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Method for testing marine anemometers

海洋测风仪器检测方法

(English Translation)

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Foreword

This document is drafted in accordance with the rules given in GB/T 1.1-2009 under the section "Directives for standardization — Part 1: Structure and drafting of standards."

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. The issuing body of this document shall not be held responsible for identifying any or all such patent rights.

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

This standard was drafted by the National Center of Ocean Standards and Metrology, China, and the South China Sea Center of Standards and Metrology of State Oceanic Administration.

The main drafters of this standard were Yu Jianqing, Weng Dexian, Zhu Liping, Zhang Yuehong and Qin Xinpei.

Method for testing marine anemometers

1 Scope

This standard specifies the test items, test equipment, test procedures and test report of marine anemometers (hereinafter referred to as “anemometers”).

This standard is applicable to test propeller anemometers and two-dimensional ultrasonic anemometers with wind velocity measurement ranges of 0–75 m/s. The testing of wind sensors may also refer to this standard.

2 Normative References

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

JJG 431-2014 Verification regulation of portable 3-cup anemometers

JJG 518 Verification regulation of pitot tubes

JJG 875-2005 Verification regulation of digital pressure gauges

3 Terms and Definitions

3.1 Propeller anemometer

An anemometer that is used to measure wind direction by directly facing the airflow after tail swing, and which measures wind velocity by airflow rotating the propeller.

Note: The propeller anemometer mainly comprises the main housing, rotating propeller, tail, wind direction convertor, wind velocity convertor and data acquisition/display unit (hereinafter referred to as “digital display unit”). When the wind direction forms an included angle with the tail, the wind produces torque force to the tail to make it swing, until the tail and wind directions are consistent. The wind direction convertor outputs wind direction signals according to the angular displacement of the tail relative to the north arrow marker line. The action of wind power rotates the propeller, and the wind velocity convertor outputs signals related to the wind velocity. The digital display unit displays the wind velocity and wind direction indications through the corresponding function calculation, according to the wind direction and wind velocity signals.

3.2 Ultrasonic anemometer

An anemometer that is used to measure the time or frequency (Doppler conversion) difference of the receiving end by sending a sound wave pulse to calculate the wind velocity and direction.

3.3 Service area in the test section of a wind tunnel

An area with a stable and uniform wind flow field in the test section of a wind tunnel.

3.4 Starting threshold of wind velocity

It is determined by measuring the lowest speed at which a rotating anemometer starts and continues to turn and produce a measurable signal when mounted in its normal position.

4 Test Items

The test items of the anemometer include appearance and power-on check, starting threshold of wind velocity, wind direction indication errors and wind velocity indication errors.

Note: The ultrasonic anemometer is not subject to the test of “starting threshold of wind velocity”.

5 Test Equipment

For the test equipment of the anemometer, see Table 1.

Table 1 Technical Indexes of Test Equipment

Test equipment	Measurement range	Technical index (uncertainty or accuracy class or maximum permissible error)
L-type pitot tube	/	K shall be within 0.99－1.01; other technical indexes shall meet the requirements in JJG 518.
Differential pressure gauge	The upper limit of measurement range shall not be lower than 3,000 Pa.	The accuracy class shall not be lower than Class 0.1 (according to JJG 875-2005); all technical indexes shall meet the requirements in JJG 875-2005.
Standard azimuth plate	0－360°	Division value: 1°; maximum permissible error: ± 0.5° ; installed on the lower wall of the test section of the wind tunnel, and able to rotate the anemometer to be tested.
Wind tunnel	Maximum wind velocity in the test section: ≥ 75 m/s; minimum wind velocity in the test section: ≤0.5 m/s	Flow field uniformity: ≤1.0%; flow field stability (3 min): ≤1.0%
Air gauge	500－1,100 hPa	The accuracy class shall not be lower than Class 0.1.
Temperature gauge	0－50 ℃	Maximum permissible error: ±0.5 ℃
Hygrometer	5－95% RH	Maximum permissible error: ±7% RH

6 Test Environmental Conditions

Ambient temperature: 15－35 ℃.

Relative humidity: Not greater than 85%.

7 Test Procedures

7.1 Appearance and power-on check

The appearance and power-on check method is as follows:

1) Inspect whether the anemometer structure is complete, and all parts are connected reliably.

2) Inspect whether the anemometer has a nameplate, and whether it is clear and marked with a non-erasable manufacturer’s name (or serial logo), model and serial no.

3) Inspect whether the surface paint layer and the cladding layer of the anemometer are uniform and smooth, and ensure they have no obvious dents, cracks, bruises, corrosion or blistering.

The metal parts shall be free of serious corrosion and other mechanical damage.

4) Manually inspect whether the rotating propeller of the propeller anemometer is able to equilibrate neutrally and to rotate smoothly. It shall be free of obvious axial and radial run-out.

5) Power on the anemometer to inspect whether it is able to display data normally.

7.2 Pre-test preparations

7.2.1 Calculate the blockage ratio. Divide the windward projected area of the anemometer (including the mounting strut and control part) to be tested by the sectional area of the test section of the wind tunnel. When its specific value is not greater than 5%, the test may be carried out.

7.2.2 Install the L-type pitot tube in the test section of the wind tunnel, keeping its measuring head axis parallel to the axis of the test section of the wind tunnel. Keep the pitot hole in the service area of the test section, aligned with the airflow direction. Connect the pitot pressure outlet to the pitot pressure inlet of the differential pressure gauge, and connect the static pressure outlet to the static pressure inlet of the differential pressure gauge.

7.2.3 Installation of the anemometer

7.2.3.1 Install the anemometer in the test section of the wind tunnel, and keep the entire rotating propeller, tail or probe in the service area of the test section.

7.2.3.2 Install the anemometer in the downstream and lower part of the L-type pitot tube. The top shall deviate from the measuring head axis of the L-type pitot tube by at least 60 mm in a horizontal direction.

7.2.3.3 Keep the mounting strut of the anemometer concentric with the standard azimuth plate, and keep the relative position between them unchanged at all times.

7.2.3.4 For the four-probe ultrasonic anemometer, keep one pair of receiving and sending end lines consistent with the flow direction of wind in the test section of the wind tunnel.

7.3 Test of starting threshold of wind velocity

7.3.1 Start the wind tunnel motor to revolve the propeller anemometer for 2–3 min at a wind speed of 10 m/s.

7.3.2 Shut down the wind tunnel motor. After the rotating propeller returns from rotation to a static state, manually adjust the tail direction to keep the acute angle between it and the airflow direction of wind tunnel as 10°. The deviations shall not exceed ±2°.

7.3.3 Read the zero of the differential pressure gauge with an accuracy of 0.1 Pa.

7.3.4 Start the wind tunnel motor, slowly increase the airflow velocity in the test section of the wind tunnel until the tail swings and then stops, and the rotating propeller changes to a state of continuous rotation. The digital display unit may continuously output the wind velocity and direction indications. Record the wind velocity indication measured.

7.3.5 Read and record three indications of the differential pressure gauge, and average them; then subtract zero to obtain the actual wind pressure. During the process of reading the indications of the differential pressure gauge, read the temperature, relative humidity and air

pressure values in the test section once. Calculate the standard wind velocity value (as specified in JJG431-2014, Annex A); that is, the starting threshold of wind velocity of such a propeller anemometer.

7.4 Test of wind direction indication errors

7.4.1 The test points of wind direction indication errors are: 0°, 30°, 60°, 90°, 120°, 150°, 180°, 210°, 240°, 270°, 300°, 330° and 355°. The deviations shall not exceed ±2°.

7.4.2 Adjust the wind velocity in the test section of the wind tunnel to 5 m/s, until the test of wind direction indication errors is completed.

7.4.3 Rotate the standard azimuth plate to keep the wind direction indication of the anemometer at 0°. Rotate the standard azimuth plate anticlockwise to each test point of wind direction indication errors, read three wind direction indications of the anemometer within 1 min after stabilization, and take their mean as the indication of such test points. Repeat the whole procedure until the test point is at 355°.

7.4.4 Continue rotating anticlockwise beyond 355° (not exceeding 360°), then rotate the standard azimuth plate clockwise to each test point of wind direction indication errors. Read three wind direction indications of the anemometer uniformly within 1 min after stabilization, and take their mean as the indication of such test points. Repeat the whole procedure until the test point is at 0°.

7.4.5 Calculate the wind direction indication errors on each test point. Take the greater of the absolute values between the two indication errors as the final indication error of such test points.

7.5 Test of wind velocity indication errors

7.5.1 Selection of wind velocity test points

For the selection of wind velocity test points, see Table 2.

Table 2 Selection of Wind Velocity Test Points

Measurement range of wind velocity	Test point (m/s)	Deviation of test points
60 m/s ≤ upper limit of measurement range ≤ 75 m/s	5, 10, 20, 30, 40, 50, 60 and upper limit of measurement points	1) In case of deviation between the set standard wind velocity in the test section of the wind tunnel and the corresponding test points, there shall be no positive deviation on the upper limit of measurement points, and the deviation shall not exceed -2 m/s. 2) Other deviations on test points shall not exceed ±1 m/s.
Upper limit of measurement range < 60 m/s	1) Set seven test points between the upper and lower limits of measurement points uniformly. 2) A test point of 5 m/s should be included; a test point less than 5 m/s shall be included at the same time.	

7.5.2 Follow the sequence from low wind velocity to high wind velocity.

7.5.3 Adjust the differential pressure gauge to keep its working state normal. Read the zero of the differential pressure gauge with an accuracy of 0.1 Pa.

7.5.4 After the wind velocity in the test section of the wind tunnel reaches the set test point, read values after stabilizing for 1 min. Read the standard indication and then read the wind velocity indication of the anemometer. Later, read three repetitions of values at intervals of 1 min. In the first reading, read the temperature, relative humidity and air pressure values in the test section. Calculate the arithmetic mean value of the three readings of the differential pressure gauge; subtract zero to obtain the actual wind pressure; and then calculate the standard wind velocity value (as specified in JJG431-2014, Annex A). Take the arithmetic mean value of the three wind velocity indications of the anemometer as its wind velocity indication on such points. See Table A.1, Annex A, for the format of the test record.

7.6 Data processing

7.6.1 Calculation of wind direction indication errors

The wind direction indication errors of the test points shall be calculated as per Formula (1). The anemometer has 13 test points within the whole measurement range:

$$\Delta A_i = A_{Ni} - A_{Bi} \quad (i=1, 2, \cdots, 13) \tag{1}$$

where:

ΔA_i -- Wind direction indication error of the anemometer on the i^{th} test point in °;

A_{Ni} -- Mean of the three wind direction indications of the anemometer on the i^{th} test point in °; and

A_{Bi} -- Standard wind direction value on the i^{th} test point in °.

7.6.2 Calculation of wind velocity indication errors

The wind velocity indication errors of test points shall be calculated as per Formula (2). The anemometer has n test points within the whole measurement range:

$$\Delta V_i = V_{Ni} - V_{Bi} \quad (i = 1, 2, \cdots, n) \tag{2}$$

where:

ΔV_i -- Wind velocity indication error of the anemometer on the i^{th} test point in m/s;

V_{Ni} -- Mean of the three wind velocity indications of the anemometer on the i^{th} test point in m/s; and

V_{Bi} -- Standard wind velocity value on the i^{th} test point in m/s.

8 Test Report

The test report shall report test results accurately, clearly and objectively, and shall

include:

a) Title: Test Report.

b) Name and address of testing organization.

c) Unique identifier of the test report and the identifier on every page, to identify every page as part of the test report; and clear identification indicating the end of the test report.

d) Name and address of client.

e) Name, model/specification, serial no. and manufacturer of the anemometer to be tested.

f) Technical documentation on which the report is based.

g) Name, position, signature or equivalent identification of approver of test report.

h) Signature of tester and verifier.

i) Date of receipt of the anemometer to be tested.

j) State of the anemometer to be tested.

k) Name, model/specification, technical index, certificate number and validity period of the test equipment.

l) Test time, location and environmental conditions.

m) Test results.

Note: When it is necessary to make an explanation about test results, record the deviation from, addition to or abridgment of the test methods; add information on specific test conditions, specific methods and additional information required by the customer group.

For the inside page format of the test report, see Annex B.

Annex A
(Informative)

Table A.1 Format of Test Record Table of the Anemometer

<table>
<tr><td colspan="2">Anemometer name</td><td colspan="2"></td><td>Certificate no.</td><td colspan="3"></td></tr>
<tr><td colspan="2">Model/specification</td><td colspan="2"></td><td>Serial no.</td><td colspan="3"></td></tr>
<tr><td colspan="2">Inspection unit</td><td colspan="2"></td><td>Manufacturing unit</td><td colspan="3"></td></tr>
<tr><td colspan="2">Standard accordance with</td><td colspan="2"></td><td>Date of receipt</td><td colspan="3"></td></tr>
<tr><td colspan="8">Test equipment</td></tr>
<tr><td colspan="2">Name</td><td>Measurement range</td><td colspan="2">Uncertainty or accuracy class or maximum permissible error</td><td colspan="2">Certificate no.</td><td>Valid until</td></tr>
<tr><td colspan="2"></td><td></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="8">Test time, location and environmental conditions</td></tr>
<tr><td>Location</td><td colspan="3"></td><td>Time</td><td colspan="3">M/Y/D</td></tr>
<tr><td>Environmental parameters</td><td colspan="7">Temperature: - ℃; relative humidity: % - %;
air pressure: - hPa</td></tr>
<tr><td colspan="8">Test results</td></tr>
<tr><td colspan="8">Appearance and power-on check</td></tr>
<tr><td colspan="8">The anemometer structure is complete, and all parts are connected reliably. Yes☐No☐
2) The nameplate is clear and marked with non-erasable manufacturer name (or serial logo), model and serial no. Yes☐No☐
3) The surface paint layer and the cladding layer are uniform and smooth without obvious dents, cracks, bruises, corrosion or blistering. The metal parts are free of serious corrosion and other mechanical damage. Yes☐No☐
4) The tester has manually inspected the rotating propeller of the propeller anemometer, which is able to equilibrate neutrally and rotate smoothly and flexibly without obvious axial and radial run-out. Yes☐No☐
5) The tester has powered on the anemometer, which is able to display data normally. Yes☐No☐</td></tr>
<tr><td colspan="8">Starting threshold of wind velocity (propeller anemometer)</td></tr>
<tr><td colspan="5">Reading of the differential pressure gauge (Pa)</td><td colspan="4">Air density (kg/m³)</td><td rowspan="2">Standard wind velocity (m/s)</td><td rowspan="2">Anemometer indication (m/s)</td></tr>
<tr><td>Zero</td><td>1</td><td></td><td></td><td>Mean</td><td>Temperature (℃)</td><td>Humidity (%RH)</td><td>Air pressure (hPa)</td><td>ρ</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Tested by: Verified by:

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Table A.1 (continued)

Table continued Serial no.

Wind direction indication errors													
Unit: °													
Standard value / Indication measured	0	30	60	90	120	150	180	210	240	270	300	330	355
Anticlockwise (forward)													
Mean													
Clockwise (reverse)													
Mean													
Indication errors													

Wind velocity indication errors														
Test point (m/s)	Reading of the differential pressure gauge (Pa) Zero:				Air density, ρ (kg/m^3)				Standard wind velocity (m/s)	Anemometer indication (m/s)				Indication errors (m/s)
	1	2	3	Mean	Temperature (℃)	Humidity (% RH)	Air pressure (hPa)	ρ		1	2	3	Mean	
Explanation of test results (if necessary):														

Tested by: Verified by:

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Annex B
(Informative)

Table B.1 Inside Page Format of Test Report

Certificate no.:				
Test equipment				
Name	Measurement range	Uncertainty/accuracy class/maximum permissible error	Certificate no.	Valid until

Test location and environmental condition
Location:
Temperature: - °C; relative humidity: - %; air pressure: - hPa

Test results	
Test item	Test result
Appearance and power-on check	
Starting threshold of wind velocity	

Indication errors							
Wind velocity Unit: m/s				Wind direction Unit: °			
Test point	Standard wind velocity	Anemometer indication	Indication errors	Test point	Standard wind direction	Anemometer indication	Indication errors
Explanation of test results (if necessary):							

Tested by: Verified by:

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