HOMOLOGATION SPECIFICATIONS
for ROAD STATIONS in WINTER-MAINTENANCE
DECISION SUPPORT SYSTEMS

CONTENTS

CHAPTER I

GENERAL

ARTICLE 1 - DEFINITION

In these specifications, the name "winter-maintenance decision support system" (WMDSS) means any automatic data-acquisition system incorporating sensors installed both:

– in the air near the roadway, and

– on or in the pavement in travel lanes,

which enables the measurement, transmission and retrieval, with or without processing, of parameters such as (the list is not exhaustive):

* ambient air temperature,

* hygrometry or dewpoint temperature of ambient air,

* road surface temperature,

* precipitation—presence or absence, quantity, nature, intensity,

* level of anti-icing protection of the road surface, called "freezing temperature",

* deposits on the road surface—nature, condition, quantity—called "surface condition".

ARTICLE 2 - GENERAL HOMOLOGATION REQUIREMENTS

Materials from the other Member States of the European Union or from states that have ratified the European Economic Area (EEA) Agreement, including tests and controls done in the producing country, which do not meet the technical specifications presented here are regarded as equivalent if they make possible an equally sustainable attainment of the levels of safety and fitness for use required by the specifications presented here, insofar as they are not incompatible with the essential requirements of the directive relating to construction products (89/106/EEC).

ARTICLE 3 - FIELD OF APPLICATION

3.1 - Field

WMDSS homologation applies only to the atmospheric sensors and road sensors of road stations, and to their measuring chains and displaying devices.

The data transmission protocol, the ergonomy of the work station, decision support (alert, precision, projections, modelization, etc.) are excluded from the field of application of this procedure.

3.2 - Subfield

The homologation procedure consists of three successive stages corresponding to three distinct subfields:

- technical documentation for the user, enabling optimal operation of the station,
- station and sensor maintenance in a conventional road environment,
- nature and quality of information provided by the various sensors.

Homologation can be granted only at the conclusion of the third stage.

The tests required by this procedure are done in the laboratory in the normal manner in order to ensure reproducibility and repeatability.

3.2.1 - Subfield “TECHNICAL DOCUMENTATION FOR THE USER”

This subfield consists in verifying that the technical documents conform to:

- reference texts on safety, contained in instructions (Appendix 1 of standard NFX 60-200),
- standard NFX 60-200 or another standard recognized as equivalent to it.

3.2.2 - Subfield “ROAD STATION AND SENSOR RESISTANCE IN A CONVENTIONAL ROAD ENVIRONMENT”

Durability is estimated by inflicting basic types of wear, one after another, on the same sensors:

– “thermal wear”, affecting the road station’s electronic box, caused by conduction and greenhouse effect,

– “chemical wear”, produced by the various melting agents used on the roadway and by hydrocarbons from vehicles,

– “mechanical wear”, inflicted by simulating the effect of traffic on road sensors.

3.2.3 - Subfield “NATURE AND QUALITY OF INFORMATION PROVIDED BY SENSORS”

This subfield is subdivided into four groups of parameters—A, B, C and D—and three levels of quality *i*—1, 2 and 3.

(a) Groups of parameters

PARAMETER GROUP	A	B	C	D
Stevenson screen air temperature	Ta	Ta	Ta	Ta
Stevenson screen relative humidity or dewpoint	RH	RH	RH	RH
Road surface temperature	Ts	Ts	Ts	Ts
Road surface: dry/not dry [1]	-	dry/not dry	dry/not dry	———
Road surface: ice cover/frost cover	ice cover/ frost cover	ice cover/ frost cover	ice cover/ frost cover	
Freezing temperature of water solution on pavement	Tf	Tf	———	
Precipitation present/absent	P	P		
Road surface: moist	moist	———		
Road surface: wet	wet			
Road surface: moist and salty	moist and salty			

1 “Not dry” means there is a liquid deposit.

(b) Quality of measurement results

The assessment of all types of measurement results and information on conditions submitted is based on the acceptance requirements defined by a set of statistical control plans conforming to standards NFX 06-021, NFX 06-022 and NFX 06-026, or to other standards recognized as equivalent.

The simple sampling plan adopted, given below, is based on a risk α (alpha) to the supplier set at 5% and a risk β (beta) to the client set at 10%.

[Table: commas represent decimal points.]

	Statistical control NFX 06-021 NFX 06-022 NFX 06-026	Accuracy subclass *i*			
PARAMETER	Simple sampling plan	*i* = 1	*i* = 2	*i* = 3	Control range
Stevenson screen air temperature	n = 770	±0.2°C A = 21			
Stevenson screen relative humidity or dewpoint Road surface temperature					
Road surface: dry/not dry Road surface: ice cover/frost cover					
Freezing temperature of water solution on pavement					
Precipitation present/absent					
Road surface: moist					
Road surface: wet					
Road surface: moist and salty					

n = number of individuals
A = acceptance criterion

ARTICLE 4 - HOMOLOGATION CLASSES

The homologation classes characterize the material by:

– the group of parameters provided,

– the minimal quality of measurement results for the group of parameters.

The classes are represented symbolically by:

– a letter—A, B, C or D—designating the group of parameters,

– a quality index *i* from 1 to 3, representing the accuracy subclass for the group of parameters.

Example: Material from company xxx

Type YYY
Year of manufacture: 1992
Homologation class: C2

Homologation is made subject to:

– compliance with the standard on technical documentation for the user,

– passing resistance tests in the environment (see article 12).

ARTICLE 5 - APPLICATION FOR HOMOLOGATION

Applications for homologation are submitted in triplicate by the manufacturer or importer to:

MINISTÈRE DE L'AMÉNAGEMENT DU TERRITOIRE,
DE L'ÉQUIPEMENT ET DES TRANSPORTS
S.E.T.R.A./C.S.T.R.
46, avenue Aristide Briand
Boîte Postale 100
92223 BAGNEUX CEDEX

An application for homologation from a foreign manufacturer not established in the EEC or the EEA is accepted only if the manufacturer can prove that it has a representative established in a Member State of the EEC or the EEA. In such a case, the application for homologation may be submitted by the representative.

The file must include:

- an application for homologation,[1]
- an undertaking,[1]
- a technical file on the material,[1]
- a technical file on the manufacturer,[1]
- the report on testing results defined in Chapter II,
- for foreign manufacturers not established in the EEC or the EEA, elements proving that it has a representative established in a Member State of the EEC or the EEA.

N.B. Persons whose duties require them to examine any elements in a file are bound by strict confidentiality. No information may be released without the written consent of the manufacturer.

1 See model in Appendix 1.

ARTICLE 6 - GRANTING OF HOMOLOGATION, AND FOLLOW-UP

6.1 - Homologation testing and prior investigation

6.1.1 - An application for homologation must be preceded by laboratory testing and verifications done in a certified laboratory (see article 8) on the candidate's initiative. The testing and verifications are done according to the procedure set forth in Chapter III, and a report on the results must be submitted.

The applicant may be asked to provide the administration with a sample for supplementary tests.

In the case of a manufacturer not yet certified for the type of equipment in question, an application for homologation always gives rise to a prior inspection of means of manufacture and control (see article 14) by a body offering the guarantees defined in article 8.

Homologation is granted on the basis of laboratory testing.

6.1.2 - When the same testing and verifications have been done in a Member State of the EEC or the EEA by a laboratory providing the guarantees defined in article 8, the candidate submits the reports on the testing and verifications done.

The testing by the laboratories in question may be done according to the procedures of the Laboratoire Central des Ponts et Chaussées (LCPC), or according to procedures defined by NF standards or recognized as equivalent to French procedures. The results are placed at the disposal of the French administration.

6.2 - Granting of homologation

On the basis of satisfactory results for testing and the prior inspection referred to above, the administration grants homologation comprised of:

– certification of the product approved by the issuance of one or more technical fact sheets valid for six years,

– certification of the manufacturer approved by a certificate of homologation that is renewable annually on the basis of control results (see article 6.3).

Homologation is granted for the product or product line defined on the technical fact sheet. It is valid only for that product or product line in a given category.

6.3 - Annual renewal of homologation

On January 31 of each year, a certified manufacturer must send an application for the renewal of some or all of its homologations.

Renewal is granted annually on the basis of satisfactory results in the control testing defined below in article 6.5.

6.4 - Control by the manufacturer

The manufacturer undertakes to provide products that conform to the specifications defined in Chapter II and to control its manufacturing in accordance with the requirements given in Chapter IV.

6.5 - Conformance control

The LCPC or any other body offering the guarantees defined in article 8 proceeds with the verification of the manufacturer's internal control and may do nonsystematic controls, by taking samples at the plant, in inventory, at the delivery stage or on site, to verify that homologated products conform to the specifications given in chapters II and III. In the event of nonconformity, only the test or tests required because of nonconforming elements are done.

6.6 - Changes in materials

Any change in a homologated material must be preceded by an application from the holder.

If the change does not alter the characteristics of the homologated product, the administration will grant certification anew on the basis of the supporting documents provided with the application.

Otherwise, the product must undergo some or all of the tests required for separate certification. The testing may be done in advance, and the testing report may be filed with the application.

ARTICLE 7 - HOMOLOGATION MARKING

All products made according to homologation requirements must bear an inscription, visible from the outside, giving:

– the homologation number (which includes the class),

– the serial or manufacturing number,

– the year of manufacture.

Homologation marking is defined in Appendix I.

ARTICLE 8 - CERTIFIED LABORATORIES

Testing and controls must be done by the Laboratoire Central des Ponts et Chaussées (LCPC) or by any other laboratory, certified by a Member State of the EEC or the EEA, that is recognized as offering guarantees regarding techniques, professionalism and independence in the field of road facilities that are appropriate and satisfactory, and that meet, in particular, the standards for the operation of testing laboratories and control bodies (EN 45000).

ARTICLE 9 - HOMOLOGATION FEES

The fees charged to companies are determined by an annual decision that is provided to candidates.

CHAPTER II

TECHNICAL SPECIFICATIONS

ARTICLE 10 - GENERAL

10.1 - Homologation is granted on the basis of the results obtained in a series of measurements (grouped by test) performed on production-line materials. The results, obtained exclusively from conventional laboratory tests, are compared with established thresholds.

There are specific tests for each homologation class and subclass.

The terminology used follows standard NFX 07-001 *Vocabulaire international des termes fondamentaux et généraux de métrologie* [international vocabulary of basic and general terms in metrology].

10.2 - Collection of samples for testing

The testing procedures described below are used with random batch samples from three road stations (measuring chain + sensors) designated by the supplier.

10.3 - Laboratory procedures

10.3.1 - Environmental chamber tests are used for:

- atmospheric sensors,
- road sensors,

and are performed under conditions that are:

- constant, or
- variable.

The systems whose homologation has been applied for are tested in an environmental chamber using apparatus specific to each test. The whole is described in article 13.1.3.

Continuous testing

> The sensors are tested between −15°C and +10°C at successive levels. However, they must be suitable for indicating the temperature up to +50°C (summer conditions). The tests are described in article 13.2.

Temperature differences of ±30°C between sensors and electronic boxes are required at the road station; the related test is described in article 12.1.

Testing under variable conditions:

Sensors are tested for ambient temperature conditions that are varied over time (article 13.2) and simulate a small number of winter situations.

10.3.2 - Durability tests are used mainly to assess road sensor resistance to mechanical and chemical wear in a road environment.

The durability tests are described in articles 12.2 and 12.3.

ARTICLE 11 - CONFORMANCE CONTROL OF TECHNICAL USER DOCUMENTATION

11.1 - Verification of the existence of USER documentation is done to see that it meets the requirements of standard NFX 60-200, with regard to

the descriptive fact sheet,
the technical fact sheet,
the general flowsheet,
the overall plans,
the functional and other diagrams,
the installation instructions,
the utilisation instructions,
the maintenance instructions,
the catalog of separate parts,
the instructions regarding changes.

Special attention is paid to the following documents and diagrams:

– installation of road sensors (method, indication, levels, masks, etc.),

– installation of atmospheric sensors (as above),

– maintenance manual (preventive, etc.),

– description of the way the various sensors interact in the determination of surface conditions (this is taken into account in the testing procedures for homologation).

11.2 - The absence of a part or the totality of the above technical documents (thoroughly identified) leads to refusal of an application for homologation.

ARTICLE 12 - CONTROL OF ROAD STATION RESISTANCE IN A CONVENTIONAL ROAD ENVIRONMENT

12.1	**TEST METHOD FOR THE EVALUATION OF STATION RESISTANCE TO THERMAL STRESS IN A ROAD ENVIRONMENT**	**1**

This test method is intended to evaluate what effect varying the temperature (daytime and nighttime radiation) of the electronic box has on the accuracy of the measurements taken.

Reference standard:

- A calibrated thin-film RTD sensor Pt 100 ohm at 0°C glued to the active part (measuring zone) of the road sensor.
- A calibrated RTD sensor Pt 100 ohm at 0°C to control the ambient temperature from +30°C to –30°C.

Test:

- The electronic box is successively exposed, in an environmental chamber, to temperatures of +30°C and –30°C for 12 hours, with a transition phase of 6 hours,
- The road-surface temperature sensor is maintained in a second environmental chamber at a constant temperature close to 0°C ± 2°C,

Procedure:

- The road-surface temperatures given by the reference system and the system under test are recorded every 12 minutes during the temperature cycle (+30°C to –30°C) to which the electronic box is subjected.
- The measurements form two matched series of n values (n = 120).

Interpretation:

The means of the two matched variables are compared using Student's t test.

12.1	**TEST METHOD FOR THE EVALUATION OF STATION RESISTANCE TO THERMAL STRESS IN A ROAD ENVIRONMENT**	**2**

DECISION	H_0 rejected	H_0 accepted
The risk α (Type I error) is shared and set at 5%.	$t < -1.658$	$-1.658 < t < -1.658$
The null hypothesis, H_0 is my = 0 ($m_1 = m_2$)	$t > 1.658$	

The discriminatory function is

[Equation]

where $yi = x_{1i} - x_{2i}$

12.2	TEST METHOD FOR THE EVALUATION OF ROAD SENSOR RESISTANCE TO CHEMICAL STRESS	1

This test method is intended to evaluate the resistance of road sensors to chemical stress related primarily to the use of melting agents.

Test

The unprotected sensor is exposed successively to a commercial diesel hydrocarbon and two melting agents in aqueous solution at the highest concentration used:

- calcium chloride $CaCl_2$, 33%
- sodium chloride NaCl, 23%

The exposure consists in immersing the road sensor(s) cyclically in a basin containing various products in succession. The immersion is done:

* at +25°C, 100 % humidity,
* for 15 days, with a cycle every 30 minutes,
* under a column of liquid 150 mm high.

Interpretation

When the test period is complete:

- the sensor must function normally and be capable of providing the information it was designed to provide. The verification is based on:
  * a control of the presence and coherence of the dry/not dry information, which must be obtained after three successive attempts at +5°C according to the method described in 13.2.5,
  * a control of surface temperature which must be obtained at ±2°C, the sensor being placed in an environmental chamber at +5°C;
- the metal parts of the sensor must show no signs of corrosion,
- the resin or synthetic parts and the electric connecting cables must not show any surface alteration (peeling, cracking, scratch marks, etc.).

12.3	TEST METHOD FOR THE EVALUATION OF ROAD SENSOR RESISTANCE TO MECHANICAL STRESS	1

These tests are intended to evaluate in a short time, in the laboratory, the resistance of road sensors to mechanical wear comparable to that occurring on roads.

Test

The sensor is sealed with resin in a premoulded concrete block, whose external dimensions are length = 500 mm, width = 180 mm and height = 140 mm, and then placed in the MLPC "ornièreur A77" [rutting tester A77] described in standard NF P 98-253-1.

The specimen sensor is subjected to:

- 10^3 passages of a wheel with a studded tire (random distribution of studs),
- 10^5 passages of a wheel with a normal tire.

The characteristics of the components of the apparatus used to hold the sensor in place are:

- sealing resin: PRODOFIX FC1, manufactured by TIB Chemie (the thickness of the seal is less than 1.5 cm),
- concrete with a minimum pressure resistance of 30 MPa at 28 days.

The main characteristics of the test are:

- a wheel with 400 x 8 tires, having a tread width of 8 ± 0.5 cm,
- a tire rolling distance of 410 ± 0.5 mm,
- a relative movement frequency of 1 ± 0.1 Hz,
- tire pressure of 0.6 ± 0.01 MPa at the beginning of the test,
- an applied rolling bad of 5000 ± 50 N measured statically at the centre of the specimen,
- a difference between the axis of the wheelpath and the specimen's theoretical axis of less than 5 mm,

– no slip angle,

– a temperature of 60°C.

Interpretation

At the end of the test:

– the sensor must function normally and be capable of providing the information it was designed to provide. The verification is based on:

  * a control of the presence and coherence of the dry/not dry information that must be obtained after three successive attempts at +5°C according to the method described in 13.2.5,

  * a control of surface temperature which must be obtained at ±2°C, the sensor being placed in an environmental chamber at +5°C;

– the sensor must show no surface cracks longer than 10 mm.

ARTICLE 13 - **TEST PROCEDURES**

13.1 - GENERAL METHODS AND TEST CONDITIONS

13.1.1 - Thermal conditions

The environmental chamber testing is done under constant and variable temperatures.

– Constant temperature levels

Sensors are tested for five levels of ambient temperature:

+5°C ± 1°C
0°C ± 1°C
–5°C ± 1°C
–10°C ± 1°C
–15°C ± 1°C

– Variable temperatures

Four typical temperature cycles are used to simulate winter atmospheric conditions and road-surface conditions.

13.1.2 Set-up of environmental chamber measuring stations

13.1.2.1 Atmospheric sensors

The atmospheric sensors and the electronic box are set up on individual masts in the environmental chamber.

13.1.2.2 Road sensors

In order to test all sensors under the same conditions, the sensors are embedded in asphalt concrete pavement which is placed on a cement concrete slab measuring 1.30 m x 1.30 m x 0.30 m thick. The asphalt pavement is divided into six identical test slabs measuring 0.60 m x 0.40 m x 0.15 m thick. The asphalt slabs are separated by a polystyrene insulating barrier.

The asphalt concrete slabs and cement concrete slab are insulated laterally by a 10 cm thickness of polystyrene. The whole is placed on the cold table in the environmental chamber (see Appendix IV, figure 1).

The asphalt concrete slabs, which are manufactured in the laboratory, are aged artificially by sandblasting (eliminating the binder between aggregate particles on the surface).

The asphalt concrete slabs are placed on a stationary support (see figure 2) and left for the builders to install the sensors, or see that they are installed, in the standard manner.

The sensors used have previously undergone mechanical resistance testing.

13.1.3 - Testing and measuring apparatus

13. 1.3.1 - Environmental chambers

Volume: 48 m^3

Temperature range: –35°C to +35°C

Class: C

13.1.3.2 - Temperature sensors (standard NF C 42-330)

– For surface temperature

  a class A RTD sensor Pt 100 ohm at 0°C
  4-wire output

– For Stevenson screen air temperature

  a class A RTD sensor Pt 100 ohm at 0°C
  four-wire output

13.1.3.3 Determination of dewpoint temperature

Dewpoint hygrometer. The air relative humidity is deduced by calculation.

Characteristics:

– Hygrometer: HGG, model 660
– Measurement range: –50°C to +100°C
– Accuracy: ±0.3°C
– Sensitivity: ± 0.06°C

13.1.3.4 Pluviometry

Tipping bucket rain gauge

Characteristics:

– 400 cm^2 collector
– Bucket tips at 8 g, or 0.2 mm of water on the collector surface. Reference: Météorologie Nationale R 01-3030.
– Bucket tips at 4 g, or 0.1 mm of water on the collector surface.. Reference: Météorologie Nationale R 01-3031.

13.1.3.5 - Measurement of surface temperature without contact

Portable spectroradiometer (bolometer) having the following minimum characteristics:

Temperature range: –15°C to +30°C
Accuracy: ±0.5°C
Sensitivity: < 0.1°C
Bandwidth: 9.5 to 11.5 micrometers
Aperture: 20°

13.1.3.6 - Measuring and acquisition chain

The values of the various parameters are acquired sequentially by a central measuring station, permitting delayed simultaneous processing on a calculator.

The essential characteristics are:

- Rate of measurement: 7, 20, 100 measurements/s
- Range of measurement: –220°C to + 250°C
- Accuracy at 7 measurements: ± (0.4% + 5UR1)
- Temperature coefficient: (0.002% + 0.01°C)°C
- Reproducibility between 2 channels: < (0.05°C + 1UR)

The central station is combined with a calculator with 512 Ko of RAM and 40 Mo of disk memory.

1 UR: unit of representation according to CEI 485, or the minimum difference between two displayed values.

13.1.3.7 - Portable measuring chain

A thermocouple calibrator/simulator and precision platinum RTDs

Characteristics:

- Pt 100/resolution 0.05°C
- linearity 0.05
- Measuring accuracy: 0.02%, reading ± 0.04 ohm

13.2 - TEST METHODS

13.2.1 AIR TEMPERATURE

13.2.2 AIR RELATIVE HUMIDITY

13.2.3 AIR DEWPOINT TEMPERATURE

13.2.4 ROAD SURFACE TEMPERATURE

13.2.5 ROAD SURFACE DRY/NOT DRY

13.2.6 ROAD SURFACE ICE COVER/FROST COVER

13.2.7 FREEZING TEMPERATURE

13.2.8 PRECIPITATION: BEGINNING/END

13.2.9 MOIST ROAD SURFACE

13.2.10 WET ROAD SURFACE

13.2.11 WET AND SALTY ROAD SURFACE

13.2.1 TEST METHOD FOR "AIR TEMPERATURE"	1

This method is intended to determine the accuracy subclass *i* of the ambient temperature, taking into account the conditioning of the sensor. The test is done in an environmental chamber under constant temperature and variable temperature conditions.

Reference standard

The reference ambient temperature is the mean value of the measurements taken with two RTD sensors Pt 100 ohm at 0°C placed:

- one, in a small weather shelter (BMO 1161 A),
- the other, in close proximity to the road sensors under test.

1. CONSTANT TEMPERATURE

Test

The sensors are tested at the five following temperature levels:

+5°C ± 1°C
0°C ± 1°C
–5°C ± 1°C
–10°C ± 1°C
–15°C ± 1°C

Procedure

The sensors under test and the reference sensors are set up in the working volume of the test chamber.

- The temperature is set at the predetermined level.
- The temperature is allowed to stabilize for two hours.
- The ambient temperature is recorded for an hour at 6-minute intervals.

The procedure is done for all five levels of ambient temperature.

13.2.1 TEST METHOD FOR “AIR TEMPERATURE”	2

2. VARIABLE TEMPERATURE

Test

The sensors are tested through three thermal cycles—a, b and c—defined below.

Procedure

– The set-up is stabilized for 12 hours at +5°C.

– The thermal cycle under study is initiated.

– The ambient temperature is recorded at 12-minute intervals.

– The procedure is done for all three thermal cycles—a, b and c—defined below.

(a) Programming of regular sine-wave cycles of ambient temperature for 72 hours. The maximum temperature is set at +5°C; the minimum temperature is set at –5°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

(b) Beginning at +5°C, programming of a regular decrease in ambient temperature (1°C/2 h) with stabilization of the temperature at 1°C. After 24 hours, increase of temperature back to +5°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

(c) The initial temperature is brought to +5°C. Programming of a sharp drop in ambient temperature to −10°C in 3 hours, with stabilization for 2 hours followed by an increase to +1°C in 6 hours and regulation at +1°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

13.2.1 TEST METHOD FOR “AIR TEMPERATURE”	4

Interpretation

– The difference between the temperature values given by the reference system and the apparatus under test constitutes the set of observed differences.

– This set contains 770 values (individuals) for the series of tests at constant temperature and at variable temperature.

Acceptance requirements

– The determination of the accuracy subclass i (i = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

– Sampling plan:

  * simple sampling
  * number of individuals n = 770
  * acceptance criterion A = 21

13.2.2 TEST METHOD FOR "AIR RELATIVE HUMIDITY"	1

This test method is intended to determine accuracy subclass *i* of the ambient air relative humidity, taking into account the conditioning of the sensor. The test is done in an environmental chamber and covers a range of relative humidity from 60% to 95%.

Reference standard

The dewpoint temperature (Td) is read with an EGG 660 dewpoint hygrometer.

Ta and Td (standard) serve to determine the air relative humidity using the following equation:

[Equation]

where Ta is the air temperature, and

Td is the dewpoint temperature

(Reference: MÉTÉO FRANCE technical notice)

1. QUASI-CONSTANT HUMIDITY

Test

The sensors are tested at the five following temperature levels:

+5°C ± 1°C
0°C ± 1°C
–5°C ± 1°C
–10°C ± 1°C
–15°C ± 1°C

During the tests, the maximum relative humidity permitted is 98%.

13.2.2 TEST METHOD FOR “AIR RELATIVE HUMIDITY”	2

Procedure

The sensors under test and the reference sensors are set up in the working volume of the test chamber.

– The temperature is set at the predetermined level.

– The temperature is allowed to stabilize for two hours.

– The ambient temperature is recorded for an hour at 6-minute intervals.

The procedure is done for all five levels of ambient temperature.

– the dewpoint temperature is recorded for one hour at 6-minute intervals.

2. VARIABLE TEMPERATURE

Test

The sensors are tested through three thermal cycles—a, b and c—defined below.

Procedure

The set-up is stabilized for 12 hours at +5°C

13.2.2 TEST METHOD FOR “AIR RELATIVE HUMIDITY”	3

– The thermal cycle is initiated.

– The ambient temperature is recorded at 12-minute intervals.

– The procedure is done for all three thermal cycles—a, b and c—defined below.

(a) Programming of regular sine-wave cycles of ambient temperature for 72 hours. The maximum temperature is set at +5°C; the minimum temperature is set at –5°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

(b) Beginning at +5°C, programming of a regular decrease in ambient temperature (1°C/2 h) with stabilization of the temperature at 1°C. After 24 hours, increase of temperature back to +5°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

(c) The initial temperature is brought to +5°C. Programming of a sharp drop in ambient temperature to −10°C in 3 hours, with stabilization for 2 hours followed by an increase to +1°C in 6 hours and regulation at +1°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

Interpretation

- The difference between the temperature values given by the reference system and the apparatus under test constitutes the set of observed differences.
- This set contains 770 values (individuals) for the series of tests at constant temperature and at variable temperature.

Acceptance requirements

- The determination of the accuracy subclass *i* (*i* = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.
- Sampling plan:
  - simple sampling
  - number of individuals n = 770
  - acceptance criterion A = 21

13.2.3 TEST METHOD FOR "AIR DEWPOINT TEMPERATURE"

As for relative humidity, but comparison is done with Td only.

13.2.4 TEST METHOD FOR "ROAD SURFACE TEMPERATURE" | 1

This test method is intended to determine the accuracy subclass *i* of the road surface temperature taken by a road sensor embedded in the pavement.

Reference standard

Three measuring apparatus are used:

(a) a set of three calibrated RTD sensors Pt 100 ohm at 0°C, for each of the 6 test slabs,

– half-embedded, and glued to the pavement surface,

– placed at intervals on each asphalt concrete slab in which the road sensor under test is installed;

(b) a calibrated thin-film RTD sensor Pt 100 ohm at 0°C glued to the active part (measurement zone) of the road sensor;

(c) a portable spectroradiometer which is aimed at each of the six test slabs on a part of the pavement surface on which no sensor is installed.

The pavement temperature reference value is taken to be equal to the arithmetic mean of the 18 measurements taken on the surface of the asphalt concrete and *n* measurements taken on the active parts of the sensor (n = 1 to 6).

The IR measurements are used simply as a noncontact means of verifying the spatial heterogeneity of temperature.

13.2.4 TEST METHOD FOR "ROAD SURFACE TEMPERATURE"	2

1. CONSTANT TEMPERATURE

Test

The sensors are tested at the five following temperature levels:

+5°C ± 1°C
0°C ± 1°C
–5°C ± 1°C
–10°C ± 1°C
–15°C ± 1°C

Procedure

- The temperatures of the chamber and cold table are set at predetermined values.
- The temperature is allowed to stabilize for two hours.
- The surface temperatures are recorded for an hour at 6-minute intervals.

The procedure is done for all five levels of ambient temperature.

2. VARIABLE TEMPERATURE

Test

The sensors are tested through four thermal cycles—a, b, c and d—defined below. The surface temperature is induced by the air temperature in the chamber. The initial temperature of the pavement/concrete structure is set at +5°C ± 1°C. The cold table is maintained at +5°C for the duration of the tests.

13.2.4 TEST METHOD FOR "ROAD SURFACE TEMPERATURE"	3

Procedure

- The set-up is stabilized for 12 hours at +5°C.
- The thermal cycle under study is initiated.

– The ambient temperature is recorded at 12-minute intervals.

– The procedure is done for the four typical thermal cycles.

(a) Programming of regular sine-wave cycles of ambient temperature for 72 hours. The maximum temperature is set at +5°C; the minimum temperature is set at –5°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

(b) Beginning at +5°C, programming of a regular decrease in ambient temperature (1°C/2 h) with stabilization of the temperature at 1°C. After 24 hours, increase of temperature back to +5°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

(c) The initial temperature is brought to +5°C. Programming of a sharp drop in ambient temperature to −10°C in 3 hours, with stabilization for 2 hours followed by an increase to +1°C in 6 hours and regulation at +1°C.

[Graph]
[Ordinate] Ambient temperature
[Abscissa] Time

(d) The initial temperature of the road surface is +9°C. It is dropped drastically to –3°C at a rate of 3°C/h.

13.2.4 TEST METHOD FOR “ROAD SURFACE TEMPERATURE”	5

Interpretation

– The difference between the temperature values given by the reference system and the apparatus under test constitutes the set of observed differences.

– This set contains 830 values (individuals) for the series of tests at constant temperature and at variable temperature.

Acceptance requirements

– The determination of the accuracy subclass i (i = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

– Sampling plan:

  * simple sampling
  * number of individuals n = 830
  * acceptance criterion A = 21

13.2.5 TEST METHOD FOR "ROAD SURFACE DRY/NOT DRY"	1

This test method is intended to determine the accuracy subclass *i* of the data for:

– a dry surface,

– a nondry surface,

provided by the sensor(s).

Test

The road sensor is tested at two temperature levels: +5°C and −5°C. The dry surface/nondry surface conditions are established 20 times in succession for each temperature.

Procedure

Tests at +5°C

– The active surface of the sensor is cleaned with demineralized water and dried with compressed air (Td = −45°C).
– A moist condition is achieved artificially by spraying the test slabs with the quantity of water required to yield a film of water (rain) about 0.1 mm thick. The condition is maintained for about 12 minutes.
– A dry condition is achieved artificially at the end of this period by drying with compressed air. The new condition is maintained for about 12 minutes.

Tests at −5°C

– The surface is dried with compressed air (Td = 45°C).
– A moist condition is achieved artificially by spraying the test slabs with the quantity of 23% NaCl aqueous solution required to yield a film of solution about 0.1 mm thick. The condition is maintained for about 12 minutes.
– A dry condition is achieved artificially at the end of this period by drying with compressed air. The new condition is maintained for about 12 minutes.

13.2.5 TEST METHOD FOR "ROAD SURFACE DRY/NOT DRY"	2

Interpretation

– Each dry and nondry situation induced and stabilized for 12 minutes serves as a reference, which, when compared with the condition detected for the apparatus under test, constitutes the data base.

– The base contains 40 values (individuals).

Acceptance requirements

– The determination of the accuracy subclass *i* (*i* = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

– Sampling plan:

  * simple sampling
  * number of individuals n = 80
  * acceptance criteria
    i = 1, A = 4
    i = 2, A = 11
    i = 3, A = 15

13.2.6	TEST METHOD FOR "ROAD SURFACE ICE COVER/FROST COVER"	1

This test method is intended to determine the accuracy subclass *i* of the data for:

– ice cover, and

– frost cover,

provided by the sensor(s).

Test

The ice cover on the road sensor is created by spraying a film of water over its surface, which has been brought to a temperature of −5°C.

The frost cover is obtained by condensation of ambient air water vapour on the sensor's surface, which is maintained at about −5°C.

The ice-cover and frost-cover conditions are created 15 times each.

Procedure

The active surface of the sensor is cleaned with demineralized water and dried with compressed air (Td = −45°C).

ICE COVER

– Establishment of temperature at −5°C (Ts and Ta).

– Establishment of a constant condition.

– The ice cover is obtained by spraying on a film of water about 0.1 mm thick. (The initial temperature of the water droplets is about +2°C.)

13.2.6	TEST METHOD FOR "ROAD SURFACE ICE COVER/FROST COVER"	2

– The detection of ice cover must be done within 12 minutes after spraying.

– The return to the initial dry condition is obtained by fusion of the ice and drying with compressed air.

FROST COVER

A constant condition is established at –5°C (Ts and Ta).

– The ambient air temperature in the chamber is raised to +3°C in order to cause solid condensation (frost) on the pavement surface.

– Detection of the frost cover must be obtained within 1 hour after the appearance of the first crystals detected by observing the pavement with a compound binocular microscope.

– The return to the initial dry condition is obtained by fusion of the ice and drying with compressed air.

Interpretation

– Each situation of ice cover and frost cover serves as a reference which, when compared with the condition detected for the apparatus under test, constitutes the data base.

– The base contains 30 values (individuals).

Acceptance requirements

– The determination of the accuracy subclass i (i = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

– Sampling plan:

  * simple sampling
  * number of individuals n = 30
  * acceptance criteria
    i = 1, A = 1
    i = 2, A = 2
    i = 3, A = 3

13.2.7 TEST METHOD FOR "FREEZING TEMPERATURE"	1

This test method is intended to determine the accuracy subclass *i* of the freezing temperature of aqueous solutions on the road sensor(s).

The determination is made under constant conditions for typical aqueous solutions of various concentrations.

Reference standard

The following aqueous solutions constitute the system of reference:

- sodium chloride (NaCl),
- calcium chloride (CaCl),
- magnesium chloride ($MgCl_2$),

at concentrations of 4%, 8%, 12%, 16% and 20%.

The freezing temperatures of these solutions, in their various concentrations, are as follows (reference: *Handbook of Chemistry and Physics*, 47th edition, except for the values marked with an asterisk):

[Table: commas represent decimal points.]

13.2.7 TEST METHOD FOR "FREEZING TEMPERATURE"	2

Test

The solutions are spread on the road sensor with a micropipette, making it possible to reproduce the volumes of solution deposited.

The sensor is tested at three temperature levels (for Ta = Ts):

+2°C
–5°C
–10°C

Procedure

– The predetermined temperatures are regulated.

– The temperatures are stabilized for two hours.

– A quantity of solution enabling a film between 0.2 mm and 0.5 mm thick to be obtained is deposited.

– The solutions are stabilized for 12 minutes and then three successive freezing temperature values are obtained within a maximum of 45 minutes.

– The sensor is washed with demineralized water and dried with compressed air (Td = –45°C).

NOTA BENE:

***** The various solutions are brought to the predetermined temperature for each test before the solution is spread on the sensor.

***** For testing at –5°C, only the 12%, 16% and 20% solutions are used.

***** For testing at –10°C, only the 16% and 20% solutions are used.

***** When systems, because of their construction, require recalibration for each type of melting agent, this is done during testing.

13.2.7 TEST METHOD FOR "FREEZING TEMPERATURE"	3

Interpretation

– The freezing temperature taken into account is the mean of the first three successive values determined by the system during the 45 minutes of the test.

– The difference between the freezing temperature values given by the reference system and the apparatus under test constitutes the set of observed differences.

– This set contains 400 values (individuals) for the series of tests under constant conditions.

Acceptance requirements

– the determination of the accuracy subclass *i* (*i* = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

– Sampling plan:

  * simple sampling
  * number of individuals n = 30
  * acceptance criteria
    i = 1, A = 1
    i = 2, A = 2
    i = 3, A = 3

13.2.8 TEST METHOD FOR "PRECIPITATION BEGINNING/END" | 1

This test method is intended to determine the accuracy subclass *i* of the "beginning/end of precipitation" data.

Reference standard

The beginning and end of precipitation is given by the presence or absence of electrical current supplying the electrovalve of the sprayjet.

Test

The sensor is set up in a chamber at +10°C and subjected to two types of precipitation:

- slight: 3 mm/h ± 0.5 mm/h
- moderate: 7 mm/h ± 0.5 mm/h

It is exposed to each type of precipitation in a cycle consisting of 20 minutes of precipitation followed by 20 minutes without precipitation. The test is repeated 20 times for each type of precipitation.

Interpretation

- The time constant of the sensor must in all cases be less than or equal to 12 minutes.
- Each precipitation "beginning/end" situation created and stabilized for 20 minutes serves as a reference, which, when compared with the condition detected by the apparatus under test, constitutes the data set.
- The set consists of 80 values (individuals).

Acceptance requirements

- The determination of the accuracy subclass *i* (*i* = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

13.2.8 TEST METHOD FOR “PRECIPITATION BEGINNING/END”	2

– Sampling plan:

* simple sampling
* number of individuals n = 80
* acceptance criteria
  i = 1, A = 4
  i = 2, A = 11
  i = 3, A = 15

13.2.9 TEST METHOD FOR "ROAD SURFACE: MOIST"	2

This test method is intended to determine the accuracy subclass *i* of the "moist pavement" data.

Test

The road sensor is tested at two temperature levels: +5°C and −5°C. The dry surface/nondry surface conditions are repeated 10 times in succession for each temperature.

Procedure

Tests at +5°C

- The active surface of the sensor is cleaned with demineralized water and dried with compressed air (Td = −45°C).
- A moist condition is achieved artificially by spraying the test slabs with the quantity of water required to yield a film of water (rain) about 0.1 mm thick. The condition is maintained for about 12 minutes.
- A dry condition is achieved artificially at the end of this period by drying with compressed air. The new condition is maintained for about 12 minutes.

Tests at −5°C

- The surface is dried with compressed air (Td = −45°C).
- A moist condition is achieved artificially by spraying the test slabs with the quantity of NaCl aqueous solution required to yield a film of solution about 0.1 mm thick. The condition is maintained for about 12 minutes.
- A dry condition is achieved artificially at the end of this period by drying with compressed air. The new condition is maintained for about 12 minutes.

13.2.9 TEST METHOD FOR "ROAD SURFACE: MOIST"	2

Interpretation

– Each "moist pavement" situation induced and stabilized for 12 minutes serves as a reference, which, when compared with the condition detected for the apparatus under test, constitutes the data base.

– The base contains 20 values (individuals).

Acceptance requirements

– The determination of the accuracy subclass i (i = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

– Sampling plan:

  * simple sampling
  * number of individuals n = 20
  * acceptance criteria
    i = 1, A = 1
    i = 2, A = 2
    i = 3, A = 3

13.2.10 TEST METHOD FOR "ROAD SURFACE: WET"	1

This test method is intended to determine the accuracy subclass *i* of the "wet pavement" data.

Test

The road sensor is tested at two temperature levels: +5°C and −5°C. The dry surface/nondry surface conditions are repeated 10 times for each temperature.

Procedure

Tests at +5°C

- The active surface of the sensor is cleaned with demineralized water and dried with compressed air (Td = −45°C).
- A wet condition is achieved artificially by spraying on a film of water (rain) sufficient to cause saturation of the surface macrotexture and natural runoff of water along the surface slope (2.5%). The condition is maintained for about 12 minutes.
- A dry condition is achieved artificially at the end of this period by drying with compressed air. The new condition is maintained for about 12 minutes.

Tests at −5°C

- The surface is dried with compressed air (Td = −45°C).
- A wet condition is achieved artificially by spraying on a quantity of 23% NaCl aqueous solution sufficient to cause saturation of the surface macrotexture and natural runoff of the solution along the surface slope (2.5%). The condition is maintained for about 12 minutes.

– A dry condition is achieved artificially at the end of this period by drying with compressed air. The new condition is maintained for about 12 minutes.

Interpretation

– Each “wet pavement” situation induced and stabilized for 12 minutes serves as a reference, which, when compared with the condition detected for the apparatus under test, constitutes the data base.

– The base contains 20 values (individuals).

Acceptance requirements

– The determination of the accuracy subclass *i* (*i* = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

– Sampling plan:

  * simple sampling
  * number of individuals n = 70
  * acceptance criteria
    i = 1, A = 1
    i = 2, A = 2
    i = 3, A = 3

13.2.11 TEST METHOD FOR "ROAD SURFACE: WET AND SALTY" | 1

This test method is intended to determine the accuracy subclass *i* of the "wet and salty pavement" data.

Test

The road sensor is tested at one temperature level: +5°C. The "wet and salty pavement" condition is produced 10 times in succession.

Procedure

Tests at +5°C

- The active surface of the sensor is cleaned with demineralized water and dried with compressed air (Td = −45°C).
- A wet and salty condition is achieved artificially by spraying on the quantity of 4% NaCl aqueous solution required to yield a film of solution about 0.1 mm thick. The condition is maintained for about 12 minutes.
- A dry condition is achieved artificially at the end of this period by drying with compressed air. The new condition is maintained for about 12 minutes.

Tests at −20°C

- The surface is dried with compressed air (Td = −45°C).
- The wet and salty condition is achieved artificially by spraying on the quantity of 33% $CaCl_2$ aqueous solution required to yield a film of solution about 0.1 mm thick.

The condition is maintained for about 12 minutes.

13.2.11 TEST METHOD FOR "ROAD SURFACE: WET AND SALTY"	2

– A dry condition is achieved artificially at the end of this period by drying with compressed air. The new condition is maintained for about 12 minutes.

Interpretation

– Each "wet and salty pavement" situation induced and stabilized for 12 minutes serves as a reference, which, when compared with the condition detected for the apparatus under test, constitutes the data base.

– The base contains 20 values (individuals).

Acceptance requirements

– The determination of the accuracy subclass i (i = 1, 2 or 3) is made by counting the proportion of nonconforming individuals.

– Sampling plan:

  * simple sampling
  * number of individuals n = 20
  * acceptance criteria
    i = 1, A = 1
    i = 2, A = 2
    i = 3, A = 3

CHAPTER III

PRIOR INVESTIGATION AND HOMOLOGATION TESTING

ARTICLE 14 - PRIOR INVESTIGATION

The prior investigation covers:

- the technical and industrial realization, and the consistency and qualification of the means employed by the company,
- the technical and industrial potential of the company's overall installations,
- the existence and organization of an internal control service and of corresponding laboratories independent of the plant director or manager.

If the applicant subcontracts some manufacturing, the subcontractors may be asked to meet the same technical requirements as the manufacturer. The premises of the subcontractor or subcontractors may also be subject to a prior investigation as defined above.

If the results are satisfactory, the homologation procedure moves forward.

ARTICLE 15 - CONTROL AND LABORATORY TESTING

The technical file's conformance to specifications is verified.

Laboratory testing is done according to the specifications given in Chapter II of this document.

CHAPTER IV

CONTROL

ARTICLE 16 - CONTINUOUS CONTROL BY THE MANUFACTURER

Manufacturers to which a homologation has been granted must enter the results of in-plant controls in their internal control register. The controls must cover:

– the source and quality of the basic materials used,

– manufacturing controls,

– the conformance of finished products.

ARTICLE 17 - CONFORMANCE CONTROL

17.1 - Verification of in-plant control

The control by the manufacturer is verified by the LCPC or any other body offering the guarantees defined in article 8. The purpose of the verification is to:

– be aware of the conditions of manufacture,

– verify that the homologation requirements are met, particularly with regard to marking,

– verify the quality of the manufacturer's internal control, either by doing verification sampling and testing in the plant's laboratory (with possible prior calibration of measuring apparatus) or by taking samples and running tests in the administration's laboratories.

17.2 - Conformance control

Interventions occur periodically for each manufacturer.

Their purpose is to verify that the products supplied conform to homologation requirements on the basis of the specifications in Chapter II.