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N-10 Multi-system Shipborne Radionavigation Receivers

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Foreword

This Guideline is a part of CCS Rules, which contains technical requirements, inspection and testing criteria related to classification and statutory survey of marine products.

This Guideline is published and updated by CCS and can be found through http://www.ccs.org.cn . Comments or suggestions can be sent by email to ps@ccs.org.cn .

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Multi-system Shipborne Radionavigation Receivers

1 Application

1.1 This guideline is applicable to the type approval and single-piece/batch product inspection of the multi-system shipborne BDS, GPS, GLONASS and GALILEO radionavigation receivers.

1.2 This guideline is not applicable to the equipment on the ships with the speed greater than 70 kn.

2 Normative references

2.1.1 SOLAS (1974) and Article 19, Chapter V in the amendment;

2.1.2 SOLAS (1974) and Article 3, Chapter X in the amendment;

2.1.3 Chapter 13, 2000 HSC Code;

2.1.4 IMO Resolution A.694 (17): General Requirements for Ship-borne Radio Equipment Forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids;

2.1.5 IMO MSC Resolution 112 (73): Adoption of Revised Performance Standards for Ship-borne Global Positioning System (GPS) Receiver Equipment;

2.1.6 IMO MSC Resolution 113 (73): Adoption of the Revised Performance Standards for Shipborne GLONASS Receiver Equipment;

2.1.7 IMO MSC Resolution 233 (82): Adoption of Performance Standards for Shipborne GALILEO Receiver Equipment;

2.1.8 IMO MSC Resolution 191 (79): Performance Standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays;

2.1.9 IMO Resolution A.1046 (27): Worldwide Radionavigation System;

2.1.10 IMO Resolution A.915 (22): Revised Maritime Policy and Requirements for a Future Global Navigation Satellite System (GNSS);

2.1.11 IMO Resolution A.953 (23): World-wide Radionavigation System;

2.1.12 IMO MSC Resolution 379 (93): Performance Standards for Shipborne Beidou Satellite Navigation System (BDS) Receiver Equipment;

2.1.13 IMO MSC Resolution 401 (95): Performance Standards for Multi-system Shipborne Radionavigation Receivers;

2.1.14 IEC 61108-1 2003: Maritime Navigation and Radio Communication Equipment and Systems - Global Navigation Satellite System (GNSS), Part 1: Global Positioning System (GPS) - Receiver Equipment - Performance Standards, Methods of Testing and Required Test Results;

2.1.15 IEC 61108-2 1998: Maritime Navigation and Radio Communication Equipment and Systems - Global Navigation Satellite System (GNSS), Part 2: Global Navigation Satellite System (GLONASS) - Receiver Equipment - Performance Standards, Methods of Testing and Required Test Results;

2.1.16 IEC 61108-3 2010: Maritime Navigation and Radio Communication Equipment and Systems - Global Navigation Satellite System (GNSS), Part 3: GALILEO - Receiver Equipment - Performance Standards, Methods of Testing and Required Test Results;

2.1.17 IEC 61162 series: Maritime Navigation and Radio Communication Equipment and Systems - Digital Interface;

2.1.18 IEC 62288 2014: Maritime Navigation and Radio Communication Equipment and Systems - Presentation of Navigation-related Information on Shipborne Navigational Displays - General Requirements, Methods of Testing and Required Test Results;

2.1.19 IEC 60945 2002: Maritime Navigation and Radio Communication Equipment and Systems - General Requirements - Methods of Testing and Required Test Results;

2.1.20 GD22-2015 Guidelines for Type Approval Test for Electric and Electronic Products of China Classification Society.

2.2 In case of any changes to the conventions, regulations, recommendations on performance and testing standards mentioned above, the latest valid editions apply.

3 Terms and definitions

For the purposes of this guideline, the terms and definitions as specified in the aforesaid approval and inspection basis apply. For the sake of the preparation and usage, the following definitions are directly cited or supplemented in this guideline.

3.1 BDS: Beidou navigation satellite system;

3.2 GPS: Global positioning system;

3.3 GLONASS: Global navigation satellite system;

3.4 GALILEO: Galileo satellite navigation system;

3.5 COG: Course over ground;

3.6 SOG: Speed over ground;

3.7 UTC: Universal time coordinated;

3.8 PVT: Position, velocity, time;

3.9 GNSS: Global navigation satellite system.

3.10 C/A code: A pseudo random code for civil use, used to modulate the GPS satellite L1 carrier (1575.42MHz) signals;

3.11 GPS standard positioning service (SPS): A public civil service offered by the GPS C/A code;

3.12 DGPS (differential GPS): A technology augmenting the GNSS by improving the navigation performance for users. In the maritime sector, the augmentation mainly applies the following two methods: 1. using the satellite-based augmentation system (SBAS), a system supplementing the satellite signals to strengthen the performance of GNSS services; 2. using the ground-based augmentation system (GBAS), a system supplementing the signals from a ground station to strengthen the performance of GNSS services.

3.13 DBDS: Differential Beidou navigation satellite system;

3.14 Dilution of precision (DOP): A factor describing the effect of the geometric location of a satellite on the error. The error of a satellite navigation system is the product of the range error multiplied by the dilution of precision. It is further classified into 3D position dilution of precision (PDOP), horizontal dilution of precision (HDOP) and time dilution of precision (TDOP) and etc., according to the object of research.

3.15 Acquisition: The process in which a user's unit completes the code identification, code synchronization and carrier phase synchronization of a received satellite signal.

3.16 Receiver autonomous integrity monitoring (RAIM): A method where a receiver determines the integrity of a satellite system by using the pseudorange measurement information of a redundant satellite. It can identify whether any visible satellites are faulty or which one is faulty and exclude the faulty ones from the navigation solutions.

3.17 WGS-84: World Geodetic System 1984, a geocentric reference system established by the United States Department of Defense through the orientation using the Geodetic Reference System 1980 and the BIH1984.0 system on the basis of the precise ephemeris system NSWC-9Z-2 corresponding to the WGS72.

3.18 CGCS2000: China Geodetic Coordinate System 2000, a terrestrial geocentric coordinate system established through the combined adjustment of the GPS continuous operation reference station, the space-geodetic control network, the astro-geodetic network and the space geodetic network of China. The China Geodetic Coordinate System 2000 is based on the ITRF 97 reference frame and the reference frame epoch is 2000.0.

4 Plans and documents

4.1 The following drawing documents shall be submitted to CCS for review:

(1) Outline drawings and structure drawings of the complete machines;

(2) Electrical schematic diagrams, wiring diagrams and electrical functional block diagrams;

(3) Schematic diagrams or block diagrams of supply apparatus and product power supply layout plans;

(4) System wiring diagrams;

(5) Product technical specifications;

The product technical specifications shall clearly specify the overall performance and design requirements of the products, at least including the following:

① Provisions on the environmental conditions of the products;

② Product composition, main purchased parts and sources of procurement;

③ A detailed description of product functions and performance indices;

④ Acceptance conditions for the complete machines.

(6) Software, at least including the following:

① A description of the main software modules of the products and software version number;

② Software maintenance and update instructions.

(7) The product operating manuals, installation manuals, familiarization materials and maintenance manuals (bilingual in Chinese and English or in English), at least including the following contents:

Operating manuals:

① The concept of the multimode system and the benefits and limitations of using two or more GNSS (the ground radio navigation system and the augmentation system may be taken into account);

② A statement on which GNSS, terrestrial radio navigation system (if any) and augmentation system (if any) are supported (i.e., as the sources for the PVT solution);

③ A sentence on which navigation phase(s) is (are) supported and by which PVT source(s);

④ The user guidance for receivers necessary to achieve the navigation phase requirements;

⑤ A detailed description of the adjustment method of indicators and threshold values;

⑥ An explanation of the fusion process and input selection for multiple systems;

⑦ A description of possible failures and their effects on the receiver equipment;

⑧ Fault analysis for functions, verifying that the equipment is designed based on the safe design principles and ensuring that the equipment is designed with the "fault safety" actions. The influence of all failure modes shall be taken into account, such as the faults caused by electrical appliances, components and radio frequency interference.

Installation Manuals:

① The details of components and the interconnections between them;

② The details of interfaces and connections for data input/output, and interconnection diagrams;

③ The configuration options and commissioning instructions;

④ The power supply and earthing arrangements; and

⑤ The recommendations on the physical layout of the equipment, including the antenna mounting requirements and necessary space for installation and maintenance.

Familiarization materials: which should explain all configurations, functions, limitations, controls, displays, alerts, indications and standard operator checks of the equipment;

Maintenance manuals: support the maintenance information of the equipment;

The manuals shall include the list of all the terms, abbreviations, symbols, and icons displayed by the systems or equipment and related interpretations. The detailed descriptions of the user operating interfaces and function menus shall be included to facilitate the understanding and operating of the users and testing personnel.

(8) Outlines of type test and delivery test

The description of the following shall be included at least: sampling of type test, batching grouping and sampling principles of delivery test, requirements for test equipment, test items, test methods and criterion of test results.

4.2 The scope and details of the submitted drawings and technical materials shall be such that the compliance of products with the regulations and related standards can be reviewed and verified, and the appearance, structures and electrical design of the products can be inspected and tested.

4.3 The submitted documents shall be managed and identified as per the regulations of the quality management system of the manufacturer. The submitted technical documents shall be convenient for checking with related technical requirements.

5 Technical requirements for design

5.1 The electrical safety, suitability of power supply conditions, environmental suitability and electromagnetic compatibility of the equipment shall be suitable for the working environment of

ships and in line with the testing requirements for the "indoor equipment" or "outdoor equipment" as specified in IEC60945.

5.2 Requirements for functions and performance

5.2.1 Operate using civil access navigation signals of at least two independent GNSS, provided in the radionavigation satellite service (space-to-earth) frequency bands designated in Article 5 of the Radio Regulations of the International Telecommunication Union;

5.2.2 Provide PVT data with the necessary level of resilience and integrity, whether it is used directly as the input to other equipment, or provided for use within the Integrated Navigation Systems (INS);

5.2.3 Where the terrestrial radionavigation system (s) signals are provided and used in the protected frequency bands, the equipment shall be able to operate using the terrestrial radionavigation system (s) signals provided in the protected frequency bands;

5.2.4 Have the facilities to process the augmentation data, in accordance with the appropriate methods;

5.2.4 Provide the facilities for the user to select or deselect the radionavigation and augmentation signals;

5.2.6 Be capable of processing and combining the above signals to provide a single PVT solution, including:

(1) The position information of the consistent common reference point in latitude and longitude, referenced to the implementation of an International Terrestrial Reference Frame (ITRF), with the coordinates in degrees and minutes to a precision reflective of the accuracy of the position information, up to 0.0001 minute;

(2) The COG of the consistent common reference point in degrees to a precision reflective of the accuracy of the calculated course information, relative to true north, up to 0.1 degree;

(3) The SOG of the consistent common reference point in knots to a precision reflective of the accuracy of the calculated course information, up to 0.01kn;

(4) The time, referenced to UTC (BIPM), accurate to 0.1 second;

5.2.7 Be capable of providing the PVT solution to the required accuracy within:

(1) 5 min where there is no valid satellite almanac data (cold start);

(2) 1 min where there is valid satellite almanac data (warm start); and

(3) 2 min, when subjected to a power interruption or loss of signals of <60 s;

5.2.8 Be capable of generating a new PVT solution at least once every 0.5s for high-speed crafts (HSC) and at least once every 1s for conventional vessels;

5.2.9 Be capable of assessing whether the performance of the PVT solution (e.g., accuracy and integrity) meets the requirements for each phase[1] of navigation. An alert shall be provided when such assessment cannot be determined;

5.2.10 Provide a caution if after 2s for HSC or 3s for conventional vessels, the equipment is unable to assess the current achieved performance (e.g., accuracy and integrity) with respect to each navigation phase;

5.2.11 Provide a warning, if after 5s for HSC or 7s for conventional vessels, the new PVT data hasn't been calculated. Under such conditions, the last known position and the time of the last valid fix, with the explicit indication of this state so that no ambiguity can exist, shall be output until the normal operation is resumed;

5.2.12 If it is not possible to provide a new position update at the next scheduled update, output the last plausible position, SOG, COG, and the time of the last valid fix, with indication of this state so that no ambiguity can exist, until the position update is resumed;

5.2.13 Provide an indication of augmentation status, including:

(1) The receipt of augmentation signals;

(2) The validity of the signals received;

(3) Whether the augmentation is applied to the position in the PVT solution; and

(4) The identification of the augmentation signals;

5.2.14 Provide the following information, in alphanumerical form, for the final PVT solution and for each individual source when requested, to a local display (or a separate interfaced display):

Note[1] The "each navigation phase" referred to herein refers to the "operating requirements" as specified in the annex of IMO A.1046 (27).

(1) Position;

(2) SOG and COG;

(3) Time;

(4) PVT solution source(s);

(5) An assessment of the navigation phase(s) for which the performance requirements are supported;

(6) The identification of the augmentation signal(s) applied to the position solution; and

(7) Any alert information.

5.3 Interface and integration requirements

5.3.1 Provide the following interfaces in accordance with the relevant international standards:

(1) At least one interface from which the PVT solution shall be available in the WGS 84 (i.e., including the location information, COG, SOG, time, PVT source(s) (available and used), assessment of phase(s) of navigation for which the performance requirements are met, and augmentation information) shall be provided. The means may be provided for transforming the computed position based upon WGS 84 into the data compatible with the datum of the navigational chart in use;

(2) At least one interface from which the data from all available sources can be provided (e.g., to an Integrated Navigation System (INS) for the enhanced assessment of the PVT information which shall be available in WGS 84);

(3) An interface for alert management (i.e., with the Bridge Alert Management (BAM)); and

(4) At least one interface for receiving the augmentation signals;

5.3.2 Be capable of operating satisfactorily under normal interference conditions, consistent with the requirements of Resolution A.694(17), and taking into account the typical electromagnetic and radio frequency spectrum environment on board and from outside a vessel;

5.3.3 Ensure that no permanent damage can result from a short circuit or grounding of the antenna or any of its input or output connections or any of the circuits.

5.4 Input and output requirements

5.4.1 The equipment shall provide the interfaces of data control/configuration receivers;

5.4.2 The output of the equipment shall meet the following requirements:

(1) Provide at least 2 output ports, through which such information as positions, UTC, COG, SOG and alerts can be sent to other equipment. The position output shall be based on the WGS 84 datum or the CGCS 2000 datum and comply with the requirements of IEC 61162.

(2) Provide at least one normally closed contact, which shall indicate the faults in a receiver;

(3) Provide a two-way communication interface in line with the requirements of IEC 61162, through which the alerts can be transmitted to an external system and the audible alerts from the receiver can be confirmed from the external system;

(4) Provide the facilities processing the data input into the receiver according to ITU-R standards and appropriate RTCM standards and indicating whether the received signals are being used for ship positioning.

5.4.3 The reporting sentences for PNT shall be in accordance with the requirements of IEC61162, and the following sentences shall be used:

DTM – Datum reference system

GBS – GNSS satellite fault detection

GFA – GNSS fix accuracy and integrity

GNS - GNSS fix data

RMC – Recommended minimum specific GNSS data

ZDA – Time and date

If the WGS-84 coordinates are not used to the sentences, the DTM sentences shall be used in accordance with the requirements of IEC 61162.

5.4.4 The reporting sentences for alarms shall be in accordance with the requirements of IEC61162, and the following sentences shall be used:

ALR - Set alarm state

ACK – Acknowledge alarm

In addition, in order to integrate with other navigational aids, the following sentences may also be provided:

GRS – GNSS range residuals

GSA – GNSS DOP and active satellites

GST – GNSS pseudorange error statistics

GSV – GNSS satellites in view

Note: The GBS, GRS, GSA, GST and GSV sentences shall support the external integrity checkout and synchronize with the corresponding fix data (GNS).

6 Materials and components

Materials and components are to comply with relevant requirements of CCS Rules.

7 Type approval and unit/batch testing

7.1 Principles

The equipment is subject to the type approval of CCS. The issuance, retention, revision, renewal and abolishment of the type approval certificates shall be in accordance with Chapter 3, Volume 1 of the Rules for Classification of Sea-going Steel Ships.

7.2 Selection of typical samples and test arrangement

The models and specifications of the test samples shall be technologically representative, covering all the products for which the applications for type approval are submitted. The test samples shall be sampled by the surveyors of CCS at the site of the product manufacturer.

7.3 Testing agency

The type approval tests shall be carried out by an authorized impartial testing agency approved by CCS and certified by international/national laboratories. If the manufacturer is provided with the required testing conditions, some test items, except for the Beidou performance test, may be

carried out at the premise of the manufacturer upon the review and approval of the surveyors of CCS and under their supervision on the site.

When determining the testing agency, the testing conditions necessary for the test items as specified in IEC 61108 shall be fully taken into account and the written documents shall be submitted and reviewed by the surveyors of CCS.

7.4 Items and requirements of type approval test

The type approval test items are as shown in the tables below.

Environment conditions test items specified in IEC60945 Table 7.4 (1)

S/N	Test item	Test method	Remarks
1.	Ergonomics and HMI inspection	IEC 60945, 6.1	May be combined with the performance test
2.	Hardware	IEC 60945, 6.2	May be combined with the performance test
3.	Software	IEC 60945, 6.3	May be combined with the performance test
4.	Connection between units	IEC 60945, 6.4	May be combined with the performance test
5.	Extreme power supply variation test	IEC 60945, 7.1	Normal test temperature
6.	Excess power supply conditions	IEC 60945, 7.2	
7.	Dry heat, including extreme power supply conditions	IEC 60945, 8.2 & 7.1	
8.	Damp heat	IEC 60945, 8.3	
9.	Low temperature, including extreme power supply conditions	IEC 60945, 8.4 & 7.1	
10.	Vibration test	IEC 60945, 8.7	
11.	Antenna part rainfall and water test	IEC 60945, 8.8	
12.	Salt mist test	IEC 60945, 8.12	Not required if the materials are provided by the manufacturer.
13.	Conducted emission test	IEC 60945, 9.2	
14.	Test of radiated emissions from enclosure ports	IEC 60945, 9.3	
15.	Immunity to conducted disturbances induced by radio-frequency fields	IEC 60945, 10.3	
16.	Radio-frequency electromagnetic field immunity	IEC 60945, 10.4	

Continued Table 7.4 (1)

S/N	Test item	Test method	Remarks
17.	Electrical Fast Transient Immunity	IEC 60945, 10.5	
18.	Surge Immunity	IEC 60945, 10.6	
19.	Power supply short-term variation immunity	IEC 60945, 10.7	
20.	Power failure immunity	IEC 60945, 10.8	
21.	Electrostatic discharge immunity	IEC 60945, 10.9	
22.	Noise and audible signals	IEC 60945, 11.1	
23.	Magnetic compass safe distance	IEC 60945, 11.2	
24.	Insulation of dangerous voltage	IEC 60945, 12.1	The IP rating of the enclosures of the equipment installed in cabins shall be at least IP20.
25.	Emissions from visual display units (VDU)	IEC 60945, 12.3	Not required for LCD screens.
26.	Withstand voltage test	Article 2.14 of GD22-2015	Complete machine test (only applicable to the power supply units above 50V)
27.	Measurement of insulation resistance	Article 2.3 of GD22-2015	
The performance inspection/test items combined with the environment conditions test shall be carried out according to the following steps: • Start the equipment from its initial state (cold start); • Check the receiver acquisition time; • Check and verify the normal signal tracking, continuous output of valid fix results and normal navigation of the receiver.			

Equipment function and performance test items **Table 7.4 (2)**

S/N	**Test item**	**GPS signal processing test**	**GLONASS signal processing test**	**GALILEO signal processing test**	**BDS signal processing test**	**Remarks**
1.	Function test	Refer to the requirements as specified in 5.2 of this guideline.				Functions of the complete machine
2.	Ship position output inspection	Clause 5.6.2 of IEC 61108-1: 2003	Clause 5.6.2 of IEC 61108-2:1998	Clause 5.6.2 of IEC 61108-3: 2010	Annex 1, Clause 3	Document review

Continued Table 7.4(2)

S/N	Test item	GPS signal processing test	GLONASS signal processing test	GALILEO signal processing test	BDS signal processing test	Remarks
3.	Interfaces with other devices and output test	Clause 5.6.3 of IEC 61108-1: 2003	Clause 5.6.3 of IEC 61108-2:1998	Clause 5.6.3 of IEC 61108-3: 2010	Annex 1, Clause 3	The specific inspection and test items shall be determined in accordance with the IEC61162 series standards on which the interfaces are based.
4.	Accuracy test	Clause 5.6.4 of IEC 61108-1: 2003	Clause 5.6.4 of IEC 61108-2:1998	Clause 5.6.4 of IEC 61108-3: 2010	Annex 1, Clause 4	Pay attention to the test conditions; the reference points and antenna oscillators are required.
5.	Acquisition test	Clause 5.6.5 of IEC 61108-1: 2003	Clause 5.6.5 of IEC 61108-2:1998	Clause 5.6.5 of IEC 61108-3: 2010	Annex 1, Clause 5	—
6.	Connection of antenna to input/output	Clause 5.6.6 of IEC 61108-1: 2003	Clause 5.6.6 of IEC 61108-2:1998	Clause 5.6.6 of IEC 61108-3: 2010	Annex 1, Clause 6	—
7.	Antenna installation	Clause 5.6.7 of IEC 61108-1: 2003	Clause 5.6.7 of IEC 61108-2:1998	Clause 5.6.7 of IEC 61108-3: 2010	Annex 1, Clause 7	Document review
8.	Sensitivity and dynamic range	Clause 5.6.8 of IEC 61108-1: 2003	Clause 5.6.8 of IEC 61108-2:1998	Clause 5.6.8 of IEC 61108-3: 2010	Annex 1, Clause 8	The special microwave anechoic chambers and signal simulators are required.
9.	Special interfering signal disturbance	Clause 5.6.9 of IEC 61108-1: 2003	Clause 5.6.9 of IEC 61108-2:1998	Clause 5.6.9 of IEC 61108-3: 2010	Annex 1, Clause 9	The signal simulators and S frequency band radars are required.

Continued Table 7.4(2)

S/N	Test item	GPS signal processing test	GLONASS signal processing test	GALILEO signal processing test	BDS signal processing test	Remarks
10.	Position update	Clause 5.6.10 of IEC 61108-1: 2003	Clause 5.6.10 of IEC 61108-2:1998	Clause 5.6.10 of IEC 61108-3: 2010	Annex 1, Clause 10	
11.	Input of the differential navigation satellite system	Clause 5.6.11 of IEC 61108-1: 2003	Clause 5.6.12 of IEC 61108-2:1998	Clause 5.6.11 of IEC 61108-3: 2010	Annex 1, Clause 11	Document review
12.	Fault alarm and status indication	Clause 5.6.12 of IEC 61108-1: 2003	Clause 5.6.11 of IEC 61108-2:1998	Clause 5.6.12 of IEC 61108-3: 2010	Annex 1, Clause 12	
13.	COG and SOG output	Clause 5.6.13 of IEC 61108-1: 2003		Clauses 5.6.13 and 5.6.14 of IEC 61108-3: 2010	Annex 1, Clause 13	
14.	UTC output	Clause 5.6.14 of IEC 61108-1: 2003		Clause 5.6.15 of IEC 61108-3: 2010	Annex 1, Clause 13	—
15.	Performance test under typical interference conditions	Clause 5.7 of IEC 61108-1: 2003		Clause 5.7 of IEC 61108-3: 2010	Annex 1, Clause 14	The special microwave anechoic chambers and signal simulators are required.
16.	Presentation of navigation-related information	Clauses 4 and 7 of IEC62288-2014				The tests as specified in Clause 4 may be combined with the performance test.

7.5 Single-piece/batch testing

Before the delivery from the factory, the single-piece/batch testing shall be performed and the certificates of marine products shall be issued.

After the type approval, the manufacturer shall, according to the quality control documents submitted for approval, control the production and testing processes of the products, perform the specified delivery test on every marine product and issue the delivery test reports. The surveyors

of CCS shall, on the basis of the review of delivery test reports, sample for testing at the rate of 5%, but no less than two sets. The single-piece/batch testing shall at least include the following items:

- Data verification of main components (parts)
- Software version confirmation
- Visual inspection
- Function verification tests: multi-system switch, display function, fault alarm, status indication and acquisition tests;
- Performance test: fix accuracy;

If the surveyors deem necessary, the test items and sample quantity shall be added.

Annex 1 Testing Methods and Required Test Results of the Beidou Navigation Satellite System (BDS)

1 For the BDS receiver equipment, the composition and quality assurance of the equipment under test (EUT) shall be checked against the documents provided by the manufacturer.

2 For the general requirements, the type of received signals, coordinate system and time reference shall be checked against the documents provided by the manufacturer.

3 The equipment output shall be verified whether it is in line with IEC 61162 by checking against the documents provided by the manufacturer and carrying out the protocol tests.

4 Accuracy

4.1 Static test

4.1.1 BDS

The test shall last for more than 24 h. The absolute horizontal fix accuracy shall be within 25 m, and the vertical fix accuracy shall be within 30 m (95% confidence level). The measurement data of HDOP≥4 and PDOP≥6 shall not be used.

4.1.2 Differential BDS

The test shall last for more than 24 h. The horizontal fix accuracy shall be within 10 m (95% confidence level). The measurement data of HDOP≥4 and PDOP≥6 shall not be used. The horizontal accuracy of the antenna used to compare with the fix data and generate the differential correction data shall be better than 0.1 m.

4.1.3 During the antenna angle movement test, at the time of ±22.5° angle movement (rolling simulation) of the antenna at the interval of about 8s (refer to IEC60721-3-6), the static tests as specified in 4.1.1 and 4.1.2 shall be repeated.

The results shall be as specified in 4.1.1 and 4.1.2.

4.2 Dynamic test

4.2.1 BDS

The dynamic accuracy test shall be carried out according to the conditions listed in the X direction

(vertical) and the Y direction (horizontal) in Table 5e) of IEC 60721-3-6. For all levels of environmental tests, the longitudinal acceleration is $5m/s^2$ and the lateral acceleration is $6m/s^2$.

A BDS signal simulator with the required properties shall be used for the dynamic accuracy test.

The BDS signal simulator shall generate the correct signals according to the following dynamic scenarios:

(1) When a properly installed and fixed EUT with locked signals sails straightly at the speed of 48kn ±2kn for at least 1min~2min, and speeds down to 0 in 5s along the same straight line;

(2) When a properly installed and fixed EUT with locked signals sails along a straight line at the speed of 24kn±1kn for at least 100m, and deviates evenly within 2m at both sides of the line at the interval of 11s～12s in at least 2min.

In the two dynamic scenarios above, the receiver shall maintain the signals locked. The errors between the positions output by the receiver and the positions programmed by the simulator shall not exceed the requirements specified in 4.1.1.

4.2.2 Differential BDS

The basis and scenarios of the differential BDS dynamic accuracy test is the same as those specified in 4.2.1.

A BDS signal simulator with the properties required for the DBDS accuracy test shall be used for the dynamic accuracy test and shall generate the DBDS broadcast signals in accordance with the ITU-R M.823 and related RTCM standards.

In the two dynamic scenarios as specified in 4.2.1, the receiver shall maintain the signals locked. The errors between the positions output by the receiver and the positions programmed by the simulator shall not exceed the requirements specified in 4.1.2.

5 Acquisition

5.1 State A - initial state

The initial state of the EUT shall be any of the following states:

(1) The initial position is set as a pseudo-position at least 1000km away from the test position, or the current satellite almanac data is deleted; or

(2) The power is disconnected for over 7d; or

(3) A BDS signal simulator is used to simulate the above scenarios, with the number of days being over 7d and the distance being more than 1000 km.

After the periods specified in Table 5, the performance test shall be carried out.

Acquisition time limits **Table 5**

Equipment state	A	B	C
Acquisition time limit (min)	12	1	1

5.2 State B - equipment shutdown and/or BDS signal receiving interrupted:

(1) Power off the EUT for the duration of 24h~25h;

(2) During the normal operation of the EUT, fully shield the antenna for the duration of 24h~25h.

After (1) and (2), resume the normal operation of the EUT and carry out the performance test after the periods specified in Table 5.

5.3 State C - temporary power interruption

During the normal operation of the EUT, power off for 60s and then resume the power supply.

After the periods specified in Table 5, the performance test shall be carried out.

6 Connection of antenna to input/output

If the equipment is provided a receiver antenna input terminal, it shall be earthed for 5min. After the test is completed, reset the EUT (if necessary) and properly connect the antenna or input/output interface. Carry out the performance test and verify there is no permanent damage.

7 Antenna installation

Check the antenna of the EUT against the technical documents provided by the manufacturer and verify whether it is suitable to be mounted on board, so as to ensure the clearance conditions required for receiving the satellite signals.

8 Sensitivity and dynamic range

8.1 Acquisition sensitivity

A BDS signal simulator shall be used and a radio test shall be carried out.

(1) The simulator shall transmit signals through an appropriate antenna;

(2) Adjust the output signal strength of the simulator and maintain the level of received signals at −125 dBm±5 dBm under the monitoring of the calibrating receiver;

(3) Replace the calibrating receiver and the antenna with the EUT;

(4) Carry out the performance test.

The EUT shall be in line with the performance requirements within the signal coverage.

8.2 Tracking sensitivity

When the level of the received satellite signals is −133 dBm, the equipment shall be in line with the tracking performance requirements.

A BDS signal simulator shall be used and a radio test shall be carried out.

(1) The simulator shall transmit signals through an appropriate antenna;

(2) Adjust the output signal strength of the simulator and maintain the level of received signals at −125 dBm±5 dBm under the monitoring of the calibrating receiver;

(3) Replace the calibrating receiver and the antenna with the EUT;

(4) Once the EUT starts the normal tracking, gradually decrease the transmitting power to −133 dBm.

The EUT shall keep tracking at least 4 satellites and output valid fix results.

9 Disturbance of special interfering signals

9.1 L band interference

In the normal working state, impose the signals by using the signal sources on the EUT for 10 min, with the frequency of 1636.5 MHz and the power flux density of 3 W/m^2.

Within 5min after the removal of the interfering signals, the equipment shall be in line with the performance inspection requirements.

9.2 S band interference

In the normal working state, impose 10 pulse train signals by using the signal sources on the EUT at the interval of 3s for 10 min, with the pulse width of 1.0 μs~1.5 μs, the duty ratio per cycle of 1600:1, the frequency of 2.9 GHz~3.1 GHz and the power flux density of 7.5 kW/m^2.

Note: The power flux density peak value measured at the EUT is 7.5 kW/m^2, equivalent to the average power flux density of 4.7 W/m^2 at the fixed radiation pattern antenna.

Within 5min after the removal of the interfering signals, the equipment shall be in line with the performance inspection requirements.

10 Position update

10.1 Slow update rate

The EUT shall be placed on a platform, moving along a nearly straight line at the speed of 5 ± 1 kn. The position data output by the EUT shall be checked every 10s, lasting above 10min. The update(s) of the output position data shall be observed during each check.

A BDS signal simulator may be used for the test.

10.2 Fast update rate

The EUT shall be placed on a platform, moving along a nearly straight line at the speed of 50 ± 5 kn. The position data output by the EUT shall be checked every 10s, lasting above 10min. The update(s) of the output position data shall be observed during each check.

During the test, a simulator may be used to transmit the signals with the simulation speed of 70kn, in which case the position update cycle of the EUT shall be 0.5s.

During the tests as specified in 10.1 and 10.2, observe and verify whether the minimum resolution of the latitudes and longitudes of the position data is conforming.

During the test, record the output values generated by the EUT as per the IEC 61162 and verify whether the recorded position data is consistent with the true position data or the position data referenced by the simulator.

11 Differential BDS input

Check the following items against the technical documents provided by the manufacturer:

11.1 Verify that the EUT processes the following communication protocols properly:

(1) The recommended standards of RTCM on differential BDS;

(2) The differential correction requirements for marine radio beacons as specified in ITU-R M.823.

11.2 Verify that:

(1) An indication is presented when receiving a DBDS signal;

(2) An indication is presented when outputting a corrected DBDS ship position data.

12 Fault alarm and status indication

12.1 General alarm tests

12.1.1 Positioning alarm test

A BDS signal simulator shall be used for the test. The test procedures are as follows:

(1) Place the EUT under the simulation environment with the horizontal dilution of precision HDOP<4;

(2) Turn off the signal output of the simulator and observe the EUT, which shall give an appropriate indication in 5s;

(3) Verify that the navigation alarm indicator shows "unsafe";

(4) Verify that the last fix data and its time stamp indicate the "losing position" status. Verify that under such conditions, the display and the output interface remain the aforesaid mode;

(5) Turn on the simulator to send signals, observe and verify that the EUT resumes the normal operation.

12.1.2 Differential BDS status presentation test

A BDS signal simulator shall be used for the test. The test procedures are as follows:

(1) Place the EUT under the simulation environment with the horizontal dilution of precision HDOP<4. Observe the EUT, which shall indicate no DBDS correction;

(2) Set the differential correction period of the EUT as 30s;

(3) Start to send the differential test signal A, observe and verify the EUT indicates the DBDS status within 40s;

(4) Stop to send the differential test signal A, observe and verify the EUT resumes the normal operation and indicates no DBDS correction within 40s.

12.2 Integrity monitoring test based on RAIM

To test the RAIM function, the real-time display of the fix errors relative to the simulation positions is recommended during the test.

12.2.1 "Safe" and "alarm" status test

Place the EUT under the environment where a BDS signal simulator is used and provide 6 serviceable active satellites that have been acquired and tracked. The test procedures are as follows:

(1) Select the precision level of 100m;

(2) Observe the EUT, which shall:

① Indicate the RAIM is "in operation"; and

② Indicate the "safe" status;

(3) Gradually reduce the quantity of serviceable active satellites until the EUT indicates the "warning" status and observe the EUT, which shall:

① Continue to indicate the RAIM is "in operation"; and

② Switch to the "warning" status within 10s after the satellite quantity is reduced;

(4) Increase the quantity of serviceable active satellites until the RAIM status indicated by the EUT becomes to the "safe" status and observe the EUT, which shall:

① Continue to indicate the RAIM is "in operation"; and

② Indicate the "safe" status within 2min after the increase of the satellite quantity. During each step, verify whether the interface provides the appropriate output.

Select the precision level of 10m and other precision levels (if applicable) and repeat the test according to the above steps.

12.2.2 "Unsafe" status test

Place the EUT under the environment where a BDS signal simulator is used and provide 6 serviceable active satellites that have been acquired and tracked. The test procedures are as follows:

(1) Select the precision level of 100m;

(2) Observe the EUT, which shall:

① Indicate the RAIM is "in operation"; and

② Indicate the "safe" status;

(3) Change the clock(s) of at least one satellite to gradually decrease the fix accuracy such that the confidence level at the selected precision level is below 95%. Observe the EUT, which shall:

① Continue to indicate the RAIM is "in operation"; and

② Switch to the "unsafe" status within 10s after the fix error exceeds the selected precision level;

(4) Restore the satellite clock(s) to the original qualified status so that the confidence level of the fix accuracy reaches 95% as required. Observe the EUT, which shall:

① Continue to indicate the RAIM is "in operation"; and

② Switch to the "safe" status within 2 min.

During each step, verify whether the interface provides the appropriate output.

Select the precision level of 10m and other precision levels (if applicable) and repeat the test

according to the above steps.

12.3 Self-test

Check the self-test function of the EUT against the documents provided by the manufacturer.

13 COG, SOG and UTC output information

13.1 COG and SOG accuracy

Place the EUT under the environment where a mobile unit or a BDS signal simulator is used and monitor all the COG output.

Set the EUT as sailing at the constant speed of 0~1kn. After 10 s, keep measuring for 2min. Test all the speed ranges listed in Table 2 in the same steps.

The test results shall be presented on a display or an approved interface.

For the SOG test, the errors between the speed readings and the actual speeds shall not exceed 2% or 0.2kn (whichever is larger).

For the COG test, the errors between the measured values and the reference values shall not exceed the limits listed in Table 2.

13.2 SOG and COG information validity test

Note: The COG and SOG validity shall be demonstrated through the model indications and navigation status indications of the GNS and VTG sentences as specified in IEC 61162.

Check the digital interfaces in accordance with IEC 61162. During the normal operation of the EUT, reduce the quantity of satellites received to generate invalid fix data. Check the contents of GNS and VTG sentences.

According to IEC 61162, check and verify the model indications and navigation status indications of the GNS and VTG sentences are "invalid" and the COG and SOG information in the VTG sentences becomes blank.

13.3 UTC information validity test

Check the digital interfaces in accordance with IEC 61162. During the operation of the EUT, reduce the quantity of satellites received to 2 satellites to generate invalid fix data. Check the

contents of GNS and ZDA sentences.

Check the UTC information resolution of the ZDA sentences according to IEC 61162. Check and verify that the validity indications of the GNS sentences are "invalid" and the ZDA sentences keep transmitting the complete UTC information.

14 Typical interference conditions

14.1 Simulator conditions. The settings of the BDS signal simulator are as follows:

(1) 6 BDS satellites;

(2) One of the satellites is set at the maximum level, i.e., –120 dBm, with the antenna gain at the elevation angle of 90°;

(3) One of the satellites is set at the minimum level, i.e., –130 dBm, with the antenna gain at the elevation angle of 5°;

(4) The rest four satellites are set at the level of –127 dBm, with the antenna gain at the elevation angle of 45°;

14.2 Navigation accuracy test

The interference conditions include the narrowband and wideband RF noise with the center frequency of 1.561,098MHz and continuous wave and impulse interference, which shall be imposed on the BDS receiver by the RF noise sources.

For the impulse interference test, the impulses shall be modulated onto the carrier waves, with the carrier peak level being -20dBm and the duty ratio being 10%. See Table 14.2 for the setting of interference parameters.

RF interference values **Table 14.2**

Narrowband/wideband interference (NBI/WBI) values		
Frequency (in MHz)	Noise signal bandwidth (in MHz)	Total RMS power (in dBm)
1561.098	1	-101.0

Impulse interference value (duty ratio: 10%)		
Frequency (in MHz)	Pulse width (in ms)	Carrier peak level (in dBm)
1561.098	1	-20

Continued Table 14.2

Continuous wave interference (CWI) value	
Frequency (in MHz)	Power (in dBm)
1561.098	-120.5

The test procedures are as follows:

(1) Impose the interference on the EUT;

(2) Set the simulator scenario and start to send the satellite signals;

(3) Ensure the EUT has been powered on and initialized;

(4) When the EUT is outputting the fix results, impose the interference on the EUT, with the strength of the interfering signals adjusted to the required value;

(5) When reaching the stable accuracy, sample and record the fix data of the EUT and the HDOP values every 2min and record at least 20 groups of data;

(6) Repeat the above steps for each type of interference.

For the static fix accuracy, if the times of the existence of fix out-of-tolerance (confidence level 95%) or positioning failure of the EUT account for more than 5% in the total sampling records, the EUT is deemed to fail the test.

14.3 Reacquisition test

The reacquisition test is to simulate the temporary loss of satellite signals (such as when blocked by a bridge). The criterion of the reacquisition test is as follows: In a single test, if the EUT provides valid fix data within 30s after the satellite signals are resumed with the required fix accuracy and maintains the tracking status in at least the following 60s, the equipment is deemed to pass the reacquisition test.

The interference conditions include the narrowband and wideband noise, as shown in Table 14.2.

The test procedures are as follows:

(1) Impose the interference on the EUT;

(2) Set the simulator scenario and start to send the satellite signals;

(3) Ensure the EUT has been powered on and initialized;

(4) Before shutting off the satellite signals, ensure the EUT reaches the stable precision;

(5) Shut off the RF output of the simulator for 30s;

(6) Resume the RF signal output of the simulator to the EUT;

(7) Record the fix data output by the EUT and the HDOP value after 30s. If the EUT fails to output any fix results after 30s, record as test failed and jump to step (9).

(8) Verify that the receiver under test continuously outputs the fix results in the following 60s;

(9) Jump to step (4) and repeat the test as required; (Note: If the simulator scenario is reset, some receivers may have to clear all the existing data for the sake of normal operation. This is because that the time data of the previous scenario is store in these receivers, and the receiver software is not able to perform the backward conversion of time after the scenario reset.)

(10) Repeat the above steps for each type of interference.

The equipment shall be deemed to fail the test in any of the following case: the EUT fails to output any fix results after 30s; or the static fix accuracy of the EUT is out of tolerance (confidence level 95%); or the EUT fails to continuously output the fix results within 60s after the acquisition and indicates the failure mode with a sample.

Annex 2 Performance Standards for Shipborne GALILEO Receiver Equipment

1 GALILEO receiver equipment

1.1 The GALILEO receiver equipment shall be provided with at least the following devices:

(1) antenna capable of receiving Galileo signals;;

(2) A GALILEO receiver and processor;

(3) means of accessing the computed latitude/longitude position;;

(4) Data controls and interfaces; and

(5) position display and, if required, other forms of output.

Note: If the GALILEO forms part of an approved integrated navigation system, the devices specified in (3), (4) and (5) may be provided within the INS.

1.2 The antenna design should be suitable for fitting at a position on the ship which ensures a clear view of the satellite constellation, taking into consideration any obstructions that might exist on the ship.

2 Performance standards for GALILEO receiver equipment

2.1 The GALILEO receiver equipment shall:

2.1.1 Be capable of receiving and processing the GALILEO PVT signals on:

(1) For a single-frequency receiver, the L1 frequency shall be used. The receiver shall broadcast its ionosphere models by using the satellite constellations to generate the ionosphere correction;

(2) For a dual-frequency receiver, the L1 and E5b frequencies or L1 and E5a frequencies shall be used. The receiver shall use the doal frequency processing and generating the ionosphere corrections;

2.1.2 Provide the position information in latitudes and longitudes (in degrees, minutes, and per mil minute);

2.1.3 Provide the time referenced to the UTC (BIPM);

2.1.4 Provide at least 2 output ports, through which such information as positions, UTC, COG, SOG and alerts can be supplied to other equipment. The position information output shall be based on the WGS 84 datum and comply with related international standards. The output of UTC, COG, SOG and alerts shall be consistent with the requirements of 2.1.16 and 2.1.18;

2.1.5 Have the static accuracy such that the antenna position may be determined within the following scopes:

(1) Within 15m (95%) in the horizontal direction and 35 m (95%) in the vertical direction for the single-frequency operation on the L1 frequency;

(2) Within 10m (95%) in both the horizontal and vertical directions for the dual-frequency operation on the L1 and E5a frequencies or L1 and E5b frequencies;

2.1.6 Have the level of dynamic accuracy equivalent to the static accuracy specified 2.1.5 according to the sea conditions and ship motions;

2.1.7 Have the position resolution equal to or better than the latitude and accuracy of 0.001 minute;

2.1.8 Have the time service accuracy and can determine the time within 50ns of UTC;

2.1.9 Be capable of automatically selecting the appropriate satellite transmission signals to determine the ship position, speed and time, with the required accuracy and update rate;

2.1.10 Be capable of acquiring the satellite signals, with the carrier level of input signals being -128 dBm to -118 dBm. Once the satellite signals are acquired and the carrier level of satellite signals drops to -131 dBm, the equipment shall continue to run satisfactorily;

2.1.11 Be capable of operating satisfactorily under the normal interference conditions as specified in the Resolution A.694 (17);

2.1.12 Be capable of acquiring the position, speed and time information with the required accuracy within 5 min where there is no valid satellite almanac data (cold start);

2.1.13 Be capable of acquiring the position, speed and time information with the required accuracy within 1 min where there is valid satellite almanac data (warm start);

2.1.14 Be capable of acquiring the position, speed and time information with the required accuracy within 1 min when subjected to a service interruption of 60s or less;

2.1.15 Be capable of generating a new position solution and output it to a display and digital interface at least once every 1s for conventional vessels and at least once every 0.5s for HSC;

2.1.16 Provide COG, SOG and UTC output, with the validity indications consistent with those of the position output. The accuracy of COG and SOG shall not be below the related performance standards for the heading, speed and distance measuring equipment, and the accuracy required under all sorts of dynamic conditions that might be encountered on board shall be provided;

2.1.17 Provide at least one normally closed contact, which shall indicate the faults in the receiver equipment;

2.1.18 Provide a two-way communication interface in line with related international standards, through which the alerts can be transmitted to an external system and the audible alerts from the GALILEO receiver can be confirmed from the external system;

2.1.19 Provide the facilities processing the differential GALILEO (DGALILEO) data according to ITU-R standards and appropriate RTCM standards and indicating the receipt of DGALILEO signals and whether they are being used for ship positions.

3 Integrity inspection, fault alarm and status indication

3.1 The GALILEO receiver equipment shall also indicate whether the performance of the GALILEO is beyond the general navigation requirements for the inland segments of the ocean-going routes, coastal routes, the routes in approach channels and restricted waters and those specified in Resolution A.953 (23) or Resolution A. 915 (22), Annex 2 and the subsequent amendments. The GALILEO receiver equipment shall at least:

3.1.1 Give an alarm within 5s after the position loss, or when it fails to calculate the new positions based on the information provided by the GALILEO satellite constellations after 1s for conventional vessels and after 0.5s for HSC. In this case, the last known position and the time of the last valid fix, with the explicit indication of this state so that no ambiguity can exist, shall be output until the normal operation is resumed;

3.1.2 Use the RAIM to e provide the provide integrity performance appropriate to the operation being undertaken;

3.1.3 Provide the self-test function.

3.2 For a receiver capable of processing the GALILEO safety of life service, the integrity monitoring and alert algorithm shall be based on the appropriate combination of the GALILEO

integrity information and RAIM. If the period beyond the horizontal alert limit (HAL) of 25m is at least 3s, the receiver shall provide an alarm within the time to alarm (TTA) of 10s upon the occurrence of the event. The probability of events shall be higher than 99.999% within 3h (integrity risks ≤ 10-5/3 h).

4 Protection

The appropriate preventive measures shall be taken to ensure that no permanent damage can result from an accident short circuit or grounding of the antenna or any of its input or output connections or any of the inputs or outputs of the GALILEO receiver equipment lasting 5min or less.