Multi-beam bathymetric sounding

8.4.1 Apparatuses

The selection of multi-beam bathymetric system shall take into account the sounding range, accuracy, coverage, renewal rate and other factors. Its main technical indicators shall comply with the following requirements:
a) Root mean square errors of sounding instruments shall comply with the requirements given in 8.3.2 a);
b) Beam angle of transducer shall not be larger than 2 degrees;
c) Measurement accuracy of attitude sensor shall not be less than 0.05 degrees for roll and pitch, 0.05 m for heave and 5% for actual heave, and 0.1 degrees for compass.

8.4.2 Technical requirements

Multi-beam measurement shall comply with the following requirements:
a) Root mean square errors in sounding shall comply with the requirements given in 8.3.2 a);
b) Depth discrepancy for overlapping points (within 1 mm on the map) shall comply with the requirements given in 8.3.2 b);
c) Root mean square error in time delay between depth sounding and positioning shall be no more than 0.1 s, and navigation delay shall be retested whenever the navigating and positioning system is changed;
d) The measurement area shall be 100% of the multi-beam measurement coverage, and the adjacent main lines shall ensure a duplicate coverage rate of 20%;

e) In order to correct the sound velocity, the time density of sound velocity profile measurement shall be no less than once a day;
f) Draft change of multi-beam transducer shall be measured before and after of each voyage and for a measurement interval of more than 3 days during the survey. Piecewise calculation may be employed to correct the change in draft of transducer, interpolated by time;
g) Observational data of measured water level shall be adopted as reference for the correction of water level in inshore section. Root mean square error in water level observation of tidal station shall be kept within 5 cm. When the coastal tide gauge station or other means cannot control the change of water level in the survey area, the predicted water level may be used to correct the water level.

8.4.3 Marine measurement implementation

Marine measurement shall be carried out in accordance with the following requirements:
a) Stability test and navigation test of multi-beam bathymetric system shall be carried out before measurement. The stability test shall be carried out in the flat seabed area. The depth contrast error obtained from repeated bathymetric measurements shall comply with the requirements given in 8.4.2 a) and 8.4.2 b). The navigation tests shall select a representative area of sea floor topography, determine the working state of the system at different depths and speeds, and require that the number of beams received by each transmitting pulse shall be greater than 95% of total number of beams, and the dynamic draft of transducer shall be measured at different speeds from static to maximum operating speeds;
b) Observe the displayed system status and beam quality, monitor the settings of system parameters, rolling and longitudinal trim correction, and heading correction of the transducer and beam integrity in the amplitude;
c) Observe the displayed sailing course to monitor for jump or overlapping of adjacent survey lines, etc.;
d) When the number of beams received is less than 80% of the number of emitted beams, the sailing speed of survey vessel shall be reduced or the survey line interval shall be adjusted;
e) Observe and record the working conditions and ensure a complete of all measurement data;
f) Blank areas between survey lines shall be given supplementary survey or be made part of supplementary survey plan;
g) Duty report shall record in great details of starting and ending point of survey lines, number of survey lines, latitude and longitude as well as abnormal conditions etc.

8.4.4 Supplementary measurement or re-measurement

Supplementary measurement or re-measurement shall be carried out in the following situations:
a) Multi-beam measurement coverage cannot meet the requirements given in 8.4.2 d);
b) When situations given in 8.3.4 a),c), d) and e) take place.

8.4.5 Data processing

8.4.5.1 Raw data files, sound velocity profile files and other data records shall be backed up.

8.4.5.2 The raw data shall be 100% check-up to delete the mutated wrong data and biased beam

data of poor quality. Reading shall be taken from 3 to 5 sounding points in each section to verify their geodetic coordinate, rectangular coordinate and water depth values and determine whether there are blank spaces failing to be measured.

8.4.5.3 Data editing shall be as follows:

a) Delete or correct sudden jump points and abnormal heading points in positioning data, and convert qualified positioning points to the position of system transducer;
b) Delete gross error, spurious signal and unqualified water depth data but shall be careful when dealing with the abnormally shallow points;
c) Depth correction includes transducer draft depth correction, sound velocity correction, water level correction, multi-beam bathymetric system parameter correction, etc. Water level correction shall be carried out in accordance with the requirements given in 8.4.2;
d) When splicing data of varied errors, low accuracy data shall be leveled to high accuracy data. When data with same accuracy are combined, high density data shall be used or leveled. Then, the difference of water depth before and after leveling is calculated, the arithmetic mean and root mean square error are counted, and root mean square error of water depth splicing is evaluated;
e) Calculate the depth inconsistency and depth root mean square error of coincidence point and the evaluation shall be performed according to the requirements given in 8.4.2 a) and 8.4.2 b);
f) Forming a digital seabed topographic information file consisting of longitude, latitude and water depth of each beam, i.e. discrete data file;
g) Set up reasonable data grid space to realize data gridding. The minimum grid space shall ensure that there are three water depth points in each grid, and the maximum grid space shall not be larger than the actual distance of 5 mm on the result map.

8.4.6 Result maps

The result maps shall be compiled according to the following requirements:
a) Compile the seabed topographic map according to the basic isobaths in Table 1. When the basic isobaths are not enough to represent special seabed topographic characteristics, add the auxiliary isobaths. Data grid interpolation and thinning shall be carried out in compilation of conventional bathymetric maps. The interval between water depth points shall not be greater than 1 cm on the map. Retain deepest point, shallowest point, and change point of slope;
b) Other requirements for bathymetric map and seabed topographic map are given in 9.6 of GB17501-1998.

8.5 Side scan sonar detection

8.5.1 Side scan sonar system shall comply with the following requirements:

a) The operating frequency shall not be less than 100 kHz, the horizontal beam angle shall not be less than 1 degree, and the maximum one-side scanning range shall not be less than 200 m;
b) Shall be able to distinguish seabed objects of 1 m^3 size;

c) Shall have the functions of speed correction and tilt distance correction;
d) Analog and digital recording can be used simultaneously.

8.5.2 Side scan sonar detection shall comply with the following technical requirements:

a) A reasonable range of sonar scanning shall be chosen according to the space between survey lines. It shall cover 100% in the corridor zone of route survey, and ensure 100% repetition coverage in adjacent line scanning. When the water depth is less than 10 m, the repetition coverage may be reduced appropriately;
b) Height of the tow fish above seabed shall be controlled at 10% to 20% of scanning range. When the water depth of surveyed area is shallow or seabed is undulating, the height of tow fish above seabed may be increased appropriately;
c) The image obtained by side scan sonar shall be clear.

8.5.3 Marine detection shall be carried out according to the following requirements:

a) Before detecting, adjust equipment in operation area or adjacent sea area to determine the best working parameters;
b) After tow fish enters the water, the vessel shall maintain a steady speed (no more than 5 kn.) and course, and avoid parking or backing up;
c) Ultra-short baseline underwater acoustic positioning system can be used to locate the position of tow fish, and manual calculation can also be used to correct the position of tow fish in shallow waters near the shore;
d) Analog recording sonar images shall be labeled, including project name, survey date and time, instrument model, instrument parameters, line number and starting and ending point number of line, etc.;
e) The contents of the shift report include project name , survey sea area, working vessel, recorder, sea conditions, obstacles on the sea surface, emergencies, instrument name and model, date, time, line number, point number, vessel speed and course, instrument operating parameters, volume number of recording paper and name of digital recording document, etc.;
f) When a suspicious target is found by preliminary interpretation of the sonar image record, additional lines in different directions shall be laid around the suspicious target for further detection.

8.5.4 Data processing shall comply with the following requirements:

a) Recognize the interference signal and noise on sonar image record;
b) Based on the data of bathymetric sounding and sediment sampling, identify and determine the type and distribution of sediments, hazard geological factors, and the location, shape, size and distribution range of seabed objects;
c) Sonar image mosaic and splicing as required.

8.5.5 Result maps include:

a) Seabed conditions map;
b) Sonar images mosaic map in local or whole area.

8.6 Stratigraphic profiling

8.6.1 The performance of stratigraphic profiler shall comply with the following requirements:

a) The sound source of sub-bottom profiler generally adopts electro acoustic or electromagnetic pulse, and the frequency spectrum is 500 Hz-15 kHz;
b) The sound source of medium stratigraphic profiler generally adopts electromagnetic pulse or small electric spark, and the frequency spectrum is 200 Hz-5 kHz;
c) The transmitter shall have enough power. The receiver shall have enough frequency bandwidth and time-varying gain adjustment function, and can simultaneously carry out analog record profile output and digital acquisition, processing and storage.

8.6.2 Stratigraphic profiling shall comply with the following technical requirements:

a) Sub-bottom profiling in submarine cable route survey shall be carried out to obtain acoustic stratigraphic profile records within 10 m under the seabed; while submarine pipeline route survey, both sub-bottom and medium stratigraphic profiling shall be carried out according to the need to obtain acoustic stratigraphic profile records at a depth of not less than 30 m under the seabed;
b) The resolution of sub-bottom profiling is better than 0.2 m, and that of medium stratigraphic profiling is better than 1 m;
c) Record profile images shall be clear, with no strong noise interference and image blurring, discontinuity, etc.

8.6.3 Stratigraphic profiling shall be carried out according to the following requirements:

a) Before profiling, adjust equipment in the operation area or adjacent sea area to determine the best working parameters;
b) Towed sound source and hydrophone array shall be towed in parallel outside the vortex region of the stern. Hydrophone array shall be stably towed under the sea surface of 0.1 m to 0.5 m;
c) The range and delay of recorder shall be timely adjusted when there are great variations with water depth;
d) The swell compensator or digital swell filter shall be used for filter processing in stormy weather;
e) Analog recording images shall be labeled, and its contents include project name, survey date and time, instrument model and parameters, line number, starting and ending point number of line and surveyor, etc.;
f) The contents of shift report shall include project name, survey area, surveyor, instrument name and model, survey date and time, line number, point number, sailing speed and course, instrument operation parameters, record paper number and digital record file name, etc.;
g) When preliminary analysis of field profile images reveals suspicious objects, supplementary survey lines shall be laid to ascertain the feature of those objects.

8.6.4 Data processing shall comply with the following requirements:

a) Identify the interference signal on the stratum section image record;

b) According to the characteristics of reflection structure, amplitude, frequency, coaxial continuity and contact relationship of reflection wave of profile image, and combined with geological drilling data, the acoustic stratigraphic sequences are divided, the stratigraphic sedimentary textures and structures are explained, and the sedimentary type and engineering geological characteristics are judged. The hazard geological factors are analyzed and their properties, forms and distribution ranges are determined;
c) Time-depth conversion shall be done on the measured sound velocity obtained by means of drilling horizon comparison, acoustic velocity logging or other measurement methods. When there is no actual measured sound velocity data, the time-depth conversion may be carried out by using the sound velocity of 1500 m/s-1700 m/s according to the depth of different formations, and marked on the map.

8.6.5 The compilation of result maps shall comply with the following requirements:

a) The vertical and horizontal scale of stratigraphic cross-section shall be appropriate. The content includes topographic section line, stratum interface, lithology, hazard geological factors, landmarks, sampling station, borehole location and its column diagram and test results;
b) The contents of the shallow geological feature map mainly include the isopach line or equal buried depth line of the important strata, important topography, geomorphology and shallow geological phenomena, hazard geological factors, landmark, seabed sampling station, drilling location, test results, etc. The shallow geological feature map can be combined with the seabed conditions map when it does not contain much content.

8.7 Magnetic detection

8.7.1 Magnetic detection is mainly used for determining the location and distribution of existing submarine cables, pipelines and other magnetic objects. The sensitivity of the selected magnetometer shall be better than 0.05 nT and the dynamic measuring range shall be at least between 20 000 nT and 100 000 nT.

8.7.2 Magnetic detection shall comply with the following technical requirements:

a) When magnetic detection is used to detect linear magnetic objects such as submarine cables and pipelines, the survey line shall be perpendicular to the extended direction of detecting target determined by historical data. The number of survey lines for each target shall not be less than three, the space between lines shall not be more than 200 m, and the length of survey line shall not be less than 500 m. The direction of adjacent survey lines shall be opposite;
b) When magnetic detection is used for determining the submarine nonlinear magnetic objects, the survey line shall be arranged in a grid layout around the targets. At least 4 survey lines shall be arranged for per target but the interval and length shall be determined according to the size of targets.

8.7.3 Marine detection shall be carried out according to the following requirements:

a) Before detecting, adjust equipment in the operation area or adjacent sea area to determine

the best working parameters;
b) After the detector enters the water, the vessel shall maintain a steady lower sailing speed and a steady heading, and avoid parking or backing up. The height of the detector above seabed shall be within 10 m, but the height may be increased appropriately in the sea areas where seabed is undulating;
c) Ultra-short baseline underwater acoustic positioning system shall be used to locate the detector, and manual calculation may also be used to correct the position of the detector in nearshore and shallow waters;
d) Ensure the integrity of detection records, and make a supplementary survey when records missing or cannot be correctly interpreted;
e) Analog recording shall be labeled, including project name, survey date and time, instrument model and parameters, line number, starting and ending point number of line, surveyor, etc.;
f) The contents of shift report shall include project name, survey sea area, surveyor, instrument name and model, survey date and time, number of line and point, vessel speed and heading, instrument operating parameters, name of digital recording document, etc.;
g) When a suspicious target is found by interpretation of the on-site record, additional lines shall be laid around the suspicious target as required.

8.7.4 Data processing shall comply with the following requirements:

a) Identify abnormal magnetic field interference caused by submarine non-magnetic objects;
b) Combined with the results of side scan sonar and stratigraphic profiling, the magnetic detection data are interpreted. Then, identify the magnetic objects on the seabed, determine their feature, location and scope, and determine the position and direction of existing submarine cables and pipelines.

8.7.5 Result maps

a) Map of measured magnetic field intensity, or magnetic anomaly plane profile;
b) Distribution map of seabed magnetic objects. The map may be merged into the seabed conditions map, and some of the more important parts may be drawn separately as required.

9 Seabed Sediment Sampling

9.1 Sampling methods

Seabed sediment sampling is divided into surface sediment sampling and core sediment sampling: The former may use grab sampler and box sampler; the latter may use gravity sampler and vibration sampler.

9.2 Technical requirements for sampling

Seabed sediment sampling shall comply with the following technical requirements:
a) The space between sampling stations: 500 m-1000 m in inshore section, 2 km-10 km in shallow sea section and no sampling stations in deep sea section. The station layout may be adjusted according to the preliminary results of engineering geophysical survey, and more sampling stations shall be set up in area with steep topographic gradient, complex sediment change or

seabed prone to geological hazards;
b) The diameter of core sample shall not be less than 65 mm. The length of cohesive soil core sample shall be longer than 2 m, and that of sandy soil shall be longer than 0.5 m. The surface sediment samples shall not be less than 1 kg;
c) Re-sampling shall be done when the core sample length cannot meet the requirements. If qualified samples still cannot be obtained after two consecutive samplings, grab or box sampler may be used instead;
d) If qualified sample cannot be collected after three consecutive samplings with grab or box sampler, analyze the reason. If it is determined that this situation results from seabed features, sampling may be stopped.

9.3 Catalogue and processing of samples

9.3.1 Sample catalogue

The sample catalogue shall include project name, number and location of sampling station, date and time of sampling, water depth, sampling times, penetration depth, length of soil sample, disturbance degree, etc.

9.3.2 Lithology description

For the lithology description, see 10.4.3 c).

9.3.3 Sample packaging

Sample packaging shall comply with the following requirements:
a) The core sample should be cut in sections, numbered separately, indicated the direction, water depth, sealed with tape and wax, and placed vertically in a special soil sample box;
b) Surface samples or disturbed core samples shall be packaged and sealed with sturdy plastic bags, labeled with station number and sampling depth, and placed in special soil sample boxes;
c) Samples used for geological, biological and chemical tests shall be sampled, packaged and stored according to their special requirements.

9.3.4 Sample storage

All samples shall be stored in sunscreen, freeze-proof and pressure-proof environments. When conditions permitted, they should be stored in laboratories under the control of temperature and humidity.

10 Engineering Geological Drilling

10.1 General requirements

10.1.1 Engineering geological drilling shall be required in submarine pipeline route survey, while it is generally unnecessary in submarine cable route survey.

10.1.2 The appropriate drilling vessel and drilling equipment shall be selected according to the working site environment and drilling requirements, and appropriate anchor type, anchor

cable and mooring cable length shall be selected according to hydro-meteorology and seabed conditions.

10.1.3 Boreholes are designed along the route center line with an interval of about 100 m to 500 m in inshore section and 2 km to 10 km in shallow sea section. The layout of stations shall be adjusted according to engineering requirements and geophysical survey interpretation results. When directional drilling, shield tunneling and other construction methods are used in pipeline crossing projects, the location of boreholes shall be laid out according to the requirements given in 4.4.8 of GB 50021-2001.

10.1.4 The borehole depth shall be designed according to the buried depth of pipeline. It is generally 8 m-10 m or 5 times of the buried depth of pipeline. If bedrock is encountered in the depth of design hole, it shall be drilled 3 m-5 m into the bedrock.

10.1.5 The measure error of drilling depth and depth of rock and soil layers shall be within ±0.2 m.

10.2 Drilling methods

The drilling method shall be in accordance with the requirements given in 9.2 of GB 50021-2001.

10.3 Sampling requirements and methods

10.3.1 Sampling interval

The sampling interval shall be determined according to engineering requirements and soil conditions, generally 1 m-1.5 m.

10.3.2 Core collection rate

The core collection rate shall not be less than 50% for sandy soil and shall not be less than 75% for cohesive soil.

10.3.3 Sampling methods

The sampling method shall be accordance with the requirement given in 9.4 of GB 50021-2001.

10.4 drilling catalogue

10.4.1 General requirements

Drilling catalogue includes drilling report and geological logging. The records shall be real, timely and according to round-trip of the drill times and successive records.

10.4.2 Drilling shift report

The drilling shift report shall include project name, sea area, number and coordinate position of borehole, rig height, drilling date, type and configurations of drilling rig, drilling patterns, water depth of borehole at the starting and ending, length of round-trip drill pipe,

round-trip drilling footage, drill hole depth of per round-trip, core length of per round-trip, core recovery rate per round-trip, sampling mode, sampler type, sampling number, notes (weather, sea condition, equipment failures, bit jumping, wellbore, hole collapse, objects falling to hole bottom), etc.

10.4.3 Geological catalogue

Geological catalogue shall comply with the following requirements:

a) The geological catalogue shall include project name, sea area, borehole number, borehole coordinates, water depth of borehole at the starting, borehole depth of per round-trip, sampling length, lithology description and stratigraphic division, etc.;

b) Lithology description of the core shall be made by means of observation and hand touching. If necessary, the existing standardized and quantitative methods, such as standard color plate colorimetry, shall be adopted to represent the color of rock and soil with color codes. The state of cohesive soil is represented by the penetration index of pocket penetrometer, and the integrity of core is represented by rock quality index value. Besides, camera can be used to take photos of rock and soil cores;

c) Lithology description shall include the followings:

1) Cohesive soil: color, state, odor, luster, shaking reflection, dry strength, toughness, structure, inclusions, etc.;

2) Silt: color, odor, humidity, density, shaking reflection, dry strength, toughness, inclusions, etc.;

3) Sandy soil: color, mineral composition, particle size distribution, particle shape, clay content, humidity, compactness, etc.;

4) Crushed stones: particle size distribution, particle shape, particle arrangement, parent rock composition, weathering degree, filling property, filling degree and compactness;

5) Rocks: geological age, weathering degree, color, main minerals, structure and rock quality index, etc.

d) Engineering geological layers shall be classified according to the engineering properties of lithology description.

10.5 Sample handling

Sample handling shall comply with the following requirements:

a) The samples shall be pushed out from sampling tube by bulldozers and stored in core box in the upper and lower order. The cores shall be separated per round-trip with core plate, and starting and ending depth of drilling shall be marked with paint on the core plate, and missing parts of the cores shall be marked;

b) Geotechnical samples shall be sealed at the scene. Mark the sampling depth, up and down, numbers, and place them vertically in sample box.

10.6 Drilling completion report

The report mainly includes drilling purpose, task, coordinates, elevation and water depth of drilling hole, construction time, drilling and coring methods, abnormal conditions, acceptance certificate of quality, preliminary division of rock and soil strata and drilling hole column diagram, etc.

11 In-situ Test

11.1 General requirements

In-situ test shall comply with the following requirements:
a) In-situ test includes cone penetration test and standard penetration test, etc. In-situ test methods shall be selected according to engineering category, geotechnical and field operation condition, etc. Cone penetration test is the most commonly used in-situ test method in submarine cable and pipeline route survey at present;
b) Holes for In-situ test shall be laid out along the center line of the route;
c) When analyzing in-situ test data, attention shall be paid to the influence of test conditions, test methods and soil heterogeneity on test results, and abnormal data shall be eliminated.

11.2 Cone penetration test (CPT)

11.2.1 Applicable scope

The cone penetration test is applicable to soft soil, cohesive soil, silt and sandy soil.

11.2.2 Apparatuses

The CPT system shall comply with the following requirements:
a) The system shall be equipped with sensors of cone tip resistance, sidewall friction resistance, pore water pressure and inclination;
b) The system shall be able to adapt to the harsh working environment such as wave fluctuation and collect in-situ test data safely and steadily;
c) The system shall have experimental data storage and processing system, which can store and process raw data on the spot;
d) Qualified and calibrated probe shall be used.

11.2.3 Field operation

Field operation shall comply with the following requirements:
a) The coordination and cooperation among the maneuvering, navigation and positioning of survey vessel, sounding of borehole depth and cone penetration test shall be guaranteed during the operation at sea;
b) The nulling correction of cone tip resistance and pore water pressure shall be carried out before starting the test;
c) During the testing, the probe shall be continuously and uniformly pressed into the soil, and the penetration rate shall be kept at 20 mm/s (±5 mm/s);
d) The depth curves of cone tip resistance, sidewall friction, pore water pressure and inclination were obtained by each test. The test results were saved and the test records were filled in log sheet;
e) The calibration, debugging and testing steps of instrument shall be carried out in accordance with the requirements given in ASTM D5778-1995.

11.2.4 Data processing and application

11.2.4.1 Correction shall be made to the original recording curve, including initial readings, curve shape and depth, etc.

11.2.4.2 Site test records, diagrams and tables of probe calibration results, curves and charts of various tests shall be submitted.

11.2.4.3 Linear characteristics and test data of various cone penetration curves shall be taken as reference for the classification of soil layers, determination of soil types and estimation of soil properties, etc.

11.3 Standard penetration test

Standard penetration test may be carried out in accordance with the methods and procedures given in 10.5 of GB 50021-2001.

12 Geotechnical Tests

12.1 Geotechnical test on shipboard

12.1.1 Test items

The test includes water content, density, soil temperature, unconfined compression, pocket vane shear test and pocket penetrometer test, shall be determined according to the engineering requirements, test conditions on board and properties of soil samples.

12.1.2 Test requirements

Shipboard geotechnical tests shall comply with the following technical requirements:
a) The collected samples shall be catalogued and processed in accordance with the requirements given in 9.3;
b) Test for water content, density and unconfined compression shall be carried out according to requirements specified in Clause 4, 5.1 and Clause 17 of GB/T 50123-1999;
c) Pocket vane shear test and pocket penetrometer test shall be carried out at both ends of the sampled core section or in the middle part of original boxed samples;
d) Pocket vane shear test and penetrometer test are suitable for homogeneous cohesive soil. Probes and instruments of different models and measuring ranges shall be selected for the tests on the grounds of hardness of the soil;
e) Soil temperature may be inferred from the relation between water temperature and soil temperature in the seabed. Or it may also be timely measured on the vessel after soil samples are collected.

12.1.3 Pocket penetrometer test

Pocket penetrometer test shall be carried out in accordance with the following requirements:
a) Hard inclusions, wormholes and cracks in the sample shall be avoided during the penetration process;
b) The distance between penetrating point and edge of the sample, the distance between

penetrating points in parallel tests shall be no less than 3 times the length of probe diameter;
c) The probe shall be kept perpendicular to the sample surface during the penetration process and shall be penetrated at a constant speed of 1 mm/s. The test shall be stopped once the scribed line of the probes reaches the soil surface. Record test readings;
d) Parallel test shall be carried out at least 3 times per sample so that the average value can be taken as the test result;
e) Soil shall be removed from the probe after each test to ensure the accuracy of test results;
f) A record shall be kept of instrument model, probe specification, sample number, depth and results of test as well as testers, etc.

12.1.4 Pocket vane shear test

Pocket vane shear test shall be carried out in accordance with the following requirements:
a) The surface of measured soil samples shall be scraped flat with soil cutter before the shear plate is vertically inserted into it. Penetration depth shall be the same as the height of shear plate;
b) The pointer shall be zeroed and the shear torsion cylinder shall be rotated at a constant speed of 6 °/s until the sample cut off;
c) Parallel test shall be carried out at least 3 times per sample so that average value can be taken as the test result;
d) The instrument model, probe specification of four-bladed vane, sample number, depth and results of test as well as testers, etc. shall be recorded.

12.2 Laboratory geotechnical test

12.2.1 Test items include natural density, natural water content, specific gravity, limit water content, particle analysis, permeability, consolidation and shear strength, etc. For the submarine pipeline engineering, dynamic triaxial shear test shall be carried out according to the requirement of sandy soil liquefaction discrimination.

12.2.2 Laboratory geotechnical test shall comply with the following requirements:

a) Dynamic triaxial shear test may be carried out according to the requirements specified in Clause 9 of GB/T 50269-1997;
b) Other tests may be carried out in accordance with GB/T 50123-1999. Relevant domestic or international standards may also be referred according to specific engineering requirements.

12.2.3 Test data shall be collated in accordance with the requirements specified in Annex A of GB/T 50123-1999. For soil classification, see Annex B.

13 Corrosive Environmental Parameters Determination

13.1 General provisions

The corrosive environmental parameters shall be measured in submarine pipeline route survey. Generally no measurement of the corrosive environmental parameters is required in submarine

cable route survey, or to be determined according to engineering design requirements.

13.2 Bottom water parameter test

13.2.1 The number of bottom water sampling stations is generally controlled at 1/5 of the total number of seabed sediment sampling stations, and with no less than 3 stations for each project. Water samples shall be collected within 1.5 m above seabed.

13.2.2 Bottom water test parameters shall include pH, Cl^-, SO_4^{2-}, HCO_3^-, CO^{2-} and corrosive CO_2.

13.2.3 Bottom water chemistry testing shall be in accordance with the requirements given in 12.1.3 of GB 50021-2001.

13.3 Seabed soil parameter test

13.3.1 The number of seabed soil sampling stations is generally controlled at 1/5 of the total number of seabed sediment sampling stations. Sampling shall usually be carried out in the layer being place where cable and pipeline are buried.

13.3.2 The test parameters of seabed soil shall include pH, Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, oxidation-reduction potential and resistivity.

13.3.3 The seabed soil parameters shall be tested according to the requirements given in 12.1.3 of GB50021-2001.

13.3.4 The measurement of sulfate reducing bacteria in seabed soil shall be carried out in accordance with the requirements specified in Clause 13 of GB/T 12763.6-2007.

13.4 fouling organisms

13.4.1 Fouling organisms include attached organisms and borehole organisms.

13.4.2 Usually, only the historical data of fouling organisms in the route sea area is collated and analyzed, and relevant results are provided. In the case of engineering needs, on-site investigation of fouling organisms shall be carried out according to the requirements specified in Clause 13 of GB/T 12763.6-2007,

13.5 Corrosiveness evaluation

Corrosiveness evaluation for the bottom water and seabed soil shall be carried out according to the requirements given in 12.2 of GB50021-2001.

14 Evaluation of Seismic Safety

14.1 Contents of the evaluation

Contents of the evaluation include probability analysis of seismic risk of engineering site,

site seismic ground motion zonation and site seismic geological hazard evaluation.

14.2 Site seismic risk analysis based on probability method

On the basis of evaluating seismic activity and tectonic environment, dividing potential seismic source areas and determining the attenuation relationship of seismic ground motions for the regions (the extension of submarine cable and pipeline site is not less than 150 km) and near fields (the extension of submarine cable and pipeline site is not less than 25 km), the probability method is used to analyze and calculate seismic risk and provide the bedrock horizontal seismic peak ground acceleration with 50-year exceedance probability of 63%, 10% and 2% for the main site points of submarine cable and pipeline route.

14.3 Site seismic ground motion zonation

14.3.1 According to the results of probability analysis of seismic risk, seismic ground motion zonation map of submarine cable and pipeline route sites shall be compiled, which includes seismic peak ground acceleration zonation map and seismic peak ground velocity zonation map. Seismic intensity zonation map may be compiled as required.

14.3.2 According to the requirements for seismic resistance design of submarine cable and pipeline engineering and other related projects, the probability level should adopt 50 years exceedance probability of 10%.

14.3.3 The evaluation of regional and near field seismic activity and seismic-tectonic environment, and determination of regional ground motion attenuation relationship shall be in accordance with the requirements specified in Clause 5, Clause 6 and Clause 8 of GB 17741-2005.

14.3.4 The interval between control points along route centerline shall not be more than 0.1 ° of latitude and longitude. The intervals between control points shall be decreased in the area where the calculation results vary greatly. The interval of spatial calculation points should be spaced not more than 0.1 °x0.1 ° of latitude and longitude.

14.3.5 The scale of seismic ground motion zonation map shall not be less than 1:500 000.

14.3.6 Seismic ground motion zonation map is used to express zonation by zonation line or isogram. In determining the boundary of zonation, special attention shall be paid to the calculation value in the location of submarine cable and pipeline route. Meanwhile, the influence of potential hypocenter area and variable range of seismic parameters, the difference of topography and geomorphology, and the accuracy of zonation parameters shall be taken into account.

14.3.7 Compiling the instruction for the use of seismic ground motion zonation map.

14.3.8 The seismic intensity shall be classified according to Table 2. The relationship between the seismic peak ground acceleration grading and the seismic intensity shall be as specified in Table 3. The seismic peak ground acceleration grading shall be as specified in Table 4. The seismic peak ground velocity grading shall be as specified in Table 5.

Table 2 Classification of seismic intensity

Grade	＜Ⅵ	Ⅵ	Ⅶ	Ⅷ	≥Ⅸ
Calculated seismic intensity	<5.7	5.8-6.7	6.8-7.7	7.8-8.7	≥8.8

Table 3 Comparison of seismic peak ground acceleration and seismic intensity in g

Grading of seismic ground motion peak acceleration	＜0.05	0.05	0.1	0.15	0.2	0.3	≥0.4
Seismic intensity	＜Ⅵ	Ⅵ	Ⅶ	Ⅶ	Ⅷ	Ⅷ	≥Ⅸ

Table 4 Classification of seismic peak ground acceleration in g

Grading of acceleration	Range of parameter value	Grading of acceleration	Range of parameter value
＜0.05	＜0.04	0.20	[0.19, 0.28)
0.05	[0.04, 0.09)	0.30	[0.28, 0.38)
0.10	[0.09, 0.14)	≥0.40	≥0.38
0.15	[0.14, 0.19)		

Table 5 Classification of seismic peak ground velocity in cm/s

Classification of velocity	Range of parameter value	Grading of velocity	Range of parameter value
＜6	＜4.7	25	[23.7-35.3]
6	[4.8-11.5]	38	[35.4-47.5]
13	[11.6-17.7]	≥50	≥47.6
19	[17.8-23.7]		

14.4 Site seismic geological hazard evaluation

14.4.1 Seismic geological hazard evaluation of submarine cable and pipeline site mainly includes sand liquefaction, landslide, collapse and surface faulting, etc.

14.4.2 According to the site engineering geological conditions, types of seismic geological hazards in the site shall be determined and influence degree shall be evaluated.

14.4.2.1 Sand liquefaction evaluation

When saturated sandy soil or silt is distributed in route area, the possibility of liquefaction shall be distinguished, and suggestions for anti-liquefaction measures shall be put forward. In the case of seismic intensity of Ⅵ, sand liquefaction need not be considered under normal circumstances. When seismic intensity greater than Ⅵ, sand liquefaction shall be distinguished according to the requirements given in 4.3.3 of GB 50011-2001.

14.4.2.2 Landslide and collapse evaluation

The areas with a seismic intensity of Ⅶ or greater than Ⅶ are designated as a seismic fortification zone. Assessment of potential landslide and collapse shall be taken into consideration in the seismic fortification area. For the seismic fortification site of

submarine cable and pipeline project, potential landslides and collapses shall be evaluated according to the requirements of 5.2 and 5.3 of GB 50011-2001.

14.4.2.3 Evaluation for the fault surface dislocation

Based on the survey results of fault activity, the characteristics of fault surface dislocation and its possible influence on site shall be evaluated. When evaluating the activity of concealed faults in the near field, it is necessary to fully collect and analyze the geophysical survey and geological drilling data of submarine cable and pipeline route area, analyze the latest active age of faults, calculate the maximum co-seismic displacement of seismic faults, and take appropriate anti-breaking measures or avoidance measures in combination with engineering geological conditions.

15 Collection and Observation of Marine Hydrographic and Meteorological Data

15.1 Hydrography

15.1.1 Wave

15.1.1.1 Collect the wave data in the route area and put forward the better and worse sea conditions in the whole year, to provide the basis for the selection of submarine cable and pipeline construction period.

15.1.1.2 In coastal or island areas, wave observation stations may be set up to obtain wave data, while in shallow sea route area, hydro-meteorological station data near the route and ship reports over the years may be collected. When necessary, wave elements may be calculated from wind data.

15.1.1.3 The requirements for wave data collation include multi-year, monthly frequency, maximum wave height, average wave height of wave occurrence in all directions, and corresponding period.

15.1.1.4 Additional calculation of wave height and period of recurrence period may be done for submarine pipeline route survey. Generally , the maximum wave height (H_{max}) and effective wave height (H_s) are required to be calculated for the recurrence period of 1 year, 10 years, 50 years and 100 years.

15.1.1.5 Observation of the wave station shall be in accordance with requirements specified in Clause 8 of GB/T 12763.2-2007.

15.1.2 Tides

15.1.2.1 Analyze the tidal quality and relationship between various tidal levels in the route area.

15.1.2.2 Tidal observatory may be set up in inshore or island areas for tidal observation for more than 1 month. In the offshore area, the method of collecting historical tide data or tide level prediction may be used.

15.1.2.3 The relations between base level and various tide levels include 1985 National Elevation Datum, local average sea level, theoretical maximum tide level and theoretical minimum tide level, etc.

15.1.2.4 Extreme tidal level in the recurrence period, that is, the calculation of the highest and lowest tidal levels for the recurrence period of 50 years and 100 years, may be added in submarine pipeline route survey.

15.1.2.5 The observation of tide shall be in accordance with the requirements specified in Clause 9 of GB/T 12763.2-2007.

15.1.3 Currents

15.1.3.1 Sources of current data: collect the past measured data in the route area, or predict the current data. In route survey of submarine pipelines, sufficient observation stations shall be set up in the route area according to the topographic conditions for full-tide hydrographic observation and one-month automatic observation buoy stations so as to obtain current data.

15.1.3.2 Current data of surface, middle and bottom layers shall be collected. The analysis items mainly include current situation in the route area, measured maximum flood and ebb tidal current velocity, average spring tidal current velocity, average neap tidal current velocity, maximum possible tidal current velocity and mainstream direction. Numerical simulation may be performed when necessary. In the submarine pipeline route survey, the calculation of maximum tidal current velocity with recurrence period of 1 year, 10 years, 50 years and 100 years may be added.

15.1.3.3 Current observation shall be in accordance with the requirements specified in Clause 7 of GB/T 12763.2-2007.

15.1.4 Water temperature

15.1.4.1 Water temperature and marine current observation shall be carried out simultaneously, and the existing water temperature observation data in the route area shall also be collected.

15.1.4.2 Water temperature observation shall be in accordance with the requirements specified in Clause 5 of GB/T 12763.2-2007.

15.1.5 Sea ice

15.1.5.1 Collect the existing sea ice observation data in the route area, and observation stations should be set up when necessary.

15.1.5.2 Sea ice data collection and observation shall be in accordance with the requirements specified in Clause 11 of GB/T 12763.2-2007.

15.2 Marine Meteorology

15.2.1 Collect and sort out the meteorological data in route area, and put forward better and

worse climate windows in the whole year, to provide the basis for the selection of submarine cable and pipeline construction period.

15.2.2 Meteorological data sources: meteorological observation on ship during the route survey; collect meteorological station data near route area, and collect measured data by ships over the years in route area.

15.2.3 The meteorological data collected and collated shall include the followings:

a) Wind, including wind frequency in all directions per month every year, average wind speed and maximum wind speed (10 m above the sea surface), and windy days each month over years;
b) Air temperature, including the extreme highest, extreme lowest and mean temperature each month over years;
c) Fog, referring to the average foggy days each month over years.

15.2.4 For submarine pipeline route survey, the calculation of maximum wind speed in the recurrence period may be added. Generally, it is required to calculate the maximum wind speed in the recurrence period of 1 year, 10 years, 50 years and 100 years within 3 s, 1 min, 10 min and 1 h respectively.

15.2.5 Meteorological observation shall be in accordance with the requirements specified in Clause 5 to Clause 11 of GB/T 12763.3-2007.

16 Submarine Cable and Pipeline Post-lay Survey

16.1 General requirements

16.1.1 After the laying of submarine pipelines or the occurrence of major geological hazards, the laying conditions of pipelines shall be surveyed. Engineering geophysical survey methods such as bathymetric sounding, side scan sonar detection and sub-bottom profiling should be used comprehensively to find out the seabed conditions adjacent to excavated seabed trench and pipeline, the plane position of pipeline, buried depth, height and length of suspended span, and appearance of pipeline protective layer. For important or complex submarine pipeline projects, ROV survey shall be carried out at the same time.

16.1.2 For important or international submarine optical cable projects, post-lay survey shall be carried out for the sections which involve special construction technologies, complicated seabed condition or unsatisfactory burial effect. Generally, ROV method is adopted in the survey.

16.2 Mapping scale and layout of survey lines

16.2.1 Mapping scale

The mapping scale is generally 1:2000 1:5000, but 1:1000 for complicated areas.
Note: complicated area refers to sections where submarine pipelines are more likely to experience suspended span, covered by concrete or be buried under gravel layer.

16.2.2 Layout of survey lines

Layout of survey lines shall comply with the following requirements:
a) Three survey lines shall be laid out parallel with route, one of which shall be laid along the route, and the rest shall be laid on both sides of the route, with a space of 25 m to 100 m;
b) Transverse survey line shall be laid out vertically with route, its length shall not be less than 50 m, the space shall be 50 m-250 m, and the space shall be decreased properly in complicated area.

16.3 Engineering geophysical survey

16.3.1 Engineering geophysical survey shall comply with the following technical requirements:

a) The single beam bathymetric system is used for sounding, swell compensation system shall be equipped to eliminate the effect of swell, time delay correction of the system shall be carried out, and the sounding shall be carried out along the transverse line;
b) When using multi-beam bathymetric system for sounding, the reasonable space between lines shall be selected according to water depth and instrument performance so as to ensure 100% overlap coverage between adjacent lines and the sounding shall be carried out along longitudinal lines;
c) When side scan sonar detection is carried out, reasonable sonar range and space between survey lines shall be selected so as to ensure 100% overlap coverage in survey corridor zone, and the detection shall be carried out along the longitudinal survey line;
d) Sub-bottom profiler with high resolution shall be used to obtain the penetration depth of 10 m under seabed. The stratum resolution is better than 0.2 m, and the detection shall be carried out along the transverse line;
e) The remaining technical requirements shall be in accordance with the provisions given in 8.3.2, 8.4.2, 8.5.2 and 8.6.2.

16.3.2 Measurement implementation on the sea shall be in accordance with the provisions given in 8.3.3, 8.4.3, 8.5.3 and 8.6.3.

16.4 Remotely operated vehicle (ROV) survey

16.4.1 ROV survey shall comply with the following requirements:

a) ROV shall be able to work normally at a current velocity of less than 2 kn., equipped with motion sensors, underwater acoustic positioning system, underwater compass, underwater camera, capable of carrying bathymetric sounding equipment, high resolution navigation sonar, side scan sonar, sub-bottom profiler, pipeline tracker, etc., and having enough data transmission channels;
b) ROV working mothership shall be equipped with dynamic positioning system, DGPS, compass and underwater acoustic positioning system; with good operational stability and the ability to maintain low speed (generally less than 1 kn.) for a long time; the ship has sufficient deck area and hoisting equipment for ROV installation and ROV launching and recovery during the survey.

16.4.2 ROV survey shall be carried out according to the followings:

a) All kinds of survey equipment shall be calibrated and debugged until they reach normal working conditions before use;
b) Before the survey, ROV working mothership, navigating and positioning system shall be coordinated with ROV and other survey equipment until the relative positions of the detection target, ROV working mothership and ROV are correctly displayed in the ROV control room and the survey ship pilothouse;
c) When the working mothership is located near the starting point of the survey, adjust the bow to the position that is most conducive to the working mothership in position and the ROV's retractable operation. Then the ROV may be launched to the water;
d) The forward speed of ROV operation shall be usually less than 2 kn., and according to underwater visibility and equipment sampling rate, adjust the forward speed to achieve the best detection effect. During the surveying for submarine cable, the height of ROV above the seabed shall not be greater than 0.2 m, and the surveying for submarine pipeline, the height of ROV above the seabed shall not be greater than 1.0 m;
e) All instrument parameters and video information of ROV shall be transmitted to ROV control room and pilothouse of working mother vessel during the operation, and save the data in time;
f) Before the survey is stopped, the working mothership cab and ROV control room shall be notified to shut down the data acquisition and recording system and mark the end point, and the ROV shall be recovered to the deck;
g) The overlap range of survey in adjacent sections shall not be less than 50 m.

16.5 Data processing

Data processing shall comply with the following requirements:
a) Identify obstacles and seabed conditions near the submarine cables or pipelines;
b) For exposed submarine pipelines, the location, exposed height, suspension length and deviation distance from the designed route shall be determined. When there are pipeline trenches, depth and width of trenches and contact relationship between submarine pipelines and trenches shall also be determined;
c) For buried submarine pipelines, location and buried depth of submarine pipelines shall be determined;
d) For the sections with cement or gravel cover, location of submarine pipeline, thickness and coverage area of cover pad or coat shall be determined;
e) Identify the appearance of protective layer of submarine pipeline.

16.6 Result maps

Result maps shall include:
a) Location map of submarine cables and pipelines;
b) Bathymetric map of survey area;
c) Seabed conditions map of survey area;
d) Transverse section of submarine cable and pipeline;
e) Longitudinal profile of submarine cable and pipeline.

16.7 Result report

Result report shall include the following contents:

a) Engineering background, origin of the task and purpose of the survey;
b) Technical basis for survey, ROV working mothership and equipment;
c) Methods and procedures of the survey;
d) Data processing and interpretation methods;
e) Exposed, suspended or buried conditions of submarine pipelines;
f) Seabed obstacles and conditions near the submarine cables and pipelines;
g) Comprehensive evaluation of the laying conditions of submarine cables and pipelines.

17 Route Conditions Evaluation and Compilation of Result Report

17.1 Route conditions evaluation

17.1.1 General requirements

Route conditions evaluation shall be carried out on the basis of route survey, test, analysis and collection of existing data, combined with engineering characteristics and requirements. The contents of the evaluation mainly include submarine engineering geological conditions, marine hydro-meteorological environment, seismic safety, corrosive environment, marine planning and development activities, etc.

17.1.2 Engineering geological conditions

The evaluation of engineering geological conditions needs to analyze the topography, geomorphology, geology, seabed condition, sediment and geotechnical properties of the route area, and to evaluate the hazard geological factors (such as scouring ditch, shallow gas, seabed collapse, landslide, turbidity current, bedrock, paleo-channel, active sand wave, mud diapir, salt diapir, soft soil intercalation, etc.) and its impact on submarine cables and pipelines, and put forward corresponding engineering measures or countermeasures and suggestions.

17.1.3 Marine hydro-meteorological environment

The evaluation of marine hydro-meteorological environment needs to analyze the elements such as wave, tide, current, water temperature, sea ice and meteorology in route area, to evaluate their possible impact on construction, operation and maintenance of submarine cables and pipelines, and to propose optimal construction period for laying submarine cables and pipelines.

17.1.4 Evaluation of seismic safety

Seismic safety evaluation needs to analyze the seismic structure and seismic environment of the route zone and near-field area, to analyze and calculate the seismic risk with the probability method, and to figure out the horizontal seismic peak ground acceleration of the bedrock with the exceeding probability of 10% for a recurrence period of 50 years. When necessary, the zonation maps of seismic peak ground acceleration and seismic intensity of route site should be compiled according to the results of seismic risk probability analysis. In addition, efforts must be made to evaluate the potential impacts of earthquake-induced sand

liquefaction, soft soil subsidence and fault surface dislocation in route zone of submarine cables and pipelines.

17.1.5 Corrosive environment

The evaluation of corrosive environment needs to analyze the corrosive environmental parameters of seabed sediments and bottom water, so as to provide the basis for the anticorrosion design of submarine cables and pipelines.

17.1.6 Marine planning and development activities

The evaluation of marine planning and development activities needs to analyze the conformity of route with marine functional zonation and marine development planning, and to evaluate whether fishing, transportation, oil and gas development, existing submarine cables and pipelines or marine reserve in the route zone conflict or interfere with the route plan, thereby proposing corresponding measures or suggestion for the design, construction and maintenance of submarine cables and pipelines.

17.2 Compilation of result report

17.2.1 The original data to be used in the result report shall be collated, checked and analyzed to eliminate any faults or errors.

17.2.2 The result report shall offer complete data, clear drawings and tables, convincing conclusions and sensible recommendations, easy to use and suitable for long-term preservation.

17.2.3 The result report shall be compiled according to the requirements of mission, characteristics of the project and specific conditions of the marine environment. It shall include following contents:

a) Purpose and task requirement of the survey;
b) Technical basis, method, procedure and workload of the survey;
c) Submarine engineering geological conditions;
d) Seismic safety evaluation;
e) Seabed erosion and siltation and foundation stability;
f) Marine hydro-meteorological elements and design parameters;
g) Seabed corrosive environmental parameters;
h) Marine functional zonation, planning and development activities;
i) Comprehensive evaluation and conclusion of route conditions.

17.2.4 Result report shall include the following attached drawings:

a) Track line map;
b) Bathymetric map (seabed topographic map);
c) Topographic profile;
d) Stratigraphic profile;
e) Seabed conditions map;
f) Alignment chart (see Annex C for pattern).

17.2.5 Annexes shall include valuable information for the survey process or results, such as project organization and personnel list, survey logs, survey vessel and equipment, instrument calibration and test reports, seabed sediment sampling or drilling records, in-situ test result charts and tables, laboratory test result charts and tables, typical geophysical survey records, sound velocity profile measurement records, marine development activity observation records, etc.

18 Data Filing

18.1 Filing scope

The filing scope includes:
a) The task contract and related technical requirements, power of attorney, etc.;
b) Survey plan, implementation plan, etc.;
c) Important original records, raw data, laboratory analysis and test reports and drawings of various carriers;
d) Phased survey results and acceptance records;
e) Final original manuscript of the survey report (electronic manuscript);
f) Report audit and review records, declaration records of achievement award, win award records, and results application records.

18.2 Filing requirements

Filing shall comply with the following requirements:
a) All written records and other materials formed in the course of survey shall be sorted out, examined and signed, After file management departments review and comply with the relevant provisions, archives can be filed;
b) Filing documents shall be unified in format, neat and orderly in handwriting, clear in pattern, firm in binding and complete signature procedures;
c) Filing materials shall be classified according to confidentiality provisions and safekeeping. Important documents, materials, survey plans, original records, raw materials, data compilation, atlas, reports, normative operating documents and retrospective records formed in the course of survey implementation shall be kept permanently;
d) For electronic document materials, the technical environment conditions, relevant software versions, data type formats, operational data, detection data and backup requirements shall be indicated.

Annex A
(Informative)
Compilation Guideline for Submarine Cable and Pipeline Route Pre-selection Report

A.1 Overview

A.1.1 Task and engineering background
A.1.2 Scope of pre-selected route sea area
A.1.3 Technical basis for route preselection
A.1.4 Work process

A.2 Geographical Location and Surrounding Environment of Landing Point

A.2.1 landing point Geographical location
A.2.2 landing point Surrounding environment

A.3 Engineering Geological Conditions in Route Area

A.3.1 Regional geological background
A.3.2 Seabed topography and geomorphological features
A.3.3 Seabed sediments and their engineering properties
A.3.4 Seabed erosion and siltation

A.4 Hydrographic and Meteorological Elements in Route Area

A.4.1 Meteorology
A.4.2 Marine hydrography

A.5 Seabed Corrosive Environment in Route Area

A.6 Marine Development Activities in Route Area

A.6.1 Marine functional zonation and planning
A.6.2 Fishery activities
A.6.3 Maritime transportation
A.6.4 Existing submarine cable and pipeline engineering
A.6.5 Submarine mineral resource exploration activities
A.6.6 Water conservancy project
A.6.7 Marine nature reserve
A.6.8 Dumping area
A.6.9 Tourist area
A.6.10 Others

A.7 Evaluation of Pre-selected Route Conditions and Suggestions

A.7.1 Pre-selected route scheme
A.7.2 Comprehensive evaluation of pre-selected route conditions
A.7.3 Conclusions and recommendations

Annex B
(Normative)
Unified Classification and Designation of Soil

B.1 General Requirements

Soil shall be classified according to the following indexes:
a) Soil particle composition and characteristics;
b) Plasticity index of soil: liquid limit (ω_L), plasticity limit (ω_P) and plasticity index (I_P);
c) Soil organic matter content.

B.2 Classification and Designation of Soil

B.2.1 Soil may be divided into inorganic soil, organic soil, peat soil and peat according to the content of organic matter. The soil with less than 5% organic content is called inorganic soil. The soil with an organic content of not less than 5%, and not more than 10%, is called organic soil. The soil with an organic content more than 10% and not more than 60% is called peat soil. The soil with an organic matter content of more than 60% is called peat.

B.2.2 According to particle gradation or plasticity index, soil may be divided into detritus stone soil, sandy soil, silt and cohesive soil.

B.2.2.1 Soil with particle size larger than 2 mm comprising more than 50% of total mass shall be designated as detritus stone soil and may be further classified according to Table B.1.

Table B.1 Classification of crushed stone soil

Name	Particle shape	Grain composition
Boulder	mainly circular and sub-circular	Mass of particles larger than 200 mm in excess of 50% of total mass
Block stone	mainly angular	
Pebble	mainly circular and sub-circular	Mass of particles larger than 20 mm in excess of 50% of total mass
Crushed Stone	mainly angular	
Cobble gravel	mainly circular and sub-circular	Mass of particles larger than 2 mm in excess of 50% of total mass
Breccia gravel	mainly angular	

B.2.2.2 Soil with particles larger than 2 mm comprising no more than 50% of the total mass and particles larger than 0.075 mm comprising more than 50% of the total mass shall be designated as sand soil, which may be further classified according to Table B.2.

Table B.2 Classification of sand soil

Name	Grain composition
Gravel	Mass of particles larger than 2 mm comprising 25% to 50% of total mass
Coarse sand	Mass of particles larger than 0.5 mm comprising more than 50% of total mass
Medium sand	Mass of particles larger than 0.25 mm comprising more than 50% of total mass
Fine sand	Mass of particles larger than 0.075 mm comprising more than 85% of total mass
Silty sand	Mass of particles larger than 0.075 mm comprising more than 50% of total mass

Note 1: Soil shall be designated according to grain composition in the sequence of large to small, with priority given to whichever comes first.
Note 2: Sand soil with particles smaller than 0.005 mm comprising more than 10% of total mass, it shall be referred to as the attribute of cohesive soil, such as coarse sand containing clayey soil.

B.2.2.3 Soil with particles larger than 0.075 mm comprising no more than 50% of total mass and plasticity index of no larger than 10 shall be designated as silt soil, which may be further classified according to Table B.3.

Table B.3 Classification of silt

Name	Particle size/mm	Content/%	Plasticity index/I_p
Sandy silt soil	> 0.075	< 50	$3 < I_p \leqslant 7$
	< 0.005	< 10	
Clayey silt soil	> 0.075	< 50	$7 < I_p \leqslant 10$
	< 0.005	> 10	

B.2.2.4 Soil with the plasticity index larger than 10 shall be designated as cohesive soil

Cohesive soil may be further classified into silty clay and clay. If the plasticity index falls within the range of 10 to 17, the soil shall be designated as silty clay, but when the plasticity index larger than 17 the soil shall be designated as clay.

B.3 Depending on the actual requirements of marine engineering, soil may also be classified according to requirements specified in ASTM D2487-2006 or other relevant international standards.

B.4 Soil classification requirements given in ASTM D2487-2006

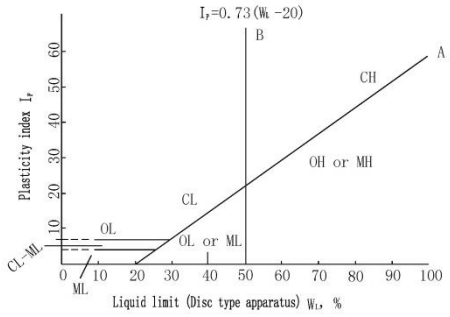
B.4.1 Soil shall be classified into coarse-grained soils and fine-grained soils according to whether the particle content retained on the No 200 American sieve (0.075 mm pore diameter) is more than 50%. Coarse-grained soils may be further classified into gravel and sand based on whether content of particles retained on NO.4 American sieve (4.75 mm pore diameter) is more than 50%. Gravel and sand can be further classified according to sorting situations and content of fine particles. Fine-grained soil may be further classified according to liquid limit, plasticity index and content of organic matters.

B.4.2 Soil classification and designation requirements in ASTM D2487-2006, see Table B.4.

Table B.4 Classification and Designation of Soil

<table>
<tr><th colspan="3">Category</th><th>Group Symbol</th><th>Representative soil name</th><th colspan="3">Classification of coarse-grained soil</th></tr>
<tr><td rowspan="6">Coarse-grained soil (more than half of the samples grain size larger than the pore diameter of No. 200 sieve)</td><td rowspan="4">Gravel (more than half of the coarse samples grain size larger than the pore diameter of No. 4 sieve)</td><td rowspan="2">Pure gravel (with no or very little fine-grained soil)</td><td>GW</td><td>Well graded gravel or gravel-sand mixture, with little or no fine-grained soil.</td><td rowspan="6">1. Determine the percentage of sand and gravel according to the grain size curve.
2. According to the percentage of fine-grained soil (grain size smaller than No. 200 sieve), coarse-grained soil may be classified as follows:
＜ 5%- GW, GP, SW, SP;
＞ 12%- GM, GC, SM, SC;
5%-12%- marked with double symbols.</td><td>$C_u \geqslant 4$;
$1 \leqslant C_c \leqslant 3$</td><td rowspan="2">Nonuniformity coefficient:
$Cu = \frac{d_{60}}{d_{10}}$
Curvature coefficient:
$C_c = \frac{d_{30}^2}{d_{10} \times d_{60}}$</td></tr>
<tr><td>GP</td><td>Poorly graded gravel or gravel-sand mixture, with little or no fine-grained soil.</td><td>Not comply with all grading requirements of GW</td></tr>
<tr><td rowspan="2">Gravel mixed with fine grained soil (quite a bit fine-grained soil)</td><td>GM</td><td>Silty gravel or gravel-sand-silt mixture</td><td>Atterberg limit below Line A or I_p＜4</td><td rowspan="2">Soil above Line A and 4 ＜ I_p＜7, marked with double symbols</td></tr>
<tr><td>GC</td><td>Clayey gravel or gravel-sand-clay mixture</td><td>Atterberg limit above Line A and I_p ＞7</td></tr>
<tr><td rowspan="6">Sand (more than half of the coarse samples grain size smaller than the pore diameter of No. 4 sieve)</td><td rowspan="2">Pure sand (with no or very little fine-grained soil)</td><td>SW</td><td>Well graded sand or gravelly sand, with little or no fine-grained soil</td><td colspan="2">$C_u \geqslant 6$, $1 \leqslant C_c \leqslant 3$</td></tr>
<tr><td>SP</td><td>Poorly graded sand or gravelly sand, with little or no fine-grained soil</td><td colspan="2">Not comply all grading requirements of SW.</td></tr>
<tr><td rowspan="2">Sand mixed with fine-grained soil (quite a bit fine-grained soil)</td><td>SM $\frac{d}{u}$</td><td>Silty sand, sand-silt mixture</td><td>Atterberg limit below Line A or I_p ＜4</td><td rowspan="2">Soil above Line A and 4 ＜ I_p ＜ 7, marked with double symbols</td></tr>
<tr><td>SC</td><td>Silty sand, sand-clay mixture</td><td>Atterberg limit above Line A and I_p ＞7</td></tr>
</table>

Table B.4 (continued)

<table>
<tr><th colspan="2">Category</th><th>Group Symbol</th><th>Representative soil name</th><th>Classification of fine-grained soil</th></tr>
<tr><td rowspan="6">Fine-grained soil (more than half of the samples grain size larger than the pore diameter of No. 200 sieve)</td><td rowspan="3">(Liquid limit ＜ 50%) Silt and clay</td><td>ML</td><td>Inorganic silt and very fine sand, rock powder, silty or clayey fine sand, or low plasticity clayey silt</td><td rowspan="6"> 

Casagrande plasticity chart
C: Cohesive soil;
M: Silty soil;
O :Organic soil;
H: High plasticity;
L :Low plasticity;
Area above line A for inorganic soil, and below for silty soil and organic soil;
Right side of line B for high-plasticity soil while the left side for low plasticity soil;
Pore diameter of No.200 sieve is 0.075 mm;
Pore diameter of No.4 sieve is 4.75 mm.</td></tr>
<tr><td>CL</td><td>Low-medium plasticity inorganic clay, gravelly clay, sandy clay, silty clay, and lean clay</td></tr>
<tr><td>OL</td><td>Low plasticity organic silt and organic silty clay</td></tr>
<tr><td rowspan="2">(Liquid limit ≥ 50%) silt and clay</td><td>MH</td><td>Inorganic silt, fine sandy soil or silty soil containing mica or diatomite, rubber silty soil.</td></tr>
<tr><td>CH</td><td>High plasticity inorganic clay, fat clay</td></tr>
<tr><td rowspan="2">High organic soil</td><td>OH</td><td>Medium-high plasticity organic clay, organic silt</td></tr>
<tr><td>Pt</td><td>Peat and other high organic soil</td></tr>
</table>

Annex C
(Informative)
Pattern of Alignment Chart

C.1 General Requirements

C.1.1 Alignment chart shall be a leveling graph composed of different bands along the route direction.

C.1.2 Alignment chart may be divided freely and cover the whole survey area with fewer maps. There shall be 3 cm overlap between adjacent charts and on both sides of the route alter course point.

C.1.3 Size of the chart adopts standard A0, A1 and A2.

C.1.4 Alignment chart shall include the following five blocks:

a) Track line, water depth, topography, etc.;
b) Seabed sediments, landform, obstacles, etc.;
c) Stratigraphic section, geotechnical characteristics, etc.;
d) Information about engineering design and construction, etc.;
e) Information on the symbol of each element, drawing parameters, guide map, project name, compilation unit and version number in the drawing, etc.

C.2 Pattern of Alignment Chart

Pattern of alignment chart, see Figure C.1.

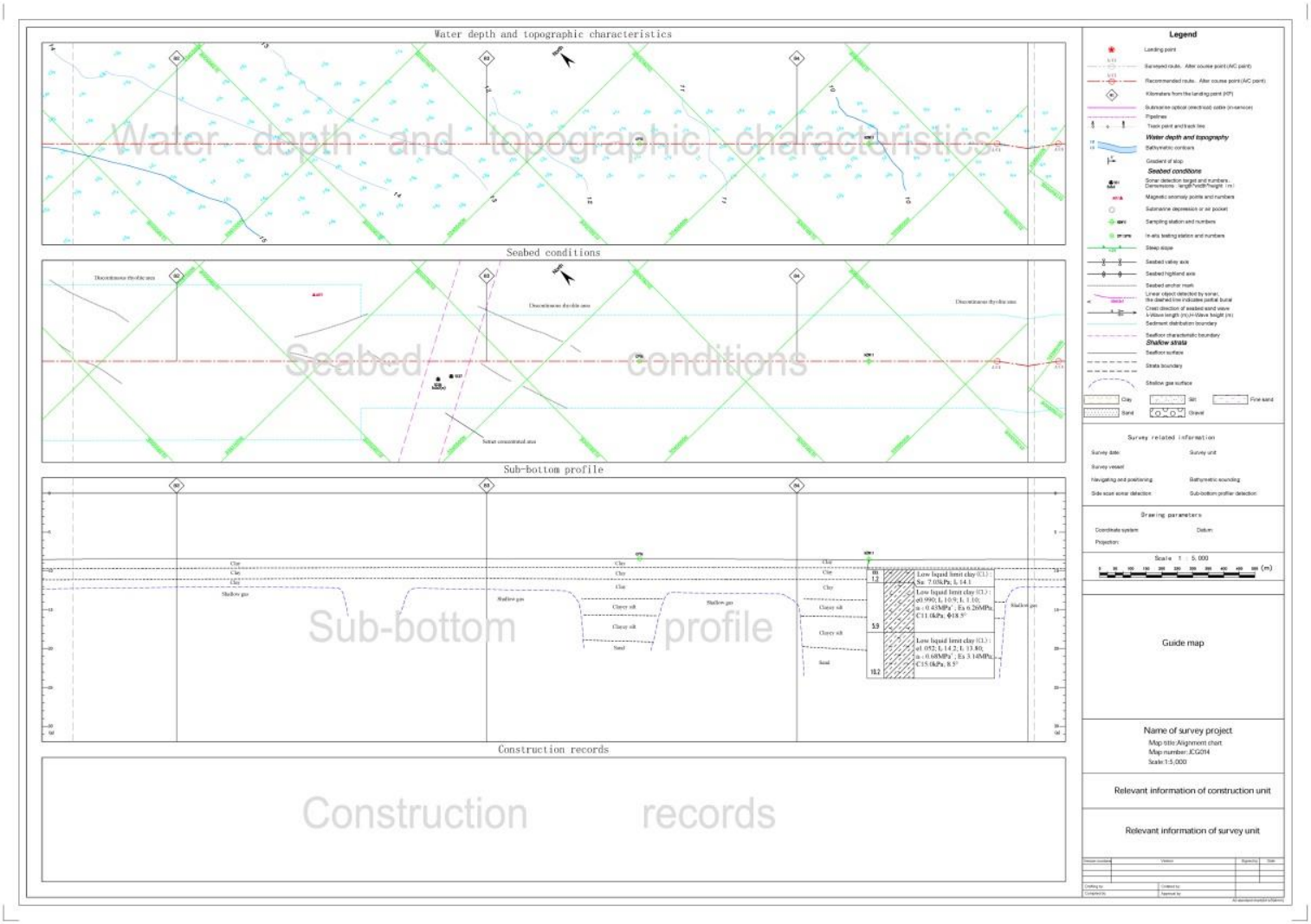


Figure C.1 Pattern of alignment chart

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