IEC 61108-1

Edition 2.0 2003-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) –
Part 1: Global positioning system (GPS) – Receiver equipment – Performance standards, methods of testing and required test results

Matériels et systèmes de navigation et de radiocommunication maritimes – Système mondial de navigation par satellite (GNSS) –
Partie 1: Système de positionnement par satellite GPS – Matériel de réception – Normes de fonctionnement, méthodes d'essai et résultats d'essai exigibles

IEC 61108-1:2003

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS) –

Part 1: Global positioning system (GPS) – Receiver equipment – Performance standards, methods of testing and required test results

FOREWORD

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International Standard IEC 61108-1 has been prepared by IEC technical committee 80: Maritime navigation and radiocommunication equipment and systems.

This second edition cancels and replaces the first edition published in 1996.

This edition of the IEC standard for GPS, compared to the previous edition, includes the following technical changes:

a) it reflects the changes brought about by IMO adopting GPS as part of the carriage requirement on ships defined in SOLAS Chapter V;

b) the new IMO performance standard, resolution MSC.112(73), replaced the previous issue, A.819(19), for new installations on the 1st of July 2002. This second edition of IEC 61108-1 incorporates revised tests for type approvals to the new performance standard;

c) changes include the need for a data output to the IEC 61162 series giving COG SOG and UTC with validity marking, operation during interference conditions and improved failure warnings.

This bilingual version (2013-01) corresponds to the monolingual English version, published in 2003-07.

The text of this standard is based on the following documents:

FDIS	Report on voting
80/371/FDIS	80/373/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS) –

Part 1: Global positioning system (GPS) – Receiver equipment – Performance standards, methods of testing and required test results

1 Scope

This part of IEC 61108 specifies the minimum performance standards, methods of testing and required test results for GPS shipborne receiver equipment, based on IMO Resolution MSC.112(73), which uses the signals from the United States of America, Department of Defence (US DOD), Global Positioning System (GPS) in order to determine position. A description of the GPS SPS is given in the normative reference – GPS, SPS signal specification – USA Department of Defence – 3rd Edition October 2001. This receiver standard applies to phases of the voyage "other waters" as defined in IMO Resolution A.529(13).

All text of this standard, whose meaning is identical to that in IMO Resolution MSC.112(73), is printed in *italics* and the Resolution and paragraph number indicated between brackets i.e. (M.112/A1.2).

The requirements in clause 4 are cross-referenced to the tests in clause 5 and vice versa.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60721-3-6:1987, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Ship environment*

IEC 60945, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 61162 (all parts), *Maritime navigation and radiocommunication equipment and systems – Digital interfaces*

IMO Resolution A.529(13):1983, *Accuracy standards for navigation*

IMO Resolution A.694(17):1991, *General requirements for shipborne radio equipment forming part of the Global maritime distress and safety system (GMDSS) and for electronic navigational aids*

IMO Resolution A.815(19):1995, *Worldwide radionavigation system*

IMO Resolution MSC.112(73):2000, *Performance standards for shipborne global positioning system (GPS) receiver equipment*

IMO Resolution MSC.114(73):2000, *Performance standards for shipborne DGPS and DGLONASS maritime radio beacon receiver equipment*

ITU-R Recommendation M.823-1:1995, *Technical characteristics of differential transmissions for global navigation satellite systems (GNSS) from maritime radio beacons in the frequency band 285 kHz-325 kHz (283,5 kHz-315 kHz in Region 1)*

ITU-R Recommendation M.823-2:1997, *Technical characteristics of differential transmissions for Global Navigation Satellite Systems from maritime radio beacons in the frequency band 283.5-315 kHz in Region 1 and 285-325 kHz in Regions 2 and 3*

ITU-R Recommendation M.1477:2000, *Technical and performance characteristics of current and planned radionavigation-satellite service (space-to-Earth) and aeronautical radio-navigation service receivers to be considered in interference studies in the band 1 559-1 610 MHz*

Global Positioning System – Standard Positioning Service – Performance Specification – USA Department of Defence – 3rd Edition October 2001

3 Terms, definitions and abbreviations

For the purposes of this document, all definitions and abbreviations used are the same as those used in the normative reference of the GPS SPS performance signal specification.

3.1 Definitions

3.1.1
integrity
ability of the system to provide users with warnings within a specified time when the system should not be used for navigation

3.2 Abbreviations

COG – Course Over Ground

DGPS – Differential Global Positioning System

GPS – Global Positioning System

HDOP – Horizontal Dilution Of Precision

PDOP – Position Dilution Of Precision

RAIM – Receiver Autonomous Integrity Monitor

SDME – Speed and Distance Measuring Equipment

SOG – Speed Over Ground

SPS – Standard Positioning Service

USNO – United States Naval Observatory

UTC – Universal Time Coordinated

4 Minimum performance standards

4.1 Object

(M.112/A1.2) *Receiver equipment for the Global Positioning System (GPS) system intended for navigational purposes on ships with maximum speeds not exceeding 70 knots* shall, *in addition to the general requirements contained in resolution A.694(17)*[1], *comply with the following minimum performance requirements.*

(M.112/A1.3) *This standard covers the basic requirements of position fixing for navigation purposes only and does not cover other computational facilities which may be* provided *in the equipment.*

This standard contains the basic minimum performance standards for use of GPS Standard Positioning Service (SPS) signals for navigational position fixing, including differential corrections, and, in addition, for the determination of speed and direction of the movement of the antenna over the ground.

Other computational activity, input/output activity or extra display functions which may be provided shall not degrade the performance of the equipment below the minimum performance standards set out in this standard.

The GPS receiver equipment shall comply with

– the provisions of IMO Resolutions A.529(13), A.815(19), MSC.112(73) and A.694(17),
– the accuracy requirements of the GPS SPS Performance Standard,
– IEC 61162-1, IEC 61162-2, as appropriate, on digital interfaces, and
– shall be tested in accordance with IEC 60945.

NOTE For high speed craft purposes the EUT has to provide an IEC 61162-2 interface with a position update rate of 2 Hz.

4.2 GPS receiver equipment

(See 5.6.1)

4.2.1 Minimum facilities

(M.112/A2.1) The words "GPS receiver equipment" as used in these performance standards include all the components and units necessary for the system to properly perform its intended functions. The equipment shall *include the following minimum facilities:*

a) *antenna capable of receiving GPS signals;*
b) *GPS receiver and processor;*
c) *means of accessing the computed latitude/longitude position;*
d) *data control and interface; and*
e) *position display and, if required, other forms of output.*

4.2.2 Configuration

The GPS receiver equipment may be supplied in one of several configurations to provide the necessary position information. Examples are:

---

1 Refer to Publication IEC 60945.

– stand-alone receiver with means of accessing computed position via a keyboard with the positional information suitably displayed;

– GPS black box receiver fed with operational parameters from external devices/remote locations and feeding an integrated system with means of access to the computed position via an appropriate interface, and the positional information available to at least one remote location.

The above examples should not be implied as limiting the scope of future development.

4.2.3 Quality assurance

The equipment shall be designed produced and documented by companies complying with approved quality systems as applicable.

4.3 Performance standards for GPS receiver equipment

4.3.1 General

(See 5.6.2)

(M.112/A3.1) *The GPS receiver equipment* shall *be capable of receiving and processing the Standard Positioning Service (SPS) and provide position information in latitude and longitude World Geodetic System (WGS-84) co-ordinates in degrees, minutes and thousandths of minutes and time of solution referenced to UTC (USNO). Means may be provided to transform the computed position based upon WGS-84 into data compatible with the datum of the navigational chart in use. Where this facility exists, the display shall indicate that co-ordinate conversion is being performed and* shall *identify the co-ordinate system in which the position is expressed.*

(M.112/A3.2) *The GPS receiver equipment* shall *operate on the L1 signal and C/A code*.

4.3.2 Equipment output

(See 5.6.3)

(M.112/A3.3) *The GPS receiver equipment* shall *be provided with at least one output from which position information can be supplied to other equipment. The output of position information based upon WGS-84 shall be in accordance with* International Standards – IEC 61162.

The position information output shall be in accordance with IEC 61162 as follows:

For positioning reporting purposes the following sentences shall be available in any combination.

DTM – Datum reference

GBS – GNSS satellite fault detection

GGA – GPS fix data

GNS – GNSS fix data

RMC – Recommended minimum specific GNSS data

VTG – Course over ground and ground speed

ZDA – Time and date

If a sentence uses a datum other than WGS-84 then the DTM sentence must be used in compliance with IEC 61162.

In addition, for integrating with other navigational aids the following sentences may be available in any combination.

GRS – GNSS range residuals

GSA – GNSS DOP and active satellites

GST – GNSS pseudorange error statistics

GSV – GNSS satellites in view

NOTE GRS, GSA, GST, GSV are required to support external integrity checking. They are to be synchronized with corresponding fix data (GGA or GNS).

4.3.3 Accuracy

(See 5.6.4)

4.3.3.1 Static accuracy

(M.112/A3.4) *The GPS receiver equipment* shall *have static accuracy such that the horizontal position of the antenna is determined to within 100 m (95 %) with horizontal dilution of precision (HDOP) ≤4 (or PDOP ≤6).* Since Selective Availability has been set to zero, the static accuracy has been determined to be within 13 m (95 %) as specified by the GPS SPS Performance Standards of October 2001.

4.3.3.2 Dynamic accuracy

(M.112/A3.5) *The GPS receiver equipment* shall *have dynamic accuracy such that the position of the ship is determined to within 100 m (95 %) with HDOP ≤ 4 (or PDOP ≤6) under the conditions of sea state and ship's motion likely to be experienced in ships.*[2] Since Selective Availability has been set to zero, the dynamic accuracy has been determined to be within 13 m (95 %) as specified by the GPS SPS Performance Standards of October 2001.

4.3.4 Acquisition

(See 5.6.5)

(M.112/A3.6) *The GPS receiver equipment* shall *be capable of selecting automatically the appropriate satellite transmitted signals for determination of the ship's position with the required accuracy and update rate.*

(M.112/A3.8) *The GPS receiver equipment* shall *be capable of acquiring position to the required accuracy, within 30 min, when there is no valid almanac data.*

(M.112/A3.9) *The GPS receiver equipment* shall *be capable of acquiring position to the required accuracy, within 5 min, when there is valid almanac data.*

(M.112/A3.10) *The GPS receiver equipment* shall *be capable of re-acquiring position to the required accuracy, within 5 min, when the GPS signals are interrupted for a period of at least 24 h, but there is no loss of power.*

(M.112/A3.11) *The GPS receiver equipment* shall *be capable of re-acquiring position to the required accuracy, within 2 min, when subjected to a power interruption of 60 s.*

Acquisition is defined as the processing of GPS satellite signals to obtain a position fix within the required accuracies.

Four conditions of the GPS receiver equipment are set out under which the minimum performance standards shall be met.

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2 IMO Resolution A.694 (17), IEC 60721-3-6 and IEC 60945.

Condition A

Initialization – the equipment has

– been transported over large distances (>1000 km to <10 000 km) without power or GPS signals or by the deletion of the current almanac; or

– not been powered for >7 days.

Condition B

Power outage: under normal operation the equipment loses power for at least 24 h.

Condition C

Interruption of GPS signal reception – under normal operation the GPS signal reception is interrupted for at least 24 h, but there is no loss of power.

Condition D

Brief interruption of power for 60 s.

No user action other than applying power and providing a clear view from the antenna for the GPS signals, shall be necessary, from any of the initial conditions above, in order to achieve the required acquisition time limits in Table 1.

Table 1 – Acquisition time limits

Equipment condition	A	B	C	D
Acquisition time limits (minutes)	30	5	5	2

4.3.5 Protection

(See 5.6.6)

4.3.5.1 Antenna and input/output connections

(M.112/A4) *Precautions* shall *be taken to ensure that no permanent damage can result from an accidental short circuit or grounding of the antenna or any of its input or output connections or any of the GPS receiver equipment inputs or outputs for a duration of 5 min.*

4.3.6 Antenna design

(See 5.6.7)

(M.112/A2.2) *The antenna design* shall *be suitable for fitting at a position on the ship which ensures a clear view of the satellite constellation*.

4.3.7 Dynamic range

(See 5.6.8)

(M.112/A3.7) *The GPS receiver equipment* shall *be capable of acquiring satellite signals with input signals having carrier levels in the range of –130 dBm to –120 dBm* as measured at the output of a 3 dBi linear polarized receiving antenna. *Once the satellite signals have been acquired the equipment* shall *continue to operate satisfactorily with satellite signals having carrier levels down to –133 dBm* as measured at the output of a 3 dBi linear polarized receiving antenna.

4.3.8 Effects of specific interfering signals

(See 5.6.9)

The GPS receiver equipment shall meet the following requirements:

a) In a normal operating mode, i.e. switched on and with antenna attached, it is subject to radiation of 3 W/m^2 at a frequency of 1636,5 MHz for 10 min. When the unwanted signal is removed and the GPS receiver antenna is exposed to the normal GPS satellite signals, the GPS receiver equipment shall calculate valid position fixes within 5 min without further operator intervention;

NOTE This is equivalent to exposing a GPS antenna to radiation from an INMARSAT-A antenna at 10 m distance along the bore sight.

b) In a normal operating mode, i.e. switched on, and with antenna attached, it is subject to radiation consisting of a burst of 10 pulses, each 1,0 μs to 1,5 μs long on a duty cycle of 1600:1 at a frequency lying between 2,9 GHz and 3,1 GHz at power density of about 7,5 kW/m^2. The condition shall be maintained for 10 min with the bursts of pulses repeated every 3 s. When the unwanted signal is removed and the GPS receiver antenna is exposed to the normal GPS satellite signals, the receiver shall calculate valid position fixes within 5 min without further operator intervention.

NOTE This condition is approximately equivalent to exposing the antenna to radiation from a 60 kW "S" Band marine radar operating at a nominal 1,2 μs pulse width at 600 pulses/s using a 4 m slot antenna rotating at 20 r/min with the GPS antenna placed in the plane of the bore site of the radar antenna at a distance of 10 m from the centre of rotation.

Advice shall be given in the manual for adequate installation of the antenna unit, to minimize interference with other radio equipment such as marine radars, Inmarsat SES's, etc.

4.3.9 Position update

(See 5.6.10)

(M.112/A3.12) *The GPS receiver equipment* shall *generate and output to a display and digital interface a new position solution at least once every 1 s.*

NOTE For craft meeting the HSC code, a new position solution at least every 0,5 s is recommended.

(M.112/A3.13) *The minimum resolution of position i.e. latitude and longitude* shall *be 0,001 min.*

4.3.10 Differential GPS input

(See 5.6.11)

(M.112/A3.15) *The GPS receiver equipment* shall *have the facilities to process differential GPS (DGPS) data fed to it in accordance with the standards of Recommendation ITU-R M.823 and an appropriate RTCM standard.*

When a GPS receiver is equipped with a differential receiver, performance standards for static and dynamic accuracies (M.112/A3.4 and A3.5) shall be 10 m (95 %) together with integrity monitoring.

An integrated DGPS receiver shall have an ITU-R M.823 compliant data output port for testing or alternatively, a possibility to display Word Error Rate (WER) on the integrated equipment. The WER is the number of incorrect ITU-R M.823 words in relation to total number of words received.

NOTE The standard for the differential GPS receiver is contained in IEC 61108-4 (Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) – Part 4: Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance requirements, methods of testing and required test results[3]).

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3 Under consideration.

4.3.11 Failure warnings and status indications

(See 5.6.12)

(M.112/A5.1) *The equipment* shall *provide an indication if the position calculated is likely to be outside of the requirements of these performance standards;*

4.3.11.1 General

(M.112/A5.2) *The GPS receiver equipment* shall *provide as a minimum*:

a) (M.112/A5.2.1) an indication within 5 s if either:

   1) *the specified HDOP has been exceeded; or*

   2) *a new position has not been calculated for more than 1 s;*

   NOTE For craft meeting the HSC Code, a new position solution at least every 0,5 s is recommended.

   3) *under such conditions the last known position and the time of the last valid fix, with explicit indication of this state, so that no ambiguity can exist,* shall *be output until normal operation is resumed;*

b) (M.112/A5.2.2) *a warning of loss of position; and*

c) (M.112/A5.2.3) *differential GPS status indication of*:

   1) *the receipt of DGPS signals; and*

   2) *whether DGPS corrections are being applied to the indicated ship's position*;

d) (M.112/A5.2.5) *DGPS text message display*. The GPS receiver either shall have as a minimum the capability of displaying appropriate DGPS text messages or forwarding those messages to for display on a remote system.

4.3.11.2 Integrity using RAIM

The GPS receiver equipment shall incorporate integrity monitoring using fault detection, for example receiver autonomous integrity monitoring (RAIM), or similar means to determine if accuracy is within the performance standards and provide an integrity indication.

An integrity indication shall be used to present the result of the integrity calculation with respect to the selected accuracy level appropriate for the vessels operational mode. According to IMO Resolution A.815 these accuracy levels shall be user selectable for 10 m and 100 m. Additional accuracy levels for user selection may be provided.

The integrity indication for different position accuracy levels shall be expressed in three states:

– "safe",

– "caution", and

– "unsafe"

for the currently selected accuracy level with a 95 % confidence level.

The integrity status shall be continuously displayed along with an indication of the accuracy level selected. The integrity status and the accuracy level selected, shall be provided to other equipment in accordance with the equipment output requirements in 4.3.2.

The manufacturer may use colours for integrity indication and if so the following colours shall be used:

– "safe" shall be green,

– "caution" shall be yellow, and

– "unsafe" shall be red.

The maximum delay for reaction of the integrity calculation by means of RAIM due to negative changes affecting the integrity status is 10 s.

The integrity status shall be provided to other equipment in accordance with the equipment output requirements in 4.3.2. For receiver equipment which do not provide information by a dedicated display, the provision of the integrity indication status and the selected accuracy level with an appropriate output interface is mandatory.

Conditions for the "safe" state

The result of integrity calculation by means of RAIM shall be stated as "safe", if the integrity calculation can be performed with a confidence level above 95 % for the selected accuracy level and RAIM calculates the probable position error to be within the selected accuracy level. This generally requires at least 5 "healthy" satellites available and in a robust geometry, i.e. the worst 4 satellite geometry is still suitable for navigation.

Conditions for the "caution" state

The "caution" status shall be used to indicate:

– insufficient information to reliably calculate with a confidence level above 95 % for the selected accuracy level, or

– the probability of false alarms >5 %, or

– the probability of not detecting an error condition >5 %.

Those conditions may occur if an insufficient number of satellites are available, for example 4 or 5 with 2 satellites "close" together in azimuth and elevation, causing the geometry to degrade to the point that the RAIM calculation becomes unreliable. Note that the resulting accuracy based on 4 or 5 satellites in use may be within the selected accuracy level, but the RAIM algorithm cannot verify it.

Conditions for the "unsafe" state

The "unsafe" status shall be used if the integrity calculation is performed with a confidence level above 95 % for the selected accuracy level, and RAIM calculates the probable position error exceeding the selected accuracy level. Note that also here a robust geometry is required to reach this confidence level. The "unsafe" state can be reached when satellite range errors degrade the navigation solution, causing the resulting accuracy to be outside the selected accuracy level.

4.3.11.3 GPS integrity status using DGPS

(M.112/A5.2) *The GPS receiver equipment* shall *provide as a minimum* GPS integrity status using DGPS.

If the range-rate correction or the pseudorange correction of a satellite is out of tolerance, the binary code in the ITU-R M.823-2 types 1, 9, 31, and 34 messages will cause the GPS receiver not to use that satellite.

4.3.11.4 DGPS integrity status and alarm

(M.112/A5.2.4) *The GPS receiver equipment* shall *provide as a minimum DGPS integrity status and alarm.*

The following functions shall be performed in either an integrated DGPS receiver or an associated GPS receiver connected to a DGPS radiobeacon receiver.