PD CEN/TS 16811-3:2015

BSI Standards Publication

Winter maintenance equipment — De-icing agents

Part 3: Other solid and liquid de-icing agents — Requirements and test methods

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National foreword

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European foreword

This document (CEN/TS 16811-3:2015) has been prepared by Technical Committee CEN/TC 337 “Road operation equipment and products”, the secretariat of which is held by AFNOR.

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Introduction

De-icing agents are important for the winter maintenance of roads and other traffic areas. They can prevent or eliminate slippery conditions. The Technical Specification describes the requirements for de-icing agents with different properties from de-icing agents according EN 16811-1 and EN 16811-2, and which are used for specific services on roads. The testing methods are included in the Technical Specification.

The multitude of products which can be used in winter maintenance - liquid or solid, natural or industrial produced substances – requires the defining of performance criteria with which the products have to comply.

These criteria are used to assess the usability of the de-icing products while taking into consideration all aspects of the safety of the road user, of the protection of the environment and of the road conditions.

1 Scope

This Technical Specification defines general specifications and performance criteria of other solid and liquid de-icing agents than chlorides of sodium, calcium and magnesium, hereinafter referred to products, which are used with their particular properties for specific uses in winter service on roads and other traffic areas, with the exception of runways and parking areas of aircrafts. It establishes the test methods to control them. The products include inorganic and organic de-icing agents, and mixtures of chlorides of sodium, calcium, magnesium and potassium with organic and inorganic components which are intended for special properties like inhibition of corrosion, enhanced melting capacity or improved spreading pattern.

NOTE This Technical Specification defines specifications and performance criteria and offers for each a variation in the form of classes of requirements. This does not mean that there are products likely to respond to all the classes and criteria of the standard. Therefore, when defining the demand the user needs to make sure prior the appropriateness of his choice and the availability of suitable products.

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 15144, *Winter maintenance equipment — Terminology — Terms for winter maintenance*

prEN 16811-1:2015, *Winter service equipment — De-icing agents — Part 1: Sodium chloride — Requirements and test methods*

prEN 16811-2:2015, *Winter maintenance equipment — De-icing agents — Part 2: Calcium chloride and Magnesium chloride — Requirements and test methods*

EN 573-1, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 1: Numerical designation system*

EN 573-2, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 2: Chemical symbol based designation system*

EN 573-3, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 3: Chemical composition and form of products*

EN 573-5, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 5: Codification of standardized wrought products*

EN 932-1, *Tests for general properties of aggregates — Part 1: Methods for sampling*

EN 1236, *Fertilizers — Determination of bulk density (loose) (ISO 3944, modified)*

EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

EN 10025-5, *Hot rolled products of structural steels — Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance*

EN 13036-1, *Road and airfield surface characteristics — Test methods — Part 1: Measurement of pavement surface macrotexture depth using a volumetric patch technique*

EN 14231, *Natural stone test methods — Determination of the slip resistance by means of the pendulum tester*

EN 1484, *Water analysis — Guidelines for the determination of total organic carbon (TOC) and dissolved organic carbon (DOC)*

EN 27888, *Water quality — Determination of electrical conductivity (ISO 7888)*

EN ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods (ISO 1461)*

EN ISO 1523, *Determination of flash point — Closed cup equilibrium method (ISO 1523)*

EN ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity (ISO 3104)*

EN ISO 9377-2, *Water quality — Determination of hydrocarbon oil index — Part 2: Method using solvent extraction and gas chromatography (ISO 9377-2)*

EN ISO 11130, *Corrosion of metals and alloys — Alternate immersion test in salt solution (ISO 11130)*

EN ISO 11885, *Water quality — Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES) (ISO 11885)*

ISO 649-2, *Laboratory glassware — Density hydrometers for general purposes — Part 2: Test methods and use*

ISO 565, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings*

ISO 758, *Liquid chemical products for industrial use — Determination of density at 20 degrees C*

ISO 2479, *Sodium chloride for industrial use — Determination of matter insoluble in water or in acid and preparation of principal solutions for other determinations*

ISO 2480, *Sodium chloride for industrial use — Determination of sulphate content — Barium sulphate gravimetric method*

ISO 5815-1, *Water quality — Determination of biochemical oxygen demand after n days (BODn) — Part 1: Dilution and seeding method with allylthiourea addition*

ISO 6060, *Water quality — Determination of the chemical oxygen demand*

ISO 2591-1, *Test sieving — Part 1: Methods using test sieves of woven wire cloth and perforated metal plate*

ISO 12846, *Water quality — Determination of mercury — Method using atomic absorption spectrometry (AAS) with and without enrichment*

ISO 15705, *Water quality — Determination of the chemical oxygen demand index (ST-COD) — Small-scale sealed tube method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15144 and the following apply.

3.1
De-icing agent
product designed to prevent ice formation and / or to ensure the fusion of ice or snow

Note 1 to entry: It can be in a solid or liquid form. It can be applied pure, diluted, dissolved or mixed. It has a set of physical-chemical properties giving it value for winter service operations (storage, use, efficiency, de-icing performance, level of impact to the road structure, environment and public health).

4 Requirements and test methods

4.1 General

The solid and liquid de-icers shall be tested in accordance with the following methods and shall conform to the following requirements.

4.2 De-icing performance

4.2.1 General

De-icing performance can be evaluated by one of the following two test methods.

4.2.2 Nancy-Test

The ability of the product to melt ice at −10 °C is determined, depending on its condition, solid or liquid form, according the test method described in C.1.

This test determines:

— the immediate melting performance (PFI) corresponding to the amount of ice melted by the product after 20 min of contact; and

— the efficient melting performance (PFE), which corresponds to the integration of the relationship between the amount of ice melted by the product and the time, over a period of 60 min.

The minimum requirements for the couple PFI / PFE are:

— PFI ≥ 5,0 ml;

— PFE ≥ 300 ml x min.

These results are obtained on the products marketed before any possible future aqueous dilution or mixing with other solid or liquid products.

4.2.3 Inzell-Test (informative)

The ability of the product to melt ice at −2 °C and −10 °C is determined, depending on its condition, solid or liquid form, according the test method described in Annex D.

The test determines the de-icing capacity corresponding to the amount of ice melted by the product after 10 min and 60 min of contact.

4.2.4 Freezing curve

The supplier shall supply the product freezing point as a function of mass percentage (weight %) in aqueous solution. It shall be complemented by the graph (freezing curve) with the freezing data (y-axis is freezing temperature, x-axis is mass percentage).

Additives for liquid and solid de-icers shall be tested with the recommended additive concentration for application in winter service.

The freezing point shall be determined by cryoscopic or spectroscopic methods. The used method shall be documented in the test report.

4.3 Slip resistance

The measurement of the variation of adhesion on a road surface, after application of the product, is performed according to the test method described in C.2.

The variation of the friction coefficient is evaluated using the apparatus described in EN 14231 compared to a water-wet road surface at +5 °C. The measurement with the product shall be performed at +5 °C and −5 °C.

Depending on the type of road or road specific use, the product shall belong to one of the following two classes (see Table 1).

Table 1 — Grip level classes

Class	Grip level induced by the product
1	$SRT_1 \geq 0{,}90\ SRT_e$
2	$SRT_1 \geq 0{,}75\ SRT_e$

The friction coefficients SRTi correspond to surface conditions as follows:

— SRT_e in the presence of de-mineralized water;

— SRT_1 in the presence of the product.

4.4 Heavy metals and hydrocarbons

The limits for heavy metals, hydrocarbons can be found in table 2.

Table 2 — Heavy metals and hydrocarbons

Parameter	Limit mg/l
Aluminium (Al)	≤ 5,00
Arsenic (As)	≤ 0,25
Chromium (Cr)	≤ 0,50
Cadmium (Cd)	≤ 0,20
Copper (Cu)	≤ 0,50
Mercury (Hg)	≤ 0,05
Nickel (Ni)	≤ 0,50
Lead (Pb)	≤ 0,50
Zinc (Zn)	≤ 2,00
Cobalt (Co)	≤ 0,20
Hydrocarbons	≤ 10

NOTE 1 The limits are for an aqueous solution of 100 g product per litre buffered to pH 4.

The content of heavy metals, except for mercury, shall be determined by inductively coupled plasma optical emission spectrometry (ICP-OES), on the basis of the test method in EN ISO 11885.

NOTE 2 Alternatively, the determination of contents of heavy metals can be carried out by atomic absorption spectrometry (AAS), in accordance with the test method in ISO 15586.

The content of mercury shall be determined by cold vapour atomic absorption spectrometry, on the basis of the test method in ISO 12846.

The content of hydrocarbons shall be determined on the basis of the test method EN ISO 9377-2.

4.5 pH

The pH of the product shall be between 5,5 and 11,5.

The pH shall be determined in accordance with the test method in EN ISO 10523 (modified: determination in a 10 weight % aqueous solution; dissolving and dilution with distilled water).

4.6 Sulphate

The content of water soluble sulphates shall be less than 3 weight % (expressed as SO_4).

The sulphate shall be determined based on the test method ISO 2480 (gravimetric method; modified).

NOTE Alternatively, the determination of content of sulphate can be carried out by inductively coupled plasma optical emission spectrometry (ICP-OES), on basis of ISO 11885 or EN 15749. A further alternative test method for the determination of sulphate is the ionic chromatography method (IC), on basis of EN 15749.

4.7 Corrosiveness

The corrosiveness of the product is determined for the following three reference metals:

— the non-alloy steel standard quality (S355 and S450) as defined in EN 10025-2 and -5;

— the non-alloy steel standard quality (S355 and S450) as defined in EN 10025-2 and -5, having received a galvanizing according to EN ISO 1461;

— the aluminium standard quality [EN AW 5754] according to EN 573-1, EN 573-2, EN 573-3 and EN 573-5.

The corrosiveness is determined according to the test method described in C.3.

The product is assigned in one of the classes of corrosion (see Table 3).

Table 3 — Corrosion classes

Class	Degree of corrosion	Corrosiveness (µm/year)
1	low	< 50
2	average	50 to < 200
3	strong	≥ 200

The corrosiveness of the product is expressed in two forms coded as follows:

$F_{10i} . G_{10j} . A_{10k}$ - $F_{Maxi} . G_{Maxj} . A_{Maxk}$

where

— F, G, A represent the tested metals (steel, galvanized steel, aluminium);

— the indices i, j, and k represent the classes of corrosion corresponding;

— the indices Max and 10 correspond to the two concentrations tested.

4.8 Flash point

The minimum required is 100 °C.

The flash point shall be determined in accordance with EN ISO 1523.

4.9 Biodegradability

The lower the ratio of chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5) is (see table 4).

Table 4 — Ratio of chemical oxygen demand (COD)

Biodegradability	Ratio COD/BOD_5
Readily biodegradable	< 2
Fairly biodegradable	2 to 3
Not readily biodegradable	> 3

The minimum requirement for the ratio of COD/BOD_5 is ≤ 5.

This provision does not apply if the COD and / or BOD_5 are not measurable.

The biodegradability of the product is assessed, firstly, by determining the chemical oxygen demand (COD) and biochemical oxygen demand in 5 days (BOD_5) in accordance with ISO 6060, ISO 15705 and ISO 5815-1, and on the other hand, the ratio of these two terms. These tests are performed on aqueous dilutions to 10 g/l in distilled water or quality equivalent.

The supplier shall supply the individual values for COD and BOD_5.

For products with chlorides, the supplier shall supply the content of total organic components (TOC). The content of TOC shall be determined on the basis of the test method in EN 1484 (modified: the presence of chloride requires an appropriate pre-treatment).

4.10 Water insoluble matter

The content of water insoluble matter shall be less than 0,3 weight % for liquid products and less than 0m5 weight % for solid products.

The matter insoluble in water shall be determined according to the test method described in C.4.

4.11 Kinematic viscosity

The supplier shall supply results of measurements of kinematic viscosity at −5 °C, +5 °C and +20 °C. Kinematic viscosity (in mm^2/second) expresses the ratio between dynamic viscosity and density.

The kinematic viscosity shall be determined in accordance with the test method in EN ISO 3104.

Solid and liquid de-icers with additives shall be tested with the recommended additive concentration for the application in winter service.

4.12 Conductivity

The supplier shall supply results of measurements of electrical conductivity (in $mS \times cm^{-1}$).

The conductivity shall be determined in accordance with the test method in EN 27888.

The test is performed on liquid de-icers and concentrated aqueous solutions of solid de-icers (saturation at 20 °C). Additives for liquid and solid de-icers with additives shall be tested with the recommended additive concentration for the application in winter service.

4.13 Bulk density

The supplier shall supply the bulk density (loose) of solid products for information purposes.

The bulk density shall be determined in accordance with the test method in EN 1236.

4.14 Density

The supplier shall supply the density (at 20 °C) of liquid products for information purposes.

The density shall be determined in accordance with the test method in ISO 758 or in accordance with the test method in ISO 649-2.

4.15 Requirements for additives and mixtures

Organic and inorganic additives for liquid and solid de-icers which are intended for special properties like inhibition of corrosion, enhanced melting capacity or improved spreading pattern shall be additional tested with the recommended additive concentration in de-icers for the application in winter service.

Mixtures of chlorides of sodium, calcium, magnesium and potassium with organic and inorganic components (additives) have to apply to the chemical requirements and to the requirements for sieve analysis of sodium chloride in prEN 16811-1:2015 and to the chemical requirements and sieve analysis of calcium chloride and magnesium chloride in prEN 16811-2:2015.

4.16 Material safety data sheet

A material safety data sheet of the product is prepared in accordance with the provisions of REACH [1]. At time of delivery latest the material safety data sheet is made available for the customer.

All information shall be given in the languages of the countries of destination.

4.17 Marking, transport, handling and storage

4.17.1 Labelling of packaged products

The following information shall be marked on the packaging:

a) the name and address of the producer or supplier;

b) the name of the product;

c) the physical-chemical composition in form of a list of key components;

d) the net weight, optionally with the volume of the package, expressed in litres;

e) the term “De-icing agent for roads and other traffic areas” with the number of this European Standard;

f) the information encoded or not, the traceability of the product, in particular its type, originally, the corresponding batch to which it belongs, the date of manufacture and expiration date (un-coded).

g) the marking of the product shall be in accordance with Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 [2].

All information shall be given in the languages of the countries of destination.

4.17.2 Information on delivery notes

The delivery note contains the following information:

a) the name and address of the producer or supplier;

b) the name of the product;

c) the net weight, optionally with the volume of the package, expressed in litres;

d) the term “De-icing agent for roads and other traffic areas” with the number of this European Standard;

e) the date of shipment;

f) the reference to the order;

g) the place of loading.

All information shall be given in the languages of the countries of destination.

4.17.3 Transport, handling and storage

Annex E provides some information.

4.18 Public health and environment

Excluded from the composition of de-icing agents are all substances included in List I of the Directive 2006/11/EC of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community [3] with the exception of those listed in § 5.2, when they are below the defined maximum values.

Substances of List II of Directive 2006/11/EC which are components of the de-icing agents shall be declared.

4.19 Product description

In tendering processes the offers shall include a product description which is dated not longer than 12 months before the date of the offer (see Annex A).

All information shall be given in the languages of the countries of destination.

5 Sampling

The sampling of solid and liquid de-icing agents shall be according the procedures described in Annex B. Further information is available from EN 932.

Annex A
(normative)

Product description for other solid and liquid de-icing agents

Product

Trade name ……

Supplier

……

Product specification (results of supplier tests; requirements in brackets)

Key components

……

- **Form:** solid ☐ liquid ☐
- **De-icing performance:**

Nancy-Test: PFI……..ml (≥ 5,0)
PFE……..ml x min (≥ 300)

Inzell-Test:

Temperature	Contact time	De-icing capacity g melted ice/g de-icing agent
-2 °C	10 min	……..
-2 °C	60 min	……..
-10 °C	10 min	……..
-10 °C	60 min	……..

- **Slip resistance:**

	Temperature +5 °C		Temperature -5 °C	
	STR	STR_1/STR_e	STR	STR_1/STR_e
De-mineralized water	…..(STR_e)	—	—	—
Product	…..(STR_1)	…..	…..	…..

(Class 1 $STR_1 \geq 0{,}90\ STR_e$; Class 2 $STR_1 \geq 0{,}75\ STR_e$)

- **Heavy metals, etc.:**

Aluminium (Al)	…… mg/l (≤ 5,00)
Arsenic (As)	…… mg/l (≤ 0,25)
Chromium (Cr)	…… mg/l (≤ 0,50)
Cadmium (Cd)	…… mg/l (≤ 0,20)
Copper (Cu)	…… mg/l (≤ 0,50)
Mercury (Hg)	…… mg/l (≤ 0,05)
Nickel (Ni)	…… mg/l (≤ 0,50)
Lead (Pb)	…… mg/l (≤ 0,50)
Zinc (Zn)	…… mg/l (≤ 2,00)
Cobalt (Co)	…… mg/l (≤ 0,20)
Hydrocarbons	…… mg/l (≤ 10)

- **pH:**……(5,5 to 11,5)

- **Sulphate:**……Weight % (<3)

- **Corrosiveness:**

Non-alloy steel (EN 10025-2 and -5)		**Non-alloy steel** (EN 10025-2 and -5), galvanized (EN ISO 1461)		**Aluminium** (EN 573-1 to EN 573-3 and EN 573-5)	
10 g/l	Max. concentration	10 g/l	Max. concentration	10 g/l	Max. concentration
……..	……..	……..	……..	……..	……..

- **Flashpoint:**…… °C (≥100)

- **Biodegradability:**

COD: ……
BOD_5: ……..
Ratio COD/BOD_5……(<5)
TOC: ……..

- **Water insoluble matter:** ……Weight % (Liquids <0,3, solid products <0,5)

- **Kinematic viscosity:**……..mm^2/second

- **Conductivity:** ……..……mS/cm

- **Bulk density (loose):** ……kg/dm^3

- **Density (20 °C):**……kg/dm^3

Other information (additives, etc.): …… …… ……
    …… **Date, signature and stamp of supplier**

Annex B
(normative)

Sampling

B.1 Solid form

B.1.1 Package shipments

Select not less than three containers at random from the shipment. For bags, take 0,5 kg samples by means of a sampling tube or other method that will ensure a sample that is representative of the material in the bag. Penetrate with the sampling tube or other method at least 300 mm into the bag.

B.1.2 Bulk shipments

For solid de-icers in bulk lots the sampling shall be in accordance with the methods described in EN 932-1.

Select samples from at least three locations in the shipment. Scrape aside the top layer to a depth of approximately 300 mm. Use a sampling tube or other method, to obtain a sample extending from the cleared surface to at least 1 m. Each sample shall contain at least 1,0 kg of material.

Use caution during the sampling operation to avoid exposing the sample unduly to atmospheric moisture. Immediately and thoroughly mix the individual samples to form a representative composite sample of material and store in a sealed glass or suitable plastic container.

B.2 Liquid form

Obtain a sample of at least 500 ml from the bulk shipping container or storage tank or during discharge. Recirculate the solution in the tank until it is homogenous, then take one or more samples by means of an appropriate sampling device.

Use caution during the sampling operation to avoid exposing the sample unduly to atmospheric moisture. If more than one sample is taken, immediately and thoroughly mix the individual samples to form a representative composite sample of material and store in a sealed glass or suitable plastic container.

B.3 Labelling and distribution of samples

The container with the samples shall have labels as follows:

— trade name of the product;

— address of the point of sampling;

— date of the sampling;

— number of the sampling report.

The sample shall be sent to the test laboratory. If more than one sample is taken, the other samples are for tests by the supplier and used as retain samples.

B.4 Sampling report

The sampling report should include the following information:

— purchasing organization;

— trade name of product;

— active ingredient;

— name and address of supplier;

— date of delivery (delivery note);

— quantity of the delivered product;

— date of sampling;

— point of sampling;

— responsible organization for sampling;

— persons present during sampling;

— short description of sampling procedure;

— number of samples;

— weight of sample;

— addressee of the samples;

— requested tests;

— signature of persons present during sampling.

Annex C
(normative)

Test methods

C.1 Determination of de-icing performance (Nancy-Test)

C.1.1 Scope

This test method covers the provision of data on the ice melting capacity of solid and liquid de-icing agents as a function of time. This test is a special application of SHRP H-205.1 and SHRP H-205.2.

C.1.2 References

— SHRP H-205.1, Test method for ice melting of solid de-icing chemicals [4]

— SHRP H-205.2, Test method for ice melting of liquid de-icing chemicals [4]

C.1.3 Principle

This test utilizes a sheet of ice of uniform thickness (3,175 mm), frozen in a flat, circular Plexiglas dish. After equilibrium to the desired temperature, a weighed quantity of solid or liquid de-icing agent is distributed over the surface of the ice. At specified time intervals, generated brines are decanted by tilting the specimen to the perimeter of the dish, withdrawn via a syringe, measured for volume, and reintroduced to the test specimen so the melting process can continue.

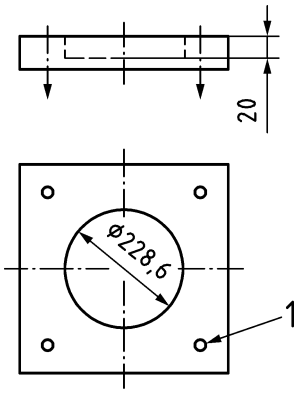
The test is performed at a temperature of −10 °C ± 1 °C.

C.1.4 Equipment

The test equipment includes the following key elements:

C.1.4.1 Plexiglas test dish

Dimensions in mm



Key
1 set screw

Figure C.1 — Test dish (plexiglas plate)

Four set screws allow the level adjustment of the test dish during the phase of freezing the ice sheet.

C.1.4.2 Plexiglas cover plate

A Plexiglas plate of 1,5 mm thickness. It is placed on the test dish during the freezing in order to limit the evaporation and sublimation.

C.1.4.3 Disc for surface finishing

This stainless steel disc is used prior to the test to smooth the surface of the ice and to eliminate all unevenness developed during freezing.

Dimensions in mm

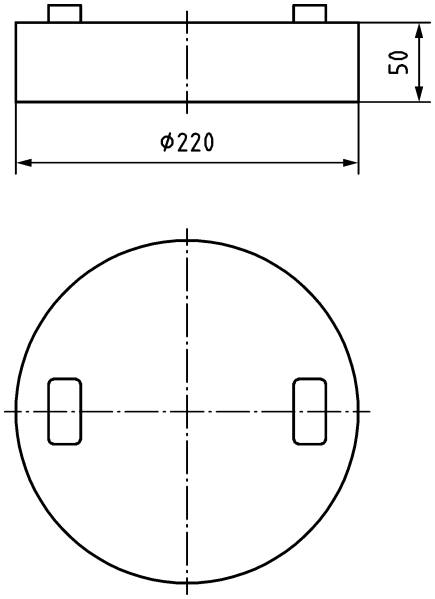


Figure C.2 — Disc for surface finishing of the ice

C.1.4.4 Cold chamber

The cold test chamber is used for freezing water sheets and allows testing at temperature stipulated in C.3.

C.1.5 Auxiliary equipment

C.1.5.1 Analytical balance

— Balance with the scales: 0 g to (6 000 ± 0,1) g.

— Balance with the scales: 0,05 g to (160 ± 0,005) g.

C.1.5.2 Usual laboratory device

— Sample bottle 200 ml.

— Syringes 60 ml capacity with 1 ml graduation.

— Syringes 5 ml capacity with 0,2 ml graduation.

— Chronometer.

C.1.6 Procedure

C.1.6.1 Preparation of the ice sheet

— 130 ml of de-ionized water is placed in the test dish (this quantity corresponds after freezing to an ice thickness of 3,175 mm in the test dish);

— the dish is then placed in a cold room on a level surface. During the freezing at the test temperature use the Plexiglas cover plate for 12 h;

— after freezing, smoothing the surface of the ice formed by applying a rotating movement of the steel disc (see C.4.3.) carried initially at 20 °C;

— refreeze the surface film of water formed by this application for 2 h.

C.1.6.2 The sample

Maintain the test products to the test temperature for 60 min before use.

C.1.6.2.1 Solid products

— Take with a spatula (4,17 ± 0,01) g of solid product[1)] that is being tested.

— Take a second sample to determine the percentage of water.

C.1.6.2.2 Liquid products

— Take 3,8 ml of liquid product using a syringe.

C.1.6.3 Test

— Remove the cover plate from the test dish;

— spread the sample evenly over the ice surface;

— start the chronometer at the end of spreading (time t_0);

— move at an orbital rotation[2)];

— at $t_1 = T_0 + 10$ min, collect the brine with the syringe;

— read the volume collected in the syringe (in the case of liquid products subtract the product volume originally distributed on the ice surface);

— after reading, immediately return the brine into the test dish evenly over the test area;

— continue moving and resume these operations for the time intervals 10 min, 20 min, 30 min, 40 min, 50 min and 60 min;

— repeat this test three times.

1) 4,17 g of de-icing agent are representative for a dosage of 100 g/m^2.

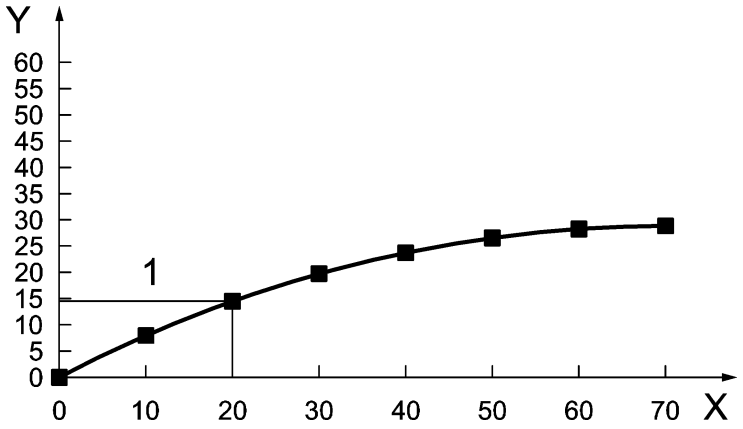
2) This moving can be done either manually or with a slow mechanical shaker.

C.1.7 Expression of results

The de-icing capacity of a solid or liquid de-icing agent is characterized by the two terms, defined below.

C.1.7.1 Immediate melting performance (PFI)

The PFI, expressed in ml, corresponds to the amount of ice melted after 20 min of contact with the product.



Key

X time in minutes

Y amount of ice melted in millilitres

EXAMPLE PFI = 15 ml

Figure C.3 — Amount of ice melted in function of the time – Illustration of PFI

C.1.7.2 Efficient melting performance (PFE)

The PFE, expressed as ml x min, corresponds to the integration of the relation between the amount of ice melted and the time, over a period of 60 minutes:

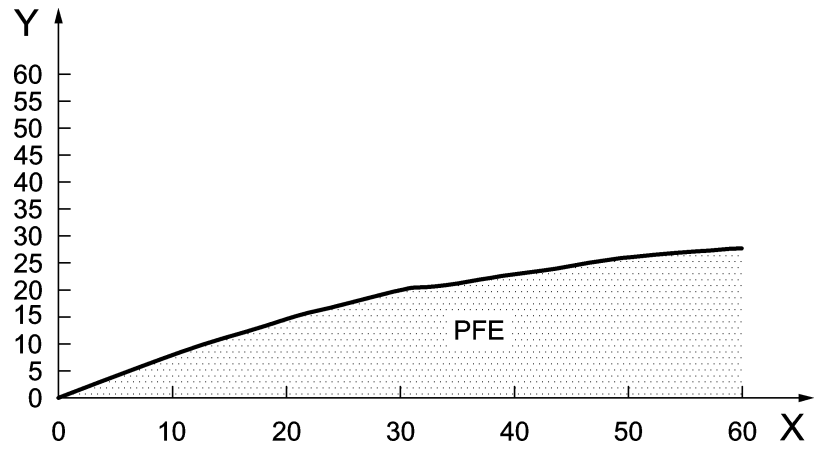
$$PFE = \int_0^{60} Q dt \text{ as ml x min}$$

where

Q is the amount of ice melted in ml;

d is the dependence of time;

t is the variable time between 0 min and 60 min.



Key

X time in minutes

Y amount of ice melted in millilitres

Figure C.4 — Amount of ice melted versus time – Illustration of PFE

C.1.7.3 Expression of results

Averaging the results of three series of tests: ($\overline{Q} = \frac{Q1 + Q2 + Q3}{3}$)

— Establish the graph for the amount of ice melted as a function of time.

— Determine the immediate melting performance (PFI = $\overline{Q}_{20}$).

— Determine the efficient melting performance (PFE = $\int_0^{60} \overline{Q}\, dt$).

For liquid products, subtract the first volume of products previously spread.

C.1.8 Test report

The report of the test shall refer to this test method and include:

— the elements of identification of the product tested;

— the percentage of water in the tested product;

— the test sheet summarizing all the measures included in the calculations;

— the operating details not specified in this test method and incidents which may have influence on the results.

C.1.9 Accuracy of measurement

This accuracy of measurement was determined from the repeatability and reproducibility of the test.

This accuracy of measurement is estimated

— For the immediate melting performance ± 1 ml;

— For the efficient melting performance ± 10 ml/min.

C.2 Determination of slip resistance

C.2.1 Scope

This test standard describes a laboratory method to assess the variation of adhesion on a road surface treated with a de-icing agent, liquid or liquid made by dissolution in water.

C.2.2 References

— EN 14231, *Natural stone test methods — Determination of the slip resistance by means of the pendulum tester*;

— EN 13036-1, *Road and airfield surface characteristics — Test methods — Part 1: Measurement of pavement surface macro texture depth using a volumetric patch technique*.

C.2.3 Principle

The principle of the test method is to determine the variation of the coefficient of adhesion on a surface, induced by the presence of a de-icing agent to be tested. The test is performed with the following specifications:

— Using the narrow sliding shoe (76 ± 1) mm;

— Procedure wet.

C.2.4 Equipment

C.2.4.1 The reference test surfaces

The reference test surfaces consist of replicas of road surfaces made of resin[3)] type semi-grained 0/10 mm bituminous concrete, having a coefficient of friction SRT of a minimum value of 0,62 determined according to EN 14231, and an average texture depth of at least 0,6 mm as defined in EN 13036-1.

C.2.4.2 The test product

The solid products are tested at their maximum concentration at +5 °C and −5°C. This is achieved by dissolving an excess amount of the product in water at +5 °C ± 1 °C and by cooling this solution to −5 °C ± 1 °C.

The liquid products are tested at +5 °C and −5 °C with the maximum mass of prescribed use.

C.2.5 Procedure

C.2.5.1 Determination of coefficient of friction of the SRT reference surface in the presence of de-mineralized water

— Determine the coefficient of friction according to EN 14231;

— SRT_e is the reference coefficient of friction at +5 °C;

3) Replica made of resin, by casting of a road footprint, in neoprene.

— dry the reference surface.

C.2.5.2 Determination of coefficient of friction SRT1 of the reference surface in the presence of product

— Treat the macro texture of the reference surface by spraying the solution of the product at +5 °C and −5 °C, so as to saturate it;

— determine the coefficient of friction SRT_1 of the reference surface thus treated in accordance with the requirements of EN 14231;

— SRT_1 is the coefficient of friction induced by the product deposited at + 5 °C and −5 °C.

C.2.5.3 Specific operating instructions

These guidelines are designed to ensure the repeatability of measurements of the coefficient of friction, even due to contamination of the device by the product solution.

C.2.5.3.1 The measurements are performed in the laboratory after brought to the test temperature of +5 °C ± 1 °C resp. −5 °C ± 1 °C the product and the measuring instruments.

C.2.5.3.2 10 measurements are performed for each point. The reported value is the average of the results of the 10 measurements.

C.2.5.3.3 SRT coefficient values are reported for + 5 °C and −5 °C.

C.2.5.3.4 Cleaning reference surfaces

After each test:

— brush the plate with warm water;

— dry with compressed air.

C.2.5.3.5 Cleaning the SRT sliding shoe

After each test:

— clean the shoe by rubbing with a cloth moistened with alcohol;

— keep the shoe in water between two tests.

C.2.6 Expression of results

Determine the relationship between the coefficient SRT_1 obtained after treatment with a de-icing agent (C.2.5.2) and the coefficient SRT_e obtained initial with wet surface (C.2.5.1).

C.2.7 Test report

The test report shall indicate:

— reference to this test method;

— all information necessary for the complete identification of the product tested;

— the results obtained;

— the operating details, not specified in this standard or optional;

— the incidents which may have influenced the results.

C.2.8 Accuracy of measurement

This accuracy of measurement was determined from the repeatability and reproducibility of the test.

This accuracy of measurement is estimated at ± 2,5 points SRT.

C.3 Determination of corrosiveness

C.3.1 Scope

This test standard describes a method for determination of corrosiveness by immersion/emersion of metal references in a liquid used as de-icing agent on roads. The result is the variation of the mass of the metals thus exposed over a defined period.

This test standard is an application of EN ISO 11130 on de-icing agents.

C.3.2 Principle

The principle of the method consists in immersing three specimens of a reference metal for 15 min in the liquid product to be tested, or in the solution when it is initially solid, then emerge for the same time. This cycle immersion/emersion is repeated 1 200 times (a total of 25 days). After these cycles the mass change of the specimens is calculated.

C.3.3 Preparation of test specimens

C.3.3.1 General

The corrosive nature of the product is determined for all three metals reference mentioned in 4.6.

C.3.3.2 Processing specimens

— Cut pieces of reference metals to the dimensions of 90 X 60 mm, minimal thickness of 6 mm.

— Drill a hole of 2 mm diameter at the edge of the specimen, centred on one of the small sides; allow it to be attached later.

C.3.3.3 Initial treatment of the surfaces of specimens

C.3.3.3.1 Test piece in steel and aluminium

— If necessary, correct the surface with the fine grinding machine.

— Polish manually with the scrubbing machine equipped with linens becoming more and more fine-graded. The polishing is performed successively on the sheets 80, 180, 320, 400 and finally 600.

— The polishing on a cloth with a given grain is performed to remove the streaks present on the surface after the grinding disk of bigger grain.

— Remove by washing and rinsing with acetone, any grease or foreign matter which may change the active surface of the metal.

Determine with an accuracy of ± 5 mm^2 the surface (S) of the test piece.

— Place the wire nylon suspension.

— During the various operations avoid contact with the polished surface.

C.3.3.3.2 Galvanized steel test piece

— Remove by washing and rinsing with acetone, any grease or foreign matter which may change the active surface of the metal.

— Determine with an accuracy of ± 5 mm^2 the surface (S) of the test piece.

— Place the wire nylon suspension.

— During the various operations avoid contact with the polished surface.

C.3.4 Preparation of test products

C.3.4.1 Test solutions

The products are tested in two aqueous solutions under mass follows:

— Pure or under maximum concentration obtained at 20 °C in the case of solid products being dissolved;

— 10 g/l of the marketed product.

The dissolving of solid products is conducted according to the following principle:

— dissolve the solid at a temperature of (+ 50 ± 2) °C with agitation;

— bring the solution to saturation;

— cool the mixture gradually to (+ 20 ± 2) °C with agitation;

— decant, and remove the solution which is the test product.

C.3.4.2 Volume of the test product relative to the volume of the immersed sample

The beakers with the products shall provide a sufficient volume to allow complete immersion of the metal specimen during the test period. The relation between volume of the liquid product and that of the metal specimen is at least 50.

C.3.5 Specific test device

The test device for immersion / emersion is a sealed chamber maintained at a temperature of (23 ± 2) °C, where the various beakers with the liquid to be tested are placed.

A camshaft equipped with several arms can animate specimens vertically therein suspended and thus obtain a movement of immersion and emersion of the specimens which are in the beakers placed below.

The device includes a timer for actuating the camshaft according to the defined cycle, alternative desired 15 min, and the number of alternations desired.

C.3.6 Procedure

For each product, perform tests simultaneously on three test specimens.

C.3.6.1 Preparation for the test

— Weigh the metal pieces with an accuracy of ± 1 mg (M1);

— equipping the specimens with a link of nylon suspend;

— attach the specimens to the arms of the camshaft;

— arrange the beakers with the products below the metal specimens.

C.3.6.2 Test

— Start with the programming of cycles of immersion / emersion, 15 min each.

— Remove the specimens at the end of 1 200 cycles.

— Rinse the specimens with deionized water, dry with a paper towel.

C.3.6.3 Final treatment of the surfaces of specimens

C.3.6.3.1 Steel test pieces

— Strip by immersion in a solution of ammonium acetate, 140 g/100 g of water, to remove the majority of oxides, paint and optionally repeating the operation;

— finish by immersion in a bath of hydrochloric acid, about 6 mol/l, at (23 ± 2) °C passivated with hexamethylenetetramine, during about 30 min, until all residual traces of corrosion are removed;

— wash thoroughly with water and then rinse with deionized water;

— dry with a paper towel.

— Weigh the metal pieces with an accuracy of ± 1 mg (M2).

C.3.6.3.2 Galvanized test pieces and aluminium

— Strip by washing with water with vigorous brushing with a stiff bristle brush in nylon;

— dry with a paper towel;

— weigh the metal pieces with an accuracy of ± 1 mg (M2).

C.3.7 Expression of results

The corrosiveness conventionally is expressed in µm/year, is equal to:

$$\text{corrosiveness} = \frac{M_2 - M_1}{\rho \times S} \times 14{,}6 \times 10^{-4}$$

where

M_1 Initial mass of the specimen, expressed in g

M_2 Final mass of the specimen, expressed in g

S Active surface of the specimen in cm^2

ρ Density of the metal under test, expressed in g/cm^3

The arithmetic mean of the results obtained on three specimens of the same metal, is the result.

C.3.8 Accuracy of measurement

The accuracy of measurement was determined from the repeatability and reproducibility of the test. It is estimated with 5 µm/year.

C.3.9 Densities of the three reference metals

— 7,85 g/cm^3 for steel;

— 2,81 g/cm^3 for aluminium;

— 7,20 g/cm^3 for galvanized steel (EN ISO 1461).

C.4 Determination of water insoluble matter

C.4.1 Scope

This test standard describes a method to determine the weight percentage of matter insoluble in water contained in a product, solid or liquid, used as a de-icing agent. This test method is a special application of ISO 2479.

C.4.2 Principle

The principle of the method consists of dissolving the solid product in water, filtration of the solution or of the original liquid product, drying and weighing of the insoluble residue.

C.4.3 Solid products

C.4.3.1 General

The representative sample of a batch is conventionally taken according to the sampling rules.

The analysis requires a test sample of approximately 500 g.

It is then prepared according to the principles described below.

C.4.3.2 Preparation of the solution

The preparation of the solution is performed at a room temperature of (23 ± 2) °C.

— Weigh out 100 g of the test sample with an accuracy of ± 0,05 g (M0).

— Place in a beaker with 400 ml of distilled water, or equivalent quality.

— Stir for 15 min, and then allow settling for 1 h.

C.4.3.3 Preparation of the filter

— Dry the medium filter (retention 6 µm) at 105 °C for 1 h.

— Leave to cool in a desiccator.

— Weigh the filter with an accuracy of ± 2 mg (M1).

C.4.3.4 Filtration

Filtration of the solution prepared in C.4.3.2, is made with medium filter (retention 6 µm) prepared in C.4.3.3, under reduced pressure, collecting the filtrate in a vacuum flask which may contain 1 000 ml.

— Filter the supernatant;

— wash the insoluble four times, and transfer the insoluble to the filtration system with the fourth time;

— wash the beaker and the insoluble twice;

— the washes were done with a total of 500 ml of distilled water or water with equivalent quality;

— dry the filter according to the method defined in C.4.3.3;

— weigh the filter with an accuracy of ± 2 mg (M2).

C.4.3.5 Expression of the result

$$Percentage\ of\ insoluble\ matter = \frac{M_2 - M_1}{M_0} \times 100$$

where

M_1 is the initial mass of the filter after drying, expressed in grams;

M_2 is the final mass of the filter after drying expressed in grams;

M_0 is the mass of the test sample, expressed in grams.

C.4.4 Liquid products

C.4.4.1 General

The representative sample of a batch is conventionally taken according to the sampling rules.

It is then prepared according to the principles described below.

C.4.4.2 Preparation of the solution

— Shake the container of the test product;

— take approximately 1 l;

— weigh into a beaker 100 g product with an accuracy of ± 2 mg;

— M_0 is then the total mass of the entire test sample + beaker.

C.4.4.3 Preparation of the filter

— Dry the filter (retention 6 microns) at 105 °C for 1 h;

— leave to cool in a desiccator;

— weigh the filter with an accuracy of ± 2 mg (M1).

C.4.4.4 Filtration

Filtration of the solution prepared in C.4.4.2., is made with a medium filter (retention 6 µm) prepared in C.4.4.3., under reduced pressure, collecting the filtrate in a vacuum flask which may contain 1 000 ml.

— Filter the product ensuring not to leave insoluble in the beaker;

— wash the beaker twice with the filtrate collected in the flask;

— weigh the empty beaker with an accuracy of ± 2 mg (M'0);

— wash the filter with distilled water or water of equivalent quality;

— dry the filter according to the method defined in C.4.4.3;

— weigh the filter with an accuracy of ± 2 mg (M2).

C.4.4.5 Expression of the result

$$Percentage\ of\ insoluble\ matter = \frac{M_2 - M_1}{M_0 - M'_0} \times 100$$

where

M_1 is the initial mass of the filter after drying, expressed in grams;

M_2 is the final mass of the filter after drying, expressed in grams;

M_0 is the mass of the beaker and the sample, expressed in grams;

M'_0 is the mass of the beaker after emptying the sample, expressed in grams.

C.4.5 Accuracy of measurement

This accuracy of measurement was determined from the repeatability and reproducibility of the test.

The accuracy of measurement is estimated with ± 0,1 weight %.

Annex D
(informative)

Determination of de-icing performance (Inzell-Test)

D.1 Scope

The test method covers the provision of data on the ice melting capacity of solid and liquid de-icing agents as a function of time and temperature.

D.2 Principle

The test utilizes a sheet of ice of uniform thickness (3,5 cm). After equilibrium to the desired temperature, a weighed quantity of solid or liquid de-icing agent is distributed over the surface of the ice. At specified time intervals (10 min and 60 min), generated brines and residual de-icing agents are centrifuged from the ice sheet. The difference between the initial and final weight of the ice sheet is the amount of the thawed ice.

The test is performed at temperatures of −2 °C and – 10 °C.

D.3 Equipment

The test equipment includes the following key elements:

— sample divider (index head with 18 dividers 12,5 mm (1/2 “) wide);

— drying oven;

— desiccator;

— vibration sieve machine (frequency 50 Hz, vibration amplitude 2 mm) with wire mesh sieves set (sieve diameter 200 mm, height 25 mm);

— approx. 10 plastic bottles for samples;

— balance for sample preparation (accuracy ± 0,01 g, resolution ± 0,01 g);

— 18 test tubes (14 × 130; rubber plug 10,5 × 14; 5 × 20);

— syringes 5 ml capacity with 0,2 ml graduation;

— cold room (adjusting the relative air humidity with the setting variation of ≤ ± 10 % and the air temperature with the setting variation of ≤ ± 0,3 °C in the working range);

— 10 slant-sided plastic shells (bottom surface: 300 × 200 mm, height 100 mm, wall inclination 5°);

— re-melting device (heating plate);

— 10 slant-sided plastic shells (bottom surface: 300 × 200 mm, height 40 mm, wall inclination approx. 25°);

— chronometer;

— 2 surface contact thermometers with measured value recording (accuracy ≤ ± 0,1 °C);

— balance to weigh the ice sheets (accuracy ± 0,1 g, resolution ± 0,1 g);

— centrifuge (475 min^{-1} and 200 mm radius);

— 2 medium-hard brushes.

D.4 Procedure

D.4.1 Sample dividing and drying

A sample of solid de-icing agent is divided with the sample divider into sub-samples at a size of about 300 g to 400 g. Two of the resulting sub-samples, whose weight shall be recorded with an accuracy of ± 0,01 g, are dried in a drying oven at 108 °C for about 13 h. It is then determined by weighing at 1-h intervals, whether the constant weight (<0,1 %) upholds the end of the drying process of both sub-samples. The samples are then cooled to room temperature in presence of a drying agent in a desiccator and the dry weight is determined again. From the weight loss of both sub-samples, the average moisture content is determined.

D.4.2 Sample sieving

With one of the two dried sub-samples the particle size distribution is determined by sieving in accordance with the test method in ISO 2591-1 (test sieves according to ISO 565) or in accordance with the test method in EN 1235. As basic grids, sieves with the following mesh sizes are used:

0,125 mm; 0,8 mm; 1,6 mm; 2,0 mm; 3,15 mm; 5,0 mm; 6,3 mm, and 10 mm.

First, a machine sieving is done with the vibration sieve machine, with time duration of 2 min. If the residue on a sieve exceeds 25 wt. % of the feed amount, appropriate intermediate sieves shall be used additionally, and then a correspondingly shortened machine sieving shall be performed again with the affected screen inserts.

Thereafter, the sieving is completed manually, separately for each screen insert, starting with the largest sieves.

An analytical error is given, when for each sub-sample the difference between the mass of the feed material and the sum of the total content of the particle classes is > 0,4 %.

The individual fractions are to be kept in sealed plastic bottles until the preparation of the test samples.

D.4.3 Preparation of test samples

The 4 g solid de-icing agent samples used for the de-icing test are compiled individually from the accrued particle fractions according to their percentages, determined in the sieve analysis, and kept in sealed test tubes until they are spread on the ice sheets. Sixteen test samples and 2 reserve samples are required per test.

For liquid de-icing agents, each injection syringe shall be filled with 4 g.

D.4.4 Preparation of ice sheets

Approximately 3,5 l of tap water is filled into slant-sided plastic shells and frozen in the cold room at −6 °C for about 72 h. The resulting blank sheets are placed onto the test form using a re-melting device. The spreading area, fused approximately 4 mm deep into the porous sheet side (bottom side during freezing), has dimensions of about 280 mm x 180 mm.

The shaped sheets shall be kept in slant-sided plastic shells (40 mm height) until the test starts. The age of the ice sheets shall not exceed 10 days.

D.4.5 De-icing test

The test is performed in the cold room. The cold room shall be set to a relative air humidity of 50 % – 80 %.

The de-icing performance at 4 measuring points is to be determined with 4 single values each time:

— - 2 °C ice sheet temperature with an exposure time of 10 min and 60 min;

— - 10 °C ice sheet temperature with an exposure time of 10 min and 60 min.

After shape melting, the ice sheets should be adjusted to the respective test temperature in about 20 h - 40 h. Similarly, the prepared test samples, including any required reserve samples, all equipment used and the ice sheets shall be stored at test temperature.

The ice sheet temperature needs to be measured on two ice sheets and recorded continuously every 10 min, until immediately before the test starts. The tests may be started only when the ice sheet temperature enters a steady-state on average. The ice sheet temperature shall not deviate from the test temperature by more than ± 0,2 °C on average.

The tests are carried out in parallel on each of two ice sheets by 2 laboratory technicians.

Within about 15 s of determining the initial weight of the two ice sheets, the application of solid de-icing agent samples from the test tube or the application of liquid de-icing agent samples from the injection syringe begins. The test material shall be distributed as evenly as possible, synchronously and by hand. The exposure time starts with the beginning of the spreading process.

At the end of exposure time, the sheets shall be placed within 15 s in the spin cages of a centrifuge. The sheets shall be spun for 45 s in the centrifuge directly afterwards. Any adhering solid de-icer residues shall be removed from the centrifuge with a non-abrasive brush before the final weight of the remaining sheet is determined.

D.5 Expression of results

The difference between the initial and final weight is the amount of the melted ice. The de-icing performance is expressed in g melted ice / g de-icing agent. The de-icing performance for one of the four measurement points results from a quarter of the arithmetic mean of the 4 single values relating to 1 g salt. Prior to performing averaging calculation, the individual values need to be checked for compatibility and outliers.

Annex E
(informative)

Transport, handling and storage

E.1 Transport

To maintain the initial quality of products, it is necessary:

For bulk products,

— to ensure the necessary cleanliness before loading means of transport, i.e. the non-presence of foreign matter in trailers, wagons and barges;

— to establish weather protection during the transport phases.

For packaged products,

— to meet the criteria set by the regulations.

E.2 Handling operations, storage

To maintain the initial quality of the product, it is necessary:

For bulk products,

— to establish weather protection during the loading phase and unloading;

— to ensure sheltered storage.

For packaged products,

— to meet the criteria set by the regulations, especially for storage sites (controlled installations, etc.).

Annex F
(informative)

Technical aspects of durability of concrete

It is recalled that:

— EN 206, 4.1 “exposure classes related to the environment” (Table 1, enumeration 5), defines the levels of exposure of concrete road structures [5].

— There is a recommendation TC 117-FDC of RILEM for testing the freeze–thaw and de-icing resistance of concrete [6]. This test method can be used to investigate the influence of solutions of de-icing agents onto the durability of concrete. The tests can be performed with diluted and concentrated de-icing agent solutions. During the test the concrete specimen were subjected to several freeze–thaw cycles. In the course of investigation, the loss of mass, the longitudinal change, the ultrasound runtime (modulus of elasticity), and the absorption and discharge of the solution are determined.

The purchaser should pay attention on the need of possible controls of this type when de-icing agents offered with particular properties.

Annex G
(informative)

Test results with the chlorides of sodium, calcium and magnesium

G.1 De-icing performance

G.1.1 Results with the Nancy-Test

Product	Quality	Water content	De-icing performance (−10 °C)	
			PFI (ml)	PFE (ml x min)
Sodium chloride (rock salt)	Solid product (grain size 0–5 mm)	2,5 % ± 0,1 %	5,0	435,0
		dried	7,3	453,3
Sodium chloride (sea salt)	Solid product (grain size 0–5 mm)	1,4 % ± 0,1 %	4,3	358,3
		dried	4,3	330,0
Calcium chloride	Solid product		7,7	519,2
Sodium chloride (23,3 weight %)	Liquid product		2,2	125
Calcium chloride (33 weight %)	Liquid product		7,0	381
Magnesium chloride (30 weight %)	Liquid product		7,7	464
NOTE Source: Laboratoire Régional des Ponts et Chaussées (LRPC), Nancy (France)				

G.1.2 Results with the Inzell-Test

Product	Temperature	Contact time	De-icing capacity (g melted ice/g de-icing agent)
Sodium chloride (4 g fine salt, > 60 weight % passing test sieve 1,6 mm)	−2 °C	10 min	8,2 – 9,2
	−2 °C	60 min	11,4 – 13,2
	−10 °C	10 min	3,0 – 4,2
	−10 °C	60 min	3,8 – 5,4
Sodium chloride (4 g coarse salt, < 60 weight % passing test sieve 1,6 mm)	−2 °C	10 min	6,2 – 8,6
	−2 °C	60 min	11,3 – 13,2
	−10 °C	10 min	2,2 – 4,0
	−10 °C	60 min	4,6 – 5,7
Sodium chloride (4 g pre-wetted salt with 30 weight % of	−2 °C	10 min	6,1
	−10 °C	10 min	2,0

Product	Temperature	Contact time	De-icing capacity (g melted ice/g de-icing agent)
a solution with 20 weight % NaCl)			
Calcium chloride (4 g 79 weight % $CaCl_2$)	−2 °C	10 min	7,8
	−2 °C	60 min	10,2
	−10 °C	10 min	3,9
	−10 °C	60 min	4,2
Sodium chloride (20 g of solution with 19 - 20 weight %)	−2 °C	10 min	8,0
	−2 °C	60 min	10,3
	−10 °C	10 min	2,0
	−10 °C	60 min	2,1
Calcium chloride (20 g of solution with 18 – 20 weight %)	−2 °C	10 min	7,7
	−10 °C	10 min	4,0
Magnesium chloride (20 g of solution with 20 weight %)	−2 °C	10 min	8,3
	−10 °C	10 min	2,9
	−10 °C	60 min	3,5
NOTE Source: Federal Highway Research Institute (BASt), Bergisch Gladbach (Germany)			

G.2 Slip resistance

Product	Slip resistance			
	Temperature +20 °C		Temperature +5 °C (extrapolated)	
	SRT	SRT/SRT_e	SRT	SRT/SRT_e
De-mineralized water (SRT_e)	66,6	-	61,6	-
Sodium chloride (23 weight %)	60,4	0,91	55,4	0,90
Sodium chloride (11,5 weight %)	62,3	0,94	57,3	0,93
Calcium chloride (26 weight %)	55,6	0,83	50,6	0,82
Calcium chloride (13 weight %)	58,3	0,88	53,3	0,87
Magnesium chloride (33 weight %)	52,2	0,78	47,2	0,77
Magnesium chloride (13,5 weight %)	57,0	0,86	52,0	0,84
NOTE Source: Laboratoire Régional des Ponts et Chaussées (LRPC), Nancy (France)				

G.3 Corrosiveness

Results expressed in µm/year:

Product	**Non-alloy steel** (EN 10025-2 and -5)		**Non-alloy steel** (EN 10025-2 and -5), galvanized (EN ISO 1461)		**Aluminium** (EN 573–1, EN 573–2, EN 573–3, EN 573–5)	
	10 g/l	Max. concentration	10 g/l	Max. concentration	10 g/l	Max. concentration
Sodium chloride (rock salt)	−1207,8	−137,2	−197,7	+16,6	+4,1	−0,5
Calcium chloride	−1696,9	−81,3	+23,1	−10,5	+23,9	+3,1
Magnesium chloride (30 weight %)	−683,3	−22,5	+37,3	−223,5	+10,9	−17,7
NOTE Source: Laboratoire Régional des Ponts et Chaussées (LRPC), Nancy (France)						

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