PD CEN/TS 15518-4:2013

BSI Standards Publication

Winter maintenance equipment — Road weather information systems

Part 4: Test methods for stationary equipment

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National foreword

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Matériel de viabilité hivernale - Systèmes d'information météorologique routière - Partie 4 : Méthodes d'essai pour les matériels fixes

Winterdienstausrüstung - Straßenzustands- und Wetterinformationssysteme - Teil 4: Prüfverfahren bei stationären Einrichtungen

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Contents

Page

Foreword

This document (CEN/TS 15518-4:2013) has been prepared by Technical Committee CEN/TC 337 “Winter maintenance and road service area maintenance equipment”, the secretariat of which is held by AFNOR.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document *Winter maintenance equipment — Road weather information systems* comprises of the following parts:

— *Part 1: Global definitions and components*;

— *Part 2: Road weather — Recommended observation and forecast*;

— *Part 3: Requirements on measured values of stationary equipments*;

— *Part 4: Test methods for stationary equipment* (the present document).

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Road Weather Information Systems (RWIS) are complex structures used for road maintenance decision support, which feature as a rule the following components: meteorological sensors and instruments, transmission technology, computer systems for processing, representation and storing of information, road weather forecasts, alarms, in relation to traffic control and traffic information systems and more.

This European Specification lays down the test procedures to verify the requirements on stationary equipment defined in EN 15518-3.

The aim is to allow for objective and reproducible measurement analysis and evaluation.

1 Scope

This Technical Specification specifies the test methods, the experimental set-up and result analysis for the laboratory qualification of stationary equipment within a RWIS.

2 Normative references

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

EN 13108-5, *Bituminous mixtures — Material specifications — Part 5: Stone Mastic Asphalt*

EN 15518-3, *Winter maintenance equipment — Road weather information systems — Part 3: Requirements on measured values of stationary equipments*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025)*

ISO 17714, *Meteorology — Air temperature measurements — Test methods for comparing the performance of thermometer shields/screens and defining important characteristics*

3 Type reception test definition

3.1 Introduction

3.1.1 General

The tests described hereafter apply to either a complete system (which can influence the measured value) consisting of sensor, processing electronics and associated terminal program software necessary to acquire, display and store the measurements in a digital form, or to some specific parts of the whole system when the inputs can be simulated, as specified by the manufacturer. Figure 1 below is an illustration of the possible functional components of a system.

The manufacturer shall specify and supervise the material set-up for the test set-up.

The manufacturer may not change the test set-up during the tests. The data shall be readable during the whole test. The whole test shall stop in case the manufacturer changes the test set-up.

If a single sensor provides measurements subject to more than one test procedure, it shall always be tested against all these procedures within the same test campaign and by the same laboratory. This is also valid for tests after technical changes to a sensor.

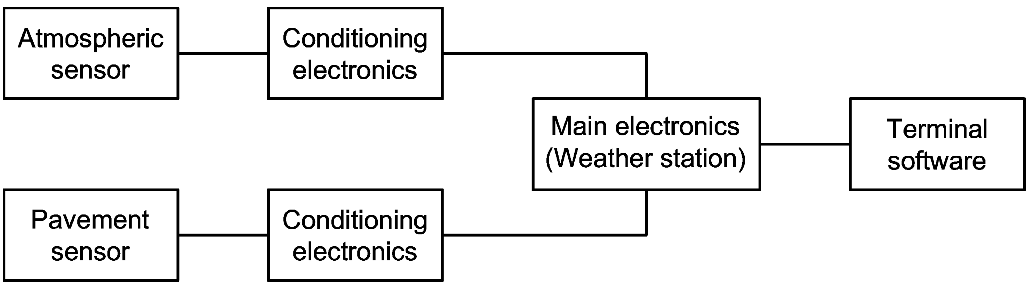


Figure 1 — Possible functional components of a system

Test protocols shall state the version and type of hardware, firmware and software components as well as the material set-up during the test.

In case of major technical changes to one or other of these components which affect the requirements of EN 15518-3, the manufacturer shall seek new certification. In case of minor changes not affecting the requirements of EN 15518-3, the manufacturer shall indicate the changes and, upon request, provide the demonstration that the changes did not affect in an adverse way the system which was originally tested and that the new system still meets the standard.

In general, if a sensor was tested as a single device, met the requirements of this standard, and its nominal output can be simulated, the RWIS manufacturer shall be allowed to demonstrate only that the measuring chain cannot influence the raw signal in a manner to exceed the allowed tolerance. This has to be confirmed by an accredited laboratory.

Therefore, this standard applies to three possible configurations:

- sensor as single device;
- electronics with simulated sensor inputs;
- complete system.

3.1.2 Test body

Wherever stated, the sensor shall be permanently installed in the centre of a test body according to the manufacturer's specifications, which shall be part of the test report. The characteristics of the test body are:

a) Minimal dimensions 600 mm by 400 mm surface and 200 mm depth. There shall be a minimal distance of 15 cm between each side of the sensor (including sealing compound, in all three dimensions) and the side of the test body. This shall be documented in the test report.

b) Realisation: Under similar conditions than road construction, having the following characteristics:

   1) material: Asphalt Concrete (heavy traffic road);

   2) layer: one single mixture (surface course) in three or more layers, the upper layer being 6 cm deep;

   3) EN 13108-5, *Bituminous mixtures — Material specifications — Part 5: Stone Mastic Asphalt:*

      i) grading rate: 8 mm: 100 %;

         5,6 mm: 90 % to 100 %;

         2 mm: 20 % to 40 %;

         0,063 mm: 5 % to 12 %;

      ii) binder rate: $B_{\text{min7,4}}$;

      iii) maximum cavity rate: V_{max3};

      iv) minimum cavity rate: V_{max2}.

Other test bodies may be defined and used in case of specific needs. The type and characteristics of the test bodies shall be mentioned in the test report.

3.2 Pavement surface temperature

3.2.1 General

This test shall be realised under stabilised and transient temperatures (see below).

Unless otherwise specified, a valid measurement value shall be delivered by the system at latest 6 min after the test conditions are met.

3.2.2 Test method

3.2.2.1 Stabilised temperature test

The sensor is plunged into a liquid bath set at stabilised temperatures. The temperature response of the sensor is compared to the temperature response of a reference thermometer.

The test does not apply to sensors working without contact.

3.2.2.2 Transient surface temperature test

The test shall take place in a cooled climatic chamber. The sensor shall be installed in a test body as per 3.1.2 above. Reference probes shall be installed on the surface of the test body in a manner to reduce as much as possible the influence of direct radiation.

A radiation source (2 halogen lamps) is switched on for a given time to simulate road heating by solar radiation and cooling by emissivity.

The temperature response of the sensor shall be compared to the temperature response of the reference probes.

3.2.3 Test equipment

3.2.3.1 Stabilised temperature test

This test requires the following equipment:

— container with liquid solution (car cooling liquid or saline solution);

— apparatus for cooling and stabilising this liquid in a container within the expressed requirements (“cryostat”);

— reference thermometer with accuracy ± 0,1 °C and sampling rate of maximum 10 s.

3.2.3.2 Transient temperature test

This test requires the following equipment:

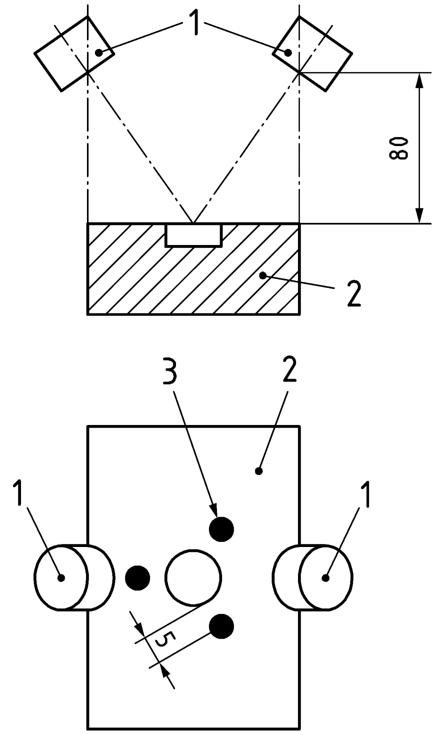
— climatic chamber;

— 2 x 500 W Halogen lamps placed as per Figure 2 below and aiming at the centre of the test body;

— test body as per 3.1.2 above;

— 3 PT 100 reference probes with polling interval less than half that of the sensor to be tested. The reference probes shall be installed horizontally in the test body in a groove 3 mm deep and covered with bitumen. They shall be located in an equilateral triangle around the sensor to be tested, each one being no more than 5 cm away from the border of the sensor to be tested (see Figure 2 below).

Dimensions in centimetres



Key

1 500 W Halogen lamps
2 test body (see 3.1.2)
3 3 PT reference probes

Figure 2 — Set-up for transient temperature test

3.2.3.3 Stabilised temperature test

Ensure a proper connection of the sensor to be tested and the whole measurement chain. The measurements of the sensor and the reference thermometer shall be recorded throughout the test.

Set the bath to the given temperature; ensure a uniform temperature of the bath (difference < 0,1 °C) by stirring the liquid. The temperature variation of the bath shall not exceed ± 0,1°C throughout the duration of each test.

Plunge the sensor into the liquid bath so that it does not touch the bottom or the walls of the container.

The measurement period shall start at soon as one of the following conditions is met:

— a first measurement of the sensor to be tested is recorded within the required accuracy;

— the reference thermometer has shown bath temperatures within requirements for 6 min.

The measurement period ends as soon as one of the following conditions is met:

— 5 consecutive samples (or all the samples during 10 min, whichever is longer) of the sensor to be tested are recorded within the accuracy requirements;

— 15 samples of the sensor to be tested (or 30 min, whichever is longer) have elapsed since the start of the measurement period.

The test shall be performed at each of the following temperatures (more test points can be added):

— 10 °C;

— 0 °C;

— -15 °C.

3.2.3.4 Transient temperature test

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

The measurements of the sensor to be tested and the reference probes shall be recorded throughout the test.

The climatic chamber (including the test bloc) shall be set to a stabilised environmental temperature of -5 °C. The climatic situation in the chamber shall remain constant throughout the test.

Before the start of the test, all the reference probes shall indicate a temperature of -5 °C ± 0,2 °C.

Switch on the halogen lamps. As soon as a surface temperature ≥ 10 °C is indicated by all the reference probes, the halogen lamps shall be switched off.

The measurements of the tested sensor and the reference probes shall be further recorded for a duration of 5 min after a surface temperature ≤ 0 °C has been indicated by all the reference probes.

3.2.4 Result analysis

3.2.4.1 Stabilised temperature test

The test is considered successful if five consecutive samples (or all the samples during a period of 10 min, whichever is longer) are recorded within the accuracy requirements, specified in EN 15518-3.

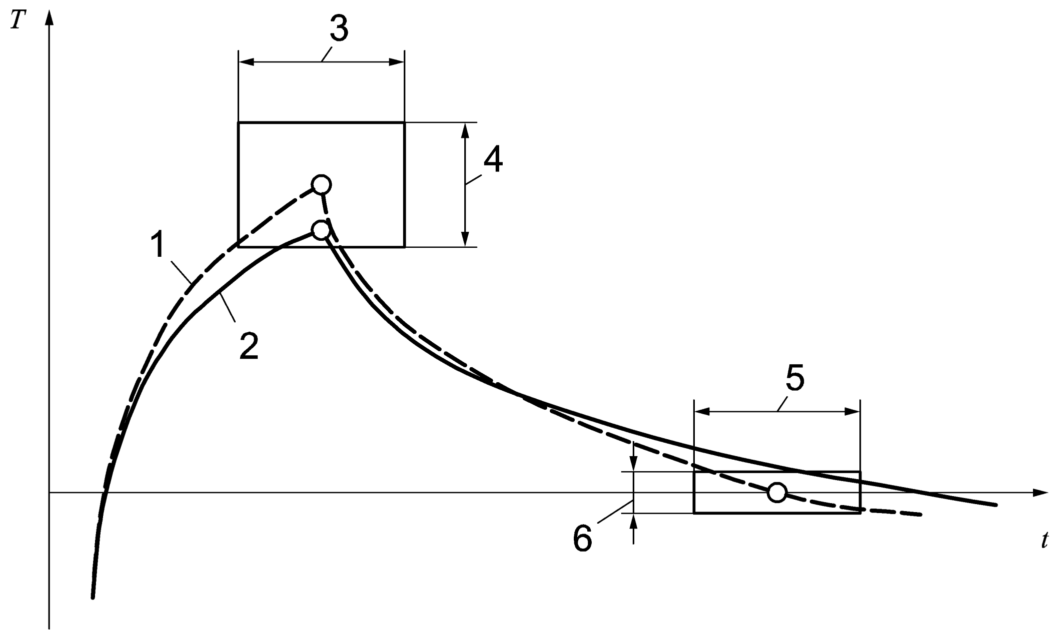
3.2.4.2 Transient temperature test

The measurements recorded from the reference probes and the sensor to be tested shall be displayed in a graph similar to Figure 3 below. Great attention shall be paid to the synchronisation of measurements before the analysis of the results.

A first allowed variation area shall be set around the highest temperature(s) measured by the reference probes (the reference value is the mathematical average between the values of the three reference probes). The allowed temperature variation (vertical axis) for this area shall be ± 2 °C. The allowed time variation (horizontal axis) for this area shall be ± 3 min.

A second variation area shall be set around the 0 °C temperature measured by the reference probes (the reference value is the mathematical average between the values of the three reference probes). The allowed temperature variation (vertical axis) for this area shall be ± 2 °C. The allowed time variation for this area (horizontal axis) shall be ± 3 min.

NOTE The definitive time and temperature variation values will be defined with the final standard.



Key

1 measurement record of reference probes
2 measurement record of the tested sensor
3 allowed time variation
4 allowed temperature variation
5 allowed time variation
6 allowed temperature variation
T temperature
t time

Figure 3 — Result analysis of transient temperature test

The test is considered successful if both following conditions are met:

— the highest temperature recorded from the sensor to be tested lies inside the first variation area;

— there is at least one measured value recorded from the sensor to be tested inside the second variation area.

Alternative: The output curve of the sensor to be tested touches the second variation area with at least one point.

3.3 Road surface condition

3.3.1 General

Unless otherwise specified, a valid measurement value shall be delivered by the system at latest 6 min after the test conditions are met.

3.3.2 Test method

3.3.2.1 General

The test shall take place in a climatic chamber. The sensor shall be installed in a test body as per 3.1.2 above.

3.3.2.2 Dry

The climatic chamber shall be set to ensure stabilised conditions (avoiding condensation) below 0 °C.

The output of the sensor to be tested shall be compared with the condition “Dry”.

3.3.2.3 Moist

The climatic chamber shall be set to ensure stabilised conditions (avoiding condensation) at two different temperatures (above and below 0 °C).

A liquid film thickness corresponding to the requirement “Moist” of EN 15518-3 shall be applied and maintained over the sensor.

The output of the sensor to be tested shall be compared with the condition “Moist”.

3.3.2.4 Wet

The climatic chamber shall be set to ensure stabilised conditions (avoiding condensation) at two different temperatures (above and below 0 °C).

A liquid film thickness corresponding to the requirement “Wet” of EN 15518-3 shall be applied and maintained over the sensor.

The output of the sensor to be tested shall be compared with the condition “Wet”.

3.3.2.5 Streaming water

The climatic chamber shall be set to ensure stabilised conditions (avoiding condensation) above 0 °C.

A liquid film thickness corresponding to the requirement “Streaming water” of EN 15518-3 shall be applied and maintained over the sensor.

The output of the sensor to be tested shall be compared with the condition “Streaming water”.

3.3.2.6 Slippery

The road status “Slippery” is reached when the pavement surface temperature is equal or below the freezing point temperature of the solution on the pavement, or when solidified water appears over the pavement.

— Phase one:

The climatic chamber shall be set to ensure stabilised conditions (avoiding condensation) above 0 °C.

A liquid film thickness with predetermined freezing point temperature shall be applied and maintained over the sensor. The temperature of the climatic chamber shall then be gradually brought to a temperature below or equal to the freezing point temperature in the climatic chamber.

The output of the sensor to be tested shall be compared with the condition “Slippery”.

— Phase two:

The climatic chamber shall be set to ensure stabilised conditions (avoiding condensation) below 0 °C.

Warmer air shall be brought in the climatic chamber by opening the doors, creating the deposit of ice crystals (hoarfrost) over the test body.

The output of the sensor to be tested shall be compared with the condition “Slippery”.

3.3.3 Test equipment

This test requires the following equipment:

- spreading equipment (accuracy better or equal to ± 10 % for a thickness of 0,01 mm) to provide controlled thicknesses of liquid solutions over the sensor;
- climatic chamber;
- precision scale with a plate of known surface (thoroughly cleaned before each test);
- reference temperature probe (air and pavement);
- test body as per 3.1.2 above;
- rain water (has to ensure correct wettability);
- NaCl solution;
- towel and fan.

3.3.4 Test procedure

3.3.4.1 General

The sequence of the tests may be modified in order to avoid repeated temperature changes in the climatic chamber.

3.3.4.2 Dry

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

Set the climatic chamber to a temperature of -5 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Using a towel and a fan, clean and dry the surface of the sensor.

Start the recording of the surface condition measurements.

Five samples or 10 min (whichever is longer) after the first reported road surface condition “Dry”, stop the recording of the surface condition measurement.

3.3.4.3 Moist

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

Set the climatic chamber to a temperature of 5 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Install the precision scale close to the sensor to be tested under the spreading device. The mass of liquid applied over the surface of the plate of the scale is recorded and converted to liquid thickness. This value serves as reference for the test.

Using a towel and a fan, clean and dry the surface of the sensor.

Start the recording of the surface condition measurements.

Apply a water film thickness between 0,012 mm and 0,015 mm over the sensor and the plate of the precision scale. This water film thickness has to remain constant for 6 min, or until the road surface condition measurement shows “Moist”, whichever is first.

Then, enough water shall be applied as needed to keep the water film thickness between 0,01 mm and 0,1 mm for the duration of the test.

Five samples or 10 min (whichever is longer) after the first reported road surface condition “Moist”, stop the recording of the surface condition measurement.

Using a towel and a fan, clean and dry the surface of the sensor.

Repeat the test at a temperature of -5 °C, using a NaCl solution having a freezing temperature of 0 °C.

3.3.4.4 Wet

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

Set the climatic chamber to a temperature of 5 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Install the precision scale close to the sensor to be tested under the spreading device. The mass of liquid applied over the surface of the plate of the scale is recorded and converted to liquid thickness. This value serves as reference for the test.

Using a towel and a fan, clean and dry the surface of the sensor.

Start the recording of the surface condition measurements.

Apply a water film thickness of 0,14 mm over the sensor (equivalent to the EN 15518-3 requirement 0,2 mm – 30 %) and bring this thickness by steps of 0,02 mm up to 0,26 mm (equivalent to the EN 15518-3 requirement 0,2 mm + 30 %), each step being longer than the time constant of the sensor to be tested. The last water film thickness has to remain constant for 6 min, or until the road surface condition measurement shows “Wet”, whichever is first.

Then, enough water shall be applied as needed to keep the water film thickness between 0,26 mm and 1 mm for the duration of the test.

Five samples or 10 min (whichever is longer) after the application of the water layer which generated the road surface condition “Wet”, stop the recording of the surface condition measurement.

Using a towel and a fan, clean and dry the surface of the sensor.

Repeat the test at a temperature of -5 °C, using a NaCl solution having a freezing temperature of -10 °C.

3.3.4.5 Streaming water

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

Set the climatic chamber to a temperature of 5 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Install the precision scale close to the sensor to be tested under the spreading device. The mass of liquid applied over the surface of the plate of the scale is recorded and converted to liquid thickness. This value serves as reference for the test.

Using a towel and a fan, clean and dry the surface of the sensor.

Start the recording of the surface condition measurements.

Apply a water film thickness of 1,4 mm over the sensor (equivalent to the EN 15518-3 requirement 2 mm – 30 %) and bring this thickness by steps of 0,4 mm to 2,6 mm (equivalent to the EN 15518-3 requirement 2 mm + 30 %), each step being longer than the time constant of the sensor to be tested. The last water film thickness has to remain constant for 6 min, or until the road surface condition measurement shows “Streaming water”, whichever is first.

Then, enough water shall be applied as needed to keep the water film thickness above 2,6 mm for the duration of the test.

Five samples or 10 min (whichever is longer) after the application of the water layer which generated the road surface condition “Streaming water”, stop the recording of the surface condition measurement.

3.3.4.6 Slippery

— Phase one:

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

Set the climatic chamber to a temperature of 5 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Install the precision scale close to the sensor to be tested under the spreading device. The mass of liquid applied over the surface of the plate of the scale is recorded and converted to liquid thickness. This value serves as reference for the test.

Using a towel and a fan, clean and dry the surface of the sensor.

Start the recording of the surface condition measurements.

Apply a liquid film thickness of 0,5 mm over the sensor using a NaCl solution having a freezing temperature of -5 °C. This liquid film thickness has to remain constant throughout the duration of the test.

Bring the temperature of the climatic chamber at a rate of 10 °C/hour to -10 °C.

Stop the recording.

Using a towel and a fan, clean and dry the surface of the sensor.

— Phase two:

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

Set the climatic chamber to a temperature of -5 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Install the precision scale close to the sensor to be tested. The mass of hoarfrost created over the surface of the plate of the scale is recorded and converted to g/m^2. This value serves as reference for the test.

Using a towel and a fan, clean and dry the surface of the sensor.

Start the recording of the surface condition measurements.

Increase relative humidity up to 100 %.

Record the time at which hoarfrost is visually detected over the sensor. A minimum quantity of 20 g/m^2 shall be recorded by the precision scale.

Five samples or 10 min (whichever is longer) after the first reported road surface condition “Slippery”, stop the recording of the surface condition measurement.

3.3.5 Result analysis

3.3.5.1 Dry

The test is successful if both following conditions are met:

- a first “Dry” road surface condition has been recorded within 6 min after the start of the test;
- the “Dry” road surface condition has then remained unchanged throughout the duration of the test.

3.3.5.2 Moist

The test is successful if both following conditions are met:

- a first “Moist” road surface condition has been recorded within 6 min after the initial application of the liquid film thickness;
- the “Moist” road surface condition has then remained unchanged throughout the duration of the test.

3.3.5.3 Wet

The test is successful if both following conditions are met:

- a first “Wet” road surface condition has been recorded between the first application of 0,14 mm of liquid and maximum 6 min after the last application of 0,26 mm of liquid;
- the “Wet” road surface condition has then remained unchanged throughout the duration of the test.

3.3.5.4 Streaming water

The test is successful if both following conditions are met:

- a first “Streaming water” road surface condition has been recorded between the first application of 1,4 mm of liquid and maximum 6 min after the last application of 2,6 mm of liquid;
- the “Streaming water” road surface condition has then remained unchanged throughout the duration of the test.

3.3.5.5 Slippery

- <u>Phase one:</u>

The test is successful if both following conditions are met:

  - a first “Slippery” road surface condition has been recorded within 6 min after the road surface temperature as measured by the sensor to be tested has reached the freezing temperature of the brine solution;
  - the “Slippery” road surface condition has then remained unchanged throughout the duration of the test.

- <u>Phase two:</u>

The test is successful if both following conditions are met:

— a first “Slippery” road surface condition has been recorded within 6 min after the visual detection of hoarfrost;

— the “Slippery” road surface condition has then remained unchanged throughout the duration of the test.

3.4 Water film thickness

3.4.1 General

The test shall take place in a climatic chamber. The sensor shall be installed in a test body as per 3.1.2 above.

Unless otherwise specified, a valid measurement value shall be delivered by the system at latest 6 min after the test conditions are met.

NOTE This test can be combined with the road surface condition test.

3.4.2 Test method

The climatic chamber shall be set to ensure stabilised conditions (avoiding condensation) above 0 °C.

A leak tight barrier (silicon) shall be set around the sensor (following the perimeter of the sensor’s surface).

Different liquid film thicknesses shall be applied and maintained over the sensor.

The sensor has to report the correct water film thickness.

3.4.3 Test equipment

This test requires the following equipment:

— spreading equipment (accuracy better or equal to ± 10% for a thickness of 0,01 mm) to provide controlled thicknesses of liquid solutions over the sensor;

— climatic chamber;

— precision scale with a plate of known surface;

— reference temperature probe (air and pavement);

— test body as per 3.1.2 above;

— rain water (has to ensure correct wettability);

— towel and fan.

3.4.4 Test procedure

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

Set the climatic chamber to a temperature of 5 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Install the precision scale close to the sensor to be tested under the spreading device. The mass of liquid applied over the surface of the plate of the scale is recorded and converted to liquid thickness. This value serves as reference for the test.

Using a towel and a fan, clean and dry the surface of the sensor.

Start the recording of the water film thickness.

Apply a water film thickness of 0,2 mm over the sensor. This water film thickness has to remain constant throughout the test.

The acquisition frequency of five samples or 10 min (whichever is longer) after the first correct water film thickness measurement, stop the recording of the water film thickness.

Repeat the test with water film thicknesses of 0,5 mm, 1 mm, 2 mm and 3 mm.

3.4.5 Result analysis

The test is successful if both following conditions are met:

- a first correct water film thickness value has been recorded within 6 min after the initial application of the liquid film thickness;
- the water film thickness value has stayed within the tolerance throughout the duration of the test.

3.5 Freezing temperature

3.5.1 General

The test shall take place in a climatic chamber. The sensor shall be installed in a test body as per 3.1.2 above.

Unless otherwise specified, a valid measurement value shall be delivered by the system at latest 6 min after the test conditions are met.

NOTE The end user or manufacturer can specify other chemicals or combinations thereof.

WARNING — The equilibrium relative humidity for sodium chloride (NaCl) is very high for low temperature (88 % for -15 °C). This may induce evaporation of the water from the solution, thus altering the concentration (and hence the freezing temperature) if there is not enough volume of solution. Besides, the working principle of certain measurement technologies in a confined environment may induce condensation, thus altering also the concentration.

Therefore, for the purpose of having stable solutions ensuring repeatable measurements, a water film thickness big enough to ensure that the effects of these phenomena are negligible shall be applied.

3.5.2 Test method

The climatic chamber shall be set to ensure stabilised conditions (avoiding evaporation and/or condensation) at and below 0 °C.

Two different thicknesses of three calibrated brine solutions shall be applied over the sensor. The difference in temperatures between the test body and the freezing temperature of the solution shall not exceed 15 °C.

The RWIS has to report the correct freezing temperature.

3.5.3 Test equipment

3.5.3.1 General

This test requires the following equipment:

- spreading equipment (accuracy better or equal to ± 10 % for a thickness of 0,01 mm) to provide controlled thicknesses of liquid solutions over the sensor;

- climatic chamber;
- precision scale with a plate of known surface;
- reference temperature probe (air and pavement);
- test body as per 3.1.2 above;
- towel and fan;
- calibrated solutions of NaCl, $CaCl_2$ and $MgCl_2$ as per Table 1. The laboratory shall define a concentration at wish, so that the resulting theoretical freezing temperature is within the given range. Please refer to the method described in 3.5.3.2 for preparing the solutions.

Table 1 — List of calibrated solutions for freezing temperature test

Solution number	Chemical	Number of tests	Mass concentration (proportion of mass of deicing chemical over total mass)	Freezing temperature range	Pavement temperature
1	NaCl	2	TBD	(–1 °C to –5 °C)	0 °C
2	NaCl	2	TBD	(–10 °C to –15 °C)	0 °C
3	NaCl	1	TBD	(–11 °C to –15 °C)	–10 °C
4	$CaCl_2$	1	TBD	(–15 °C to –20 °C)	–10 °C
5	$MgCl_2$	1	TBD	(–15 °C to –20 °C)	–10 °C

3.5.3.2 Preparation of the solutions

3.5.3.2.1 General

A scale with a precision equal or better than 0,1 mg shall be used for weighting the ingredients.

3.5.3.2.2 NaCl solutions

The mass concentrations given in the Table 2 below shall be prepared using NaCl for analysis (99,5 % purity), which has been previously dried at 105 °C during 24 h in an oven.

The salt shall be dissolved after at least 15 min magnetic stirring.

Table 2 — Mass values for preparing calibrated NaCl solutions

Mass distilled water g	Mass NaCl g	Freezing temperature °C
1 000	17,4	–1
1 000	34,6	–2
1 000	51,9	–3
1 000	68,9	–4
1 000	85,5	–5
1 000	101,9	–6
1 000	117,8	–7
1 000	133,2	–8
1 000	148,3	–9
1 000	162,9	–10
1 000	177,1	–11
1 000	190,9	–12
1 000	204,3	–13
1 000	217,4	–14
1 000	230,1	–15

3.5.3.2.3 $CaCl_2$ solutions

The mass concentrations given in the Table 3 below shall be prepared using $CaCl_2$, $2H_2O$ for analysis (purity > 98 %), which has been previously dried at 70 °C during 24 h in an oven.

The salt shall be dissolved after at least 15 min magnetic stirring.

Table 3 — Mass values for preparing calibrated CaCl2 solutions

Mass distilled water g	Mass $CaCl_2$ g	Freezing temperature °C
1 000	218,0	–15
1 000	226,9	–16
1 000	235,2	–17
1 000	241,6	–18
1 000	247,9	–19
1 000	257,0	–20

3.5.3.2.4 $MgCl_2$ solutions

The mass concentrations given in the Table 4 below shall be prepared using anhydrous $MgCl_2$ for synthesis (purity > 98 %), which has been previously dried at 105 °C during 24 hours in oven.

The salt shall be dissolved after at least 15 min magnetic stirring.

Table 4 — Mass values for preparing calibrated MgCl2 solutions

Mass distilled water g	**Mass $MgCl_2$** g	**Freezing temperature** °C
1 000	173,7	–15
1 000	180,4	–16
1 000	187,5	–17
1 000	193,2	–18
1 000	199,0	–19
1 000	204,8	–20

3.5.4 Test procedure

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

Set the climatic chamber to a temperature of 0 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Install the precision scale close to the sensor to be tested under the spreading device. The mass of liquid applied over the surface of the plate of the scale is recorded and converted to liquid thickness. This value serves as reference for the test.

Using a towel and a fan, clean and dry the surface of the sensor.

Apply a film thickness of 0,1 mm of solution number 1 (see Table 1 above) over the sensor. This water film thickness has to remain constant throughout the test.

Start recording the freezing temperature 6 min after application, or as soon as a first value within the agreed tolerances has been reported, whichever comes first.

Keep recording the freezing temperature for five consecutive measurements or 30 min, whichever comes first.

Repeat the test with a film thickness of 0,2 mm.

Using a towel and a fan, clean and dry the surface of the sensor.

Repeat the tests above with solution number 2 (see Table 1 above).

Set the climatic chamber to –10 °C. Dew point temperature shall be at least 1 °C below the air temperature to avoid condensation. The temperatures of air and sensor shall be identical and stabilised.

Repeat the test above with solution number 3 (see Table 1 above) and a thickness of 0,2 mm.

Repeat the test above with solution number 4 (see Table 1 above) and a thickness of 0,2 mm.

Repeat the test above with solution number 5 (see Table 1 above) and a thickness of 0,2 mm.

3.5.5 Result analysis

The test is successful if both following conditions are met:

— a first freezing temperature value within the tolerance has been recorded within 6 min after the start of the recording;

— the reported freezing temperature value has stayed within the tolerance throughout the duration of the test.

NOTE The applicable tolerances for calculated freezing temperature and measured freezing temperature are different.

3.6 Road body temperature

3.6.1 Test method

The underground temperature sensor shall be installed in the test bloc according to the manufacturer's procedure. A reference probe is installed in the test bloc at the same depth near the underground sensor. The test is performed during the pavement surface temperature test.

In case the underground sensor has several measuring elements (several depths), a reference probe will be installed at each depth.

The measurements are recorded for stabilised and transient temperatures.

3.6.2 Test equipment

See pavement surface temperature test.

3.6.3 Test procedure

See pavement surface temperature test.

3.6.4 Result analysis

The test is successful the following condition is met:

— The reported road body temperatures have stayed within tolerance throughout the duration of the test.

3.7 Air temperature

3.7.1 Test method

The sensor is installed outside with a reference temperature sensor close by. The data are logged. Specific radiation and wind condition shall have to be met over a given period of time in order to validate the results.

3.7.2 Test equipment

— Reference air temperature sensor consisting of a Pt100 temperature probe (1/3 DIN class B or better) in an aspirated dual walled radiation shield. The sampling frequency has to be at least six samples per minute. The sensor has to be installed at a representative height of 1,25 m to 2 m. In case of a naturally ventilated weather screen this is the location of the temperature probe and for an aspirated radiation shield it is the location of the air intake.

— Reference global radiation sensor with sampling frequency of at least one sample per minute.

— Reference wind sensor for measuring scalar average 1 min wind speed and wind direction at the installation height of the temperature measurement. For this purpose ultrasonic anemometers are most suitable.

— Precipitation detector.

3.7.3 Test procedure

3.7.3.1 General

Install the temperature sensor and radiation shield/screen to be tested in the field at the same height as the reference sensor with a maximum tolerance of ± 5 % of the height and at a horizontal distance of 3 m to 4 m. All screens should be freely exposed to sunshine and wind and should not be shielded by trees, buildings or other obstructions. For further details refer to ISO 17714. Record the data (maximal interval shall be 6 min) which is then the time basis for the evaluation. As soon as the test validity conditions have been fulfilled, stop the recording.

The test validity conditions are as follows:

3.7.3.2 Radiation protection test

This test is performed in high solar radiation conditions at low wind speed. It is intended to prove the efficiency of the radiation shield (weather screen).

- radiation: above 500 W/m^2;
- wind speed: below 1 m/s;
- precipitation: none;
- duration: until at least 200 data points have been collected (can be spread over several events of minimum 20 consecutive samples).

3.7.3.3 Accuracy test

This test is intended to state the accuracy of the temperature probe.

- night time (i.e. elevation of sun < 0°);
- radiation: ± 15 W/m^2;
- precipitation: none;
- wind speed: above 1 m/s;
- air temperature: between –10 °C and 10 °C;
- duration: until at least 200 data points have been collected (can be spread over several events of minimum 20 consecutive samples).

3.7.3.4 Rain conditions test

This test is intended to investigate the effect of psychrometric cooling.

- rainfall intensity at least 0,1 mm/h;
- wind speed: below 2 m/s;
- duration: until at least 200 data points have been collected (can be spread over several events of minimum 20 consecutive samples).

3.7.4 Result analysis

Compare the values measured by the sensor to be tested with the output of the reference sensors throughout the test records. The maximum absolute deviation shall not exceed 1,5 °C for radiation protection test, 0,5 °C for accuracy test and 1,0 °C for rain conditions test.

In addition, the average temperature calculated over the samples of the accuracy test shall be within 0,3 °C of the average temperature of the reference sensor.

3.8 Relative humidity

3.8.1 Test method

3.8.1.1 Stabilised conditions

The sensor shall be tested in the laboratory at three different relative humidity levels and at two different temperatures.

3.8.1.2 Transient conditions

The sensor shall be tested in the laboratory with rapid changing relative humidity conditions.

3.8.2 Test equipment

- Small climatic chamber with controlled humidity generator and access port allowing to quickly insert the sensor without influence on the condition of the room.
- Reference relative humidity sensor in the climatic chamber (two-pressure humidity generator or a chilled mirror system may be used as reference).
- Reference relative humidity sensor (in the room).
- Reference air temperature sensor (in the room).

3.8.3 Test procedure

3.8.3.1 Stabilised humidity test

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

At each humidity control point the temperature of the climatic chamber should vary less than 0,1 °C and relative humidity of the climatic chamber as well as indicated by the sensor to be tested should vary less than 0,5 % over a time period of 10 min before the test can start.

Set the climatic chamber at 5 °C and the relative humidity successively at 50 %, 85 %, 95 %, 85 % and 50 %.

Set the climatic chamber at –5 °C and the relative humidity successively at 50 %, 80 %, 90 %, 80 % and 50 %.

At each humidity control point at least 10 min of data or 30 samples, whichever is longer, should be recorded.

3.8.3.2 Transient humidity test

Ensure a proper connection of the sensor to be tested and the whole measurement chain.

The room shall be at an ambient temperature of 20 °C ± 2 °C with a relative humidity of 70 % ± 5 %.

Set the small climatic chamber at 95 % relative humidity and at room temperature. Start recording the values out of the sensor to be tested when it is still in room conditions.

Quickly place the sensor to be tested inside the climatic chamber through the access port. The sensor head shall be well inside the climatic chamber with an airtight sealing of the sensor body at the access port to avoid any exchange of air at this point.

10 min after having set the sensor in the climatic chamber, remove it quickly.

Keep recording the values for at least 10 min.

3.8.4 Result analysis

3.8.4.1 Stabilised humidity test

The test is considered successful if at each humidity control point, 95 % of all samples are within the following accuracy requirements:

- 3 % for positive temperatures;
- 5 % for negative temperatures.

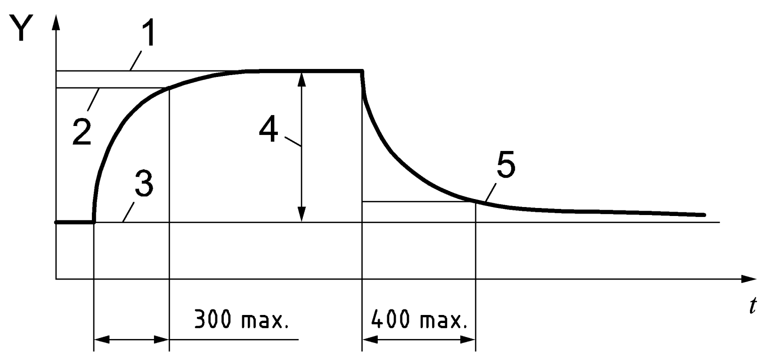
NOTE The test also takes into account possible hysteresis effects.

3.8.4.2 Transient humidity test

Report the measurements on a graph as shown in Figure 4. Calculate the difference between the relative humidity values of the room and the climatic chamber (= 100 % humidity step). Determine the time T_{97} that the humidity sensor needed to give a 97 % reference relative humidity value of the considered control step.

Determine the same time in the reverse direction (when the sensor was removed from the climatic chamber).

The test is considered successful if T_{97} after insertion < 300 s and T_{97} after removal < 400 s.



Key

1 relative humidity value of climate chamber (=100 % step, reference value)
2 97 % of reference value
3 relative humidity values of the room
4 difference between the relative humidity values of the room and the climatic chamber
5 graph

Figure 4 — Result analysis of transient humidity test

3.9 Dew point temperature

3.9.1 General

The dew point provided by the sensor to be tested shall be recorded during the stabilised humidity test.

The reference dew point should be calculated using the formula in “Guide to Meteorological Instruments and Methods of Observation" [3] with the reference temperature and relative humidity of the climatic chamber.

At each humidity control point the dew point has to be constant at least ± 0,1 K.

3.9.2 Test method

This test is performed at the same time as the stabilised humidity test (see 3.8.1.1).

3.9.3 Test equipment

Same as relative humidity test (see 3.8.2).

3.9.4 Test procedure

Record the dew point values during the stabilised humidity test.

3.9.5 Result analysis

The recorded dew point shall have a maximal deviation of 1,5 K compared to the reference dew point.

3.10 Precipitation detection time

3.10.1 General

The precipitation test shall be performed outdoors. Because of the uneven distribution of precipitation (inaccuracy of reference), the accuracy requirements have been set to larger values.

3.10.2 Test method

3.10.2.1 General

Install the sensor outdoor together with a reference precipitation intensity sensor. The following test conditions have to be met:

3.10.2.2 Light precipitation

- Precipitation intensity between 0,1 mm/h and 0,4 mm/h;
- duration: at least 10 min.

3.10.2.3 Medium precipitation

- Precipitation intensity between 0,4 mm/h and 1,2 mm/h;
- duration: at least 6 min.

3.10.2.4 Heavy precipitation

- Precipitation intensity above 1,2 mm/h;
- duration: at least 2 min.

3.10.3 Test equipment

— Reference sensor (optical disdrometer until 30 mm/h, traceable to a calibrated precipitation gauge).

3.10.4 Test procedure

Record the precipitation information from the sensor to be tested. The data has to be time stamped.

3.10.5 Result analysis

3.10.5.1 General

The sensor to be tested shall report precipitation within the following time after the given intensity has been continuously measured by the reference:

3.10.5.2 Light precipitation

10 min.

3.10.5.3 Medium precipitation

6 min.

3.10.5.4 Heavy precipitation

2 min.

3.11 Precipitation type

3.11.1 General

This test shall be performed outdoors and use a reference discriminating the type of precipitation sensor. This test is aimed at verifying the ability of the sensor to correctly distinguish the type of precipitation, as well as the absence of precipitation.

3.11.2 Test method

Install the sensor to be tested outdoors. The test period can be divided into two parts: one for liquid precipitation events and one for solid. The data shall be recorded throughout the test period(s).

One test period has to be at least five days. There shall be at least ten starts of precipitation lasting more than 1 h, with interruptions lasting more than 6 h in-between.

Only the samples of the first hour following the start of precipitation and the first hour following the end of precipitation shall be considered for the test.

3.11.3 Test equipment

— Reference sensor (optical disdrometer).

3.11.4 Test procedure

Record the precipitation information from the sensor to be tested. The data has to be time stamped.

3.11.5 Result analysis

Each sample of the sensor to be tested shall be compared with the corresponding sample (time stamp) of the reference sensor. The sum of all samples shall be recorded in a table as shown in Table 5. The test is successful if the required levels of correspondence are reached.

Table 5 — Result analysis of precipitation type test

		Reference sensor		
		No precipitation	Liquid precipitation	Solid precipitation
Sensor to be tested	No precipitation	≥ 75 %		
	Liquid precipitation		≥ 75 %	
	Solid precipitation			≥ 75 %

3.12 Precipitation intensity

3.12.1 Test method

The precipitation intensity test shall be performed outdoors. This test requires a tight time synchronisation between the reference sensor and the sensor to be tested.

The data acquired during the precipitation type test can be used for this test.

The sensor to be tested shall be capable of providing intensity values integrating the last 60 s. The output interval shall be one minute.

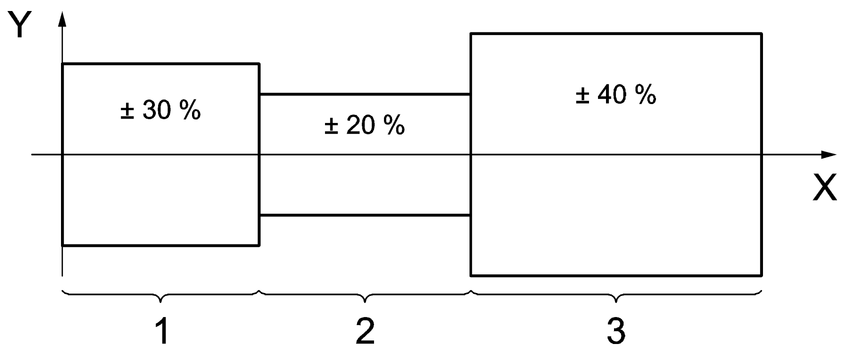
3.12.2 Test equipment

— Reference sensors (optical disdrometer and tip-bucket (Rain Gauge).

3.12.3 Test procedure

Using the samples recorded throughout the precipitation type test, perform averages of the measured precipitation intensity over 10 min periods for the reference sensor and the sensor to be tested.

Report the values over a graph as shown in Figure 5.



Key

1 0,1 mm/h to 0,4 mm/h: ± 30
2 0,5 mm/h to 4,9 mm/h: ± 20 %
3 5 mm/h and above: ± 40 %

Figure 5 — Graph for precipitation intensity test

3.12.4 Result analysis

The test is successful if the values of the sensor to be tested are within the following tolerances:

- 0,1 mm/h to 0,4 mm/h: ± 30 %;
- 0,5 mm/h to 4,9 mm/h: ± 20 %;
- 5 mm/h and above: ± 40 %.

3.13 Snow depth

3.13.1 Test method

This test shall be performed outdoors. The sensor to be tested shall be installed in a configuration similar to its final use. A calibrated measurement is performed parallel to the measurement of the sensor to be tested.

3.13.2 Test equipment

- Calibrated laser distance meter.

3.13.3 Test procedure

Snow fall events with certain intensity are the test situation. Start the measurement at the beginning of the snow fall. The test is considered valid if a minimum snow layer of 10 cm has been reached.

3.13.4 Result analysis

The test is successful if the values of the sensor to be tested are within the following tolerances:

- 0 cm to 50 cm: ± 2 cm

3.14 Wind speed

3.14.1 Test method

The sensor shall be placed in an accredited wind tunnel according to ISO/IEC 17025. Different wind speeds shall be generated.

3.14.2 Test equipment

- Accredited wind tunnel with reference sensor.

3.14.3 Test procedure

Install the sensor to be tested in the wind tunnel. This test shall be performed at ambient temperature.

Generate a stabilised wind speed of 1 m/s.

Start recording the values out of the sensor to be tested. Keep recording for five samples or 10 min, whichever is longer.

Repeat the test with wind speeds of 10 m/s and 35 m/s.

3.14.4 Result analysis

The test is successful if the values of the sensor to be tested are within the following tolerances:

- 1 m/s and 10 m/s: ± 1 m/s;
- 35 m/s: ± 3,5 m/s.

3.15 Gust of wind

3.15.1 General

The purpose of this test is to verify the ability of the sensor to cope with sudden wind increases. Due to the small time constant, a sampling frequency of minimum 10 Hz shall be used.

This test is only applicable to rotating anemometers. Ultrasonic devices do not need to be tested because they do not suffer from any inertia.

3.15.2 Test method

The sensor shall be placed in an accredited wind tunnel according to ISO/IEC 17025. The distance constant shall be determined by a step response test.

3.15.3 Test equipment

- Accredited wind tunnel with reference sensor.

3.15.4 Test procedure

Install the sensor to be tested in the wind tunnel. This test shall be performed at ambient temperature.

Generate a stabilised wind speed of 1 m/s and prevent mechanically the anemometer from rotating.

Start recording the values out of the sensor to be tested at a minimum sampling frequency of 10 Hz.

Release the anemometer.

Keep recording for the next 15 s.

Repeat the test five times.

3.15.5 Result analysis

For each test output, determine the time (in s) necessary for the sensor output to increase from zero to 63 % of its final or equilibrium speed in the air-stream.

Calculate the distance constant by multiplying the time by the given speed of 1 m/s.

The test is successful if the distance constant is comprised between 2 m and 5 m.

3.16 Wind direction

3.16.1 General

The purpose of this test is to verify the ability of the sensor (mechanical or ultrasonic) to indicate the right wind direction. Only the correct response of the sensor shall be tested, and not the averaged vector over a 10 min period. This is why a sampling frequency of 1 Hz shall be used.

Mechanical devices shall also be tested as to their ability to line up in the wind stream.

3.16.2 Test method

The sensor shall be placed in an accredited wind tunnel according to ISO/IEC 17025 on a controlled rotating table. It shall be placed at different angles from the wind stream.

3.16.3 Test equipment

— Accredited wind tunnel with reference sensor.

— Controlled rotating table.

3.16.4 Test procedure

3.16.4.1 Mechanical devices

Install the sensor to be tested in the wind tunnel. This test shall be performed at ambient temperature.

Generate a stabilised wind speed of 0,5 m/s and set mechanically the vane at an angle of 90° form the wind stream.

Start recording the values out of the sensor.

Release the vane of the sensor.

Keep recording for the next 15 s.

Repeat the test five times.

3.16.4.2 All devices

Install the sensor to be tested in the wind tunnel, on a controlled rotating table. This test shall be performed at ambient temperature.

Place the rotating table so that the wind stream is in the north direction of the sensor (0°).

Generate a stabilised wind speed of 5 m/s.

Start recording the values out of the sensor.

Keep recording the values for 30 s. Then rotate the table of an angle of 30° and keep recording the values for 30 s after the table has reached its new position.

Repeat the steps above until the rotating table has accomplished a complete rotation (360°).

3.16.5 Result analysis

3.16.5.1 Mechanical devices

The test is successful if the sensor reports the correct wind direction (i.e. 0°) within 10 s after the vane was released.

3.16.5.2 All devices

The test is successful if at least 60 % of the measurements of each position indicate the corresponding direction within ± 10°.

3.17 Visibility

3.17.1 Test method

This test shall be performed outdoors. The output of the sensor to be tested shall be compared with a reference sensor (transmissometer). Only stabilised visibility conditions shall be used for the test.

Precipitation events during the test shall be recorded (type of precipitation). The test data shall be classified in three categories:

- no precipitation;
- liquid precipitation;
- solid precipitation.

3.17.2 Test equipment

- Reference transmissometer.
- Reference disdrometer (for precipitation type detection).

3.17.3 Test procedure

Install the sensor to be tested outdoors. This test can be performed together with the precipitation type and intensity test. The output interval of the sensor to be tested and the reference sensor shall be one minute. All data shall be time-stamped.

The test period shall last at least five days. There shall be at least ten distinct events with Meteorological Optical Range (MOR) under 500 m with interruptions (MOR ≥ 4 000 m) lasting more than 6 h in-between.

Within the ten visibility events retained for the test, there shall be at least two events classified with liquid and two events classified with solid precipitation.

3.17.4 Result analysis

For each event with MOR under 500 m, a homogeneity indicator shall be calculated for each data point of the reference sensor, in order to retain only stabilised conditions. This homogeneity factor shall be determined as follows:

Mean value of the ten samples around each data point:

$$\mu_i = \frac{1}{11}\sum_{k=i-5}^{i+5} V_k \qquad (1)$$

Standard deviation of the ten samples around each data point:

$$\sigma_i = \sqrt{\frac{\sum_{k=i-5}^{i+5}(V_k - \mu_i)^2}{10}} \qquad (2)$$

Homogeneity indicator of each data point:

$$H_i = \frac{\sigma_i}{\mu_i} \qquad (3)$$

where

V_k is the visibility value for the sample number k.

Only samples for which the homogeneity indicator is ≤ 0,1 shall be retained.

Compare the retained samples of the reference sensor with the corresponding values of the sensor to be tested.

The test is successful if all values of the sensor to be tested are within ± 10 m or ± 20 % (whichever is greater) of the corresponding reference values.

Bibliography

[1] EN 15144, *Winter maintenance equipment — Terminology — Terms for winter maintenance*

[2] EN 15518-1, *Winter maintenance equipment — Road weather information systems — Part 1: Global definitions and components*

[3] *Guide to Meteorological Instruments and Methods of Observation*, WMO-No. 8, 7th ed., 2008

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