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Ships and marine technology — General specification for shipborne meteorological instruments

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Foreword

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Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A shipborne meteorological instrument (SMI) forms a combined system installed on a ship and is used to measure meteorological elements at the ship's position. The meteorological information acquired by the system can be used as input for meteorological applications that support forecasts, warning and climatological services, with a view to ensuring for safe navigation. This meteorological information can also be used for commercial or scientific needs.

Information sharing is an important feature at the time of publication of this document. The importance of exchanging or sharing meteorological information is also evident.

The number of ships that carry shipborne meteorological instruments with diverse sensors is extensive and in flux. It is generally desirable that the meteorological data measured by ship meteorological instruments can be exchanged and shared with other ships, land-based meteorological information platforms or global meteorological observation systems such as the Voluntary Observing Ship (VOS) Scheme of the World Meteorological Organization (WMO).

This document establishes a set of general technical specifications for all shipborne meteorological instruments, including terms, definitions and test methods, to ensure the quality of different shipborne meteorological instruments and the efficiency in exchanging or sharing meteorological information. In doing so, this document aims to help shipborne meteorological instruments play a more important role in safe navigation, weather forecast and other climatological services, such as wind energy or commercial or technical research.

Ships and marine technology — General specification for shipborne meteorological instruments

1 Scope

This document specifies the technical requirements and test methods for shipborne meteorological instruments (SMIs).

This document applies to shipborne meteorological instruments installed on ships that shares marine meteorological data with other ships, national meteorological services or other users.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 10596:2009, *Ships and marine technology — Marine wind vane and anemometers*

IEC 60092-101:2018, *Electrical installations in ships — Part 101: Definitions and general requirements*

IEC 60092-305, *Electrical installations in ships — Part 305: Equipment — Accumulator (storage) batteries*

IEC 60092-376, *Electrical installations in ships — Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)*

IEC 60092-504:2016, *Electrical installations in ships — Part 504: Automation, control and instrumentation*

IEC 60533, *Electrical and electronic installations in ships — Electromagnetic compatibility (EMC) — Ships with a metallic hull*

WMO-No. 8, Guide *to Instruments and Methods of Observation (*2021 Edition*)*

WMO-No. 488, Guide *to the Global Observing System* (2010 Edition, Updated in 2017)

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
shipborne meteorological instrument
SMI
system installed on a ship that includes one or more meteorological sensors to measure meteorological parameters, and components to process, store and transmit the meteorological data

Note 1 to entry: The meteorological parameters include air temperature, relative humidity, wind direction, wind speed, atmospheric pressure, visibility, sea-surface temperature, etc.

3.2
true north
northerly direction of the meridian

Note 1 to entry: See ISO 19018:2020, 5.1.1 for further information.

3.3
true wind
vector with a speed referenced to the fixed earth and a direction referenced to *true north* (3.2)

Note 1 to entry: The true wind is calculated from the *relative wind speed* (3.4.2) and *direction* (3.4.1), the ship's motion (speed and course over ground), and *true heading* (3.8).

3.3.1
true wind direction
TWD
direction relative to *true north* (3.2) from which the wind is blowing

3.3.2
true wind speed
TWS
magnitude of the *true wind* (3.3) vector

3.4
relative wind
wind vector measured relative to the ship

3.4.1
relative wind direction
RWD
direction relative to the bow of the ship from which the wind is blowing

Note 1 to entry: The direction conventions are 0° for wind from the bow, 90° for wind from the starboard side, 180° for wind from the stern, and 270° for wind from the port side.

3.4.2
relative wind speed
RWS
speed of the wind relative to the ship

3.5
apparent wind
wind vector measured on the vessel with a direction relative to the *true north* (3.2) instead of the bow of the ship

3.5.1
apparent wind direction
equal to the *relative wind direction* (3.4.1) adjusted from the *true north* (3.2)

3.5.2
apparent wind speed
equal to the *relative wind speed* (3.4.2)

3.6
speed over the ground
SOG
speed of the ship relative to the Earth, measured on board of the ship

Note 1 to entry: See ISO 19018:2020, 6.3.4 for further information.

3.7
course over the ground
COG
direction of the ship's movement relative to the Earth, measured on board the ship, expressed in angular units from *true north* (3.2)

Note 1 to entry: See ISO 19018:2020, 6.1.14 for further information.

3.8
true heading
HDT
horizontal direction at which the bow of a ship is pointing, expressed as an angular displacement from *true north* (3.2)

Note 1 to entry: See ISO 19018:2020, 6.1.5 for further information.

4 Requirements

4.1 General requirement

4.1.1 Appearance and installation

4.1.1.1 The coated surface of an SMI shall be uniform and free of peeling. The structural parts of an SMI shall be free of mechanical damage or cracks.

4.1.1.2 Signs or marks of an SMI shall be clear and correct.

4.1.1.3 All parts of an SMI shall be installed correctly, firmly and reliably, and the adjustable mechanical parts shall be free from being sluggish, stuck or loose.

4.1.1.4 An SMI shall be treated against moisture, salt mist and mildew.

4.1.1.5 The underwater parts of an SMI shall be treated against erosion by living plants and animals (algae, scum, coral, etc.).

4.1.1.6 See Annex A for details on the installation of sensors.

4.1.2 Material

The material of an SMI shall be in accordance with IEC 60092-101:2018, 4.7.

4.1.3 Cable

If cables are provided, they shall be in accordance with IEC 60092-376.

4.1.4 Battery

If batteries are provided, they shall be in accordance with IEC 60092-305.

4.2 Technical specification of meteorological parameter measurement

The specifications in Table 1 shall be met.

Table 1 — Technical specifications of sensors used

Meteorological parameter	Range	Uncertainties	Resolution
Wind speed[a]	0 ms^{-1} to 60 ms^{-1}	0,5 ms^{-1} (≤5 ms^{-1}) 10 % (>5 ms^{-1})	0,1 ms^{-1}
Wind direction[b]	0° to 360°	5°	1°
Air temperature	−40 °C to 60 °C	0,2 °C	0,1 °C
Relative humidity	5 % to 100 %	3 % (≤80 %) 5 % (>80 %)	1 %
Atmospheric pressure	800 hPa to 1 060 hPa	0,3 hPa	0,1 hPa
Visibility	50 m to 20 000 m	50 m (≤600 m) 10 % (>600 m to ≤ 1 500 m) 20 % (>1 500 m)	1 m
Sea-surface temperature	−2 °C to 40 °C	0,2 °C	0,1 °C

NOTE Meteorological parameters acquired by an SMI are not limited to those shown in Table 1. For example, precipitation or net-radiation are possible additional parameters. The meteorological parameters shown in Table 1 can be selected as needed.

[a] Wind speed is the relative wind speed.

[b] Wind direction is the relative wind direction.

4.3 Safety

Safety marks against electric shock, mechanical hazard and combustion shall comply with IEC 60092-101 and IEC 60092-504.

4.4 Environmental conditions

Environmental conditions shall be in accordance with IEC 60092-101:2018, 4.6.

4.5 Enclosure protection

Enclosure protection shall be in accordance with IEC 60092-101:2018, 4.14.

4.6 Electromagnetic compatibility

Electromagnetic compatibility shall be in accordance with IEC 60533.

4.7 Sampling, algorithm and meteorological data quality control

4.7.1 Sampling rate

Based on WMO-No. 488 and WMO-No. 8, the sampling rate of meteorological parameters should comply with the recommendations in Table 2.

Table 2 — Recommended minimum sampling rates

Meteorological parameter	Sampling times per minute
Air temperature	> 5
Relative humidity	> 5
Atmospheric pressure	> 5
Relative wind speed	≥ 60
Relative wind direction	≥ 60
Visibility	≥ 4
Sea-surface temperature	≥ 5

4.7.2 Algorithm and data quality control

The algorithm and meteorological data quality control shall comply with WMO-No. 488 and WMO-No. 8.

4.8 Data storage and transmission

4.8.1 Data storage

An SMI should be able to store the latest measurement data of at least 180 days, including the information on the corresponding time and location, as detailed in Annex C.

4.8.2 Data transmission

The mode that enables the transmission of data to national meteorological services or other users shall be selected, with the appropriate communication transmission device and system, or the data transmission system which is connected to the ship equipped.

4.8.3 Communication interface

An SMI should be equipped with a communication interface matched with the selected transmission mode, such as RS-232, RS-485 (i.e. TIA-232 or TIA-485)[16, 17], LAN (Local Area Network) and CAN (Controller Area Network). Wired transmission (RS-232 / 485, CAN or Ethernet) can be adopted to transmit data to the applications of the ship's devices or system at the frequency of 1 time per second.

A SMI should be equipped with a satellite communication system.

NOTE RS-232 and RS-485 are possible standards for serial communication from EIA (Electronics Industries Alliance) or TIA (Telecommunications Industry Association).

4.8.4 Transmission format

The data transmission format should be based on the communication/data format of the WMO VOS (Voluntary Observing Ship Scheme). When the meteorological data are transmitted ashore, the frequency should be at least one observation per hour, the transmission format should allow the use of the current FM 94-XIV BUFR format and the relevant sequences specified in the WMO Manual on Codes WMO-No. 306, volume 1.2, for data sharing with national meteorological services.

4.9 Display

A display should be equipped if required.

4.10 Clock

4.10.1 Time error

An internal clock shall be equipped and the time error shall not exceed 15 s in 30 days.

4.10.2 Synchronized time

The clock should be synchronized one time every day with Coordinated Universal Time (UTC).

4.11 Power supply

The nominal voltage of the power supply should be 12 V d.c. or 24 V d.c., 115 V a.c. or 230 V a.c.

5 Test methods

5.1 Test ambient conditions

The following requirements shall be met:

— temperature: from 15 °C to 35 °C;

— relative humidity: from 20 % to 75 %;

— atmospheric pressure: from 860 hPa to 1 060 hPa.

5.2 Test standard apparatus

The test standard apparatuses used for measuring performance of SMI shall meet the requirements shown in Table 3.

Table 3 — Apparatus for measuring performance tests

No.	Name of the apparatus	Specifications
1	Atmospheric pressure standard apparatus	Range: 800 hPa to 1 100 hPa Uncertainty: 0,1 hPa
2	Temperature standard apparatus	Range: −40 °C to 60 °C Uncertainty: 0,06 °C
3	Relative humidity standard apparatus	Range: 5 % to 100 % Uncertainty: 1 %
4	Wind direction standard apparatus	Range: 0° to 360° Uncertainty: 1°.
5	Wind speed standard apparatus	Range: 0 ms^{-1} to 60 ms^{-1} Uncertainty: 1 %
6	Visibility test apparatus	Range: 10 m to 20 000 m Uncertainty: 5 % (≤1 500 m); 10 % (>1 500 m)

5.3 General requirements check

5.3.1 Appearance and installation

Perform a visual and manual check.

5.3.2 Material

The flame retardment test of electrical materials shall be carried out in accordance with IEC 60092-101:2018, 4.7.

5.3.3 Cable

The cables shall be inspected and tested in accordance with IEC 60092-376:2017, Clause 6.

5.3.4 Battery

If batteries are provided, they shall be inspected in accordance with IEC 60092-305.

5.4 Safety

The safety marks against electric shock, mechanical hazard and combustion shall be checked or tested in accordance with IEC 60092-101:2018 and IEC 60092-504:2016.

5.5 Environmental conditions

The environmental conditions test shall be in accordance with IEC 60092-504:2016, Table 1, items 6 to 12.

5.6 Technical performance of meteorological parameters

5.6.1 Atmospheric pressure

At least five measurement points (including the upper and lower limits of the measurement range in Table 1) within the measurement range shall be uniformly selected. The measurements should be carried out by an atmospheric pressure standard apparatus from the lower point to the upper point and reverse.

NOTE Only the range of the sensor can be tested, otherwise the sensor can be damaged.

5.6.2 Air temperature

At least five measurement points (including the upper and lower limits of the measurement range in Table 1, and 0 °C) shall be uniformly selected. The test should be carried out by a temperature measurement apparatus.

5.6.3 Relative humidity

At least five measurement points within the measurement range in Table 1 shall be uniformly selected. The test should be carried out by a humidity measurement apparatus forwardly and reversely.

5.6.4 Relative wind direction

The relative wind direction test shall be carried out in accordance with ISO 10596:2009, 8.1.1.

5.6.5 Apparent wind speed

The apparent wind speed test shall be carried out in accordance with ISO 10596:2009, 8.1.2.

5.6.6 True wind speed and true wind direction

The true wind speed (TWS) and the true wind direction (TWD) are calculated. The algorithm of the calculation is shown in Clause 6.

The test cases shown in Table 4 are proposed to check the true wind algorithm.

Table 4 — Suggested test for true wind speed and true wind direction

No.	Test	RWS ms^{-1}	RWD (°)	HDT (°)	COG (°)	SOG ms^{-1}	TWS ms^{-1}	TWD (°)
1	Ship not moving, heading North Relative wind is equal to true wind	5,0	40,0	0,0	0,0	0,0	5,0	40,0
2	Ship not moving, heading South true wind is opposed to relative wind	5,0	40,0	180,0	0,0	0,0	5,0	220,0
3	Ship slow, no heading No true wind computation because SOG ≤3 kt[a]	5,0	40,0	/	0,0	1,5	/	/
4	No relative wind, heading East, no drift. True wind is opposed to ship displacement	0,0	0,0	90,0	90,0	5,0	5,0	270,0
5	North relative wind	10,0	360,0	150,0	150,0	5,0	5,0	150,0
6	No true wind	5,0	360,0	360,0	360,0	5,0	0,0	0,0
7	Random 1	10,0	250,0	40,0	30,0	5,0	11,9	265,6
8	Random 2, no heading True wind calculated assuming HDT = SOG	10,0	250,0	/	30,0	5,0	12,6	258,1
9	Random 3	15,0	5,0	91,0	90,0	12,0	3,3	118,3

Key

RWS relative wind speed

RWD relative wind direction

HDT true heading

COG course over the ground

SOG speed over the ground

TWS true wind speed

TWD true wind direction

NOTE The specifications of the table are calculated based on methods from Reference [18].

[a] 3 kt = 1 543 ms^{-1}.

5.6.7 Visibility

The visibility test points shall be selected at 50 m, 500 m, 1 000 m, 1 500 m, 5 000 m, 10 000 m and 20 000 m. The test should be carried out by a visibility measurement apparatus.

5.6.8 Sea-surface temperature

At least five measurement points (including the upper and lower limits of the measurement range, and 0 °C) shall be uniformly selected. The test should be carried out by a temperature measurement apparatus.

5.7 Data storage and transmission

5.7.1 Data storage and integrity

After an SMI runs continuously for three days, calculate the available days for storage according to Formula (1), and check the integrity of the measured data in accordance with Annex C.

$$d = \frac{S_1 + S_2}{S_2} \times n \tag{1}$$

where

d is available days for storage;

S_1 is free space;

S_2 is occupied space;

n is the number of days (here it is set to 3).

5.7.2 Data transmission

Set up the communication transmission in terms of mode, interface and format according to the document of SMI and run it for not less than 1 h. Check the integrity of the received data in accordance with Annex C.

5.8 Clock

Shut down the synchronize function of clock, and then operate the SMI continuously for three days before checking the clock error.

5.9 Power supply

Depending on the user manual of SMI, connect the nominal power supply to check if the SMI is running normally.

6 True wind calculation

6.1 Principle

The wind induced by the ship's motion shall be removed from the apparent wind to compute the true wind (see Figure 1). Consequently, the true wind vector is the sum of the apparent wind vector and the motion vector.

Computations hereafter are done according to mathematic coordinates. Units are degrees for angles and ms^{-1} for speed. Conversion shall be done if speeds are given in other units (e.g. if SOG is measured in knots). See Annex B about the requirements of measured true heading, course over the ground (COG), and the speed over the ground (SOG).

6.2 Components of the apparent wind ($S_{wa,X}$ and $S_{wa,Y}$)

The apparent wind speed component along X-axis and Y-axis are calculated according to Formulae (2) and (3).

$$S_{wa,X} = - S_{wr} \sin[(D_{wr} + D_{hd})\pi/180] \quad (2)$$

$$S_{wa,Y} = - S_{wr} \cos[(D_{wr} + D_{hd})\pi/180] \quad (3)$$

where

$S_{wa,X}$ is the X component of apparent wind in the Cartesian coordinate system, expressed in metres per second (ms^{-1});

$S_{wa,Y}$ is the Y component of apparent wind in the Cartesian coordinate system, expressed in metres per second (ms^{-1});

S_{wr} is the RWS (relative wind speed) measured by SMI, expressed in metres per second (ms^{-1});

D_{wr} is the RWD (relative wind direction) measured by SMI, expressed in degrees (°);

D_{hd} is the HDT (true heading), expressed in degree (°).

6.3 Components of the ship's motion ($S_{m,X}$ and $S_{m,Y}$)

The ship's motion speed component along X-axis and Y-axis are calculated according to Formulae (4) and (5).

$$S_{m,X} = S_m \sin(D_m \pi/180) \quad (4)$$

$$S_{m,Y} = S_m \cos(D_m \pi/180) \quad (5)$$

where

$S_{m,X}$ is the X component of ship's motion speed in the Cartesian coordinate system, expressed in metres per second (ms^{-1});

$S_{m,Y}$ is the Y component of ship's motion speed in the Cartesian coordinate system, expressed in metres per second (ms^{-1});

S_m is the SOG (speed over the ground), expressed in metres per second (ms^{-1});

D_m is the COG (course over the ground), expressed in degree (°).

6.4 Components of the true wind ($S_{wt,X}$ and $S_{wt,Y}$)

The true wind speed component along X-axis and Y-axis are calculated according to Formulae (6) and (7).

$$S_{wt,X} = S_{wa,X} + S_{m,X} \quad (6)$$

$$S_{wt,Y} = S_{wa,Y} + S_{m,Y} \quad (7)$$

where

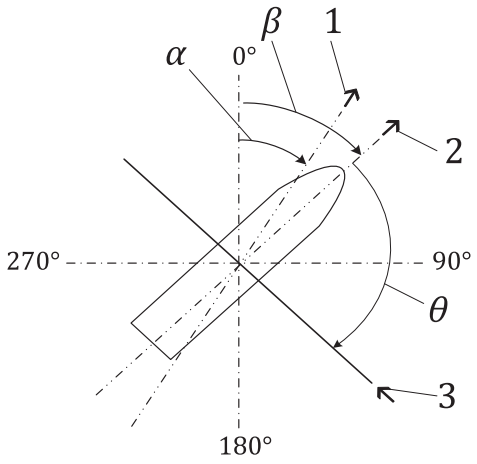
$S_{wt,X}$ is the X component of TWS (true wind speed) in the Cartesian coordinate system, expressed in metres per second (ms^{-1});

$S_{wt,Y}$ is the Y component of TWS (true wind speed) in the Cartesian coordinate system, expressed in metres per second (ms^{-1}).

6.5 Calculation of the true wind direction and true wind speed (D_{wt} and S_{wt})

The true wind direction is calculated according to Formula (8), and the true wind speed is calculated according to Formula (9). The angle and vectors relevant for true wind calculation are shown in Figure 1 and Figure 2. In these figures, the 0° direction is referred to the true north, the apparent wind direction is the sum of HDT (true heading) and RWD (relative wind direction), as shown in Figure 1. The RWD (relative wind direction) is translated to the apparent wind direction, which is calculated from true north, for calculation of

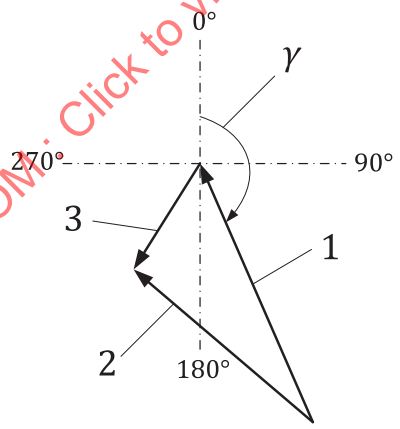
the apparent wind speed components, as shown in Formulae (2) and (3). The relationship between vectors of true wind, relative wind and motion wind is shown in Figure 2. The motion wind is generated only by the ship's motion, which has the same speed but the opposite direction to the ship's motion.



Key

α angle of COG
β angle of HDT
θ angle of RWD
1 COG
2 HDT
3 RWD

Figure 1 — Angle relevant for true wind calculation



Key

γ angle of true wind vector
1 true wind vector
2 relative wind vector
3 motion wind vector

Figure 2 — Vectors relevant for true wind calculation

$$D_{wt} = 270 - \text{atan2}(S_{wt,Y}, S_{wt,X})180/\pi \quad \text{(modulo 360°)} \tag{8}$$

NOTE 1 atan2 is the C function which gives the inverse tangent over 360° for any couple of values along the X- and Y-axes.

$$S_{wt} = \sqrt{(S_{wt,X})^2 + (S_{wt,Y})^2} \quad (9)$$

NOTE 2 If the measurement data of true heading D_{hd} is not available, an approximate computation of the true wind can be done assuming that the heading is equal to the course ($D_{hd} = D_{COG}$) but only if the ship speed is higher than 3 kt (3 kt = 1,543 ms^{-1}).

Annex A
(informative)

Installation requirements

A.1 General

This annex provides installation requirements for shipborne meteorological instruments. See WMO-No. 8 for further information on installation requirements.

A.2 Wind sensor

The following requirements apply:

a) install the wind sensor on the mainmast, foremast or compass deck where the air flow from all directions is unobstructed, and keep the distance between the wind sensor and the lower closest platform at least 2 m;

b) keep the direction mark of the wind sensor aligned with the midship line.

A.3 Temperature and/or humidity sensor

To prevent the temperature and/or humidity sensor from solar radiation and maintain natural ventilation, the following requirements apply:

a) install the temperature or humidity sensor in a ventilation and radiation shield;

b) do not place the temperature or humidity sensor near artificial airflow (such as from air conditioning or exhausts);

c) keep the distance between the sensor and the installation deck within a range of at least 1,5 m to 2,0 m.

A.4 Atmospheric pressure sensor

The following requirements apply:

a) avoid air flow disturbance and sunlight;

b) install a static pressure head at the air inlet of the sensor to reduce the influence of wind on barometric pressure measurements.

A.5 Visibility sensor

Keep the distance between the sensor and the installation deck at least 2 m.