

INTERNATIONAL STANDARD

**Maritime navigation and radiocommunication equipment and systems –
Shipborne voyage data recorder (VDR) –
Part 1: Voyage data recorder (VDR) – Performance requirements, methods of
testing and required test results**



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Shipborne voyage data recorder (VDR) –
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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE

XA

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MARITIME NAVIGATION AND RADIOCOMMUNICATION
EQUIPMENT AND SYSTEMS –
SHIPBORNE VOYAGE DATA RECORDER (VDR) –****Part 1: Voyage data recorder (VDR) –
Performance requirements, methods of testing
and required test results**

FOREWORD

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International Standard IEC 61996-1 has been prepared by IEC technical committee 80: Maritime navigation and radiocommunication equipment and systems.

This first edition cancels and replaces IEC 61996 published in 2000 and constitutes a technical revision. A new requirement has been added to 4.3.5 for an interface to be used for downloading the stored data to an external computer. This is defined in Annex C which is derived from amendments published by the IMO in resolution MSC.214(81). An optional LAN interface for connection to radar has been added in 5.8. Some corrections to the text have also been made. Subclause 4.3.5 (Assessment of final recording medium) has been renumbered as 4.3.4.2 and subclause 4.3.6 (Interfaces) has been renumbered as 4.3.5.

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

CDV	Report on voting
80/470/CDV	80/499/RVC

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

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

A list of all parts of the IEC 61996 series, under the general title *Maritime navigation and radiocommunication equipment and systems – Shipborne voyage data recorder (VDR)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – SHIPBORNE VOYAGE DATA RECORDER (VDR) –

Part 1: Voyage data recorder (VDR) – Performance requirements, methods of testing and required test results

1 Scope

This part of IEC 61996 specifies the minimum performance requirements, technical characteristics and methods of testing, and required test results, for shipborne voyage data recorder (VDR) installations as required by Chapter V of the International Convention for Safety of Life at Sea (SOLAS), as amended. It takes account of IMO resolution A.694(17) and is associated with IEC 60945. When a requirement in this standard is different from IEC 60945, the requirement in this standard takes precedence.

This standard incorporates the applicable parts of the performance standards included in IMO Resolutions A.861(20) and MSC.214(81) Annex 1.

NOTE All text of this standard, whose wording is identical to that of IMO Resolution A.861, is printed in *italics*, and the Resolution and associated performance standard paragraph numbers are indicated in brackets.

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 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60268-16:2003, *Sound system equipment – Part 16: Objective rating of speech intelligibility by speech transmission index*

IEC 60945:2002, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 61097-2, *Global maritime distress and safety system (GMDSS) – Part 2: COSPAS SARSAT EPIRB – Satellite emergency position indicating radio beacon operating on 406 MHz – Operational and performance requirements, methods of testing and required test results*

IEC 61097-7:1996, *Global maritime distress and safety system (GMDSS) – Part 7: Shipborne VHF radiotelephone transmitter and receiver – Operational and performance requirements, methods of testing and required test results*

IEC 61162-1, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 1: Single talker and multiple listeners*

IEC 61162-2, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 2: Single talker and multiple listeners, high-speed transmission*

IEC 61260:1995, *Electroacoustics – Octave-band and fractional-octave-band filters*

IEC 61672-1:2002, *Electroacoustics – Sound level meters – Part 1: Specifications*

IMO A.658(16): *Use and fitting of retro-reflective materials on life-saving appliances*

IMO A.662(16): *Performance standards for float-free release and activation arrangements for emergency radio equipment*

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

IMO A.810(19): *Performance standards for float-free satellite emergency position-indicating radio beacons (EPIRBs) operating on 406 MHz*

IMO A.830(19): *Code on alarms and indicators*

IMO A.861(20): *Performance standards for shipborne voyage data recorders (VDRs)* IMO A.689:1991, *Testing of life saving appliances*

IMO MSC.214(81): Annex 1: *Amendments to the recommendation on performance standards for shipborne voyage data recorders (VDRs) (Resolution A.861(20))*

IMO:1974, *International Convention for the Safety of Life at Sea (SOLAS), as amended*

ITU-R M.633-1:1990, *Transmission characteristics of a satellite emergency position-indicating radiobeacon (satellite EPIRB) system operating through a low polar-orbiting satellite system in the 406 MHz band*

Eurocae: ED56A Amendment 1 – *Minimum operational performance specification (MOPS) for cockpit voice recorder system*

VESA:1996, *Video electronics standards association – Discrete monitor timings standard 1.0, Revision 0.7 (DMTS)*

SAE AS8045:1988, *Engineering Society for advancing mobility land sea air and space – Minimum performance standard for underwater locating devices – acoustic-self-powered*

3 Terms, definitions and abbreviations

3.1 Definitions

3.1.1

activation of a suitable alarm

mutable audible alarm and persistent visual indication, given according to the requirements of A.830, but with an audible level in the range of 55 dBA – 65 dBA

3.1.2

bridge work station

position at which a person is expected to be when performing one of the normal bridge duties at, for example, the following work stations:

- centre line conning
- bridge wing(s)
- main radar
- chart table
- helmsman
- communication

3.1.3**data**

any item of information received by the VDR for recording, including numerical values, text and audio or radar signals, except where specifically stated or the context dictates otherwise

3.1.4**dedicated reserve power source** (A.861/4.5)

secondary battery, with suitable automatic charging arrangements, dedicated solely to the VDR, of sufficient capacity to operate it as required by 4.5.3

3.1.5**final recording medium** (A.861/4.3)**(FRM)**

item of hardware on which the data is recorded such that access to it would enable the data to be recovered and played back by use of suitable equipment

3.1.6**playback equipment** (A.861/4.4)

equipment, compatible with the recording medium and the format used during recording, employed for recovering the data. It includes also the display or presentation hardware and software that is appropriate to the original data source equipment. Playback equipment is not normally installed on a ship and is not regarded as part of a VDR within this standard

3.1.7**recorder** (A.861/4.1)**(VDR)**

complete system, including any items required to interface with the sources of input data, for processing and encoding the data, the final recording medium in its capsule, the power supply and dedicated reserve power source

3.1.8**resolution**

smallest detectable increment between two values

3.1.9**sensor** (A.861/4.2)

any unit external to the VDR to which the VDR is connected and from which it obtains data to be recorded

3.2 Abbreviations

ALR	IEC 61162 sentence: Set alarm state
DPT	IEC 61162 sentence: Depth relative to the transducer
DTM	IEC 61162 sentence: Geodetic datum reference
EPFS	Electronic position-fixing system
EUT	Equipment under test
GMDSS	Global maritime distress and safety system
GNS	IEC 61162 sentence: GNSS fix data
GNSS	Global navigation satellite system
HTC	IEC 61162 sentence: Heading/track control command
HTD	IEC 61162 sentence: Heading/track control data
HDG	IEC 61162 sentence: Magnetic compass heading
HDT	IEC 61162 sentence: True heading
IMO	International Maritime Organization

INS	Integrated navigation system
ITU	International Telecommunication Union
MWV	IEC 61162 sentence: Wind speed and angle
OOW	Officer of the Watch
ROV	Remotely operated vehicle
RPM	IEC 61162 sentence: Revolutions per minute
RSA	IEC 61162 sentence: Rudder sense angle
SAR	Search and rescue
SENC	System electronic navigation chart
SINAD	Signal to noise and distortion
STI	Sound transmission index
TXT	IEC 61162 sentence: Text message
UTC	Coordinated universal time
VHF	Very high frequency
VBW	IEC 61162 sentence: Dual ground water speed
XDR	IEC 61162 sentence: Transducer measurements
ZDA	IEC 61162 sentence: Time and date

NOTE For IEC 61162 sentences, see Annex A.

4 Performance requirements

4.1 General

Performance requirements described in this Clause are specified by reference to the numbered paragraphs of IMO Resolution A.861.

4.2 Purpose

(A.861/1)

The purpose of a Voyage Data Recorder (VDR) is to maintain a store, in a secure and retrievable form, of information concerning the position, movement, physical status, command and control of a vessel over the period leading up to, and following, an incident having an impact thereon. Information contained in a VDR shall be made available to both the Administration and the shipowner. This information is for use during any subsequent investigation to identify the cause(s) of the incident.

4.3 Operational requirements

(A.861/5)

4.3.1 Design and construction

(A.861/5.1.4)

The design and construction, which shall be in accordance with the requirements of resolution A.694(17) and international standards acceptable to the International Maritime Organization (IMO), shall take special account of the requirements for data security and continuity of operation as detailed in 4.4 and 4.5.

4.3.2 Maintenance of sequential records

(A.861/5.1.1)

The VDR shall continuously maintain sequential records of pre-selected data items relating to the status and output of the ship's equipment, and command and control of the ship, referred to in 4.6.

4.3.3 Co-relation in date and time

(A.861/5.1.2, 5.4.1)

To permit subsequent analysis of factors surrounding an incident, the method of recording shall ensure that the various data items can be co-related in date and time during playback on suitable equipment.

The recording method shall be such that the timing of all recorded data items can be derived on playback with a resolution sufficient to reconstruct the history of an incident in detail (see 4.6.1).

4.3.4 Protective capsule

(A.861/5.1.3)

4.3.4.1 Type of protective capsule

The final recording medium shall be installed in a protective capsule. The capsule may be designed to remain fixed to the ship in all circumstances. Alternatively, it may be designed to float free automatically if the ship sinks (see 5.2).

4.3.4.2 Assessment of final recording medium

NOTE This subclause was numbered 4.3.5 in IEC 61996.

Where the storage medium cannot be readily and reliably inspected after an incident, means shall be provided to enable an accident investigator to determine, prior to an attempted replay, whether the storage medium has been subjected to an excessive level of heat, where the survival of the stored data may be in doubt.

4.3.4.3 Access to capsule

(A.861/5.1.3.1)

The capsule shall be capable of being accessed following an incident but secure against tampering

The capsule shall enclose the final recording medium. The final recording medium shall not be accessible by standard operating procedures during normal ship operations.

A means shall be provided to retrieve stored information via an external device without opening the protective capsule.

4.3.4.4 Recovery

(A.861/5.1.3.2)

The capsule shall maximise the probability of survival and recovery of the final recorded data after any incident (see 5.2).

4.3.4.5 Structure of the capsule

The capsule containing the final recording medium shall be designed to be installed on the external deck of the vessel. It may be designed to remain fixed to the ship in all circumstances. Alternatively, it may be designed to float free automatically if the ship sinks (see 5.2).

The capsule shall be designed to protect the stored data against the following (see 5.2):

- shock;
- penetration;
- fire;
- deep-sea pressure and immersion.

4.3.4.6 Visibility and marking

(A.861/5.1.3.3)

The capsule, together with any outermost shell, shall be of a highly visible fluorescent orange colour, marked with retro-reflective materials that comply with the relevant requirements of IMO A.658 and marked with the legend:

“VOYAGE DATA RECORDER – DO NOT OPEN –
REPORT TO AUTHORITIES”

4.3.4.7 Location

(A.861/5.1.3.4)

The capsule shall be fitted with an appropriate device to aid location.

Both fixed and float free designs shall include an acoustic underwater beacon. In the case of a protective capsule intended for float-free operation, it shall also have a suitable radio transmitter, and a light (see 5.2).

4.3.5 Interfaces

(A.861/7)

NOTE This subclause was numbered 4.3.6 in the first edition.

4.3.5.1 Compliance with IEC 61162

Interfacing to the various sensors required shall be in accordance with the relevant international interface standard, IEC 61162 series, where possible (see Annex A).

The interfaces for bridge audio, communications audio and radar are defined in 5.6.1, 5.7.1 and 5.8.1 respectively.

Any interface units which may be required to convert non-IEC 61162 signals, shall conform to the requirements of IEC 60945.

In all cases, any connection to any item of the ship's equipment shall be such that the operation of that equipment suffers no deterioration, even if the VDR system develops faults.

NOTE No loss of steering or propulsion is allowed.

4.3.5.2 Data interface

The VDR shall provide an interface for downloading the stored data to an external computer (see Annex C).

4.4 Data selection and security

(A.861/5.1.4)

4.4.1 Selection of data items

(A.861/5.2.1)

The minimum selections of operational data items to be recorded by the VDR are specified in 4.6. Optionally, additional items may be recorded provided that the requirements for the recording and storage of the specified selections are not compromised.

4.4.2 Configuration data

In addition to the operational data referred to in 4.4.1, a data block defining the configuration of the VDR and the sensors to which it is connected shall be written into the final recording medium during commissioning of the VDR. This configuration data shall be permanently retained in the final recording medium and protected from modification other than by a duly authorised person following any change to the configuration. Any change to the configuration of this data block shall not affect the recording of the mandatory items.

The following system configuration information and data source identity shall be included in this data block:

- a) type approval authority and reference;
- b) IMO vessel identification number;
- c) software version(s) used;
- d) automatic insertion of date and time of last amendment;
- e) microphone locations, recording port allocation, and ID (two character identification for example M1, M2, etc.);

NOTE This does not imply that microphone audio channels shall be separated.

- f) VHF communications – Location of connected VHF installation(s) and recording port allocation, and ID (two character identification, for example V1, V2, etc.);
- g) Radar – which display output(s) are connected (at which channel), and ID (two character identification, for example R1, R2, Rx, etc.);
- h) date and time – from which source obtained;
- i) ship's position – from which EPFS and relative position of this EPFS on the vessel;
- j) other data inputs, at the minimum for all data required by IMO A.861(20) 5.4:
 - i. identification of which equipment is supplying the data;
 - ii. identification of the sentence (IEC 61162) which is carrying the information (see Annex A for approved sentences);
 - iii. if received as proprietary sentences according to IEC 61162 (for example containing converted analogue or discrete signals), information to include the location of the information within the sentence and the specification of the relations between sensor values (RPM, rudder angles, state of alarm or indicator, etc.) and received values.

4.4.3 Resistance to tampering

(A.861/5.2.2)

The equipment shall be so designed that, as far as is practical, it is not possible to tamper with the selection of data being input to the equipment, the data itself nor that which has already been recorded. Any attempt to interfere with the integrity of the data or the recording shall be recorded.

4.4.4 Recording integrity

(A.861/5.2.3)

The recording method shall be such that each item of the recorded data is checked for integrity, i.e. it is identical to the data being received, and an alarm given if a non-correctable error is detected according to IMO A.830(19) but with an audible level in the range of 55 dBA - 65 dBA.

The VDR shall automatically continuously monitor the following (see 6.1.10):

- a) power supply;
- b) record function;
- c) bit error rate;
- d) microphone functionality.

Malfunction of any of the above shall generate an alarm in accordance with the relevant requirements of IMO A.830(19) at the position from which the vessel is normally navigated. It shall be possible to mute the alarm but a visual indication shall remain until the equipment is serviceable. It shall also indicate its alarm status by means of contacts of a relay (or equivalent) which is held energized in the no-alarm condition.

4.5 Operation

4.5.1 Recording and saving of data

(A.861/6)

The unit shall be entirely automatic in normal operation. Means shall be provided to ensure that the recorded data may be saved by an appropriate method following an incident, with minimal interruption to the recording process and without requiring opening of the protective capsule.

- a) Controls for use during the saving process shall be simple to use.
- b) The recording process to the final recording medium shall not be interrupted for more than 10 min during the saving process. The data recorded in the final recording medium shall not be erased.
- c) The data saved shall be automatically checked to ensure that it is identical to the recorded data on the final recording medium. Any failure shall be indicated.
- d) When the saving process is completed, means shall be provided to enable the transfer of this data set to another storage device in order to allow data relating to subsequent incidents to be saved.

NOTE "saving process" means – preserving a copy of the data contained in the final recording medium. A saved data set shall be protected against unauthorized or inadvertent overwriting.

4.5.2 Power source

(A.861/5.3.1)

To ensure that the VDR continues to record events during an incident, it shall be capable of operating from the ship's emergency source of electrical power. Whenever electrical power is available the VDR shall operate, except as permitted in 4.5.4 (see 6.1.15).

4.5.3 Dedicated reserve power source

(A.861/5.3.2)

If the ship's emergency source of electrical power supply fails, the VDR shall continue to record bridge audio (see 4.6.5) from a dedicated reserve source of power for a period of 2 h. At the end of this 2 h period all recording shall cease automatically.

4.5.4 Recording period and duration

(A.861/5.3.3)

Recording shall be continuous unless interrupted briefly in accordance with 4.5.1 or terminated in accordance with 4.5.3. The time for which all stored data items are retained shall be at least 12 h. Data items which are older than this may be overwritten with new data.

Recording may also be terminated, by means of a key or other secure method.

NOTE This may occur under the following circumstances:

- a) during essential maintenance purposes whilst the vessel is in port;
- b) when the vessel is laid-up;
- c) upon request by an investigation authority, for example after the vessel had been involved in a marine incident.

4.6 Data items to be recorded

(A.861/5.4)

4.6.1 Date and time

(A.861/5.4.1)

Date and time referenced to UTC, shall be obtained from a source external to the ship (for example, an EPFS or radio time signal) if available, or from an internal clock at least once per hour. The recording shall indicate which source is in use. The recording method shall be such that the timing of all other recorded data items can be derived on playback with a resolution sufficient to reconstruct the history of the incident in detail, not worse than 1 s.

4.6.2 Ship's position

(A.861/5.4.2)

Latitude and longitude, and the datum used, shall be derived from a designated EPFS or INS if available. The recording shall ensure that the identity and status of the source can always be determined on playback. The ship's position shall be recorded, as available on the ship, up to a resolution of 0,000 1 min of arc.

4.6.3 Speed

(A.861/5.4.3)

Speed through the water, or speed over the ground (transverse as well as longitudinal in either case, as available on the ship), including an indication from which it is derived, from the ship's designated speed and distance measuring equipment, shall be recorded, as available on the ship, up to a resolution of 0,1 knots.

4.6.4 Heading

(A.861/5.4.4)

As indicated by a designated ship's compass. The ship's heading shall be recorded, as available on the ship, up to a resolution of 0,1°.

4.6.5 Bridge audio

(A.861/5.4.5)

One or more microphones positioned on the bridge shall be placed, such that conversation at or near the conning stations, radar displays, chart tables etc., (i.e. at work stations as defined in 3.1.9) may be adequately recorded. As far as is practicable, the positioning of microphones shall also capture the input and output of intercom, public address systems and the audible alarms on the bridge (bridge mounted equipment) (see 5.6 for technical characteristics).

The audio signals at all work stations shall be recorded continuously. Optionally, means may be provided so that the originating work station can be identified with the audio signal being analysed during playback of the recorded information.

4.6.6 Communications audio

(A.861/5.4.6)

VHF communications relating to ship operations shall be recorded, independently of the bridge audio. The recording shall include both transmitted and received audio signals and shall be continuous from a directly connected fixed VHF set to be designated at installation (see 5.7 for technical characteristics).

4.6.7 Radar data – post-display selection

(A.861/5.4.7)

This shall include electronic signal information from within one of the ship's radar installations which records all the information which was actually being presented on the master display of that radar at the time of recording. This shall include any range rings or markers, bearing markers, electronic plotting symbols, radar maps, whatever parts of the SENC or other electronic chart or map that were selected, the voyage plan, navigational data, navigational alarms and the radar status data that were visible on the display. The recording method shall be such that, on playback, it is possible to present a faithful replica of the entire radar display that was on view at the time of recording, albeit within the limitations of any bandwidth compression techniques that are essential to the working of the VDR (see 5.8).

4.6.8 Echo sounder

(A.861/5.4.8)

This shall include depth under keel, up to a resolution of 0,1 m as available on the ship. The depth scale currently being displayed and other status information shall be recorded where available.

4.6.9 Main alarms

(A.861/5.4.9)

This shall include the status of all IMO mandatory alarms on the bridge. (see annex B).

The status of all IMO mandatory alarms shall be recorded by the bridge audio and as a data parameter where practicable.

4.6.10 Rudder order and response

(A.861/5.4.10)

Both rudder order and response angles shall be recorded up to a resolution of 1° as available and permitted on the ship. Status and settings of heading or track controller, if fitted, shall also be recorded.

4.6.11 Engine order and response

(A.861/5.4.11)

This shall include the positions of any engine telegraphs or direct engine/propeller controls, including shaft(s) rpm (or equivalent), and feedback indications, if fitted, including ahead/astern indicators. This shall also include status of bow and stern thrusters if fitted. RPM shall be recorded up to a resolution of 1 rpm and pitch shall be recorded up to a resolution of 1°.

4.6.12 Hull openings (doors) status

(A.861/5.4.12)

This shall include all IMO mandatory status information required to be displayed on the bridge.

4.6.13 Watertight and fire door status

(A.861/5.4.13)

This shall include all IMO mandatory status information required to be displayed on the bridge.

4.6.14 Accelerations and hull stresses

(A.861/5.4.14)

Where a ship is fitted with *IMO mandated* hull stress and response monitoring equipment, all the data items that have been pre-selected within that equipment *and are available shall* be recorded.

4.6.15 Wind speed and direction

(A.861/5.4.15)

This shall be applicable where a ship is fitted with a suitable sensor. Either relative or true wind speed and direction may be recorded, but an indication of which it is shall be recorded.

5 Technical characteristics

5.1 Co-relation in date and time

(A.861/5.1.2/5.4.1)

To ensure that relative timings can be determined within a resolution of 0,1 s, all data items shall, when sampled by the VDR, be recorded with a time index derived from a VDR system clock with an resolution of 0,05 s. The drift of this system clock shall be not more than 1 s in 1 h.

5.2 Particular design requirements for the protective capsule

Where a float-free release mechanism is used, it shall comply with the relevant requirements of IMO Resolution A.662.

Any float-free release mechanism shall be inhibited automatically if the protective capsule has been subjected to a fire temperature more severe than the fire protection of the radio transmission device required by 4.3.4.7.

Both float-free and fixed designs shall have a release mechanism to facilitate recovery under water both by a diver or a remotely operated vehicle (ROV). Possible items to be considered are:

- a) the use of break-away bolts;
- b) release levers; or
- c) twist lock.

To ensure that the capsule may be retrieved safely after release, suitable large pad eyes or handles should be incorporated.

NOTE It should be borne in mind that the manipulator jaws of typical underwater recovery machines have a maximum opening of only 300 mm, a gripping force limit of about 1 kN, and a pulling force limit of about 500 N.

5.3 Location beacon(s) for the protective capsule

These shall include an acoustic underwater beacon operating in the frequency band of 25 kHz to 50 kHz with a battery life of at least 30 days, which shall meet SAE AS 8045.

In the case of a protective capsule intended for float-free operation, it shall also have a suitable radio transmitter, complying with appropriate international resolutions and recommendations, to transmit signals suitable for location purposes, for example, IMO A.810, IMO A.812, ITU-R M.632-3

and ITU-R M.633-1. It shall also have a light conforming to the appropriate requirements of IMO A.689. The battery life for both the radio and light functions shall be at least seven days.

The buoyancy characteristics of a float-free protective capsule shall ensure that the radio antenna will radiate an essentially hemispherical and vertically polarised signal. The float-free protective capsule shall be designed in such a way that a usable signal is provided in, at least, open sea state 7 (equivalent to Beaufort wind-scale 10).

5.4 Survivability of recorded data

5.4.1 Long-term retention under normal conditions

The final recording medium shall retain the recorded data for a period of at least two years, following termination of recording, under operational and storage conditions specified by the equipment manufacturer. Consideration should be given to the distribution of data within the recording medium.

5.4.2 Survival following an incident

The capsule shall be designed to ensure that the data held in the final recording medium, shall be retrieved without loss after it has been subjected to the following conditions:

- a) Shock
A half sine-wave pulse of 50 g, with a duration of 11 ms, as specified in Clause 11 of IEC 60068-2-27.
- b) Penetration
A mass of 250 kg with a pin of 100 mm diameter, dropped from a height of 3 m, as specified in 5.3.2b of ED56A.
- c) Fire
A low temperature fire of 260 °C nominal for 10 h, as specified in 5.3.2e of ED56A.
A high temperature fire of 1 100 °C nominal for 1 h, as specified in 5.3.2.d of ED56A.
- d) Deep-sea pressure and immersion
Immersion in sea water at a pressure of 60 MPa (equivalent to a depth of 6 000 m), as specified in 5.3.2f of ED56A.

5.5 Information to be included in the manufacturer's documentation

5.5.1 Installation guidelines

The following installation guidelines apply:

- a) Siting of the protective capsule.
The protective capsule shall be sited in the vicinity of the bridge on the external deck area of the vessel so as to maximise the probability of its survival and recovery following an incident. The capsule shall be positioned clear of rigging and other potential obstructions and as near to the centreline of the ship as practically possible.
Criteria to be considered when assessing the optimum position shall include but not be limited to the following.
 - 1) Separation from fuel or other potential fire sources.
 - 2) Separation from probable sources of mechanical damage.
 - 3) Operational environment for continued serviceability.
 - 4) Accessibility for copying of recorded data and for routine maintenance.
 - 5) Facilitation of underwater removal and retrieval by both divers and ROVs. There shall be a clear unobstructed space in the vicinity of the capsule to allow an ROV or diver to work.
 - 6) In the case of float-free configuration, minimisation of the risk of obstruction after release.

- b) Siting of microphones.
- c) Siting of all other components of the VDR configuration.
- d) Entering and updating the static configuration data of 4.4.1.
- e) The requirement for interface units to comply with 4.3.5.

5.5.2 Operation and maintenance manual

The manual shall include the following:

- a) instructions on normal operation of the VDR;
- b) instructions on how to copy data from the equipment (see Annex C);
- c) instructions on the action to be taken following the activation of any VDR alarm;
- d) instructions for downloading and verification of the final recording medium data. These should be carried out whenever maintenance or repair has been carried out on any sensor or on the VDR itself, or at least annually;
- e) maintenance tasks required to ensure the serviceability and continued seaworthiness of the VDR. An analysis shall be performed by the equipment installer to identify those sensors or transducers where the serviceability or accuracy could be degraded and remain undetected. The maintenance tasks to be performed shall take account of this analysis by requiring appropriate functional and calibration checks at suitable intervals.

5.5.3 Information for use by an investigation authority

The following shall be available:

- a) instructions to enable an investigation authority to manufacture any special tools or interface equipment required for retrieval of recorded data from the recorder;
- b) details of the necessary actions to be followed for data retrieval from an undamaged protective capsule;
- c) details of the necessary actions to be followed for data retrieval from a protective capsule that has been damaged in an incident;
- d) software and instructions required to enable the download and playback of recorded data (see Annex C).

5.6 Bridge audio specifications

5.6.1 Input interface

The microphones forming the bridge audio data source are to be considered to be parts of the VDR. The form of the connections, signal levels and impedances, are at the option of the manufacturer. However, for the purposes of testing, each microphone shall be connected via a plug/socket combination, which is referred to hereafter as an **input port**.

5.6.2 Reference signal

The manufacturer shall declare a reference signal, for each microphone input, at the electrical input port of the VDR. This shall be defined as a 1 kHz sinusoid at the maximum level for which the equipment is designed to meet this performance specification.

5.6.3 Audio frequency response

Signal levels of both 6 dB and 45 dB below the reference signal level, shall be applied to every bridge area microphone input port in turn. With the frequency swept continuously at a rate not exceeding 0,1 octaves per second, over the range of 150 Hz to 6 000 Hz, the level of signal recovered from the VDR shall not vary by more than a total range of 6 dB, on playback. Any other microphone input ports shall have no signals applied at this time.

5.6.4 Quality index

The quality of the recording shall be established for single and multiple microphone inputs.

5.6.4.1 Single microphone

The quality of the recording for each of the bridge area microphone ports shall be established at the electrical equivalent level of 75 dBA. This shall not be less than that corresponding to the quality value for the speech transmission index of 0,85 (see IEC 60268-16), with no signal being simultaneously applied to other microphone ports.

5.6.4.2 Multiple microphones

The quality of the recording for each of the bridge area microphone ports shall be established at the electrical equivalent level of 75 dBA. This shall not be less than that corresponding to the quality value for the speech transmission index of 0,60 (see IEC 60268-16) with all of the other microphone ports having inputs at the electrically equivalent level of 65 dBA.

5.6.4.3 Audio noise level – signal to no signal

With no signal applied to any bridge area microphone port, the reproduced signal at any replay output shall be at least 48 dB below the output level, which would be produced by an input level equal to the reference signal level. This requirement shall be met across the frequency band as defined in 5.6.3 with the inputs both open and short-circuited. The above signal to no signal performance shall be met in the presence of out-of-band input signals and also at the reference signal level.

5.6.5 Audio noise level – signal to noise and distortion

With all other input ports, except the one in use, short-circuited, the reproduced signal to noise and distortion (SINAD) ratio shall be at least 24 dB across the frequency band as defined in 5.6.3 and with input levels in the range of 0 dB to –20 dB relative to the reference signal level for all input ports.

5.7 Communications audio

5.7.1 Input interfaces

The audio connection with the designated VHF equipment shall be in accordance with the requirements of IEC 61097-7. For the purposes of testing, the connection shall be via a plug/socket combination referred to hereafter as the **input port**.

5.7.2 Reference signal

The reference signal level for both transmitted and received communications audio is defined as 0,775 V r.m.s.

5.7.3 Audio frequency response

With a signal level 6 dB below the reference signal level applied to the VHF radio communications input port of the VDR and with its frequency continuously swept at a rate not exceeding 0,1 octaves per second over the range of 150 Hz to 3 500 Hz, the level of the signal recovered from the VDR on playback shall not vary by more than 6 dB.

5.7.4 Quality index

The quality of the recording for the VHF radio communications port shall be established and shall not be less than that corresponding to the quality value for the speech transmission index of 0,75 (see IEC 60268-16).

5.7.5 Audio noise level – signal to no signal

With no signal applied to a VHF radio communications port, the reproduced signal shall be at least 48 dB below the output level produced by an input equal to the reference signal level. This requirement shall be met across the frequency band as defined in 5.7.3 with the input port both open and short-circuited. The above signal to no signal performance shall be met in the presence of out-of-band input signals and also at the reference signal level.

5.7.6 Audio noise level – signal to noise and distortion (SINAD)

The reproduced SINAD ratio shall be at least 24 dB across the frequency band as defined in 5.7.3 and with input levels in the range of 0 dB to –20 dB relative to the reference signal level.

5.8 Radar data – post-display selection

5.8.1 Input interface

5.8.1.1 Source and acquisition

5.8.1.1.1 Buffered radar display video output

The VDR shall be capable of being connected to a buffered video output from the radar display whose image it is to record.

5.8.1.1.2 LAN radar display video output

The VDR may optionally be capable of being connected to a LAN interface from the radar for receiving the radar images according to IEC 62388.

5.8.1.1.3 Display video acquisition interval

The VDR shall record a series of single and complete screen video frames from the dedicated buffered output port of the radar. One complete radar screen video frame shall be acquired at intervals of 15 s or less.

5.8.1.2 Mandatory image input format

The VDR shall meet fully the requirements of 6.2.4 with buffered outputs meeting the electrical specifications of VESA DMTS, where that standard refers to display monitors having screen resolutions between 640×350 and $1\,280 \times 1\,024$ and refresh rates between 60 Hz and 85 Hz and $1\,600 \times 1\,200$ with a refresh rate of 60 Hz.

5.8.1.3 Optional image input format

Optionally the VDR may operate with other forms of buffered outputs that have been defined by an individual radar manufacturer. These outputs shall buffer the signals actually used to generate the image screen.

5.8.2 Image outputs

5.8.2.1 Format and resolution

When used with playback equipment specified by the manufacturer, the resolution of the output image shall be equal to or greater than the resolution of the image input. The specified playback equipment shall have an output meeting VESA DMTS, and a digital output meeting the requirements of 6.2.4.2.

5.8.2.2 Fidelity

The recording shall be subjectively lossless, as determined by the objective tests described in 6.2.4.1 to 6.2.4.6. In addition to those objective tests, the screen display on the playback equipment shall be a subjectively satisfactory facsimile of the original display as determined by the test described in 6.2.4.7.

6 Methods of testing and required test results

6.1 General

6.1.1 Test setup

6.1.1.1 Equipment under test (EUT)

In this Clause, except where specifically stated otherwise, any reference to the equipment under test (EUT) shall be interpreted as comprising all the parts of a shipborne VDR configuration including:

- a) IEC 61162 listener port(s);
- b) microphone(s) and associated self-test device;
- c) communications audio input(s) unit;
- d) radar input unit;
- e) control and display unit(s);
- f) the final recording medium in its protective capsule;
- g) power supply unit(s);
- h) all other item(s) declared by the manufacturer;
- i) manufacturer's documentation.

The EUT shall be installed in the test facility using interconnection and input cabling and methods representative of a normal installation, but this material and installation shall not be considered part of the EUT.

6.1.1.2 Standard input data

Except where input data is detailed for individual tests, the following shall be applied for all general performance tests and checks. Test data streams for the audio and radar inputs shall be chosen to exercise the data processing methods. A copy of the data set shall be retained for comparison purposes.

- Bridge audio – the maximum number of microphones specified by the manufacturer shall be connected to the EUT. Audio signals consisting predominantly of speech at a level of approximately 75 dBA shall be presented to each microphone. A common loudspeaker may be used.
- Communications audio – the maximum number of communications audio inputs specified by the manufacturer shall be connected to the EUT. Audio signals consisting predominantly of speech at the level specified by the manufacturer shall be presented to each input.
- Radar data – a test signal shall be presented to the EUT.
- IEC 61162 data inputs – a representative data signal consisting of a continuous stream of appropriate IEC 61162 sentences shall be applied to each IEC 61162 input port. A timed log shall be kept of the input data to enable comparisons to be made.

6.1.1.3 Full performance test

The recorded data shall be viewed using the playback equipment (see 6.1.2). Sufficient detailed examinations shall be made throughout the specified duration of the recording to ensure that recording was continuous and consistent with the standard input data. Typically, examinations of 30 s duration shall be made on all data channels at intervals of approximately 30 min throughout the duration of the recording.

6.1.1.4 Performance check

An abbreviated qualitative examination shall be made at least once on each data channel at the start of the check and then typically of 30 s duration at intervals of approximately 1 h as appropriate to the individual test.

6.1.2 Download and playback equipment

The manufacturer shall demonstrate to the satisfaction of the testing authority that the data saved from the final recording medium (see 4.5.1 and Annex C) can be downloaded within the time specified in Annex C following the required tests and reproduced with the supplied playback software. The playback equipment is not to be considered as part of the EUT, although the relevant software documentation shall be included.

6.1.3 Sequence of tests

Except where specifically stated otherwise, the tests shall all be conducted on a single EUT but may be performed in any sequence agreed between the manufacturer and the test authority.

6.1.4 Requirements to be checked by inspection only

The testing authority shall check, by inspection of the EUT, manufacturing drawings and other relevant documentation to be provided by the manufacturer, compliance with all requirements of 4 and 5, including those for which no test is specified in this Clause. This inspection shall include, but not be limited to, items in the following list. The result of this inspection shall be stated in the test report.

a) Tamper resistance (see 4.3.4.2 and 4.4.2).

Particular reference shall be made to the following:

- 1) access to any part of the system shall require the use of tools or keys;
- 2) operation of any controls or keyboard keys, or any combination of these, shall not affect recording;
- 3) termination of recording shall only be possible by means of a key or other secure method;
- 4) recorded data shall be protected against unauthorised access by use of a password.

b) Marking (see 4.3.4.6).

c) Location devices (see 4.3.4.7, 5.3).

d) Power source (see 4.5.2).

e) Documentation (see 5.5).

6.1.5 Environmental test conditions for normal operation

The special conditions and tests for survival of data after an incident are given in 6.1.13.

The manufacturer shall determine which components of the VDR system will be protected or exposed, as defined in IEC 60945.

Prior to and after detailed tests, the equipment shall be subjected to a series of performance checks to demonstrate that it satisfies the relevant requirements of IEC 60945.

It is important to ensure, either by test in the EUT or separately, that the battery of the dedicated reserve power source meets the requirements of 4.5.3 and 6.1.7 at the extreme operating temperatures specified in IEC 60945.

6.1.6 Recording duration

(See 4.5.4)

6.1.6.1 Test method

The equipment shall operate continuously using normal external electrical power, recording test signals specified in 6.1.1.2 for a duration in excess of 12 h.

6.1.6.2 Required results

By a series of performance checks recording shall be demonstrated to be continuous in compliance with the requirements of the appropriate subclauses of 4.5.

6.1.7 Reserve power source

(See 4.5.3)

6.1.7.1 Test method

Whilst operating the EUT using normal external electrical power, and recording test signals as specified in 6.1.1.2 the power shall be removed for a period in excess of 2 h. The normal external electrical power shall then be restored for a period of 10 min and the test then terminated.

6.1.7.2 Required results

A suitable alarm shall be generated when the normal external electrical power is removed. To conserve battery power, it shall be muted automatically after 2 min, if it has not been acknowledged in that period.

The EUT shall continue to operate from its reserve source of power for 2 h and shall then terminate automatically in accordance with 4.5.3.

After normal external electrical power has been restored it shall be demonstrated by performance checks that:

- a) the VDR resumes normal operation;
- b) 9 h 50 min of recording prior to power interruption has been retained, followed by 2 h of recording of bridge audio, followed by 10 min of normal recording.

6.1.8 Recharging of reserve source of power

(See 4.5.3)

6.1.8.1 Test method

On completion of the test of 6.1.7, normal external electrical power supply shall be maintained for a continuous period of 10 h. Test 6.1.7 shall then be repeated.

6.1.8.2 Required results

It shall be demonstrated that the reserve source of power was recharged sufficiently to operate the equipment for 2 h, as specified in 6.1.7.2.

6.1.9 Brief interruption of electrical power

(See 4.5.2/4.5.3)

6.1.9.1 Test method

The test of 6.1.7.1 shall be repeated, but normal external electrical power shall be restored after a period of 3 min instead of 2 h.

6.1.9.2 Required results

The alarm behaviour of 6.1.7.2 shall occur. After normal external electrical power has been restored it shall then be demonstrated by performance checks that:

- a) the VDR resumes normal operation within 1 min after normal restoration of power;
- b) at least 11 h 45 min of recording prior to the power interruption has been retained;
- c) recording of bridge audio continued during the power interruption.

6.1.10 System integrity

(See 4.4.3)

For each of the following it shall be demonstrated that a suitable alarm is activated:

a) Power supply

Whilst operating using normal external electrical power, this power shall be removed.

NOTE This test is included in the tests of 6.1.7, 6.1.8 and 6.1.9.

b) Record function, bit error rate

The manufacturer shall demonstrate that if the test data signals (radar, audio and data) are not being correctly recorded on the final recording medium, a suitable alarm is activated. The bit error rate for digital signals shall not exceed 1 in 10^8 .

NOTE To avoid the need to create an actual fault condition in the EUT, it is acceptable for this to be checked by examination of documentation.

c) Microphone functionality

The manufacturer shall demonstrate that at least once every 12 h there is an unobtrusive acoustic test of all microphones.

6.1.11 Maintenance of sequential records

(See 4.3.2)

The manufacturer shall demonstrate that the VDR maintains sequential records as required by 4.3.2.

6.1.12 Co-relation in date and time

(See 4.3.5/5.1)

6.1.12.1 Test method

The VDR shall record the test data set of 6.1.1.2 for a period of 30 min. This recorded data shall be replayed.

6.1.12.2 Required results

The time indices of the replayed data shall meet the requirements of 4.3.3 and 5.1.

6.1.13 Design and construction of the protective capsule

(See 4.3.1/4.3.4/5.2)

6.1.13.1 Definition of EUT for 6.1.13

For these tests only, any reference to “the EUT” shall mean

- a) the protective capsule, complete with all internal fittings, linings, heat insulators;
- b) the final recording medium, as normally installed inside the capsule;
- c) any power supply units or batteries that normally form part of the capsule contents;
- d) all mounting hardware and release mechanism(s), including the automatic release mechanism in the case of a float-free design;
- e) the acoustic beacon or a mechanically equivalent dummy;
- f) the normal electrical or other cable through which data is transferred between the main units of the VDR and the final recording medium during normal operation.

6.1.13.2 Test data to be pre-loaded into the final recording medium

Test data signals as specified in 6.1.1.2 shall be recorded for 12 h.

6.1.13.3 Tests and test sequence

The EUT shall be subjected to the tests of 6.1.13.4 to 6.1.13.8 inclusive, in the order listed

- a) shock;
- b) penetration;
- c) low temperature fire test;
- d) high temperature fire test;
- e) sea-water immersion to test the release mechanism for a float-free design only;
- f) deep-sea immersion.

These tests shall be normally carried out on a single EUT. If more than one EUT is used, the following sequences are acceptable:

If two EUTs are used the sequence of tests shall be:

- a), b) on one unit and c), d), e) and f) on the other, or
- a), b), c), e) and f) on one unit and a), b), d), e) and f) on the other.

If three EUTs are used the sequence of tests shall be:

- a), and b) on one unit, c), e) and f) on the second unit, and d), e) and f) on the third unit.

As a minimum, the fire test, the sea-water immersion test (where applicable) and the deep-sea immersion tests shall be conducted on the same EUT. However, it is not a mandatory requirement that a single EUT shall survive the other tests in addition to these.

The deep-sea immersion test can be carried out on the recording medium itself if it can be shown that the recording medium cannot be damaged as a consequence of collapse of the protective capsule.

6.1.13.4 Shock

The EUT shall be secured to the test rig in accordance with the manufacturer's normal installation instructions.

It shall then be subjected to the test requirements of Clause 11 of IEC 60068-2-27, with the following parameters:

- a) pulse shape – half sine;

- b) tolerances – as Figure 2 of Clause 11;
- c) velocity change special case – not applicable;
- d) transverse motion – not applicable;
- e) method of mounting – fastened to the testing machine or table using the normal shipboard installation mounting arrangements specified by the manufacturer;
- f) peak acceleration – 50 g, duration of the nominal pulse 11 ms;
- g) pre conditioning – nil;
- h) initial measurements (see 6.1.3);
- i) direction and number of shocks – standard;
- j) survive the conditions of shock;
- k) acceptance and rejection criteria;
- l) not applicable;
- m) not applicable;
- n) not applicable.

6.1.13.5 Penetration

The EUT shall be secured to the test rig in accordance with the manufacturer's normal installation instructions.

The protective capsule shall be subjected to the requirements of 5.3.2b of ED56A. The mass used shall be 250 kg, with a pin diameter of 100 mm, dropped from a height of 3 m.

6.1.13.6 Fire

The protective capsule shall be subjected to a low temperature fire test for 10 h at 260 °C and a high temperature test of one hour at 1 100 °C to the requirements of ED56A, amendment 1.

NOTE If an actual acoustic beacon is used during the test, caution must be exercised due to possible explosion of the battery.

6.1.13.7 Shallow sea-water immersion

This test is applicable only to capsules designed to float free. The float-free release mechanism shall be tested for compliance with the appropriate requirements of IMO A.662. It shall be demonstrated that the float-free mechanism is inhibited if the fire exceeds the fire survivability of the radio transmission device as in 4.3.4.3.1.

6.1.13.8 Deep-sea immersion

The protective capsule shall be subjected to the requirements of 5.3.2f of ED56A. Both the 6 000 m 24-hour test described in paragraph 1 and the 3 m 30-day test described in paragraph 2 shall be carried out.

6.1.13.9 Required results of 6.1.13.4 to 6.1.13.8

After completion of the test sequences, all the release mechanisms shall function according to the appropriate specifications. Repairs to the final recording medium shall be minimal.

After completion of the tests, the stored data shall be retrieved following the manufacturer's instructions, which may include error correcting. Repairs to the final recording medium shall be minimal. For the purposes of playback, the final recording medium may be removed from the EUT and installed into standard replay equipment as supplied by the recorder manufacturer. Recordings shall meet the requirements of the performance test specification as set out 6.1.1.3 with at least

99 % of the data being recoverable. Thermal, mechanical or corrosive damage to the recording medium incurred during the test that results in the loss of data, shall constitute a failure.

The under water locator beacon need not survive the fire tests, but shall remain attached to the protective capsule throughout.

6.1.13.10 Aid(s) to location

(See 5.3)

The acoustic beacon shall be tested for compliance with SAE AS 8045.

If the capsule is designed for float-free operation, the radio transmitter and light shall be tested for compliance to the appropriate parts of IEC 61097-2 and IMO A.689 (see also 5.3), but with a required duration of seven days.

6.1.14 Selection of data items

(See 4.4.1)

The manufacturer shall demonstrate that the configuration data specified in 4.4.1 can be entered, maintained and retrieved.

6.1.15 Power source

(See 4.5.2)

It shall be confirmed that the VDR operates at all times when electrical power is applied.

6.2 Data items to be recorded

(See 4.6)

6.2.1 Date/time – ship's position – speed – heading

(See 4.6.1/4.6.2/4.6.3/4.6.4)

6.2.1.1 Test method

The test method and result required are the same for these four parameters.

Present the date/time, ship's position, speed and heading data, one at a time, conforming to the format specified in 4.3.5 to the port designated for the relevant parameter. The data shall be presented at a rate greater than once per second and changed at a rate less than once per second. Record the data for 30 min. Replay the data.

6.2.1.2 Required results

All the changed data shall be accurately reproduced at a rate of at least once per second.

6.2.2 Bridge audio

(See 4.6.5)

6.2.2.1 Audio frequency response for bridge audio

(See 5.6.3)

6.2.2.1.1 Test method

The following test equipment is required:

- a) sweep frequency audio signal generator;
- b) audio power meter;
- c) frequency counter.

With all other area microphone port inputs short-circuited, connect the audio signal generator to the port under test and adjust its output to obtain a signal capable of continuously sweeping over the frequency range. Adjust the sweep frequency rate to 0,1 octave per second. Set the level to 6 dB below the reference signal level at the equipment input. Record this signal.

Replay the recording and measure the output level and frequency. Determine the level variation over the frequency band. Repeat for all other area microphone ports.

Repeat the tests with the input set at 45 dB below the reference level.

6.2.2.1.2 Required results

The test results shall meet the requirements of 5.6.3.

6.2.2.2 Quality index for bridge audio

(See 5.6.4)

6.2.2.2.1 Single port

(See 5.6.4.1)

6.2.2.2.1.1 Test method

The following test equipment is required:

- a) STI signal generator;
- b) STI analyser;
- c) white noise generator;
- d) audio band-pass filter (150 Hz to 6 000 Hz).

With all other area microphone port inputs short-circuited, connect the signal generator to the port under test. Adjust the signal generator to a level equivalent to 75 dBA. Record the signal.

Replay the recording and analyse the STI. Repeat for all other area microphone ports.

6.2.2.2.1.2 Required results

The test results shall meet the requirements of 5.6.4.1.

6.2.2.2.2 Multiple ports

(See 5.6.4.2)

6.2.2.2.2.1 Test method

With all other area microphone ports having an electrical input equivalent to 65 dBA of band limited white noise, connect the signal generator to the port under test. Adjust the signal generator to level equivalent to 75 dBA. Record the signal.

Replay the recording and analyse the result. Repeat for all other area microphone ports.

6.2.2.2.2.2 Required results

The test results shall meet the requirements of 5.6.4.2.

6.2.2.3 Audio noise level – signal to no signal for bridge audio

(See 5.6.4.3)

6.2.2.3.1 Test method

The following test equipment is required:

- a) audio signal generator;
- b) A-weighted filter to IEC 61672;
- c) third octave filters to IEC 61260;
- d) audio power meter.

With all other area microphone port inputs short-circuited, connect the audio signal generator to the port under test. Record the signal.

Operate the recorder for 30 s for each of the following five input conditions, open, shorted, and with three separate out-of-band signals applied. For the out-of-band tests, connect the signal generator to each port under test and set the input signal to the reference signal level. Select, in turn, frequencies of 8 kHz, 10 kHz and 12,5 kHz. Replay the recordings measuring the A-weighted noise level in the third octave bands. Table 1 is an example for entering this data. Enter the noise level in the third octave bands as a ratio relative to the output for the reference signal input, expressed in dB. Record the lowest value in the last row of the table. Repeat the test for the other area microphone ports.

6.2.2.3.2 Required results

The test results shall meet the requirements of 5.6.4.3.

Table 1 – Bridge audio, signal to no signal measurements**Reference level:** _____

Centre frequency of third octave band	Output A-weighted level relative to reference level				
	dB				
	Out of band at reference level				
Hz	Open	Shorted	8 000 Hz	10 000 Hz	12 500 Hz
200					
250					
315					
400					
500					
630					
800					
1 000					
1 250					
1 600					
2 000					
2 500					
3 150					
4 000					
5 000					
Minimum signal to no-signal ratio =					

6.2.2.4 Audio noise level – signal to noise and distortion for bridge audio

(See 5.6.5)

6.2.2.4.1 Test method

The following test equipment is required:

- a) attenuator;
- b) band-pass filter;
- c) distortion meter.

With the other area microphone ports short-circuited, connect the port under test via an attenuator to the signal source of the distortion meter and record signals at third octave intervals over the band varying the level from the reference level to –20 dB in 5 dB steps recording the signal at each

step. Replay the recordings and measure the total harmonic distortion plus noise for each test condition. Table 2 is an example for entering this data. Optionally, the measurement may be made after passing the replayed signal through a band-pass filter of 150 Hz to 6 000 Hz. Enter the distortion plus noise as a power ratio, expressed in dB. Record the lowest value in the last row of the table. Repeat the test for the other area microphone port.

6.2.2.4.2 Required results

The test results shall meet the requirements of 5.6.5.

Table 2 – Bridge audio, signal to noise and distortion (SINAD) measurements

Reference level: _____

Frequency	Input relative to reference level				
	0 dB	–5 dB	–10 dB	–15 dB	–20 dB
150					
200					
250					
315					
400					
500					
630					
800					
1 000					
1 250					
1 600					
2 000					
2 500					
3 150					
4 000					
5 000					
Minimum signal to noise and distortion ratio =					

6.2.3 Communications audio

(See 5.7)

6.2.3.1 Audio frequency response for communications audio

(See 5.7.3)

6.2.3.1.1 Test method

The following test equipment is required:

- a) sweep frequency audio signal generator;
- b) audio power meter;
- c) frequency counter.

Connect the audio signal generator to the port under test and adjust its output to obtain a signal which continuously sweeps over the frequency range. Adjust the sweep frequency rate to 0,1 octave per second. Set the level to 6 dB below the reference signal level at the equipment input. Record this signal.

Replay the recording and measure the output level and frequency. Determine the level variation over the frequency band.

6.2.3.1.2 Required results

The test results shall meet the requirements of 5.7.3.

6.2.3.2 Quality index for communications audio

(See 5.7.4)

6.2.3.2.1 Test method

The following test equipment is required:

- a) STI signal generator;
- b) STI analyser.

Connect the STI signal generator to the port under test. Adjust the STI signal generator to a level 6 dB below the reference level. Record the signal.

Replay the recording and analyse the STI.

6.2.3.2.2 Required results

The test results shall meet the requirements of 5.7.4.

6.2.3.3 Audio noise level – signal to no signal for the communications audio

(See 5.7.5)

6.2.3.3.1 Test method

The following test equipment is required:

- a) audio signal generator;
- b) A-weighted filter to IEC 61672;
- c) third octave filters to IEC 61260;
- d) audio power meter.

Connect the audio signal generator to the port under test. Record the signal. Operate the recorder for 30 s for each of the following five input conditions: open, shorted, and with three separate out-of-band signals applied. For the out-of-band tests, connect the signal generator to each port under test and set the input signal to the reference signal level. Select, in turn, frequencies of 5 kHz, 6,3 kHz and 8 kHz. Replay the recordings measuring the A-weighted noise level in the third octave bands. Table 3 is an example for entering this data. Enter the noise level in the third octave

bands as a ratio relative to the output for the reference signal input, expressed in dB. Record the lowest value in the last row of the table.

6.2.3.3.2 Required results

The test results shall meet the requirements of 5.7.5.

Table 3 – Communications audio, signal to no-signal measurements

Reference level: _____

Centre frequency of third octave band	Output A-weighted level relative to reference level				
	dB				
	Out of band at reference level				
Hz	Open	Shorted	5 000 Hz	6 300 Hz	8 000 Hz
200					
250					
315					
400					
500					
630					
800					
1 000					
1 250					
1 600					
2 000					
2 500					
3 150					
Minimum signal to no-signal ratio =					

6.2.3.4 Audio noise level-signal to noise and distortion for communications audio

(See 5.7.6)

6.2.3.4.1 Test method

The following test equipment is required:

- a) attenuator;
- b) band-pass filter;
- c) distortion meter.

Connect the port under test via an attenuator to the signal source of the distortion meter and record signals at third octave intervals over the band varying the level from the reference level to –20 dB in 5 dB steps recording the signal at each step. Replay the recordings and measure total harmonic distortion plus noise for each test condition. Table 4 is an example for entering this data. Optionally the measurement may be made after passing the replayed signal through a band-pass filter of 150 Hz to 3 500 Hz. Enter the distortion plus noise as a power ratio, expressed in dB. Record the lowest value in the last row of the table.

6.2.3.4.2 Required results

The test results shall meet the requirements of 5.7.6.

Table 4 – Communications audio, signal to noise and distortion (SINAD) measurements

Reference level: _____

Frequency	Input relative to reference level				
	0 dB	–5 dB	–10 dB	–15 dB	–20 dB
Hz					
150					
200					
250					
315					
400					
500					
630					
800					
1 000					
1 250					
1 600					
2 000					
2 500					
3 150					
Minimum signal to noise and distortion ratio =					

6.2.4 Radar data, post-display selection

(See 4.6.7/5.8)

6.2.4.1 Test objective

The tests outlined in 6.2.4 determine that the VDR meets the functional requirements of 4.6.7. They measure errors between input images, generated from a pre-determined test data set, and the

output of a VDR that has recorded them. Recognising that, with currently available 'final storage media', the VDR must first acquire and digitise an image before it can store it, two different categories of errors are considered:

colour errors, where a feature is rendered in a different colour or brightness on the input image compared to the output image; and

positional errors, where an image feature is in a different position on the input image compared to the output image

With regard to colour, the general aim is to permit only those errors that, ideally, a human observer would not notice and which, necessarily, could not introduce ambiguity.

With regard to position, small scaling errors are permitted if the linearity is good: for example, a small overall increase in the size of the image is acceptable, but a scaling of similar magnitude which varies over the image is not. For this reason, a linearity measure is applied in various ways to assess the acceptability of the errors that occur.

The definitions below are for the purposes only of 6.2.4.2 to 6.2.4.6 inclusive.

colour

triple of real values (r, g, b) specifying amounts of red, green and blue respectively, where $0 \leq r \leq 1$, $0 \leq g \leq 1$ and $0 \leq b \leq 1$. As such, 'colour' includes both hue and intensity

image

function which defines a colour for each value of a pair of real numbers (x, y) representing Cartesian co-ordinates, where $0 \leq x \leq 1$ and $0 \leq y \leq 1$

pixel

rectangular region of an image where the colour of the image is constant. The region is defined by two pairs (x_0, y_0) and (x_1, y_1) representing the Cartesian co-ordinates of diagonally opposite corners of the rectangle. The sides of the rectangle shall be parallel to the Cartesian axes and $x_0 < x_1$ and $y_0 < y_1$

input image

one of a number of pre-determined test images (see 6.2.4.4). The test images are defined mathematically and are made up of a grid of pixels of various colours

input image resolution

integers X and Y that represent respectively the numbers of pixels on the x and y co-ordinates of the input image(s) with which the VDR manufacturer declares the VDR will operate

output image

image that is produced by the playback equipment when a recording of the original image is played back

bit-mapped image

image composed entirely of pixels and for each pixel, the products Xx_0 , Yy_0 , Xx_1 and Yy_1 are integers

6.2.4.2 The principles of the test

The manufacturer shall declare at what X, Y resolutions of input images, specified in 5.8.1.2 and with which optional inputs, permitted by 5.8.1.3, the VDR is designed to operate. All the test equipment shall operate at sufficiently high resolutions. The EUT is connected as shown in Figure 1.

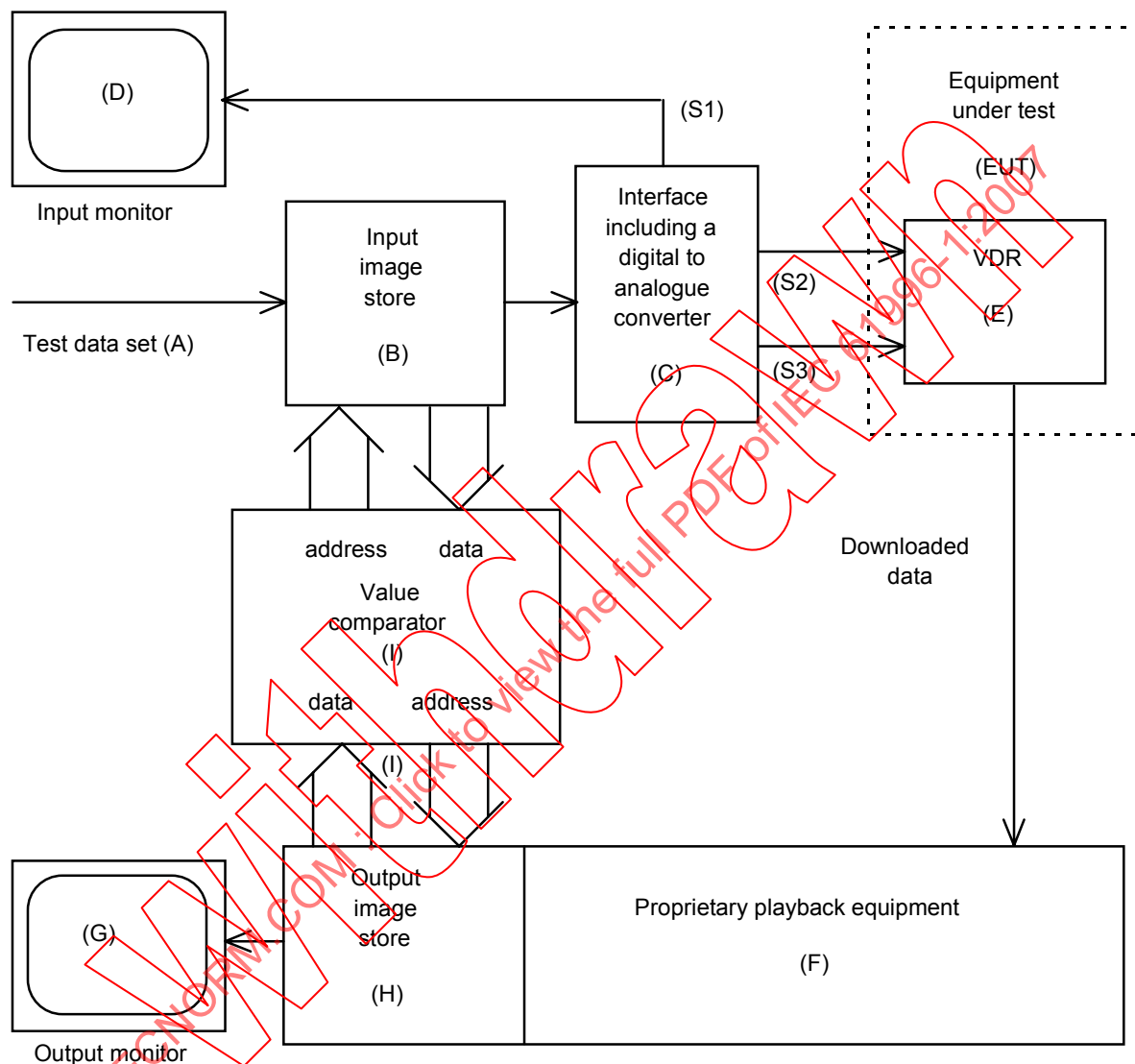
A test data set (A), representing a pre-determined, bit-mapped, test image is loaded into the input image store (B). That store is then read via an interface that includes a digital to analogue converter (C) that, in its turn, provides two mandatory output signals and one optional one.

Signals (S1) and (S2) are identical.

Signal (S1) shall meet the VESA DMTS and drives a monitor (D) that has been approved to the same standard.

Signal (S2) provides the input image to the EUT (E) and shall satisfy the requirements of 5.8.1.2.

Signal (S3) is any signal, optionally chosen by the VDR manufacturer, in accordance with 5.8.1.3, as an input to the EUT (E).



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NOTE Interface block (C) may not require a digital to analogue converter.

Figure 1 – Test set-up block diagram

During the test, the detailed timings of the video signals shall be varied within the limits allowed by the DMTS and by the additional limits required by 5.8.1.2. Where a VDR manufacturer additionally opts to connect to an input image permitted by 5.8.1.3, the timings shall be varied within the limits specified by the radar manufacturer.

The data stored in the final recording medium that relates to the recorded image shall be recovered by a means specified or supplied by the manufacturer as required by 4.3.4.2 and provided as an input to a playback equipment (F) that is also specified or supplied by the manufacturer. That playback equipment shall have two outputs. The first is a video signal meeting the DMTS that is

connected to a monitor (G): the second is the digital data from an externally addressed output image store (H) which may be virtual or real.

The essence of the test is that the value comparator (I) obtains the red, green and blue values of some pixel, at an integer address xX, yY , from the input image store (B), and requests the value from output image store (H) for the same address. This is done for every pixel in the input image store.

The contents of the two image stores are divided into small rectangles that are compared individually. The positions of corresponding rectangles in the two images can be shifted slightly relative to one another before comparison to allow for a certain amount of alignment error in the recorded images. The amount of shift is permitted to vary slightly over the image to allow for various non-linearities. Any shift shall be of the whole rectangle and of every address, corresponding to an input image pixel that it contains. Linearity is assessed separately in the x and y directions by considering individually the rows and columns of rectangles.

6.2.4.3 Comparison of images

NOTE Reference should be made to Figure 2.

Errors in colour and position are determined separately: both are defined in terms of differences between the input digital image store (B) and the output digital image store (H). For analytical convenience and to make the test method independent of image resolution, pixel co-ordinates and the amplitudes of the analogue signals representing the values of red (r), green (g) and blue (b) signals are normalised prior to comparison by dividing their actual value by their maximum one.

For example $r = r_{\text{actual}} / R$, $0 \leq r_{\text{actual}} \leq R$, $x = x_{\text{actual}} / X$, $0 \leq x_{\text{actual}} \leq X$ etc.

All of the tests described in 6.2.4.4 and 6.2.4.5 shall be passed for each of the images in the test set defined in 6.2.4.2.

The x and y axes of the input image are each divided into integer n equal parts, where $n = 8$.

NOTE To assist comprehension, reference is made in the following text to variable n , although its value is fixed at 8.

Thus the whole image is divided into n^2 rectangles indexed by two integer variables j and k , where $0 \leq j \leq n-1$ and $0 \leq k \leq n-1$. Rectangle (j, k) has diagonally opposite corners at co-ordinates $(j/n, k/n)$ and $((j+1)/n, (k+1)/n)$, and has its edges parallel to the Cartesian axes.

For each rectangle (j, k) a corresponding and equally sized rectangle is chosen in the output image, as specified by the manufacturer. That rectangle has its diagonally opposite corners at real co-ordinates $(p_{jk}/n, q_{jk}/n)$ and $((p_{jk}+1)/n, (q_{jk}+1)/n)$, where $0 \leq p_{jk} \leq n-1$ and $0 \leq q_{jk} \leq n-1$: its edges are parallel to the Cartesian axes. The correspondence between rectangles in the input and output images may be chosen afresh for each rectangle but shall remain constant for each test image. Figure 2 illustrates four of the 64 rectangles, with indicative displacements of the output, for the case when $X = 1\,280$ and $Y = 1\,024$.

6.2.4.4 Pre-determined test images

There are three test images that are specifically designed to work with the test method 6.2.4.3 so as to allow it to satisfy the test objective 6.2.4.1. As such, they are not suitable for use as part of any other test within this specification.

It is required that all of the tests of 6.2.4.4 and 6.2.4.5 shall be passed on test images 1, 2, and on at least three examples of test image 3.

6.2.4.4.1 Test image 1

This shall consist of overlaid horizontal and vertical bands of red ($r=1, g=0, b=0$), green ($r=0, g=1, b=0$), blue ($r=0, g=0, b=1$) and black ($r=0, g=0, b=0$). The colours of the bands shall be a repeating sequence of red, fixed-width black, green, fixed-width black, blue and variable-width black. The intersections between the horizontal and vertical bands shall comply with the Table 5.

Table 5 – Intersection colours of test images 1 and 2

Vertical Horizontal	red	green	blue	black
red	red	green	blue	red
green	red	green	blue	green
blue	red	green	blue	blue
black	red	green	blue	black

The red, green, blue and fixed-width black bands shall be one pixel wide and the variable-width black bands shall have widths that change over the image.

The widths of the vertical variable-width black bands shall be the smallest integer that is greater than the value of the expression $0,5 + |\sin(2\pi x/X) \cdot X/20|$ where x is the x co-ordinate of the leftmost edge of the band. The widths of the horizontal variable-width black bands shall be the smallest integer that is greater than the value of the expression $0,5 + |\sin(2\pi y/Y) \cdot Y/15|$ where y is the y co-ordinate of the topmost edge of the band.

6.2.4.4.2 Test image 2

This shall be identical to test image 1 except that the expressions for the widths of the vertical and horizontal variable-width black bands shall be $0,5 + |\cos(2\pi x/X) \cdot X/20|$ and $0,5 + |\cos(2\pi y/Y) \cdot Y/15|$ respectively.

6.2.4.4.3 Test image 3

This shall consist of a palletised, pseudo-random collection of pixels having various colours. Each image shall be generated by the following algorithm:

- pseudo-randomly select a value for I such that I is a real number on the interval $-1/8 \leq I < 1/8$;
- for each of the variables ρ , γ and β pseudo-randomly allocate one of the probabilities 0,78, 0,16, 0,04 and 0,02 to each of the numbers $1/8$, $3/8$, $5/8$ and $7/8$;
- for each pixel in the image pseudo-randomly select a value for each of ρ , γ and β , with the allocated probabilities, from the numbers $1/8$, $3/8$, $5/8$ and $7/8$.
- for each pixel set $r = I + \rho$, $g = I + \gamma$ and $b = I + \beta$.

6.2.4.5 Colour errors

6.2.4.5.1 Test method

For every pair (i) of input and output pixels, within each input and output rectangle that each contain (α) such pixels, the colour error ($C\mathcal{E}_i$) is represented as

$$C\mathcal{E}_i = \left[u \left(r_{(in)i} - r_{(out)i} \right)^2 + v \left(g_{(in)i} - g_{(out)i} \right)^2 + w \left(b_{(in)i} - b_{(out)i} \right)^2 \right]^{1/2}$$

Where $u = 0,089\ 401$, $v = 0,344\ 569$ and $w = 0,012\ 996$, being the squares of the ITU weightings for converting RGB values to luminance values.

The colour test metric (TM_c) is then: $TM_c = \alpha^{-1} \sum_{i=1}^{\alpha} C\epsilon_i$

6.2.4.5.2 Required results

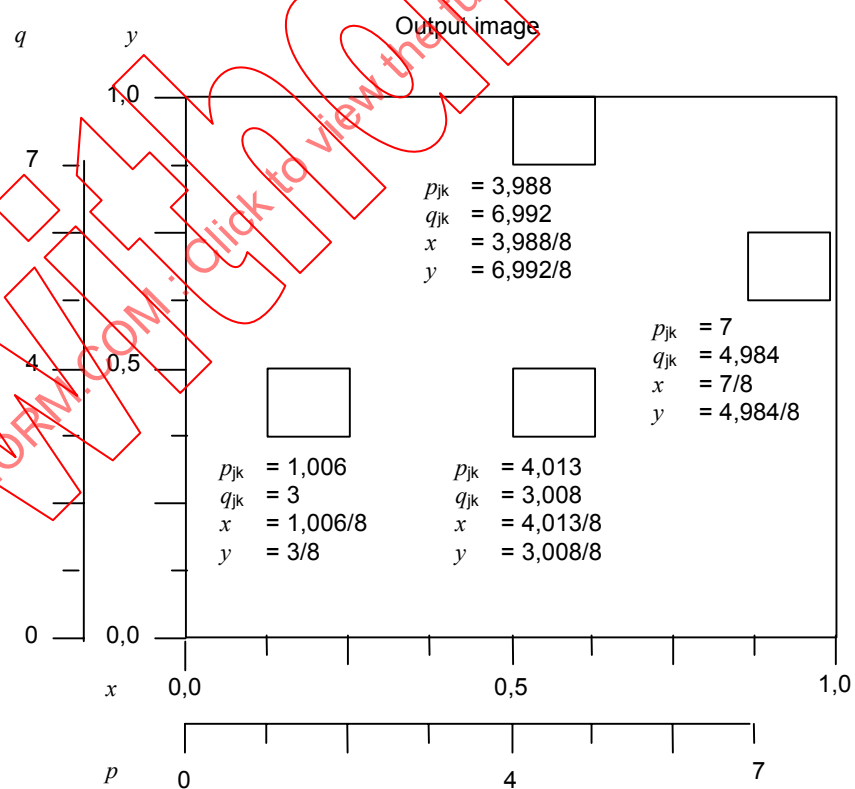
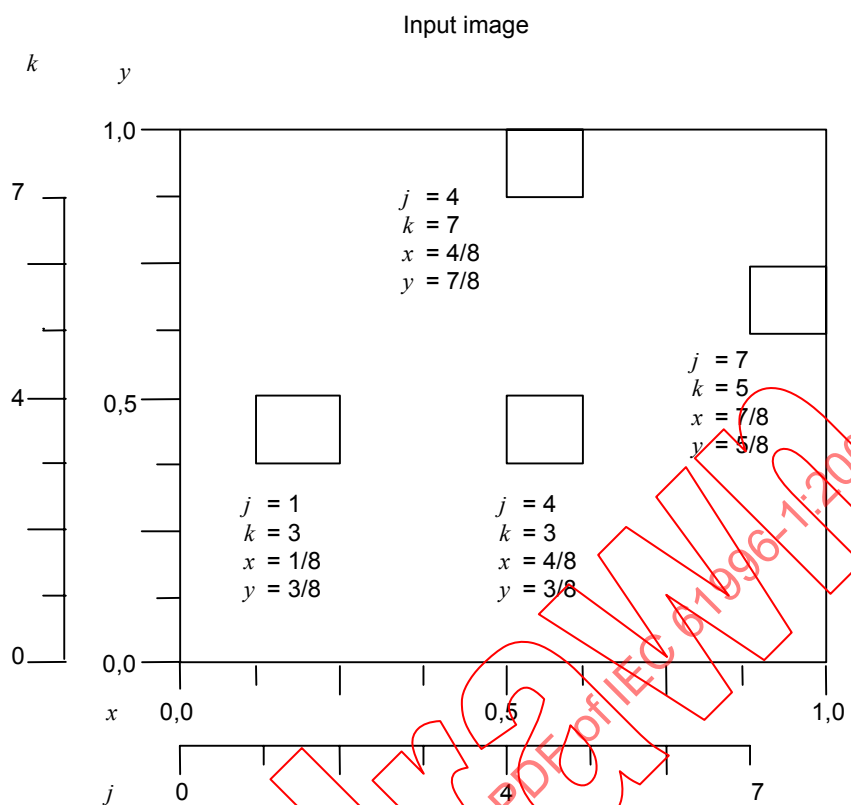
It is required that $TM_c \leq 0,05$ for each of the n^2 rectangles in the image.

6.2.4.6 Positional errors

For each of the n^2 rectangles of the input test image having their corners at j,k , there will be a corresponding output rectangle, whose bottom left-hand corner is at p_{jk}, q_{jk} , that was specified by the manufacturer. It will probably be, but not necessarily, the output rectangle that gave the smallest value of TM_c . It shall be that which passed the tests of 6.2.4.5.

All positional errors are functions of some of the variables j , k , p_{jk} and q_{jk} . The test technique is to consider the pairs of data points j, p_{jk} and k, q_{jk} where, for each of the n values of k , there are n sets of j, p_{jk} and, for each of the n values of j , there are n sets of k, q_{jk} .

The j, p_{jk} set defines any horizontal position errors and the k, q_{jk} set defines any vertical position errors.



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Figure 2 – Comparison of images

6.2.4.6.1 Horizontal position errors

6.2.4.6.1.1 Test method

For each of the n values of k , there will be a row of rectangles on the input image each of whose left-hand edges are defined by the n possible values of j . For convenience and consistency of notation, set $i = j$, $x = j/n$ and $y = p_{jk}/n$.

If there are no positional errors then $y_i = x_i$ for all i , in terms of a linear equation $y_i = mx + c$, where $m = 1$ and $c = 0$. That will not be the case if there are horizontal positional errors. In that case there will be a best-fit line, of form $y = mx + c$, that has some of the data points lying off the line. The test technique is to set limits on the values of m and c (to limit linear offsets and scalings) and also on the amount by which data points can be displaced from the line (to limit non-linearities).

The possible errors are that the image can be scaled by some constant ($m \neq 1$), offset by some constant ($c \neq 0$) or displaced by different amounts at different parts of the image.

Where $y = mx + c$ is the best-fit line, there will be n values of y_i that have a horizontal error:

$$X\mathcal{E}_i = |mx_i + c - x_i|$$

The X linearity test metric TM_x is the mean value of all $X\mathcal{E}_i$ where $0 \leq i = j \leq n - 1$

$$TM_x = n^{-1} \sum_{i=0}^{n-1} X\mathcal{E}_i$$

6.2.4.6.1.2 Required results

It is required that $0,99 \leq m + c \leq 1,01$ and that $-0,01 \leq c \leq 0,01$ for each of the n rows of rectangles indexed by k .

It is required that $TM_x \leq 0,002$ for each of the n rows of rectangles indexed by k .

In addition, because it would be undesirable to have any discontinuities within the image, it is required that $|(mx_i + c - y_i) - (mx_{i+1} + c - y_{i+1})| \leq 0,005$ for all values of i , $0 \leq i = j \leq n - 2$.

NOTE For clarity the discontinuity expression is not simplified.

6.2.4.6.2 Vertical position errors

6.2.4.6.2.1 Test method

For each of the n values of j , there will be a row of rectangles on the input image each of whose bottom edges are defined by the n possible values of k . For convenience and consistency of notation, set $i = k$, $x = k/n$ and $y = q_{jk}/n$.

Hereafter, the analysis and method of test is the same as that used for horizontal errors.

If there are no positional errors then $y_i = x_i$ for all i , in terms of a linear equation $y_i = mx + c$, where $m = 1$ and $c = 0$. That will not be the case if there are vertical positional errors. In that case there will be a best-fit line, of form $y = mx + c$, that has some of the data points lying off the line. The test technique is to set limits on the values of m and c (to limit linear offsets and scalings) and also on the amount by which data points can be displaced from the line (to limit non-linearities).

The possible errors are that the image can be scaled by some constant ($m \neq 1$), offset by some constant ($c \neq 0$) or displaced by different amounts at different parts of the image ($m_i \neq m_{i+1}$ or $c_i \neq c_{i+1}$ for all i).

Where $y = mx + c$ is the best-fit line, there will be n values of y_i that have a vertical error

$$Y\mathcal{E}_i = |mx_i + c - y_i|$$

The Y linearity test metric TM_y is the mean value of all $Y\mathcal{E}_i$ where $0 \leq i = k \leq n - 1$.

$$TM_y = n^{-1} \sum_{i=0}^{n-1} Y\mathcal{E}_i$$

6.2.4.6.2.2 Required results

It is required that $0,99 \leq m + c \leq 1,01$ and that $-0,01 \leq c \leq 0,01$ for each of the n columns of rectangles indexed by j .

It is required that $TM_y \leq 0,002$ for each of the n columns of rectangles indexed by j .

In addition, because it would be undesirable to have any discontinuities within the image, it is required that $|(mx_i + c - y_i) - (mx_{i+1} + c - y_{i+1})| \leq 0,005$ for all values of i , $0 \leq i = k \leq n - 2$.

NOTE For clarity the discontinuity expression is not simplified.

6.2.4.7 Subjective evaluation

6.2.4.7.1 Test method

A series of images, from a radar complying with any of the IEC 60936 series, and consistent with 4.6.7, including ones having small groups of isolated pixels, shall be recorded. These shall be played back alongside the original images. A competent person shall be called upon to compare the original and the recorded images.

6.2.4.7.2 Required results

It is required that, in the professional opinion of the competent person, the original and the recorded images are identical with regard to all operational respects.

6.2.5 Echo sounder – main alarms – rudder order and response – engine order and response – hull openings (doors) status – watertight and doors status – acceleration and hull stresses – wind speed and direction

(See 4.6.8/4.6.9/4.6.10/4.6.11/4.6.12/4.6.13/4.6.14/4.6.15)

6.2.5.1 Test method

The test method and result required is identical in all the items in 6.2.5.

Present the data, item by item, conforming to the format specified in 4.3.5 to the port designated for the specific item. The data shall be presented at a rate greater than once per second and changed at a rate less than once per second. Record the data for 30 min. Replay the data.

6.2.5.2 Required results

It is required that all the changed data are accurately reproduced at a rate of at least once per second.

6.2.6 Interfaces

(See 4.3.5)

The manufacturer shall demonstrate that all interfaces meet the requirements of 4.3.5.

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Annex A (normative)

IEC 61162 sentence formats

Table A.1 – References in this standard

Parameter to be recorded	Subclause(s)	Sentence formatter	Notes
Date and time	4.6.1	ZDA	
Ship's position and datum used	4.6.2	GNS and DTM	
Speed (water and/or ground)	4.6.3	VBW	
Heading (true)	4.6.4	THS, HDT	Note 1
Heading (magnetic)	4.6.4	HDG	
Depth (echo sounder)	4.6.8	DPT	
Alarms	4.6.9	ALR, ALA, FIR, WAT	Note 2
Rudder order/response manual	4.6.10	RSA	Note 3
Rudder order/response automatic	4.6.10	HTC, HTD	
Engine order/response	4.6.11	ETL, PRC, TRC, TRD, RPM, XDR	Notes 2 and 4
Hull openings, watertight doors	4.6.12 & 4.6.13	DOR, GEN, XDR	Notes 2 and 4
Accelerations and hull stress	4.6.14	HSS, XDR, ALR	Note 2
Wind speed and direction	4.6.15	MWV	
VDR alarm output		ALR	Note 5
<p>NOTE 1 The HDT has been deprecated with the safety enhanced THS introduced in the third edition of IEC 61162-1.</p> <p>NOTE 2 IEC/PAS 61162-102 defined sentences specifically for the VDR and S-VDR. These are now included in the third edition of IEC 61162-1.</p> <p>NOTE 3 The current specification for RSA does not have fields for 'order', only 'response'.</p> <p>NOTE 4 The table of transducer types in the current specification for XDR does not specifically include these uses.</p> <p>NOTE 5 There is no requirement for the VDR to send alarm messages. If as an option, such messages are sent, then the appropriate sentence formatter is ALR.</p>			

Annex B (informative)

Mandatory alarms

IMO resolution A.861 requires in 5.4.9 the recording of “mandatory alarms on the bridge”. This phrase is not defined in any published IMO specification or recommendation. The following list has been drawn up by IEC technical committee 80 and discussed with representatives of IMO (see explanatory notes in Tables B.1 and B.2).

Table B.1 – IMO instrument: SOLAS Chapter II-1¹

No.	IMO clause	Function	Type of alert	Notes
1	29.5.2 30.3	Main and auxiliary steering gear power units	Audible + Visual	Failure of power to any steering gear power unit. Operation of devices for short circuit protection, overload, loss of phase in three-phase system
2	29.8.4	Main and auxiliary steering gear control system	Audible + Visual	Failure of power to control system
3	29.12.2	Steering gear, low hydraulic fluid level	Audible + Visual	Low level of fluid in hydraulic fluid reservoir
4	31.2.7 49.5	Propulsion machinery remote control system failure	Audible + Visual	For vessels with bridge control of propulsion machinery and manned engine room: failure of remote control of propulsion machinery
5	31.2.9 49.7	Propulsion machinery low starting air pressure	Audible + Visual	Vessels as 4. Low start air pressure but further starting of propulsion machinery possible
6	52	Automatic shut-down of propulsion machinery		Vessels with periodically unattended machinery spaces. Shut-down of propulsion and other machinery due to serious malfunction
7	51.1.3	Fault requiring action by or attention of the OOW	Audible + Visual	Vessels as 6
8	51.2.2	Alarm system normal power supply failure	Audible + Visual	Vessels as 6. Failure of normal power supply to alarm plant
9	15.7.3.1 ²	Watertight door low hydraulic fluid level	Audible + Visual	Passenger ships constructed on or after 1 February 1992 with hydraulic power operated sliding watertight doors. Low level of fluid in hydraulic reservoir
10	15.7.3.1 ²	Watertight door low gas pressure, loss of stored energy	Audible + Visual	Vessels as 9. Low gas pressure or loss of stored energy in operating hydraulic accumulator
11	15.7.8 ²	Watertight door electrical power loss	Audible + Visual	Vessels as 9. Failure of electrical power to operating or control system
12	21.1.6.2 ²	High water alarm	Audible + Visual	High water level in space where water has drained from enclosed cargo space or freeboard deck
13	23-2.1 ²	Shell door position indicator		Ro-Ro passenger vessels. Door open or locking device not secured. System to have mode switch for ‘sea or harbour’. System active in ‘sea’ mode
14	23-2.2 ²	Water leakage detection indicator	Audible + Visual	Vessels as 13. Leakage of water into Ro-Ro cargo spaces or special category spaces through shell doors
¹ These tables do not include the alarms separately identified for specialist vessels such as gas carriers, fishing vessels, nuclear ships, high speed craft or mobile offshore drilling units.				
² Applicable to vessels constructed on or after 1 February 1992.				