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Functional properties of runway deicers

Study report

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Functional properties of runway deicers

Study report

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Abstract

This new study corroborates the first data published in 2009, on the assessment of the performance of runway deicers used by airport operators for their winter activity.

12 off-the-shelf formulations (8 liquid and 4 solid) have been tested as part of this study. All the results are presented in this document, which is a baseline of technical knowledge enabling runway deicing operational procedures to be optimized, and air safety and environmental risks to be mitigated.

This issue has been reworked to include the following improvements:

- the product data sheets are complemented by a report presenting and analyzing the main results, together with recommendations for use; this report is now the master part of this document,
- all the "product data sheets" have been updated to include the results of new, standardized tests (self-ignition point, flash point, biodegradability, particle size, kinematic viscosity, etc.),
- the "product data sheets" are now available for solid, sodium formate and acetate based formulations, and a liquid formulation produced by the agro-industry.

We received technical support for this study from the "winter maintenance – engineering and equipment" resource team at the Laboratoire Régional des Ponts et Chaussées in Nancy, France.

1. Introduction

1.1. Purpose of the document

As part of its expert evaluation, study and research missions, the STAC (French civil aviation technical center) is pursuing its commitment to the field of airport winter operations, by publishing a consolidated document dedicated to the assessment of the performance of runway deicers.

This new issue is part of a procedure to optimize deicing operational procedures and to mitigate air safety and environmental risks. It is in the form of a commented, detailed report, about the results of runway deicer analyses performed by the STAC with several public and private laboratories. This report is complemented by a set of "product data sheets" corresponding to each off-the-shelf formulation studied since 2009.

This document is mainly aimed at airport operators in charge of snow-removal and deicing pavements, and is a baseline of technical knowledge, enabling the following:

(1) The completion and precision of data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) The improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) The support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

We received technical support for this study from the "winter maintenance – engineering and equipment" resource team at the Laboratoire Régional des Ponts et Chaussées in Nancy, France. The product suppliers have made all the product samples available to the STAC.

1.2. Reading guidelines

This document is a technical baseline, resulting from tests performed on the functional, physical, chemical and environmental properties of runway deicers.

It includes the following sections:

- Caution on the use of data,
- Presentation of the runway deicers, and the physical, chemical, environmental and functional tests performed as part of this study,
- Performance of the runway deicers, and recommendations for use: analysis of the tests performed by the STAC, with comments. This analysis is accompanied by recommendations for use,
- Data sheets for all the runway deicers which have been tested by the STAC up to now.

1.3. Data use warnings

Caution

(1) The document produced by the STAC complements the data released by runway deicer suppliers for the attention of airport operators, on the basis of a series of standardized, harmonized tests.

(2) The document produced by the STAC does not deal with the "health risks, customary precautions, disposal" of the products. The product supplier is responsible for providing this information on an SDS (safety data sheet), written in compliance with the European regulation, REACH no. 1907/2006 and with regulation (CE) no. 1272/2008.

(3) The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the specifications in force in this field, in particular AMS 1435 "Liquid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

The data presented in this report are the result of a series of tests performed by the STAC with several public and private analytical laboratories. Section 1.5 and each of the data sheets refer to the normative or protocol references inherent to each of the tests performed as part of this study. In-house protocols, except for those documents which are likely to include a confidentiality clause, may be made available to a user, upon simple request to the STAC.

Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

1.4. Presentation of runway deicers

The off-the-shelf formulations listed below have been analyzed as part of this study.

Produit	Société	Nature	État
SAFEGRIP	Abax Industrie	Potassium acetate	Liquid
SAFEGRIP FR	Abax Industrie	Potassium formate	Liquid
SAFEWAY KF HOT	Clariant	Potassium formate	Liquid
SAFEWAY KA HOT	Clariant	Potassium acetate	Liquid
SAFEWAY SF	Clariant	Sodium formate	Solid
CLEARWAY F1	Kemira	Potassium formate	Liquid
CLEARWAY 1	Kemira	Potassium acetate	Liquid
CLEARWAY 6S	Kemira	Sodium acetate	Solid
CLEARWAY SF3	Kemira	Sodium formate	Solid
ESTOROB D-ICER	Novance	Glycerol	Liquid
CRYOTECH E36	Proviron Industries NV	Potassium acetate	Liquid
CRYOTECH NAAC	Proviron Industries NV	Sodium acetate	Solid

1.5. Presentation of the runway deicer performance tests

Physical and chemical data

Test: State and visual appearance

Normative reference: -

Definition: Visual inspection of products.

Test performed on liquids and solids.

Test: Density

Normative reference: NF EN ISO 3838*

Definition: Determines the ratio between the substance's mass and its volume. The results are given in kg/m³.

Test performed on liquids.

** Crude oil and liquid or solid petroleum products – Determination of the density – Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004.*

Test: Bulk density

Normative reference: In-house method no. 108 - LRN

Definition: Determines the ratio between the substance's mass and its volume. The results are given in kg/m³.

Test performed on solids.

Test: Kinematic viscosity

Normative reference: NF EN ISO 3104*

Definition: Viscosity defines the state of a fluid whose molecules cannot move freely, due to more or less intense molecular associations or interactions; it depends on the forces to which the fluids are submitted and the temperature. Viscosity can thus be defined as a fluid's resistance to flow when flowing. So, when the viscosity increases, the ability of the fluid to flow decreases.

Dynamic viscosity represents absolute viscosity. Kinematic viscosity (in mm²/second) expresses the ratio between dynamic viscosity and density. This test is performed at 20 °C, and by derogation at 5 °C and – 5 °C for the purposes of this study.

Test performed on liquids.

** Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996.*

Test: pH

Normative reference: NF T 90-008*

Definition: The pH (potential hydrogen) expresses the chemical activity of hydrogen ions in a solution. pH measurements indicate the acidity (pH < 7), neutrality (pH = 7) or basicity (pH > 7) of a solution.

Test performed on liquids and solids (solutions at 30 % w/w).

** Water quality – Determination of pH – February 2001.*

Test: Refractive index

Normative reference: LRN in-house protocol

Definition: The refractive index is a measure of the speed of light in a fluid. It is expressed as the ratio of the speed of light in a vacuum and the speed of light in the deicing fluid. It is used to control the quality of the product.

Test performed on liquids.

Test: Active principle

Normative reference: LRN in-house protocol (determination by spectrometry)

Definition: The active principle indicates the concentration of the main molecule contained in the product. It is expressed as a % (mass of the main molecule(s)/mass of the product).

Test performed on liquids (in progress for solids).

Test: Conductivity

Normative reference: NF EN 27 888*

Definition: Electrical conductivity defines the capacity of a fluid to freely conduct electricity. It is expressed in millisiemens per centimeter ($mS. cm^{-1}$), and depends on the nature and concentration of the ions present in the deicer.

Test performed on liquids.

** Water quality – Determination of electrical conductivity – January 1994.*

Test: Particle size

Normative reference: NF P 98-180*

Definition: The particle size refers to the sizes of the particles making up the solid deicers. The cumulated percentages passing through each sieve are shown in the form of a table and a diagram.

Test performed on solids.

** Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.*

Test: Flash point

Normative reference: NF ISO 3680*

Definition: The flash point is a measure of the minimum temperature above which the product yields sufficient vapor to cause ignition in air on contact with a flame combustion is not self-sustaining. This test method does not measure the deicer's flash point, it only measures its behavior at a chosen equilibrium temperature (90 °C). The flash point is expressed in °C.

Test performed on liquids.

** Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004.*

Test: Autoignition temperature

Normative reference: ASTM E 659*

Definition: Its measurement is used to determine the temperature at which a substance spontaneously autoignites in air, when there is no pilot flame. It is expressed in °C.

Test performed on liquids and solids.

** Standard Test Method for Autoignition Temperature of Liquid Chemicals – 2005.*

Product toxicity and environmental data

Test: Biochemical oxygen demand

Normative reference: NF EN 1899-1*

Definition: Its measurement is used to express the quantity of oxygen needed to biologically oxidize organic matter. It is used to calculate the biodegradable fraction of the carbonaceous pollution load of runoff water. It is expressed in mg/l or mg/kg.

Test performed on liquids and solids.

** Water quality – Determination of biochemical oxygen demand after n days – Part 1: dilution and seeding method with allylthiourea addition – May 1998.*

Test: Chemical oxygen demand

Normative reference: NF T 90-101*

Definition: Its measurement is used to express the oxygen consumption needed for the biochemical oxidation of the organic and mineral substances in a substance. It is used in the same way as the BOD, to assess the pollution load of runoff water. It is expressed in mg/l or mg/kg.

Test performed on liquids and solids.

** Water quality – Determination of chemical oxygen demand (COD) – February 2001.*

Test: COD/BOD ratio

Normative reference: -

Definition: Corresponds to the biodegradability index of an effluent's oxidizable matter.

-COD/BOD5 ratio < 2: the effluent is readily biodegradable,

-COD/BOD5 ratio between 2 and 3: the effluent is fairly biodegradable,

-COD/BOD5 ratio > 3: the effluent is not readily biodegradable.

Test performed on liquids and solids.

Test: Duration of biodegradation

Normative reference: NF EN ISO 9888

Definition: This measurement is used to qualify the time needed to degrade 10 %, 50 % and 90 % of the organic load contained in the runway deicers. It is expressed in hours.

Test performed on liquids and solids.

Test: Acute toxicity test on Daphnia

Normative reference: NF EN ISO 6341*

Definition: This measurement is used to express the inhibition of the mobility of Daphnids

(micro- crustacea) using a comparative agent. It determines the concentration which inhibits the mobility of 50 % of the daphnids in 24 hours and/or 48 hours. This concentration is known as immobilization concentration, and is designated by EC 50i %. It is expressed in g/l or mg/l.

Test performed on liquids and solids.

**Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996.*

Product effectiveness

Test: Freezing point

Normative reference: LRN in-house protocol (determination by spectroscopy)

Definition: This measurement is used to express the freezing point in °C, determined as a function of the solution's strength by mass. It is complemented by the product's freezing curve.

Test performed on liquids and solids.

2. Performance of runway deicers and recommendations for use

2.1. Criteria for choosing runway deicers

The choice of a runway deicer remains a delicate step in the preparation of the airport winter season. This choice is made following a rigorous, methodical analysis of all the technical and commercial information made available to airport operators.

Besides the analysis of the technical criteria on which part of the product selection is based, an off-the-shelf formulation must also be selected with respect to more general, but equally important, considerations, such as the physical, chemical, environmental and functional properties of the products.

So, as shown in figure 1, the airport operator should use several criteria, which will enable it to examine and gage the interest of a product, to the best of its ability, with respect to the internal and external requirements which it has to face.

The choice of a product may be dictated by the following parameters, for example:

- Physical, chemical, functional and environmental properties of the products;
- Inter-compatibility of the products;
- Cost of the products;
- Configuration of the infrastructure (type of surfacing) and technical means (type of storage and spreading equipment);
- Climatology and local environment (type of climate events, etc.);
- Statutory requirements (environmental, health and air safety requirements, for example);
- Operational procedures for the winter service (treatment strategies, quality objectives, etc. with reference to the airport's snow plan);
- Air traffic control requirements (no interruption to air traffic, 24 hours a day operation, etc.);
- Financial capacity of the operator,
- And so on.

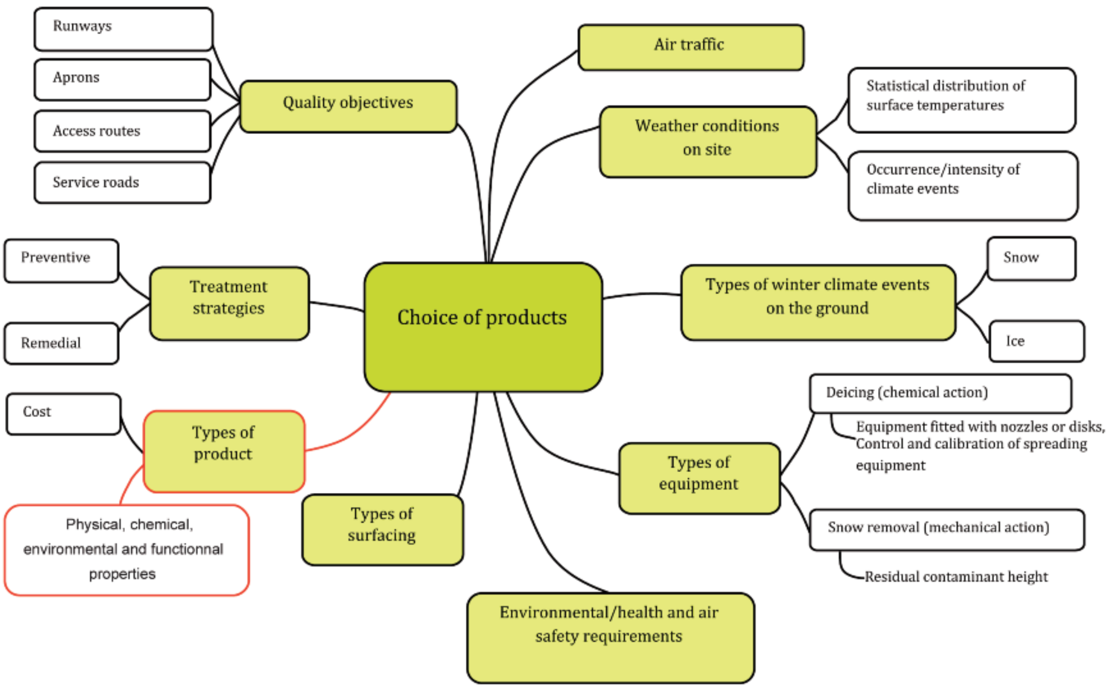


Figure 1: Criteria used to choose runway deicers.

The physical, chemical, functional and environmental properties of the products therefore seem to be some of the main, but not exclusive, criteria which lead airport operators to choose a runway deicer and to specify what it is to be used for.

The information given in this section of the report comes from the physical, chemical, environmental and functional tests performed on each of the products specified under the AMS 1435 or 1431 specifications developed by the SAE and used in France. It is a commented analysis of several results, accompanied by technical recommendations.

2.2. Runway deicer operating principle

2.2.1. Product composition

There are two distinct types of runway deicer used at airports:

- **solid formulations** made up of sodium formates or acetates,
- **liquid formulations** made up of:
  - potassium formates or acetates,
  - molecules from the agro-industry (glycerol, propanediol, etc.) which may be mixed with potassium and/or sodium formates or acetates.

	Traditional runway deicers				New-generation runway deicers				
	Potassium acetate	Potassium formate	Sodium acetate	Sodium formate	Glycerol	Potassium acetate + glycerol	Potassium acetate + propanediol	Propanediol	Potassium acetate + sodium acetate + propanediol
Abax Industrie	Safegrip	Safegrip FR							
Clariant	Safeway KA	Safeway KF (et KF Hot)		Safeway SF					
Cryotech	Cryotech E36		Cryotech NAAC				BX 36	XT360	EX 180
Kémira	Clearway 1 et 3	Clearway F1	Clearway 6S	Clearway SF3					
Novance					Estorob Bio deicer				
Basic solutions						GEN3			

Table 1: List (not limited) of the main runway deicers (2011)

Table 1 below draws up the list of the main runway deicers likely to be used at airports during the winter period.

We remind you that each product must comply with one of the following international specifications:

Liquids: AMS 1435 "Liquid, Generic, Deicing/Anti-Icing Runways and Taxiways" (SAE).

Solids: AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" developed by the SAE.

If using a new formulation, we recommend that you perform in situ tests so as to ensure the products are effective. We also recommend that you include performance criteria in purchasing contracts (SHRP – Strategic Highway Research Program – methods).

Potassium and sodium formates and acetates

When acetic and formic acids are combined with alkaline metals, such as potassium or sodium, they form soluble salts in water called potassium or sodium formates or acetates. These chemicals are produced by combining a weak acid and a strong base. Some physical and chemical properties can be modified by adding a small quantity of additives to the mixture (freezing point depressor, corrosion inhibitor, etc.)

Glycerol, propanediol and/or succinic acid based products of vegetable origin are produced mainly by the agroindustrial sector (biorefining) using vegetable biomass of agricultural origin (maize, sugar cane, etc.). Biorefining is also used to obtain biofuels and chemicals which may replace products obtained by refining crude oil.

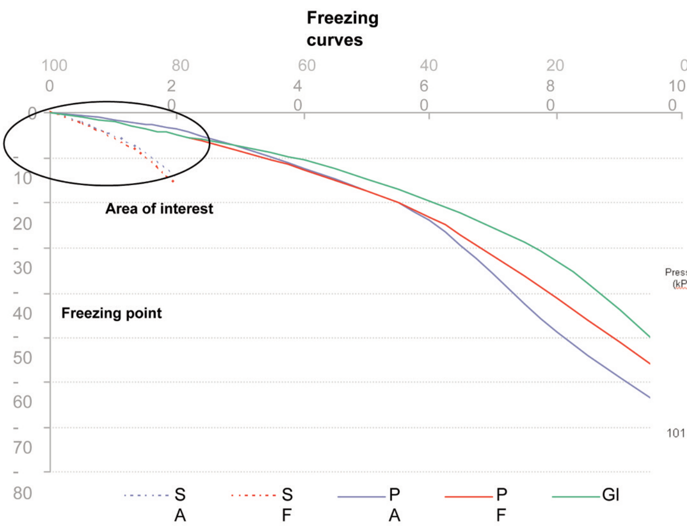
Given the physical and chemical properties of these products, the latter are likely to be included in the composition of new-generation runway deicers.

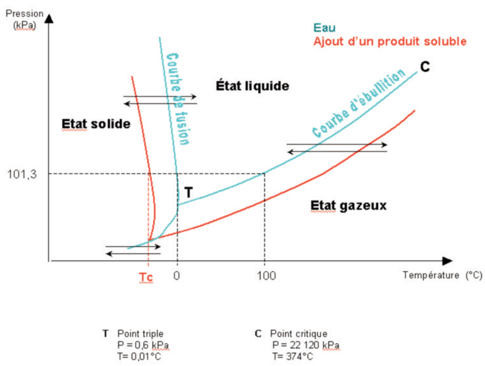
Potassium acetate based formulations	Potassium acetates + water + additives
Sodium acetate based formulations	Sodium acetates + additives
Potassium formate based formulations	Potassium formates + water + additives
Sodium formate based formulations	Sodium formate + additives
Glycerol or propanediol based formulations...	Glycerol or propanediol (*) + water + additives

(*) glycerol and propanediol may also be combined with an acetate or formate.

2.2.2. Product operating principle

A distinctive feature of water-soluble runway deicers is that they are able to lower the freezing point of water. This capacity is represented by the freezing curve of marketed products. Figure 2 shows the various data available on the subject, especially at different product concentrations (or degrees of dilution with a contaminant). This parameter thus gives a real indication about the performance of the runway deicer and its level of protection.





Freezing points (°C)	Mass balance							
	5%	10%	15%	20%	40%	60%	80%	100%
Potassium acetates (PA)				-3.5	-12.2	-24	-48.5	-68.5
Potassium formates (PF)				-5	-12.6	-23.1	-41.1	-61
Glycerol (Gly)				-5	-10.5	-19.5	-33	-56
Sodium acetates (SA)	-3.1	-6.4	-10.5	-15.6				
Sodium formates (SF)	-3.4	-7.2	-11.7	-17.4				

Figure 2 : Freezing points and curves for runway deicers.

A contaminant (snow, ice, rime, etc.) can change state (transition from a solid state to a liquid state) upon contact with a runway deicer, at a more or less rapid pace, depending on the type of deicer, its strength by mass, quantity and the temperature.

When a solid runway deicer is spread in the form of granules or pellets, it must become hydrated. The hydration mechanism uses energy (either exothermic or endothermic), and thus contributes to the overall heat balance. The ability to become hydrated depends on the physical and chemical properties of the product, and the availability of water in the environment to be treated (surface water, water vapor in the atmosphere). Some climate events contain little or no free water (supercooled, solidified water, dry snow). In this case, the granules or pellets are usually ineffective. The greater the specific surface of the granules or pellets, the quicker the melting.

When the solid has become hydrated and transformed into a solute, or when it is applied in liquid form, the beginning of the melting of the ice (case of corrective treatments) has a double effect: cooling (harnessing of the ice melting equivalent: 334 J/g – figure 3), and dilution of the solution thru the addition of meltwater (diagram of the phases). If the environmental temperature is relatively low, the additional cooling may lead to a blockage in the melting process, or even to regelation (figure 4).

LIQUID RUNWAY DEICERS

1. Melting of ice

Endothermic reaction
The melting of ice using a liquid requires energy.

Fusion enthalpy of ice: + 334 kJ.kg^{-1}

2. Energy balance

Endothermic reaction
The melting of ice absorbs energy and consequently lowers the temperature

Heat balance: + 334 kJ.kg^{-1}

SOLID RUNWAY DEICERS

1. Hydration & dissolution of pellets

Exothermic or endothermic reaction
The dissolution of pellets releases or absorbs energy.

Pellet dissolution enthalpy:
between -200 and +145 kJ.kg^{-1}

2. Melting of ice

Endothermic reaction
The melting of ice requires energy.

Fusion enthalpy of ice: + 334 kJ.kg^{-1}

3. Energy balance

Endothermic reaction
The dissolution of pellets and the melting of ice require energy and consequently lower the temperature.

Heat balance: between +134 and +479 kJ.kg^{-1}

Figure 3: Presentation of the energetic actions governing the way runway deicers work

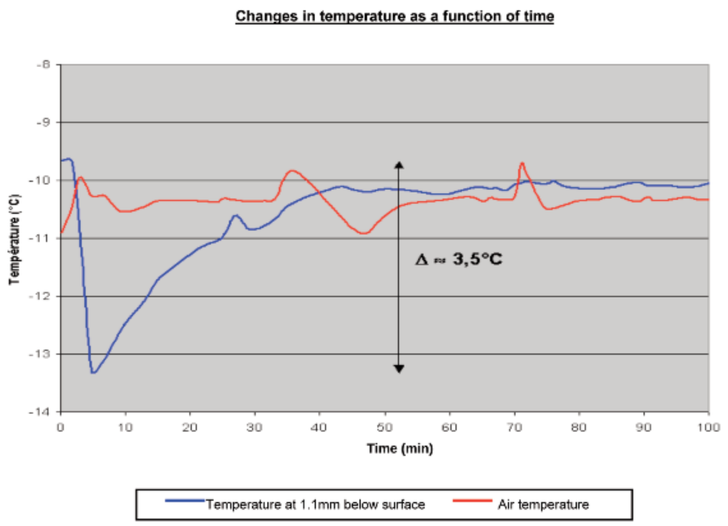


Figure 4: Changes in temperature when 6,2 g of liquid deicer are applied to glaze 1,1 mm thick at – 10 °C

1 - Energy needed for water to change from solid state to liquid state

Preventive treatment of glaze or snow

This strategy means that the snow or ice melting equivalent is not harnessed (or is spread over such a duration that it does not really affect the surfacing's heat balance).

The action of a solid deicer may be altered by the hydration and dilution periods, and by the risk of being naturally swept away by wind or traffic.

Remedial treatment of glaze

A liquid deicer works by progressively "eroding/melting" the ice surface. The solution which forms generally dilutes rapidly and flows laterally due to the pavement transverse profiles.

A solid deicer works in several stages, in addition to the hydration mechanism, the granules or pellets fit into the film of ice and perforate it. When these granules or pellets reach the pavement surfacing, the solution spreads at the interface and removes the glaze locally, which may make it easier to remove mechanically at a later stage.

Remedial treatment of snow

Note: Snow is only treated with a deicer after it has been removed using scrapers/brooms. This treatment therefore only aims at melting the residual film of snow once the snow removal tools have been used.

A liquid deicer works by percolating/spreading/melting thru the porous matrix of the film of snow. This mechanism leads to both a rapid dilution of the solution which forms, and the harnessing of a large amount of energy (latent heat of fusion).

A solid deicer works by perforation/localized breakdown of the film of snow. The deicer granules or pellets rapidly perforate the film of snow, and if they are big enough, they reach the pavement surface. Otherwise, they continue their hydration and the localized melting of the contaminant (if these granules are very fine, they may not reach the pavement, and cause regelation of the layer of snow).

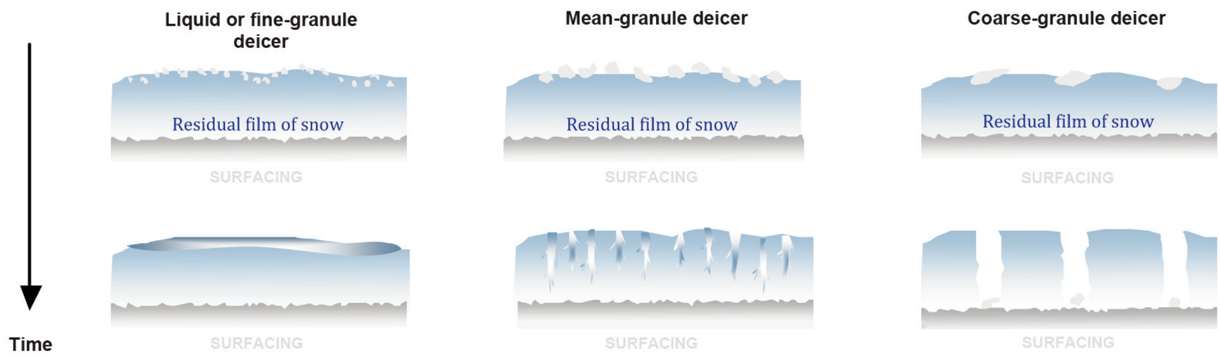


Figure 5: Runway deicer operating principles

2.3. Physical and chemical properties of runway deicers

2.3.1. General appearance of the products

Runway deicers have various forms:

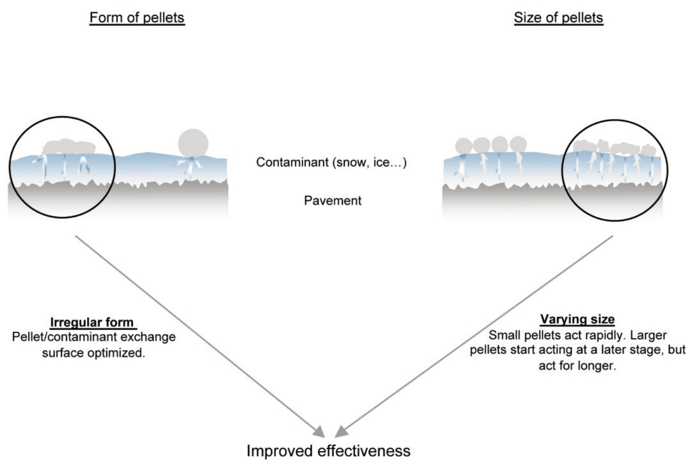
- Colorless or light blue liquids, for potassium formates and acetates, and glycerol,
- Solids, for sodium formates and acetates

There are advantages and disadvantages for both forms.

Liquids tend to cover the surfacings more uniformly than the pellets of solid formulations, which remain sensitive to rebound and to dispersion caused by traffic and/or wind.

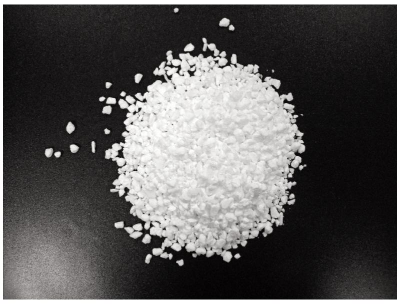
Irregular pellets can partially remedy the problem of dispersion, by providing a larger contact surface for the contaminant (snow, ice, etc.) or for the surfacing. This contact surface also plays a role in the effectiveness of the products. The larger the surface, the more effective the contaminant's melting capacity. This phenomenon is all the more true when there are solid formulations made up of pellets of varying sizes (small to large diameter) which will spread the effectiveness of the product over time; pellets with a small diameter act rapidly, while those with larger diameters take longer to act (figure 6).

Figure 6: Form and size of pellets



Visual appearance of solid deicers

2 - The colors of runway deicers are specified in section 3.1.2 of AMS 1435 "Liquid, Generic, Deicing/Anti-Icing Runways and Taxiways"



There is a close link between the flowability of solids coming out of the spreaders, and the deicer particle size (figure 7) and moisture content (table 2).

The analysis of the deicer particle size refers to standard NF P98-180, which is used to grade salts (in particular, road fluxes).
The particle-size ranges of the deicers studied as part of the work performed by the STAC have a high proportion of coarse components with a diameter of between 2 and 5 mm. Despite the size of the pellets, these products remain particularly friable and powdery. You must therefore take special precautions when using them.

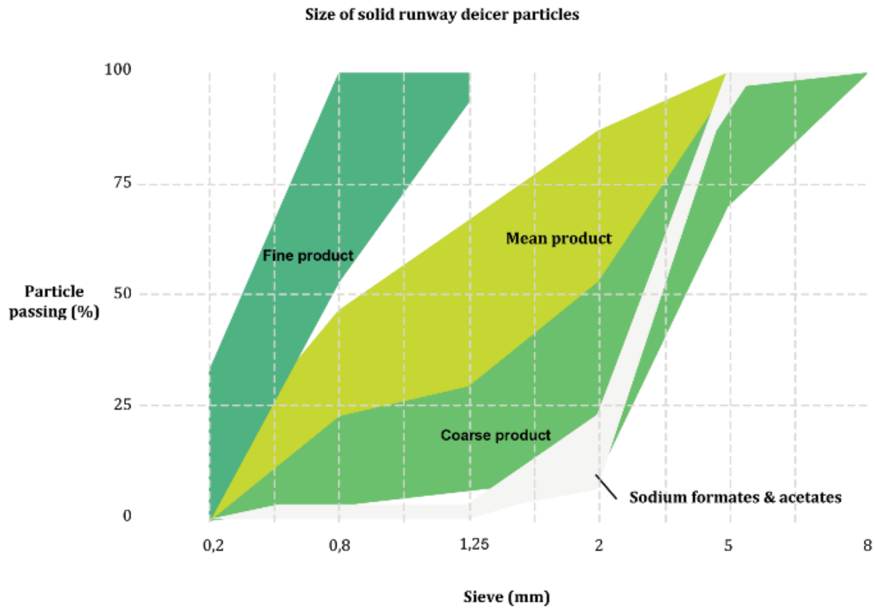
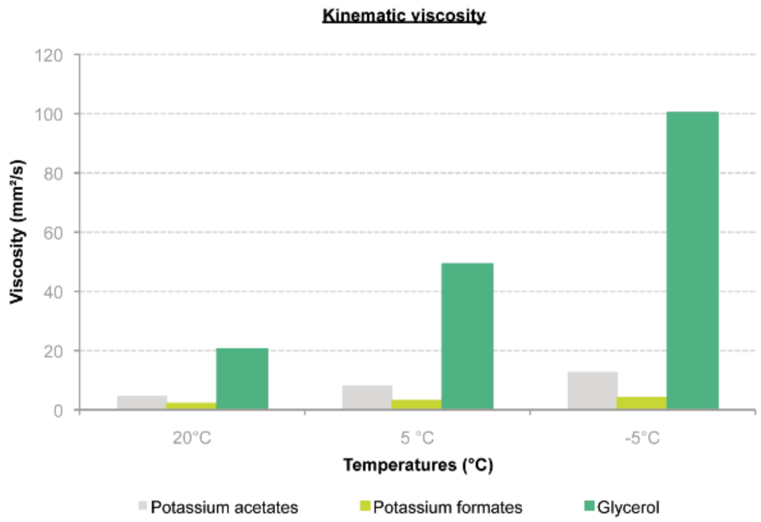


Figure 7 : Size-distribution curves for solid runway deicers – Comparison with the particle-size brackets of standard NF P 98-180

	Moisture content (%w/w)
Sodium formates	Between 0.5 and 0.6 %
Sodium acetates	Between 1.5 and 16.5 % (for trihydrate forms)

Table 2 : Mean moisture content of solid runway deicers

There is a close link between the "covering" and spreading abilities of liquid formulations, and their viscosity. The latter also depends on the temperature to which the products are exposed (figure 8).
The tests performed up til now show that the viscosities of potassium formates are relatively low compared to those of potassium acetates, and glycerol in particular. Formates are also less sensitive to temperature variations, which leads us to think that they can be used in any airport, especially those exposed to harsh winter conditions entailing significant changes in temperature.
Although the quantities spread per m² may seem relatively small (20 to 50 g/m²), products with a high viscosity are likely to create problems of operational adherence, particularly in the case of preventive use.



	Kinematic viscosity		
Mean kinematic viscosity (mm²/s)	20 °C	5 °C	-5 °C
Potassium formate	2,082	3,034	4,107
Potassium acetate	4,684	8,195	12,793
Glycerol	20,53	49,21	100,30

Figure 8 : Viscosity of liquid runway deicers as a function of temperature.

Recommendations

1. Control and use of the products

Liquids :

The appearance and color of the products must be regularly checked during reception and use. They must be homogenous (no suspended particles or deposits), colorless, or if colored, light blue.

The variations in viscosity induced by the temperatures to which the products are exposed could lead us to recommend the use of potassium acetates at airports located in geographical zones where winter conditions are rarely severe (low ranges of temperature). As for potassium formates, they could be of particular interest for the majority of airports, especially those exposed to harsh winter conditions (high ranges of temperature). Given the viscosity of glycerol-based products, they must be tested on pavements, especially during preventive deicing operations, before being used.

Solids :

It is recommended to regularly check the general appearance of the materials, particularly the pellets (particle size and structure) so as to avoid or prevent the products from solidifying.

In order to guarantee optimum, long-lasting effectiveness of the products (compared with the melting capacity), it is recommended to preferably use formulations composed of pellets of different sizes and irregular form. The spreaders must also be regularly calibrated, in order to reduce the risk of over-proportioning.

2. Handling and storing the products

Regardless of the type of product used, the handling and storage conditions are described in the safety data sheets (wearing ofpersonal protective equipment : mask for powdery products, gloves, etc.). Due to the creation of fines during the handling of solids, and because of their hygroscopicity, it is recommended to minimize handling operations insofar as possible (moving stock, filling and unstuffing spreaders, etc.).

2.3.2. Product density

Density is an interesting lever when you need to size the technical means to be implemented, to ensure deicing operations (sizing, number of spreaders for each chemical operation, configuration of the snow train, filling of tanks, number of replenishments, etc.).

Generally speaking, the density of liquid runway deicers varies between 1250 kg/m3 and 1370 kg/m3. The bulk density of solids varies between 890 kg/m3 and 1050 kg/m3

		Densities (liquids) and bulk densities (solids) in kg.m-3
Solids	Sodium acetate[1]	890
	Sodium acetate trihydrate[2]	770
	Sodium formate[3]	1050
Liquids	Potassium formate[4]	1348
	Potassium acetate[5]	1281
	Glycerol[6]	1177

(1) one value. (2) one value. (3) mean of 2 values. (4) mean of 3 values. (5) mean of 4 values. (6) one value.

Table 3: Density of runway deicers.

Density and storage of the products

The value of product density may be used in relation with the storage capacities available at airports. A product with a high density will have a lower storage requirement.

Example of an order for 20000 tons of runway deicer:

- Sodium acetates require an available volume of 22500 m³,
- Sodium formates require an available volume of 19050 m³,
- Potassium acetates require an available volume of 15625 m³,
- Potassium formates require an available volume of 14850 m³,
- Glycerol requires an available volume of 17000 m³.

Low density = high storage requirement

Density and use of the products

For the same treatment guidelines, the quantity of product to be spread over airport pavements may vary significantly, depending on the product and its density.

If you read the table below, you will be able to appreciate the interest of solid and liquid formates compared with acetates and glycerol. So, for the same treatment guidelines, the volume of formate-based product required will be a lot lower than that of the other products.

		Guidelines Dosage per ha (kg/ha) Dosage for 1 runway of 13,5 ha (T/runway)	20 g/m² 200 2,70	30 g/m² 300 4,05	40 g/m² 400 5,40	50 g/m² 500 6,75
Solids	Sodium acetate (890 kg/m³)	Dosage per ha (m³/ha) Volume needed for each runway (m³)	0,225 3,03	0,337 4,55	0,449 6,07	0,562 7,58
	Sodium acetate trihydrate (770 kg/m³)	Dosage per ha (m³/ha) Volume needed for each runway (m³)	0,260 3,51	0,390 5,26	0,519 7,01	0,649 8,77
	Sodium formate (1050 kg/m³)	Dosage per ha (m³/ha) Volume needed for each runway (m³)	0,190 2,570	0,286 3,860	0,381 5,140	0,476 6,430
Liquids	Potassium formate (1348 kg/m³)	Dosage per ha (l/ha) Volume needed for each runway (l)	148 2000	223 3000	297 4010	371 5010
	Potassium acetate (1281,8 kg/m³)	Dosage per ha (l/ha) Volume needed for each runway (l)	156 2110	234 3160	312 4210	390 5270
	Glycerol-based productsl (1177 kg/m³)	Dosage per ha (l/ha) Volume needed for each runway (l)	170 2295	255 3443	340 4590	425 5738

Table 4: Density and use of runway deicers

For the same guidelines, the spreaders loaded with liquid and solid formates will be generally more autonomous, as the working volume for pavement deicing is slightly lower.

2.3.3. Flash point and self-ignition point of the products

The flash point is defined as being the lowest temperature at which a combustible entity releases enough vapor to form a gaseous mixture with the ambient air, which will ignite when subjected to a source of heat energy such as a pilot flame ; the combustible entity does not release enough vapor for the combustion to sustain itself (for this, the ignition point must be reached). If the ignition does not require a pilot flame, it is referred to as self-ignition.

Aircraft and service vehicles taxiing on deiced pavements may lead to the dispersion of runway deicers, and them coming into contact with several heat sources (aircraft engines, service vehicles, etc.). At certain temperatures, the runway deicers may self-ignite and release noxious fumes.

By way of example, the tests performed as part of this study indicate that liquid and solid formulations have flash points above 90 °C and self-ignition points above 500 °C. Mixed formulations (a mixture of liquids and solids) have a flash point above 300 °C (at 100 °C, the mixture begins to boil and to form foam above 200 °C). As these values are particularly high, the risk that the products coming into contact with the hot aircraft surfaces will ignite therefore seems relatively low.

Recommendations

According to the safety data sheets, some deicers decompose when heated, producing noxious fumes. So, even if the flash and self-ignition points are high, these results should not prevent the airport operator from considering the risks of ignition on product storage sites.

In order to reduce the risk of ignition and release of fumes in the cabin in particular, airlines may be advised to optimize air conditioning control during taxiing. This recommendation may be combined with a preliminary assessment of health risks.

2.3.4. Corrosion and modification of aeronautical and airport materials

The role played by runway deicers in the modification of aeronautical materials (carbon brakes, connectors and electrical wiring, etc.) has been highlighted by the aeronautical community for several years. The different works conducted by the SAE G12F "deicing" committee and by the Airport Cooperative Research Program (which is supported by the Federal Aviation Administration) mention a certain number of corrosion problems related to the use of potassium and sodium-based runway deicers (alkaline salts).

As the tests performed by the STAC concerning the performance of runway deicers were not necessarily meant to assess the impact of runway deicers on materials, we cannot offer details of this in this document. However, the information below should enable us to understand the basics of these problems.

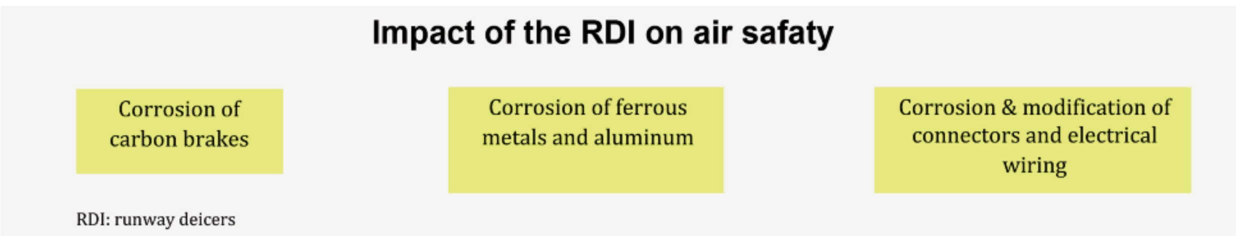


Figure 9 : Main effects of runway deicers on aircraft and airport materials.

Generally speaking, the salts present in water increase the electrical conductivity of a solution. This physical property plays a role in corrosion, despite the addition of corrosion inhibitors in traditional runway deicers. So, a runway deicer with high conductivity may modify materials and cause electrical malfunctions.

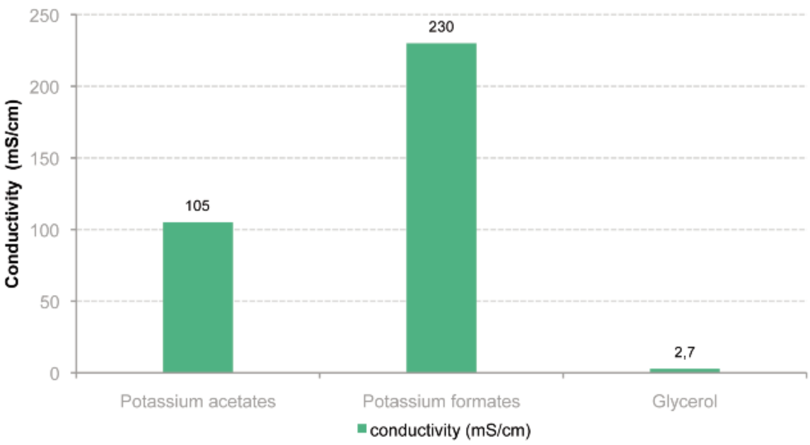


Figure 10 : Conductivity of liquid runway deicers.

Corrosion of carbon brakes

The problem the most easily identified by the aeronautical community is the increase in the risk of accelerated modifications of carbon brakes, brought on by the use of potassium and sodium-based chemical fluxes. This problem has been technically investigated, and further to this, the role of runway deicers in brake oxidation phenomena has been identified.

Thermal oxidation

Carbon brake corrosion is a normal phenomenon of the wear of carbon disks subjected to high pressures and temperatures, especially during aircraft landing and taxiing. It is a case of functional wear created by the high braking temperatures (between 500 and 600 °C ; up to 1 400 °C during phases of accelerate-stop) and the release of around 500 million Joules of energy (that is, approximately 140 000 Wh).

Catalytic oxidation

Indirectly spraying RDI products on aircraft landing gear during taxiing and braking on deiced pavements increases the risk of chemical oxidation of carbon disks.

At temperatures of between around 169 °C (potassium formate) and 290 °C (potassium acetate), runway deicers release the sodium or potassium in the form of hydroxides. These molecules will act as a catalyst, by lowering the temperature at which oxidation appears, and by accelerating it.

3 - Corrosion is a phenomenon by which metals and metallic alloys are attacked by their environment, which results in them turning back into their original mineral form. A distinction should be made between hot corrosion and wet corrosion :
- Dry, or hot, corrosion develops at high temperatures (several hundred °C) when a metal is exposed to an oxidizing gas like oxygen.
- Wet corrosion can be very insidious, despite the low temperature, as it is not the result of a simple succession of the same physical and chemical processes. There are around ten types of wet corrosion, in particular, uniform corrosion, galvanic corrosion (occurs when different metals are combined) and pitting corrosion (localized corrosion affecting metals or alloys).

Despite the fact that all traditional products are concerned by this phenomenon, potassium formate-based formulations seem particularly incriminated in catalytic oxidation.

Thermal oxidation of carbon

Temperature	Time it takes for the mass to decrease by 5 %
400 °C	3 years
500 °C	14 days
600 °C	12 hours
700 °C	49 minutes

Catalytic oxidation of carbon

Temperature	Time it takes for the mass to decrease by 5 %
400 °C	33 days
500 °C	15 hours
600 °C	45 minutes
600 °C	4 minutes

(Source : Airbus, 2010)

Table 5 : Carbon brake service life with respect to the oxidation process (Source : Airbus, 2010).

RDI	Molecular mass (g/mol)	Amount of potassium	Amount of sodium
Potassium formate (KCHO2)	84	46,43 %	-
Potassium acetate (KC2H3O2)	98	39,80 %	-
Sodium formate (NaCHO2)	68	-	33,80 %
Sodium acetate (NaC2H3O2)	82	-	28 %

Molecular masses (g/mol) : potassium : 39, sodium : 23, carbon : 12, hydrogen : 1, oxygen : 16 (STAC, 2010)

Table 6 : Molecular masses of runway deicers

Corrosion of metals and aluminum

Corrosion is the main cause of metal degradation, before wear and fatigue. It is a long process which brings about a change in appearance, a decrease in the mass and mechanical properties of the materials. Nearly all industrial alloys are sensitive to corrosion, at varying degrees. Nevertheless, the kinetics with which the phenomenon develops may vary greatly depending on the situation, and may change over time with phases of acceleration or deceleration.

Part of the corrosion of metals (cadmium and aluminum, in particular) seems to be due to sodium and potassium acetate and formate-based runway deicers. The literature available on this subject remains somewhat compartmented, and prevents us from really understanding the phenomena at stake.

Cadmium and aluminum corrosion are known phenomena, but their mechanisms remain to be investigated. The initial insight gained enables us to establish a link between corrosion and the pH and electrical potential of the runway deicer in contact with the metal (electro-chemical process). We can take the example of potassium-based formulations, which are at the origin of aluminum corrosion, especially on certain parts of the landing gear and flight control hydraulic systems.

Recommendations

Despite the fact that the literature on the subject is particularly detailed, there is still little information available on the impact of runway deicers on airport and aeronautical materials.

Only a few studies have been conducted to date, by aircraft manufacturers, manufacturers and runway deicer suppliers ; they specify the impact of runway deicers on materials, and incriminate potassium-based formulations in particular.

In the absence of more detailed data on the subject, especially the causal link between the use of products and the cost of maintaining aircraft, it is difficult to recommend the use of one particular off-the-shelf formulation rather than another.

We nevertheless suggest that airport operators add a special technical specification to runway deicer supply contracts, about the compatibility of off-the-shelf formulations with the materials (especially composites), and make any test results on this subject available for consultation.

2.4 Runway deicers and the environment

The question of the impact of runway deicers on the environment can be addressed at two levels: product toxicity, and their impact on the environment with respect to the organic pollution created by their use.

2.4.1. Product toxicity

The concept of toxicity is often complex, as it is highly dependent on biological considerations which cannot be easily controlled. The toxicity of runway deicers is mainly related to their physical and chemical composition, and more particularly to the specific character of the additives in off-the-shelf formulations.

On the face of the analyses conducted on toxicity, the off-the-shelf formulations used in France may be considered as being of relatively low toxicity.

Solid formulations remain slightly less toxic than liquid, potassium formate and acetate-based formulations. Glycerol-based formulations are of particularly low toxicity.

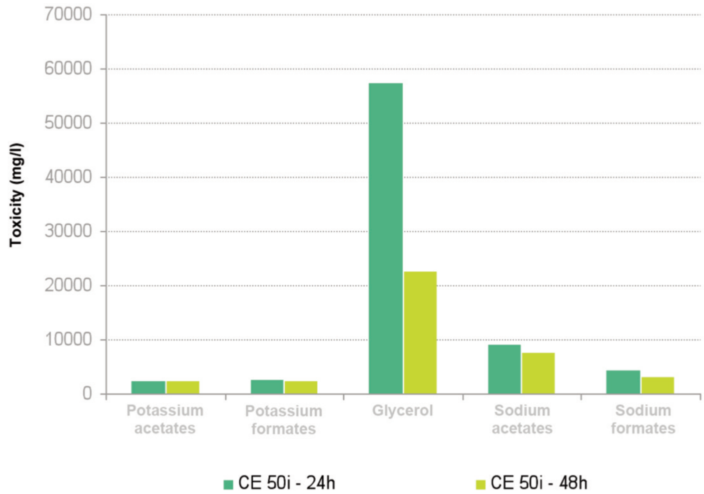


Figure 11 : Toxicity of runway deicers (test performed on Daphnies magna).

2.4.2. Product biodegradability and organic pollution

The main environmental issues surrounding the use of runway deicers lie in their organic load and in their biodegradability.

It is essential for the environment that the substances spread are biodegradable (to avoid them accumulating in the ecosystems), but the amount of oxygen needed to degrade them must not be too high, for fear of creating long-lasting asphyxiation of the aquatic environments, which will in turn lead to its overall depletion [CNRS, 2006, Corsi et al., 2001].

Organic load of the products

Organic loads are identified at airports by measuring several parameters, such as the BOD_5[5], the COD[6] or the TOC[7]; each of these parameters express a degree of mineral and/or organic pollution of an effluent or a solution.

Generally speaking, they are used to understand the environmental impact of runway deicers. Regardless of the form of formates, they seem less problematic than products made up of acetates or glycerol, the latter being particularly harmful for the environment.

4 - Tests performed on Daphnids (micro-crustacea).
5 - BOD : Biochemical Oxygen Demand
6 - COD : Chemical Oxygen Demand
7 - TOC : Total Organic Carbon

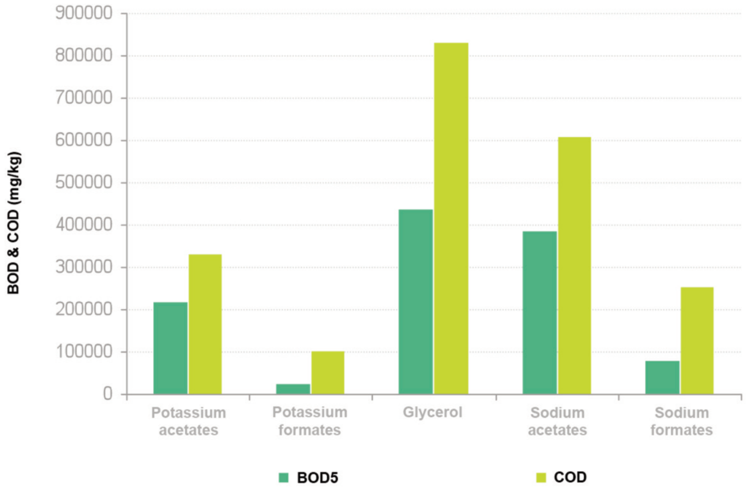


Figure 12: Biological and chemical demands of runway deicers.

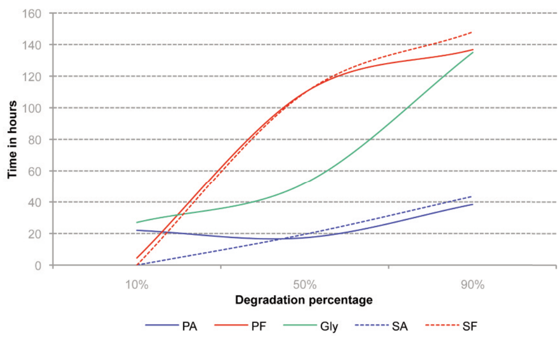
Biodegradability of runway deicers

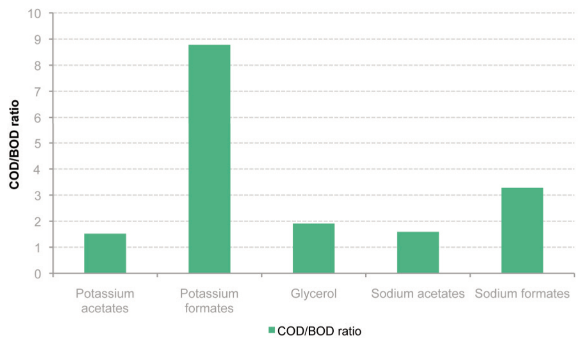
The biodegradability of runway deicers can be looked at by considering two parameters: the COD/BOD5 ratio, and the time it takes products to biodegrade.

The COD/BOD_5 ratio expresses the biodegradation capacity of runway deicers (figure 14).

- COD/BOD_5 < 2: readily biodegradable effluent
- 2 ≤ COD/BOD_5 < 3: biodegradable effluent with a selected biomass
- COD/BOD_5 ≥ 3: unreadily biodegradable effluent

The biodegradation time is the expression of the percentage of biodegraded product over a given time. The degradation of this organic load is characterized by following the changes in the dissolved organic carbon over time (figure 13).





Figures 13 and 14: Biodegradation time (test performed at 20 °C) & biodegradability of runway deicers.

When taking the BOD5 and the COD into consideration, the environmental impact of formates is significantly lower than glycerol and acetates. They consequently seem less problematic as regards the statutory requirements of the Act on water and aquatic environments. This initial appreciation should be put into perspective, given the biodegradability of the products and the time it takes for them to biodegrade. It should therefore be reconsidered with respect to the following two findings:

(1) The biodegradability tests (COD/BOD5 ratio) show that formates are harder to biodegrade than acetates and glycerol (due to the possible presence of organic matter which is biodegradation-resistant, and mineral matter).

(2) The tests performed on the biodegradation time corroborate the previous point (1). Formates degrade at a slower rate than acetates and glycerol, regardless of the test temperature (10 or 20 °C).

These results thus show that the biodegradation of both formates and glycerol is more problematic than that of acetates (longer degradation), despite the environmental impact of the former being a lot lower.

Recommendations

By taking the results of the environmental analyses into account, the choice of product can be dictated by two different approaches; both approaches are suggested with respect to the environmental and statutory requirements of the airport:

(1) Qualitative approach of water resources: tend towards the use of formates which have lower BOD and COD. Despite their environmental impact being reduced, high-performance sanitation and storage structures must be made available to manage the organic loads over long periods of time.

This approach may require high ground coverage, so as to guarantee the storage and treatment of effluents over technically longer periods of time.

(2) Quantitative approach (managing volumes of runoff water loaded with products rapidly): tend towards the use of acetates, which will degrade more easily over shorter periods of time, despite a higher, initial organic load (see BOD and COD), and therefore a significantly higher environmental impact compared to formates.

2.5. Conclusion

The second year of investigations has enabled us to complete our knowledge of the functional properties of runway deicers, and to offer a series of customary precautions to those airport operators which are committed to optimizing runway deicing operational procedures.

Although the choice of the product lies with the airport operator, the technical data presented in this document aim at accompanying users in their decision-making process.

The results of the analyses performed on 12 off-the-shelf formulations between 2009 and 2010 can be used to characterize the performance and effectiveness of the products, on the one hand, and to compare the product families (see figure 15 & 16: summary of the functional specificities of product families), on the other.

Liquids or solids

The results of this study generally indicate that liquid formulations have several advantages which cannot be ignored in terms of effectiveness, especially when they are used to control climate events of low to medium intensity, in either remedial or pre-remedial mode.

Stronger and harsher climate events may be treated more effectively in remedial mode, with solid formulations. Despite these products being subject to a preliminary hydration phase, they are more effective over time and better protect pavements. It is recommended to preferably use formulations made up of pellets of varying sizes and irregular form, in order to ensure optimum, long-lasting effectiveness of the products.

Although this point is not dealt with in this study, the combined use of liquids and solids may be of interest in the management of strong climate events, especially as a remedial, or even preventive, application.

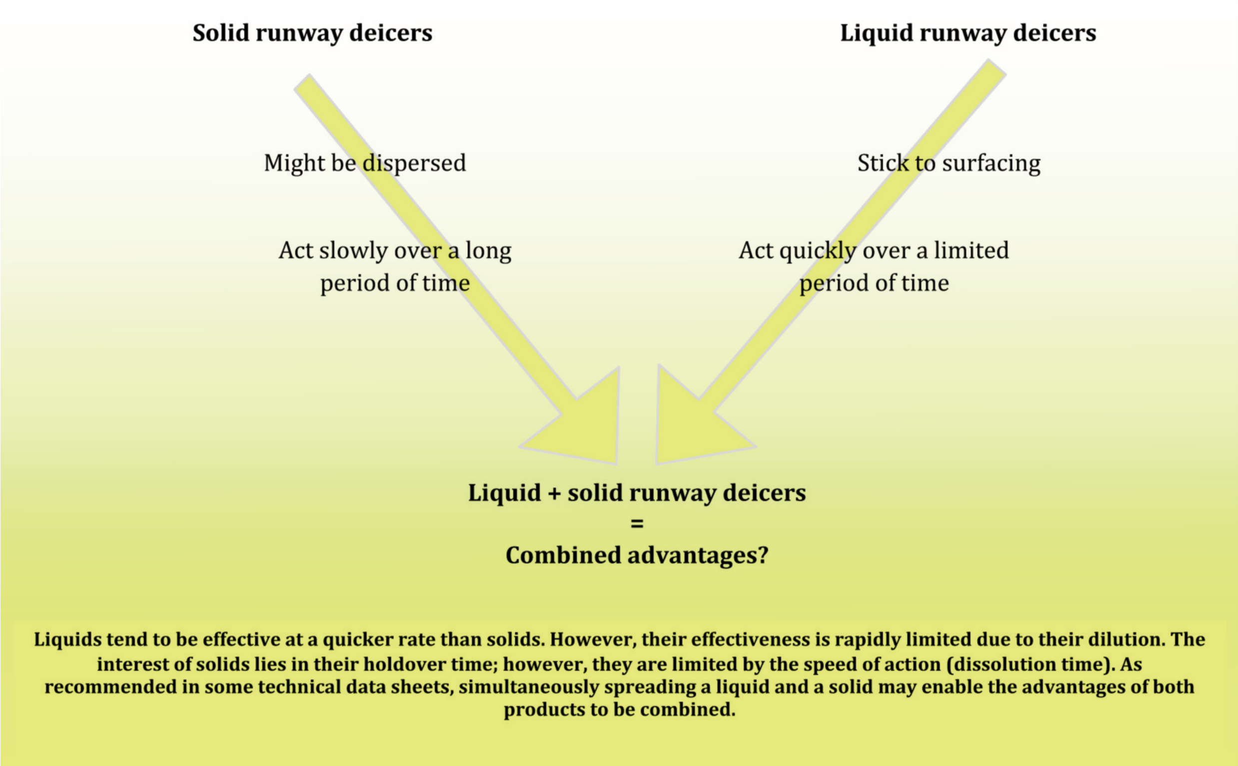


Figure 15: Use of solids and liquids.

Formates, Acetates or Glycerol ?

Formates are generally presented, for marketing purposes, as substances which have little impact on the environment, glycerol as being particularly biodegradable and hardly corrosive, and acetates as products situated in between the two.

The real advantage of glycerol lies in its low toxicity and weak impact on the oxidation of materials (especially aircraft carbon brakes). Glycerol is a real breakthrough in oxidation, when compared with formates and acetates, and probably foreshadows one of the main axes of development of new chemical formulations. This development should nevertheless continue, by focusing on the production of formulations with the following :

- low environmental impact,
- the same, or even better, effectiveness, especially with respect to product viscosity, the freezing point and melting capacities of the contaminants,
- optimized operating conditions (treatment guidelines).

<u>Environmental impact of the products :</u>

The tests performed to date on all the off-the-shelf formulations add to several commercial arguments put forward by some product suppliers.

Regarding the environment, we have to admit that, despite the fact that formates have a low impact on the environment (as regards the BOD and COD in particular), they are nevertheless not readily degradable (high COD/BOD ratio, long biodegradation time) compared to acetates (and to glycerol, to a lesser extent), which have high BOD and COD but better degradation time and biodegradability.

<u>Product effectiveness :</u>

We cannot differentiate a product family with regard to the tests performed to date (freezing points and curves). Additional tests concerning the holdover time and melting capacity of a contaminant should add to the data available on the subject to date.

<u>Product operating conditions :</u>

We are currently able to claim that, for the same treatment guidelines, spreaders loaded with formates are more autonomous than those loaded with glycerol and acetates, taking the density of products into consideration for example.

This evaluation still remains to be linked to the cost of the products. Indeed, the product savings obtained thru the use of products with high density (example of formates) may be offset by their cost, which could often be higher.

Finally, regardless of the typology and kind of products used, special precautions should be taken when handling and storing them, given their physical and chemical properties. It is strongly recommended to store them in confined spaces fitted with fire-fighting equipment. Personal protective equipment must be worn when handling the products, to avoid any risk of swallowing and prolonged contact with skin. All this information must be included in the safety data sheets distributed by the suppliers of runway deicers.

The second edition will be updated in the near future, in order to include new formulations, some of which come from the agro-industry. Information on the possible advantages of the combined use of liquids and solids will also be proposed.

8 - Article 31 and annex II of REACH regulation no.1907/2006 and standard 11 014 of March 2009.

<table>
<tr><th rowspan="2">Tests</th><th colspan="3">Liquids</th><th colspan="2">Solids</th></tr>
<tr><th>Potassium formates</th><th>Potassium acetates</th><th>Glycerol</th><th>Sodium formates</th><th>Sodium acetates</th></tr>
<tr><th></th><th colspan="5">Physical and chemical data</th></tr>
<tr><td>State (liquid/solid)</td><td colspan="3">+
Good covering and adherence to surfacing.</td><td colspan="2">+/–
Covering and adherence to surfacing depend on particle size and pellet shape.</td></tr>
<tr><td>Viscosity</td><td>+
Low viscosity, hardly affected by temperature variations</td><td>+/–
Mean viscosity, significantly affected by temperature variations</td><td>–
High viscosity, strongly affected by temperature variations</td><td>-</td><td>-</td></tr>
<tr><td>Density
(and product storage)</td><td>+</td><td>+/–</td><td>–</td><td>+</td><td>–</td></tr>
<tr><td></td><td colspan="5">Low density: high storage requirement</td></tr>
<tr><td>Density
(and use of products)</td><td>+</td><td>–</td><td>–</td><td>+</td><td>–</td></tr>
<tr><td></td><td colspan="5">For the same treatment guidelines, the spreaders loaded with liquid and solid formates will be generally more autonomous, as the working volume for pavement deicing is slightly lower.</td></tr>
<tr><td>Electrical conductivity
(and risks of oxidation)</td><td>–</td><td>+/–</td><td>+</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td></td><td colspan="3">Formates likely to be more problematic when it comes to the oxidation of metals, electrical malfunctions, etc.</td></tr>
<tr><th></th><th colspan="5">Environmental data</th></tr>
<tr><td>COD & BOD</td><td>+</td><td>–</td><td>–</td><td>+</td><td>–</td></tr>
<tr><td></td><td colspan="5">Environmental impact: Formates < Acetates < Glycerol</td></tr>
<tr><td>COD/BOD ratio</td><td>–</td><td>+</td><td>+/–</td><td>–</td><td>+</td></tr>
<tr><td></td><td colspan="5">Biodegradability: Formates < Glycerol < Acetates</td></tr>
<tr><td>Biodégradation time</td><td>–</td><td>+</td><td>+/–</td><td>–</td><td>+</td></tr>
<tr><td></td><td colspan="5">Biodegradation time: Acetates < Glycerol < Formates</td></tr>
<tr><td>Acute toxicity for Daphnia</td><td>+/–</td><td>+/–</td><td>+</td><td>–</td><td>+/–</td></tr>
<tr><td></td><td colspan="5">Glycerol of low toxicity, Acetates slightly less toxic than Formates</td></tr>
<tr><th></th><th colspan="5">Functional data</th></tr>
<tr><td>Adherence to surfacing</td><td colspan="3">+
Adhere to surfacing</td><td colspan="2">–
Adherences varies as a function of particle size and pellet shape</td></tr>
<tr><td>Speed of action</td><td colspan="3">+
Acts instantly</td><td colspan="2">–
Acts slowly
(needs to become hydrated beforehand)</td></tr>
<tr><td>Effective duration</td><td colspan="3">–
Does not act for a long time</td><td colspan="2">+
Acts for a long time</td></tr>
</table>

+ : Positive mark **–** : Negative mark **+/–** : Mean mark

Figure 16 : Summary of the functional specificities of runway deicers.

3. Product data sheets

3.1. List of products analyzed

The products listed below have been analyzed as part of our study

Product	Corporation	Nature	State
SAFEGRIP	Abax Industrie	Potassium acetate	Liquid
SAFEGRIP FR	Abax Industrie	Potassium formate	Liquid
SAFEWAY KF HOT	Clariant	Potassium formate	Liquid
SAFEWAY KA HOT	Clariant	Potassium acetate	Liquid
SAFEWAY SF	Clariant	Sodium formate	Solid
CLEARWAY F1	Kémira	Potassium formate	Liquid
CLEARWAY 1	Kémira	Potassium acetate	Liquid
CLEARWAY 6s	Kémira	Sodium acetate	Solid
CLEARWAY SF3	Kémira	Sodium formate	Solid
ESTOROB D-ICER	Novance	Glycerol	Liquid
CRYOTECH E36	Proviron Industries NV	Potassium acetate	Liquid
CRYOTECH NAAC	Proviron Industries NV	Sodium acetate	Solid

The analysis reports are backed up with a sheet comparing the results of formates, acetates and glycerol.

3.2. Sheet typology

Each sheet includes the following information:

- Product trade name
- Product manufacturer
- Product supplier
- Type of product
- Date on which product was received
- Date on which tests were validated

(1) Product physical and chemical properties

LIQUIDS	
Tests 1 and 2	Visual appearance and state
Test 3	Density
Test 4	Kinematic viscosity
Test 5	pH
Test 6	Refractive index
Test 7	Active principle
Test 8	Electrical conductivity
Test 9	Flash point
Test 10	Self-ignition point

SOLIDS	
Tests 1 and 2	Visual appearance and state
Test 3	Bulk density
Test 4	Active principle
Test 5	Particle size
Test 6	Self-ignition point
Test 7	pH

(2) Product toxicity and environmental data

LIQUIDS	
Tests 11	BOD
Test 12	COD
Test 13	COD/BOD ratio
Test 14	Biodegradation time
Test 15	Toxicity for Daphnia magna

SOLIDS	
Tests 8	BOD
Test 9	COD
Test 10	COD/BOD ratio
Test 11	Biodegradation time
Test 12	Toxicity for Daphnia magna

(3) Product effectiveness

LIQUIDS	
Tests 16	Freezing curve and point

SOLIDS	
Test 13	Freezing curve and point

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on SAFEGRIP

SAFEGRIP

ABAX Industries SPCA - 9, voie de Seine - 94290 VILLENEUVE LE ROI
Runway deicer: *Potassium acetate*
Date on which samples were received: *January 29 th, 2009*

IIt is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) the support of airport services in the definition of the criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

Caution

(1) - The document produced by the STAC complements the data released by runway deicer suppliers for the attention of airport operators, on the basis of a series of standardized, harmonized tests.

(2) - The document produced by the STAC does not deal with the "health risks, customary precautions, handling, storage and disposal" of the products. The product supplier is responsible for providing this information on an SDS (safety data sheet), written in compliance with the European regulation, REACH no. 1907/2006 and with regulation (CE) no. 1272/2008.

(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

The data presented in this report are the result of a series of tests performed by the STAC with several public and private analytical laboratories. The main document and each of the data sheets refer to the normative or protocol references inherent to each of the tests performed as part of this study. In-house protocols may be made available to a user, upon simple request to the STAC.

Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	01/29/2009	-
2	Color (visual)	-	Transparent	01/29/2009	-
3	Density	g/L	1284	05/11/2009	NF EN ISO 3838 (1)
4	Kinematic viscosity 20 °C 5 °C -5°C	mm^2/s	 4,832 8,512 13,40	10/22/2010	NF EN ISO 3104 (2)
5	pH	-	10,54	05/11/2009	NF T 90-008 (3)
6	Refractive index at 20 °C	-	1,3862	09/30/2009	LRN in-house method
7	Active principle [CH_3COOK	%	53	12/03/2010	LRN in-house method
8	Conductivity	mS	103,1	05/11/2009	NF EN 27888 (4)
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680 (5)
10	Self-ignition point	°C	> 500	10/22/2010	ASTM E 659 (6)

**the flame goes out when temperature reaches 90 °C, but the apparatus does not detect a flash.*

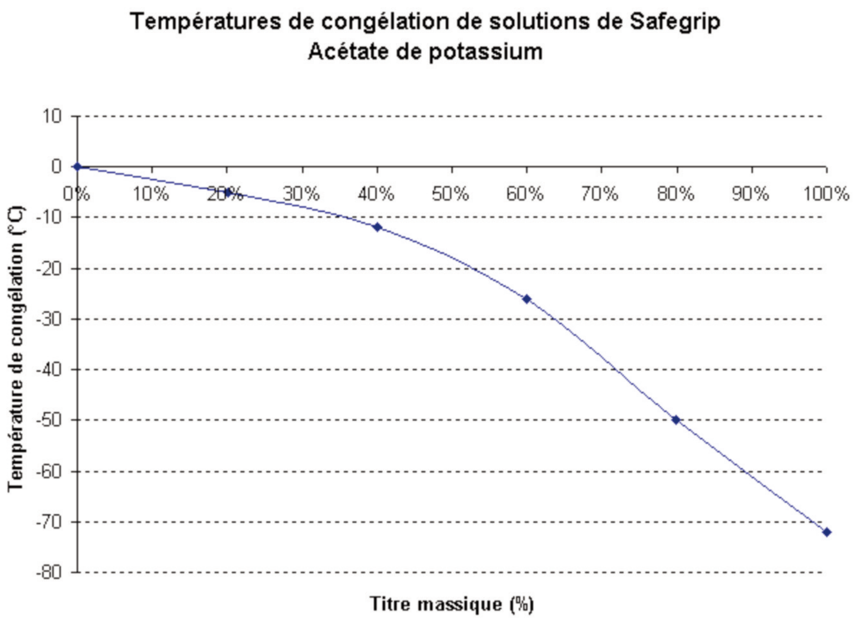
Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
11 12	BOD_5 (20 °C) COD	mg/kg mg/kg	234271 343556	12/08/2009 12/08/2009	NF EN 1899-1 (7) NF T 90-101 (8)
13	COD/BOD_5 ratio	-	1,47	12/08/2009	
14	Biodegradability 20 °C 10 % 50 % 90 %	hours	 3 17 36	05/06/2011	NF EN ISO 9888 (9)
15 15a 15b	Acute toxicity for Daphnia EC 50i - 24 hours EC 50i - 48 hours	g/L	 2,82 (2,56-3,20) 2,69 (2,43-2,94)	07/30/2009	NF EN ISO 6341 (10)

1 - Crude oil and liquid or solid petroleum products – Determination of the density - Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004.
2 - Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996
3 - Water quality – Determination of pH – February 2001
4 - Water quality – Determination of electrical conductivity – January 1994
5 - Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004
6 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005
7 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998
8 - Water quality – Determination of chemical oxygen demand (COD) – February 2001
9 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999
10 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours)

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%) Mass percentage: 20 % Mass percentage: 40 % Mass percentage: 60 % Mass percentage: 80 % Mass percentage: 100 %	°C	 -5 -12 -26 -50 -72	11/09/2009	LRN in-house method



Test 16 : Product freezing points as a function of mass percentage

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on SAFEGRIP FR

SAFEGRIP FR

ABAX Industries SPCA - 9, voie de Seine - 94290 VILLENEUVE LE ROI
Runway deicer: Potassium formate
Date on which samples were received: January 29 th, 2009

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) the support of airport services in the definition of the criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

Caution

(1) – The document produced by the STAC complements the data released by runway deicer suppliers for the attention of airport operators, on the basis of a series of standardized, harmonized tests.

(2) - The document produced by the STAC does not deal with the "health risks, customary precautions, handling, storage and disposal" of the products. The product supplier is responsible for providing this information on an SDS (safety data sheet), written in compliance with the European regulation, REACH no. 1907/2006 and with regulation (CE) no. 1272/2008.

(3) – The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

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Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	01/29/2009	-
2	Color (visual)	-	Colorless	01/29/2009	-
3	Density	g/L	1344	01/29/2009	NF EN ISO 3838 (1)
4	Kinematic viscosity 20 °C 5 °C -5°C	mm^2/s	 2,034 2,943 3,948	10/22/2010	NF EN ISO 3104 (2)
5	pH	-	10,84	05/11/2009	NF T 90-008 (3)
6	Refractive index at 20 °C	-	1,3869	09/30/2009	LRN in-house method
7	Active principle [HCOOK]	%	51	12/03/2010	LRN in-house method
8	Conductivity	mS	231,0	05/11/2009	NF EN 27888 (4)
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680 (5)
10	Self-ignition point	°C	> 500	10/22/2010	ASTM E 659 (6)

**the flame goes out when temperature reaches 90 °C, but the apparatus does not detect a flash.*

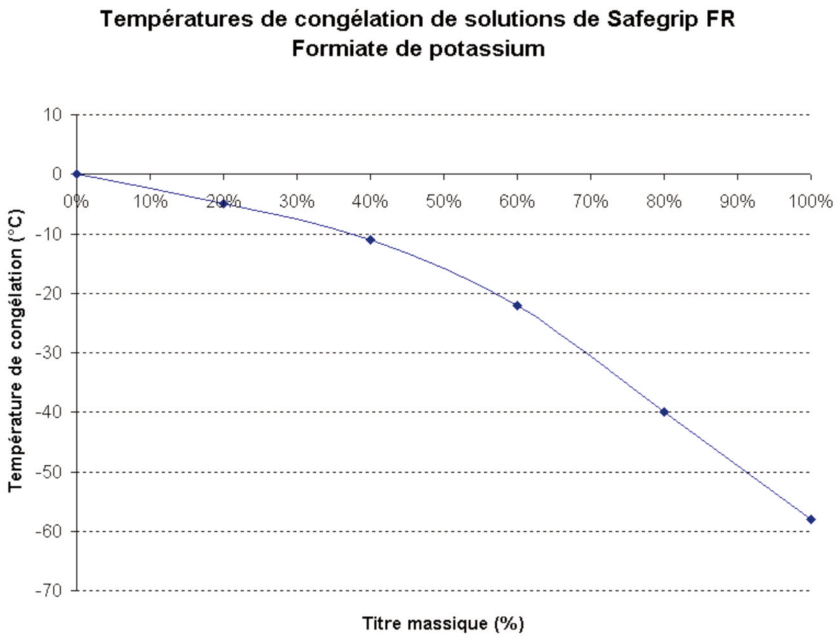
Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
11 12	BOD_5 (20 °C) COD	mg/kg mg/kg	22669 93084	12/08/2009 12/08/2009	NF EN 1899-1 (7) NF T 90-101 (8)
13	COD/BOD_5 ratio	-	4,11	12/08/2009	
14	Biodegradability 20 °C 10 % 50 % 90 %	hours	 38 102 136	05/06/2011	NF EN ISO 9888 (9)
15 15a 15b	Acute toxicity for Daphnia EC 50i - 24 hours EC 50i - 48 hours	g/L	 2,28 (2,01-2,55) 2,28 (2,01-2,41)	07/30/2009	NF EN ISO 6341 (10)

1 - Crude oil and liquid or solid petroleum products – Determination of the density - Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004.
2 - Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996.
3 - Water quality – Determination of pH – February 2001.
4 - Water quality – Determination of electrical conductivity – January 1994.
5 - Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004.
6 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005.
7 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
8 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
9 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
10 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%) Mass percentage : 20 % Mass percentage : 40 % Mass percentage : 60 % Mass percentage : 80 % Mass percentage : 100 %	°C	 -5 -11 -22 -40 -58	11/09/2009	LRN in-house method



Test 16 : Product freezing points as a function of mass percentage

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on Safeway KF HOT Runway Deicer

SAFEWAY KF HOT Runway De-icer

Clariant Produkte (Deutschland) GmbH 65926 Frankfurt am Main
Runway deicer: Potassium formate
Date on which samples were received: January 27 th, 2010

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) the support of airport services in the definition of the criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

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(2) - The document produced by the STAC does not deal with the "health risks, customary precautions, handling, storage and disposal" of the products. The product supplier is responsible for providing this information on an SDS (safety data sheet), written in compliance with the European regulation, REACH no. 1907/2006 and with regulation (CE) no. 1272/2008.

(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

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The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	01/27/2010	-
2	Color (visual)	-	Colorless – light orange	01/27/2010	-
3	Masse volumique	Kg/m3	1356	06/17/2010	NF EN ISO 3838 (1)
4	Kinematic viscosity 20 °C 5 °C -5°C	mm²/s	 2,154 3,140 4,235	10/22/2010	NF EN ISO 3104 (2)
5	pH	-	10,58	06/17/2010	NF T 90-008 (3)
6	Refractive index at 20 °C	-	1,3895	02/04/2010	LRN in-house method
7	Active principle [HCOOK]	%	55	12/03/2010	LRN in-house method
8	Conductivity	mS	225,7	06/17/2010	NF EN 27888 (4)
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680 (5)
10	Self-ignition point	°C	> 500	10/22/2010	ASTM E 659 (6)

**the flame goes out when temperature reaches 90 °C, but the apparatus does not detect a flash.*

Product toxicity and environmental data

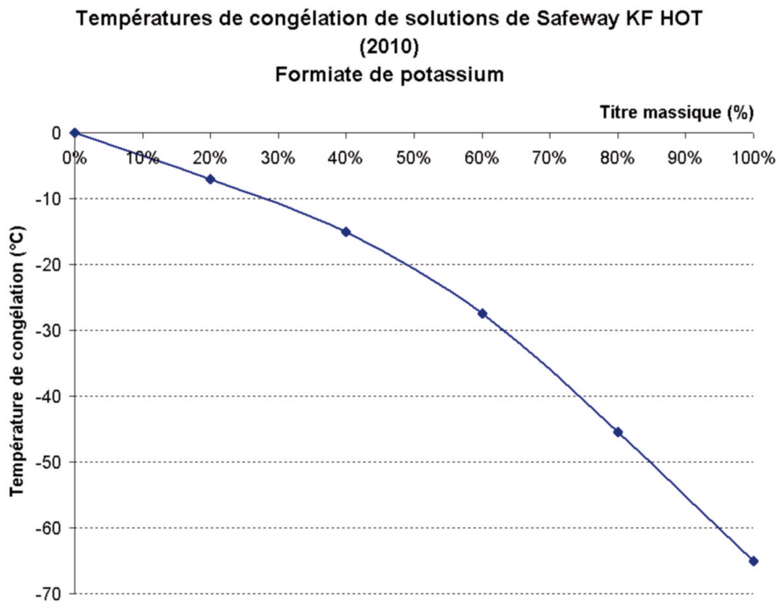
N°	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	5266	11/12/2010	NF EN 1899-1 (7)
12	COD	mg/kg	106667	08/03/2010	NF T 90-101 (8)
13	COD/BOD_5	-	20,3	11/12/2010	
14	Biodegradability 20 °C 10 % 50 % 90 %	hours	 74 118 137	05/06/2011	NF EN ISO 9888 (9)
15 15a 15b	Acute toxicity for Daphnia EC 50i - 24 hours EC 50i - 48 hours	g/L	 3,25 (3,11-3,66)* 3,25 (2,98-3,52)*	08/20/2010	NF EN ISO 6341 (10)

**The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).*

1 - Crude oil and liquid or solid petroleum products – Determination of the density - Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004
2 - Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996
3 - Water quality – Determination of pH – February 2001
4 - Water quality – Determination of electrical conductivity – January 1994
5 - Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004
6 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals – 2005
7 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998
8 - Water quality – Determination of chemical oxygen demand (COD) – February 2001
9 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999
10 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours)

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%) Mass percentage : 20 % Mass percentage : 40 % Mass percentage : 60 % Mass percentage : 80 % Mass percentage : 100 %	°C	-7 -15 -27,5 -45,5 -65	10/25/2010	LRN in-house method



Test 16 : Product freezing points as a function of mass percentage

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on Safeway KA HOT Runway Deicer

SAFEWAY KA HOT Runway De-icer

Clariant Produkte (Deutschland) GmbH 65926 Frankfurt am Main
Runway deicer: Potassium acetate
Date on which samples were received: January 21 st, 2009

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,
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(3) the support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.
The runway deicer holdover tests were organized by the “winter maintenance – engineering and equipment” resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

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Use of data

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Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	02/15/2009	-
2	Color (visual)	-	Colorless	02/15/2009	-
3	Color (visual)	g/L	1284	05/11/2009	NF EN ISO 3838 (1)
4	Kinematic viscosity 20 °C 5 °C -5°C	mm^2/s	4,98 8,671 13,59	08/27/2009	NF EN ISO 3104 (2)
5	pH	-	9,94	05/11/2009	NF T 90-008 (3)
6	Refractive index at 20 °C	-	1,3966	09/30/2009	LRN in-house method
7	Active principle [CH_3COOK]	%	54	12/03/2010	LRN in-house method
8	Conductivity	mS	101,9	05/11/2009	NF EN 27888 (4)
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680 (5)
10	Self-ignition point	°C	> 500	10/22/2010	ASTM E 659 (6)

**the flame goes out when temperature reaches 90 °C, but the apparatus does not detect a flash.*

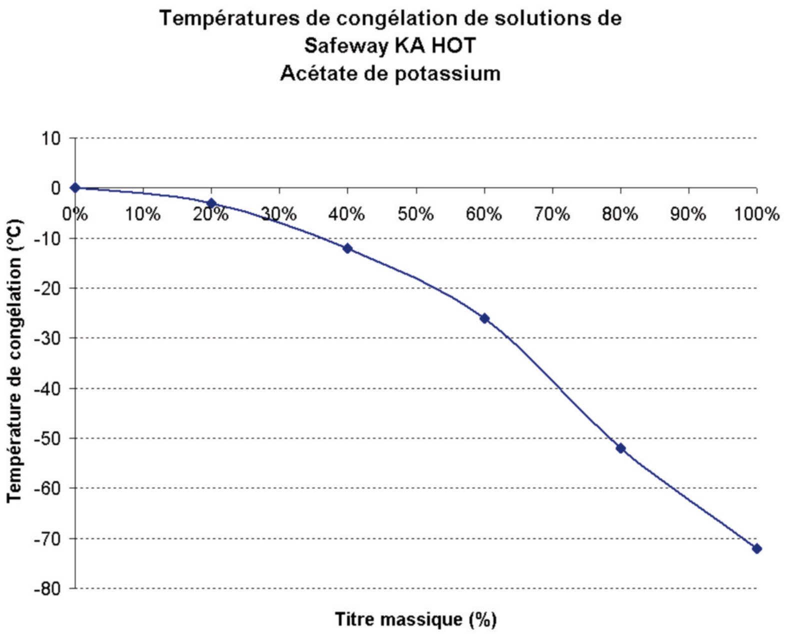
Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	235694	12/08/2009	NF EN 1899-1 (7)
12	COD	mg/kg	327940	12/08/2009	NF T 90-101 (8)
13	BOD_5/COD ratio	-	1,39	12/08/2009	
14	Biodegradability 20 °C 10 % 50 % 90 %	hours	3 16 37	05/06/2011	NF EN ISO 9888 (9)
15	Acute toxicity for Daphnia				
15a	CE 50i - 24 hours	g/L	2,30 (2,18-2,56)	07/30/2009	NF EN ISO 6341 (10)
15b	CE 50i - 48 hours		2,30 (2,18-2,56)		

1 - Crude oil and liquid or solid petroleum products – Determination of the density - Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004.
2 - Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996.
3 - Water quality – Determination of pH – February 2001.
4 - Water quality – Determination of electrical conductivity – January 1994.
5 - Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004.
6 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005.
7 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
8 - Water quality – Determination of chemical oxygen demand (COD) – February 2001
9 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
10 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%) Mass percentage : 20 % Mass percentage : 40 % Mass percentage : 60 % Mass percentage : 80 % Mass percentage : 100 %	°C	 -3 -12 -26 -52 -72	11/09/2009	LRN in-house method



Test 16 : Product freezing points as a function of mass percentage

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on SAFEWAY SF

SAFEWAY SF

Clariant Produkte (Deutschland) GmbH Industriepark 1 Burgkirchen, 84508 Germany
Runway deice: Sodium formate
Date on which samples were received: January 27 th, 2010

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) the support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

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(2) - The document produced by the STAC does not deal with the "health risks, customary precautions, handling, storage and disposal" of the products. The product supplier is responsible for providing this information on an SDS (safety data sheet), written in compliance with the European regulation, REACH no. 1907/2006 and with regulation (CE) no. 1272/2008.

(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

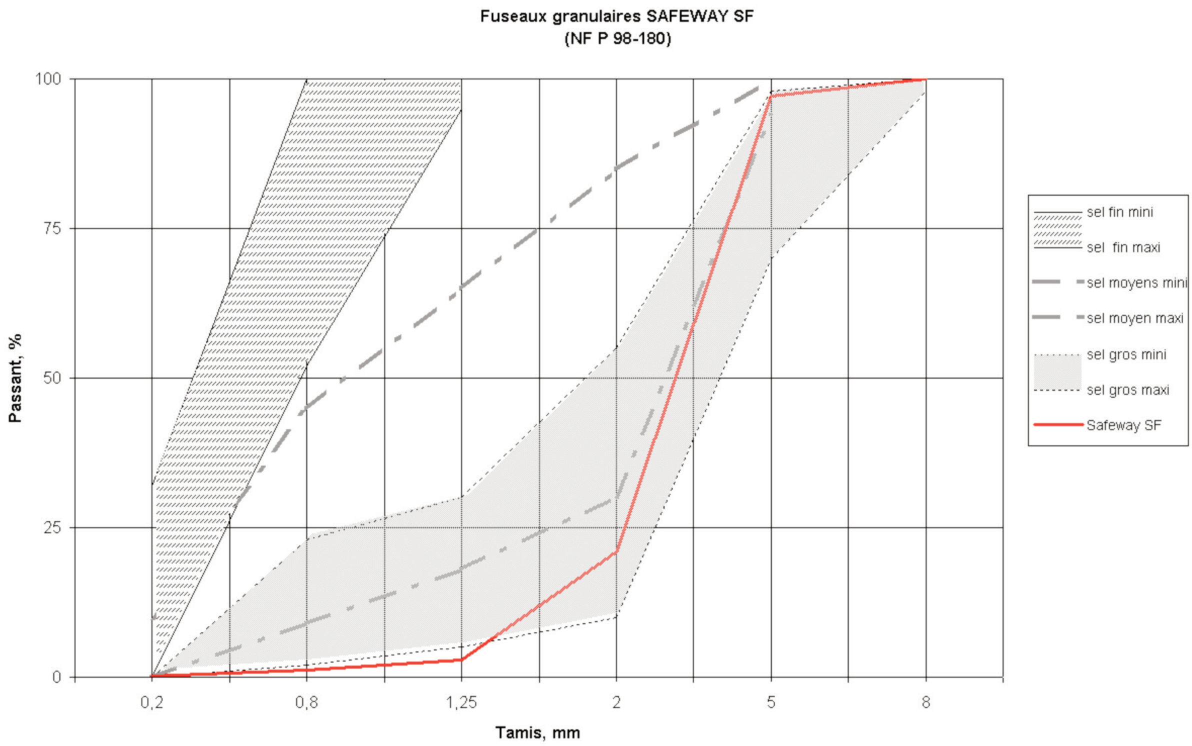
The data presented in this report are the result of a series of tests performed by the STAC with several public and private analytical laboratories. The main document and each of the data sheets refer to the normative or protocol references inherent to each of the tests performed as part of this study. In-house protocols may be made available to a user, upon simple request to the STAC.

Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Solid in the form of irregular pellets	03/10/2010	-
2	Color (visual)	-	white	03/10/2010	-
3	Bulk density	kg/m^3	1090	09/06/2010	LRN in-house method, no.108
4	Active principle [HCOONa]	%	In progress	-	LRN in-house method
5	Particle size	Sieve mesh in mm	Cumulated particle passing measured as a %	08/05/2010	NF P 98-180 (1)
		0,2	0,2		
		0,8	1,2		
		1,25	2,8		
		2	21,0		
		5	97,1		
		8	100,0		
6	Auto-ignition point	°C	> 500	10/22/2010	ASTM E 659 (2)
7	pH	-	11,40	06/09/2010	NF T 90-008



Test 5 : Particle size

1 - Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.
2 - Standard Test Method for Autoignition Temperature of Liquid Chemicals - 2005.

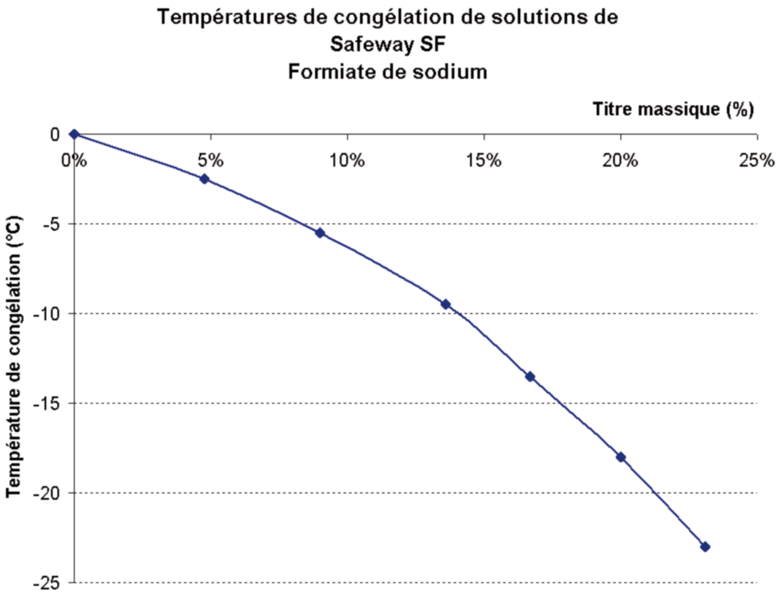
Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
8	BOD_5 (20°C)	mg/kg	68163	08/03/2010	NF EN 1899-1 [3]
9	COD	mg/kg	260064	08/03/2010	NF T 90-101 [4]
10	COD/BOD_5	-	3,81	08/03/2010	
11	Biodegradability 20 °C 10 % 50 % 90 %	hours	32 111 -	11/12/2010	NF EN ISO 9888 [5]
12 12a 12b	Acute toxicity for Daphnia CE 50i - 24 hours CE 50i - 48 hours	g/L	4,18 (3,80-4,60) 2,90 (2,62-3,20)	08/20/2010	NF EN ISO 6341 [6]

The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

Product effectiveness

N°	Name	Unit	Values	Date	Normatives reference
13	Product freezing point as a function of mass percentage (%) Mass percentage : 5 % Mass percentage : 10 % Mass percentage : 15 % Mass percentage : 20 %	°C	-3,4 -7,9 -13,2 -19,1	10/25/2010	LRN in-house method



Test 13 : Product freezing point as a function of mass percentage

3 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
4 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
5 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
6 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours)

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on Clearway F1 Runway Deicer

CLEARWAY F1 Runway De-icer

Kemira ChemSolutions b.v. P.O. Box 60 - 4000AB Tiel NETHERLANDS
Runway deicer: Potassium formate
Date on which samples were received: February 14 th, 2009

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) the support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

Caution

(1) - The document produced by the STAC complements the data released by runway deicer suppliers for the attention of airport operators, on the basis of a series of standardized, harmonized tests.

(2) - The document produced by the STAC does not deal with the "health risks, customary precautions, handling, storage and disposal" of the products. The product supplier is responsible for providing this information on an SDS (safety data sheet), written in compliance with the European regulation, REACH no. 1907/2006 and with regulation (CE) no. 1272/2008.

(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

The data presented in this report are the result of a series of tests performed by the STAC with several public and private analytical laboratories. The main document and each of the data sheets refer to the normative or protocol references inherent to each of the tests performed as part of this study. In-house protocols may be made available to a user, upon simple request to the STAC.

Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	02/15/2009	-
2	Color (visual)	-	Colorless	02/15/2009	-
3	Density	g/L	1344	05/11/2009	NF EN ISO 3838 (1)
4	Kinematic viscosity 20 °C 5 °C -5°C	mm^2/s	 2,086 3,018 4,047	10/22/2010	NF EN ISO 3104 (2)
5	pH	-	10,95	05/11/2009	NF T 90-008 (3)
6	Refractive index at 20 °C	-	1,3880	09/30/2009	LRN in-house method
7	Active principle [HCOOK]	%	51	03/12/2010	LRN in-house method
8	Conductivity	mS	231,0	05/11/2009	NF EN 27888 (4)
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680 (5)
10	Auto-ignition point	°C	> 500	10/22/2010	ASTM E 659 (6)

**the flame goes out when temperature reaches 90 °C, but the apparatus does not detect a flash.*

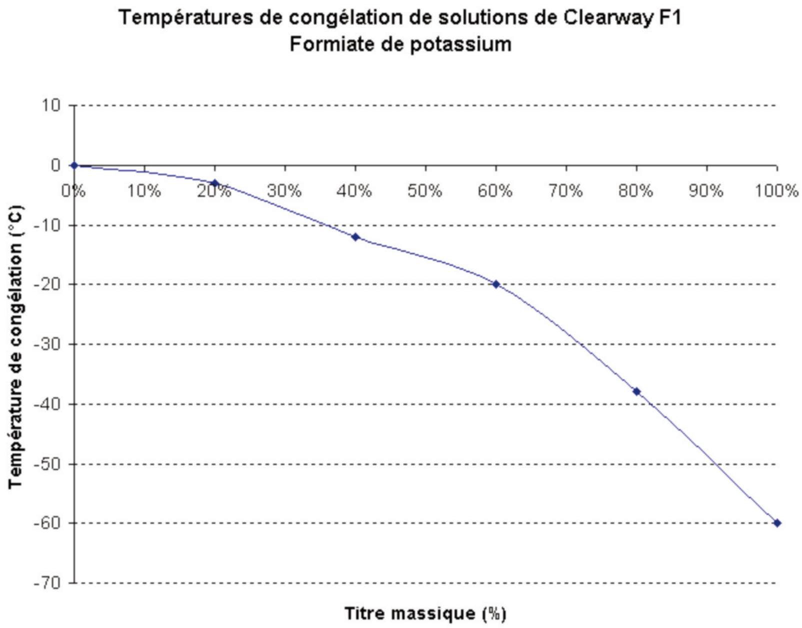
Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
11 12	BOD_5 (20 °C) COD	mg/kg mg/kg	54039 104344	- 12/08/2009	NF EN 1899-1 (7) NF T 90-101 (8)
13	COD/BOD_5 ratio	-	1,93	12/08/2009	
14	Biodegradability 20 °C 10 % 50 % 90 %	hours	 44 109 138	05/06/2011	NF EN ISO 9888 (9)
15 15a 15b	Acute toxicity for Daphnia CE 50i - 24 hours CE 50i - 48 hours	g/L	 2,41 (2,14-2,68) 2,01 (1,47-2,68)	07/30/2009	NF EN ISO 6341 (10)

1 - Crude oil and liquid or solid petroleum products – Determination of the density - Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004.
2 - Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996.
3 - Water quality – Determination of pH – February 2001.
4 - Water quality – Determination of electrical conductivity – January 1994.
5 - Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004.
6 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005.
7 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
8 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
9 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
10 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%) Mass percentage : 20 % Mass percentage : 40 % Mass percentage : 60 % Mass percentage : 80 % Mass percentage : 100 %	°C	 -3 -12 -20 -38 -60	11/09/2009	LRN in-house method



Test 16 : Product freezing points as a function of mass percentage

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on Clearway 1 Runway Deicer

Clearway 1 Runway De-icer

Kemira ChemSolutions b.v. - PO Box 60 - 4000AB Tiel - NETHERLANDS
Runway deicer: Potassium acetate
Date on which samples were received: January 14 th, 2009

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) the support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

Caution

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(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

The data presented in this report are the result of a series of tests performed by the STAC with several public and private analytical laboratories. The main document and each of the data sheets refer to the normative or protocol references inherent to each of the tests performed as part of this study. In-house protocols may be made available to a user, upon simple request to the STAC.

IPlease bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	02/15/2009	-
2	Color (visual)	-	Colorless	02/15/2009	-
3	Density	g/L	1282	05/11/2009	NF EN ISO 3838 (1)
4	Kinematic viscosity 20 °C 5 °C -5°C	mm^2/s	 4,549 7,910 12,24	10/22/2010	NF EN ISO 3104 (2)
5	pH	-	11,30	05/11/2009	NF T 90-008 (3)
6	Refractive index at 20 °C	-	1,3947	09/30/2009	LRN in-house method
7	Active principle [CH_3COOK]	%	52	12/03/2010	LRN in-house method
8	Conductivity	mS	107,5	05/11/2009	NF EN 27888 (4)
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680 (5)
10	Auto-ignition point	°C	> 500	10/22/2010	ASTM E 659 (6)

**the flame goes out when temperature reaches 90 °C, but the apparatus does not detect a flash.*

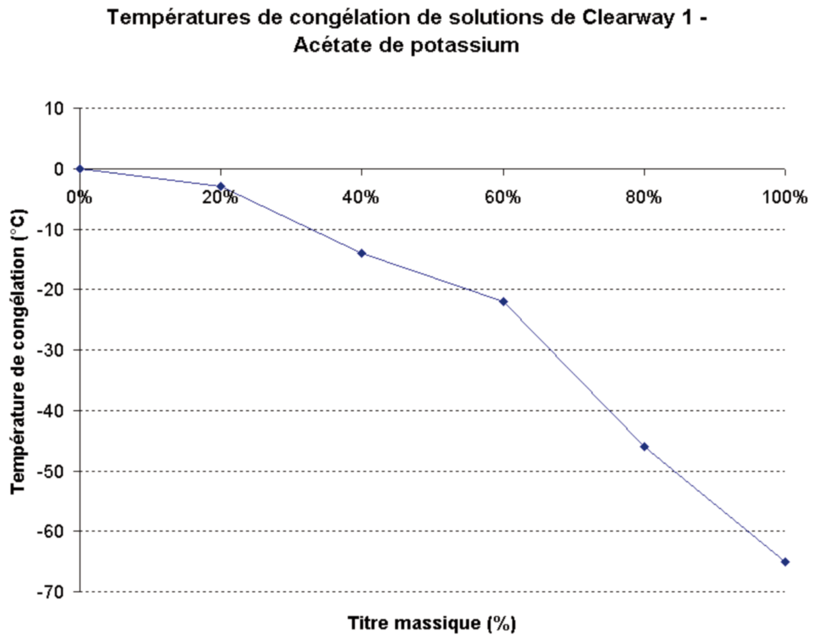
Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
11 12	BOD_5 (20 °C) COD	mg/kg mg/kg	208223 331270	12/08/2009 12/08/2009	NF EN 1899-1 (7) NF T 90-101 (8)
13	COD/BOD_5 ratio	-	1,59	12/08/2009	
14	Biodegradability 20 °C 10 % 50 % 90 %	hours	 4 19 40	05/06/2011	NF EN ISO 9888 (9)
15 15a 15b	Acute toxicity for Daphnia CE 50i - 24 hours CE 50i - 48 hours	g/L	 2,30 (2,18-2,56) 2,18 (2,05-2,43)	07/30/2009	NF EN ISO 6341 (10)

1 - Crude oil and liquid or solid petroleum products – Determination of the density - Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004.
2 - Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996.
3 - Water quality – Determination of pH – February 2001.
4 - Water quality – Determination of electrical conductivity – January 1994.
5 - Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004.
6 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005.
7 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
8 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
9 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
10 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%)				
	Mass percentage : 20 %		-3		
	Mass percentage : 40 %		-14		
	Mass percentage : 60 %	°C	-22	11/09/2009	LRN in-house method
	Mass percentage : 80 %		-46		
	Mass percentage : 100 %		-65		



Test 16 : Product freezing points as a function of mass percentage

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on Clearway 6S

Clearway 6S

Kemira ChemSolutions b.v. - PO Box 60 - 4000AB Tiel - NETHERLANDS
Runway deicer: Sodium acetate
Date on which samples were received: February 11 th, 2010

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) the support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

Caution

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(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

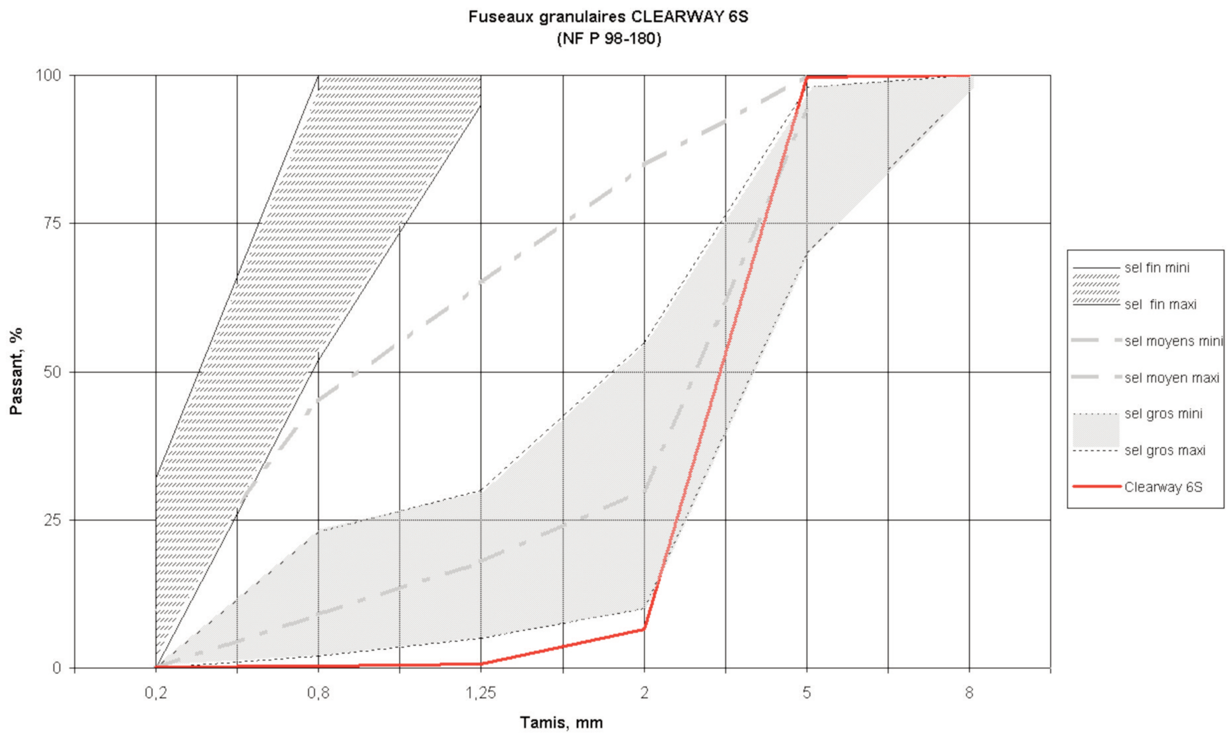
The data presented in this report are the result of a series of tests performed by the STAC with several public and private analytical laboratories. The main document and each of the data sheets refer to the normative or protocol references inherent to each of the tests performed as part of this study. In-house protocols may be made available to a user, upon simple request to the STAC.

Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Solid, in the form of irregular pellets	03/10/2010	-
2	Color (visual)	-	white	03/10/2010	-
3	Bulk density	kg/m³	770	09/06/2010	LRN in-house method, no.108
4	Active principle [CH_3COONa]	%	In progress	-	LRN in-house method
5	Particle size	Sieve mesh in mm	Cumulated particle passing measured as a %	08/05/2010	NF P 98-180 (1)
		0,2	0,1		
		0,8	0,3		
		1,25	0,6		
		2	6,5		
		5	99,6		
		8	100,0		
6	Auto-ignition point	°C	> 500	10/22/2010	ASTM E 659 (2)
7	pH	-	8,50	09/06/2010	NF T 90-008



Test 5 : Particle size

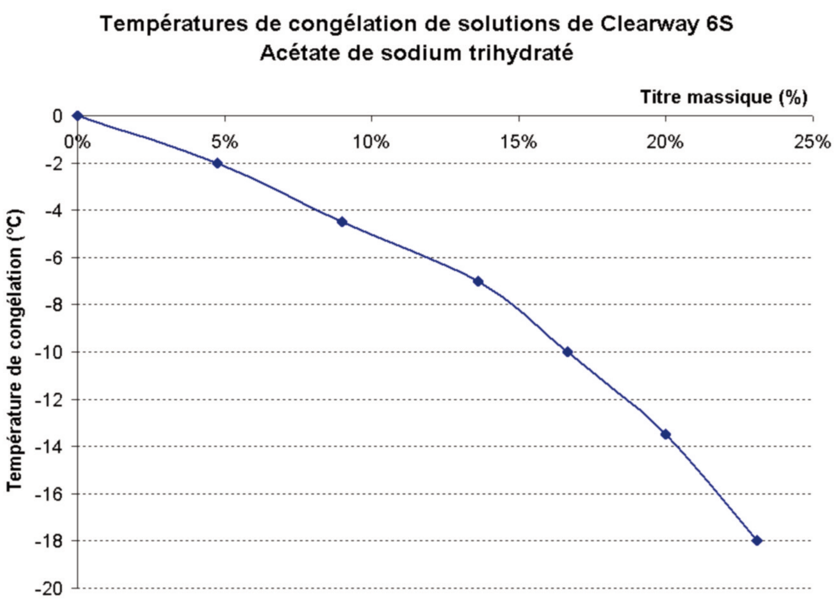
1 - Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.
2 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005.

Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
8	BOD_5 (20 °C)	mg/kg	304373	08/03/2010	NF EN 1899-1 (3)
9	COD	mg/kg	500573	08/03/2010	NF T 90-101 (4)
10	COD/BOD_5	-	1,64	08/03/2010	
11	Biodegradability 20 °C 10 % 50 % 90 %	hours	 5 19 43	11/12/2010	NF EN ISO 9888 (5)
12 12a 12b	Acute toxicity for Daphnia CE 50i - 24 hours CE 50i - 48 hours	g/L	 12,1 (11,4-12,9) 10,2 (9,42-11,0)	08/20/2010	NF EN ISO 6341 (6)

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
13	Product freezing point as a function of mass percentage (%) Mass percentage : 5 % Mass percentage : 10 % Mass percentage : 15 % Mass percentage : 20 %	°C	 -2,8 -6,0 -9,7 -14,4	10/25/2010	LRN in-house protocol



Test 13 : Product freezing points as a function of mass percentage

3 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
4 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
5 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
6 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on Clearway SF3

Clearway SF3

Kemira ChemSolutions b.v. - PO Box 60 - 4000AB Tiel - NETHERLANDS
Runway deicer: Sodium formate
Date on which samples were received: February 11 th, 2010

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,
(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,
(3) the support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.
The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

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(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

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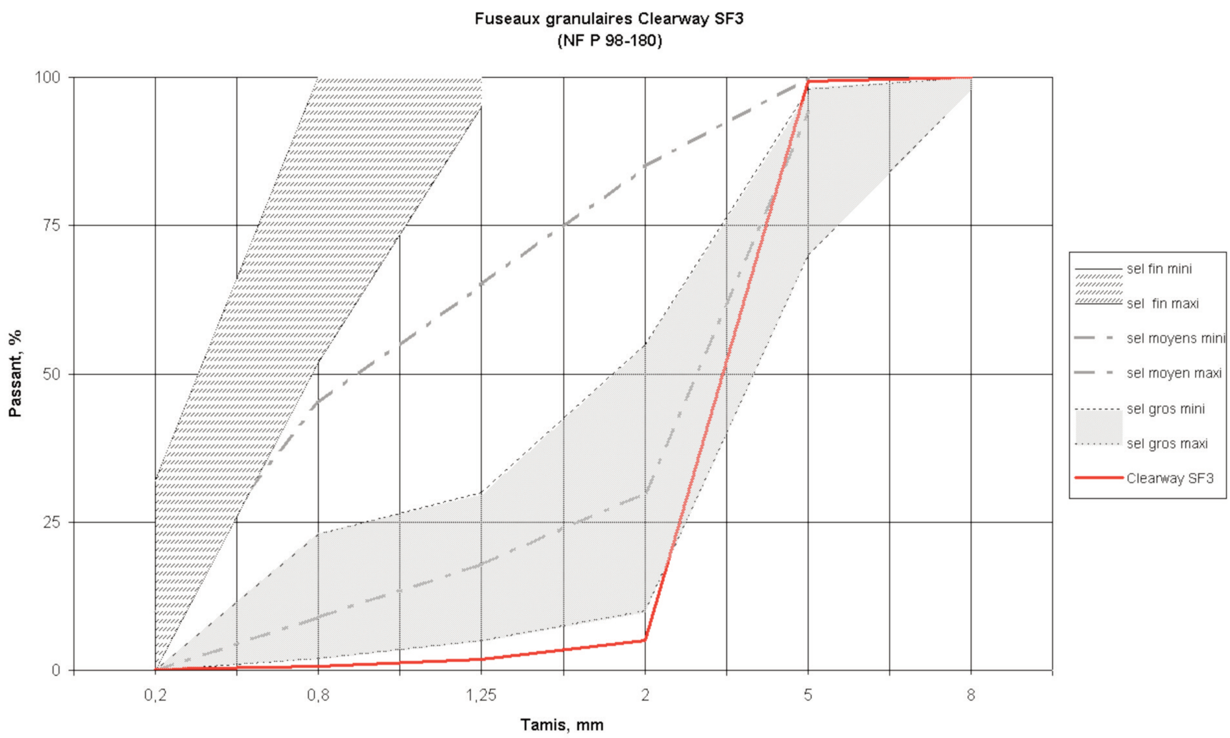
Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.
The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Solid, in the form of irregular pellets	03/10/2010	-
2	Color (visual)	-	white	03/10/2010	-
3	Bulk density	kg/m^3	1010	09/06/2010	LRN in-house method, no.108
4	Active principle [CHOONa]	%	In progress	-	LRN in-house method
5	Particle size	Sieve mesh in mm 0,2 0,8 1,25 2 5 8	Cumulated particle passing measured as a % 0,1 0,7 1,9 5 99,3 100,0	08/05/2010	NF P 98-180 (1)
6	Self-ignition point	°C	> 500	10/22/2010	ASTM E 659 (2)
7	pH	-	10	09/06/2010	NF T 90-008



Test 5 : Particle size

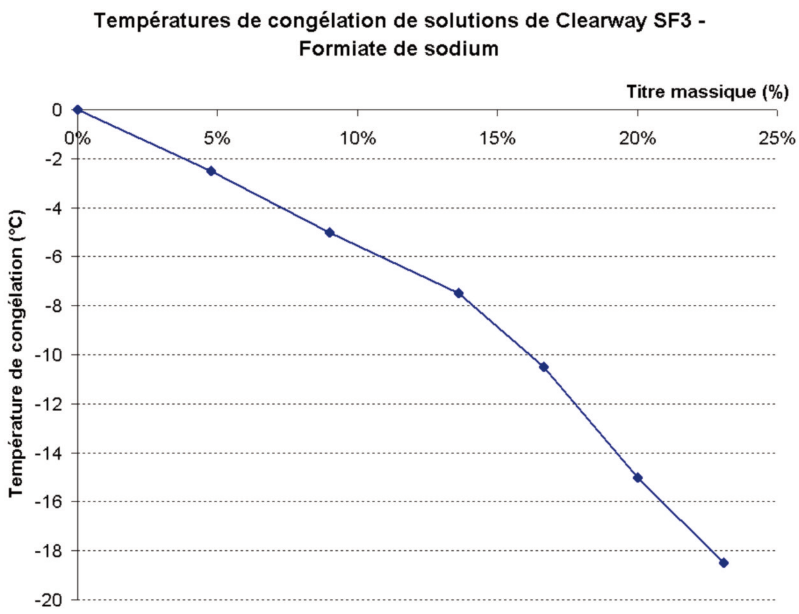
1 - Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.
2 - Standard Test Method for Autoignition Temperature of Liquid Chemicals - 2005.

Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
8	BOD_5 (20 °C)	mg/kg	91360	08/03/2010	NF EN 1899-1 (3)
9	COD	mg/kg	250972	08/03/2010	NF T 90-101 (4)
10	COD/BOD_5	-	2,75	08/03/2010	
11	Biodegradability 20 °C 10 % 50 % 90 %	hours	22 108 148	11/12/2010	NF EN ISO 9888 (5)
12 12a 12b	Acute toxicity for Daphnia CE 50i - 24 hours CE 50i - 48 hours	g/L	4,99 (4,67-5,34) 3,44 (3,10-3,81)	08/20/2010	NF EN ISO 6341 (6)

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
13	Product freezing point as a function of mass percentage (%) Mass percentage : 5 % Mass percentage : 10 % Mass percentage : 15 % Mass percentage : 20 %	°C	-3,3 -6,5 -10,2 -15,7	10/25/2010	LRN in-house method



Test 13 : Product freezing points as a function of mass percentage

3 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
4 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
5 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
6 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on ESTOROB BIO D-icer

Estorob Bio D-icer

NOVANCE BP 20609 60206 VENETTE - France
Runway deicer: Glycerol
Date on which samples were received: January 28 th, 2010

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) he support of airport services in the definition of the criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the “winter maintenance – engineering and equipment” resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

Caution

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(2) - The document produced by the STAC does not deal with the “health risks, customary precautions, handling, storage and disposal” of the products. The product supplier is responsible for providing this information on an SDS (safety data sheet), written in compliance with the European regulation, REACH no. 1907/2006 and with regulation (CE) no. 1272/2008.

(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 “Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways” and AMS 1431 “Compound, Solid Runway and Taxiway Deicing/Anti-Icing” written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

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Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

TN°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	01/28/2010	-
2	Color (visual)	-	Colorless	01/28/2010	-
3	Density	Kg/m³	1177	06/17/2010	NF EN ISO 3838 (1)
4	Kinematic viscosity 20 °C 5 °C -5°C	mm²/s	 20,53 49,21 100,30	10/22/2010	NF EN ISO 3104 (2)
5	pH	-	7,77	06/17/2010	NF T 90-008 (3)
6	Refractive index at 20°C	-	1,4256	02/04/2010	LRN in-house method
7	Active principle [$C_3H_8O_3$]	%	69	12/03/2010	LRN in-house method
8	Conductivity	mS	2,70	06/17/2010	NF EN 27888 (4)
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680 (5)
10	Auto-ignition point	°C	> 500	10/22/2010	ASTM E 659 (6)

*the flame goes out when temperature reaches 90 °C, but the apparatus does not detect a flash.

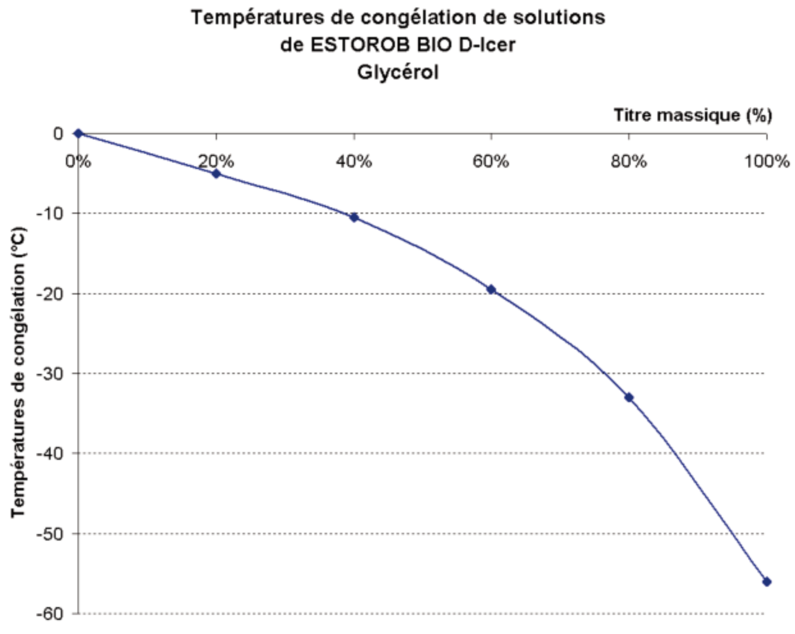
Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
11 12	BOD_5 (20 °C) COD	mg/kg mg/kg	437317 833402	08/03/2010 08/03/2010	NF EN 1899-1 (7) NF T 90-101 (8)
13	COD/BOD_5	-	1,91	11/12/2010	
14	Biodegradability 20 °C 10 % 50 % 90 %	hours	 22 52 135	05/06/2011	NF EN ISO 9888 (9)
15 15a 15b	Acute toxicity for Daphnia CE 50i - 24 hours CE 50i - 48 hours	g/L	 57,6 (52,8-63,6) 22,8 (20,4-25,2)	08/20/2010	NF EN ISO 6341 (10)

1 - Crude oil and liquid or solid petroleum products – Determination of the density - Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004.
2 - Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996.
3 - Water quality – Determination of pH – February 2001.
4 - Water quality – Determination of electrical conductivity – January 1994
5 - Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004.
6 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005
7 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
8 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
9 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
10 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%) Mass percentage: 20 % Mass percentage: 40 % Mass percentage: 60 % Mass percentage: 80 % Mass percentage: 100 %	°C	 -5,0 -10,5 -19,5 -33,0 -56,0	10/25/2010	LRN in-house method



Test 16: Product freezing points as a function of mass percentage

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on CRYOTECH E36

CRYOTECH E36

P R O V I R O N - G. Gilliotstraat 60 - 2620 Hemiksem, Belgium
Runway deicer: Potassium acetate
Date on which samples were received: January 22nd, 2009

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,

(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,

(3) the support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

Caution

(1) - The document produced by the STAC complements the data released by runway deicer suppliers for the attention of airport operators, on the basis of a series of standardized, harmonized tests.

(2) - The document produced by the STAC does not deal with the "health risks, customary precautions, handling, storage and disposal" of the products. The product supplier is responsible for providing this information on an SDS (safety data sheet), written in compliance with the European regulation, REACH no. 1907/2006 and with regulation (CE) no. 1272/2008.

(3) - The document produced by the STAC applies to liquid and solid runway deicers used for the preventive and corrective treatment of airport pavements. It is not a substitution for the standards and specifications in force in this field, in particular AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" and AMS 1431 "Compound, Solid Runway and Taxiway Deicing/Anti-Icing" written by the SAE (Society of Automotive Engineers). These specifications remain the authoritative reference documents for this domain, and each product supplier must therefore comply with the requirements laid out in them.

Use of data

The data presented in this report are the result of a series of tests performed by the STAC with several public and private analytical laboratories. The main document and each of the data sheets refer to the normative or protocol references inherent to each of the tests performed as part of this study. In-house protocols may be made available to a user, upon simple request to the STAC.

IPlease bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.

The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	01/23/2009	-
2	Color (visual)	-	Colorless	01/23/2009	-
3	Density	g/L	1277	05/11/2009	NF EN ISO 3838 (1)
4	Kinematic viscosity 20 °C 5 °C -5°C	mm^2/s	 4,445 7,685 11,94	10/22/2010	NF EN ISO 3104 (2)
5	pH	-	10,68	05/11/2009	NF T 90-008 (3)
6	Refractive index at 20 °C	-	1,3940	09/30/2009	LRN in-house method
7	Active principle [CH_3COOK]	%	52	12/03/2010	LRN in-house method
8	Conductivity	mS	108,9	05/11/2009	NF EN 27888 (4)
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680 (5)
10	Auto-ignition point	°C	> 500	10/22/2010	ASTM E 659 (6)

**the flame goes out when temperature reaches 90°C, but the apparatus does not detect a flash.*

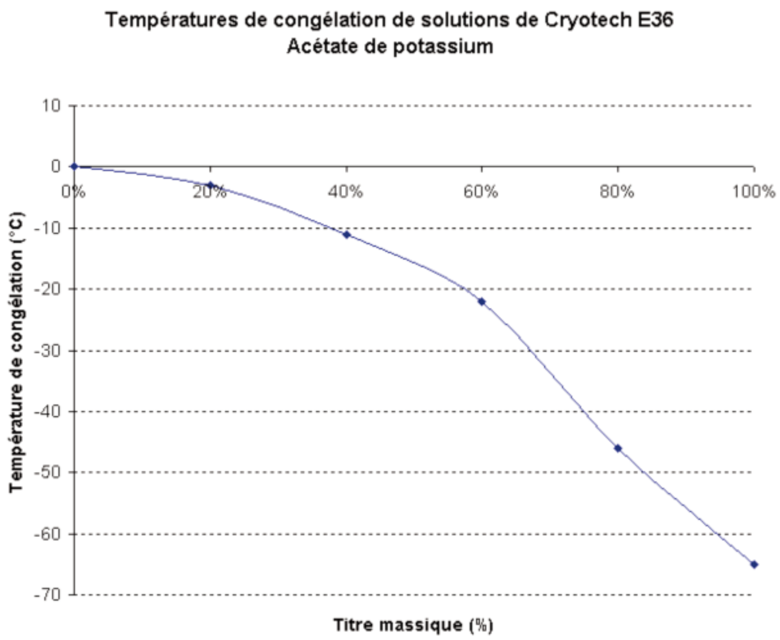
Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
11 12	BOD_5 (20 °C) COD	mg/kg mg/kg	203524 330502	12/08/2009 12/08/2009	NF EN 1899-1 (7) NF T 90-101 (8)
13	COD/BOD_5 ratio	-	1,62	12/08/2009	
14	Biodegradability 20 °C 10 % 50 % 90 %	hours	 4 18 42	05/06/2011	NF EN ISO 9888 (9)
15 15a 15b	Acute toxicity for Daphnia CE 50i - 24 hours CE 50i - 48 hours	g/L	 2,82 (2,56-3,20) 2,56 (2,30-2,94)	07/31/2009	NF EN ISO 6341 (10)

1 - Crude oil and liquid or solid petroleum products – Determination of the density - Method using a capillary plug pycnometer and a graduated bicapillary pycnometer – May 2004.
2 - Petroleum products – Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity – August 1996.
3 - Water quality – Determination of pH – February 2001.
4 - Water quality – Determination of electrical conductivity – January 1994.
5 - Determination of flash/no flash – Rapid equilibrium closed cup method – April 2004.
6 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005
7 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
8 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
9 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
10 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%)				
	Mass percentage : 20 %	°C	-3	11/09/2009	Determination by spectroscopy
	Mass percentage : 40 %		-11		
	Mass percentage : 60 %		-22		
	Mass percentage : 80 %		-46		
	Mass percentage : 100 %		-65		



Test 16 : Product freezing points as a function of mass percentage

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on Cryotech® NAAC

CRYOTECH® NAAC

P R O V I R O N - Industries N.V. Zone 2 - G. Gilliotstraat 60 - 2620 Hemiksem, Belgium
Runway deicer: Sodium acetate
Date on which samples were received: March 10 th, 2010

It is part of a wider test campaign on the assessment of the performance of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,
(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,
(3) the support of airport services in the definition of criteria used for product sourcing.

The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.
The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Data use warnings

Caution

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Use of data

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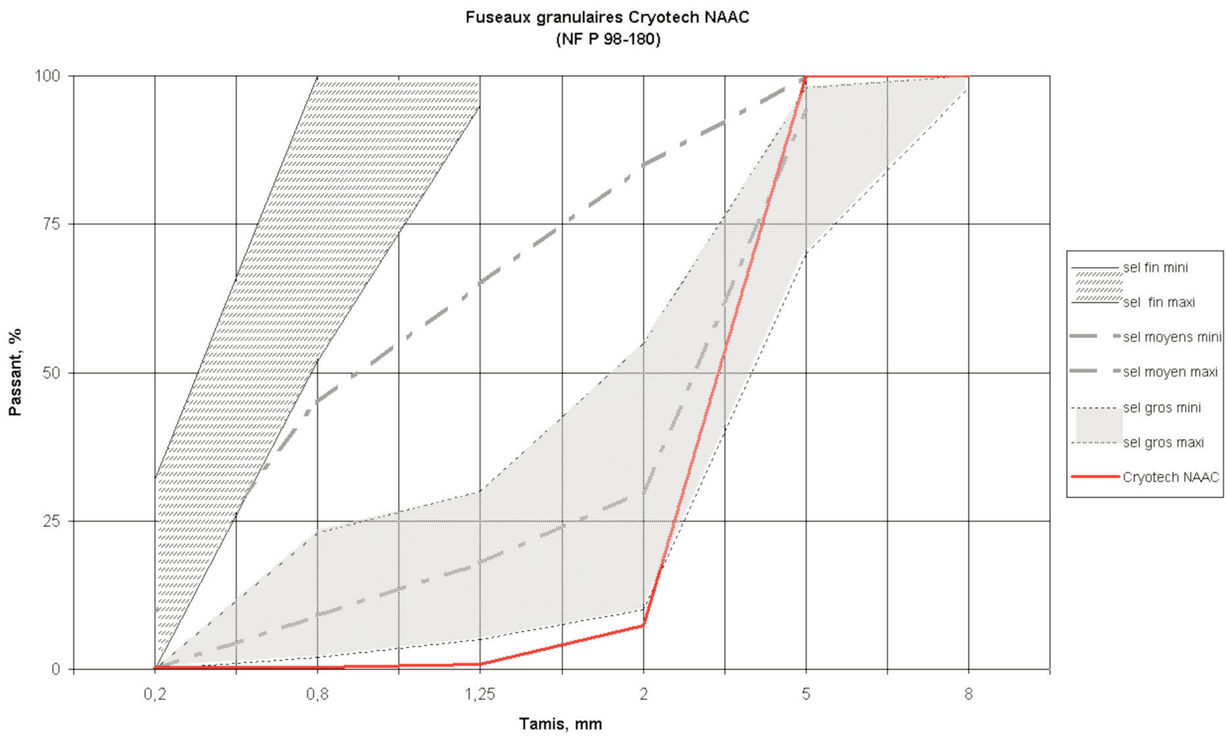
Please bear in mind that the STAC cannot be held liable for the use and interpretation of the data included in this document.
The STAC will inform users of any update, revision or cancellation of part or all of this document.

Physical and chemical properties of the product

N°	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Solid, in the form of beads	03/10/2010	-
2	Color (visual)	-	white	03/10/2010	-
3	Bulk density	kg/m^3	890	09/06/2010	LRN in-house method, no.108
4	Active principle [CH_3COONa]	%	In progress	-	LRN in-house method
5	Particle size	Sieve mesh in mm	Cumulated particle passing measured as a %	08/05/2010	NF P 98-180 (1)
		0,2	0,3		
		0,8	0,4		
		1,25	0,8		
		2	7,3		
		5	100,0		
		8	100,0		
6	Self-ignition point	°C	> 500	10/22/2010	ASTM E 659 (2)
7	pH	-	8,30	09/06/2010	NF T 90-008



Test 5 : Particle size

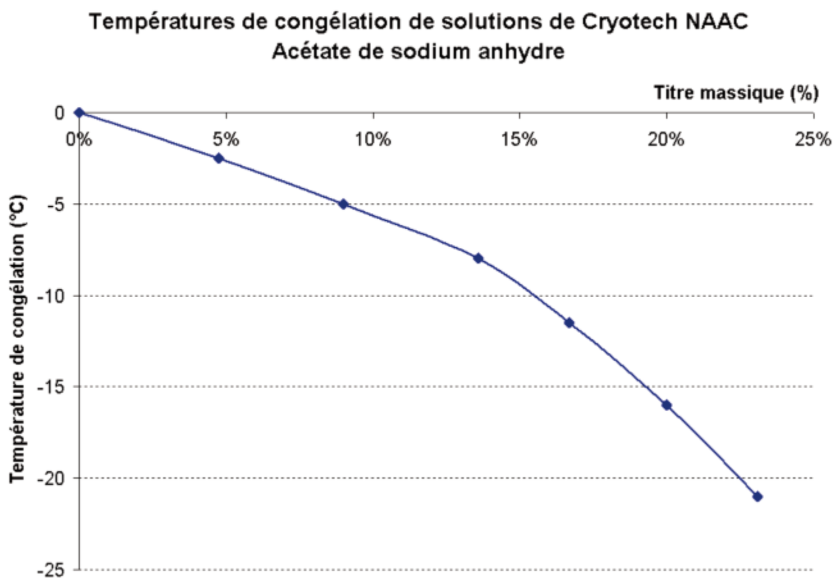
1 - Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.
2 - Standard Test Method for Auto-ignition Temperature of Liquid Chemicals - 2005.

Product toxicity and environmental data

N°	Name	Unit	Values	Date	Normative references
8	BOD_5 (20 °C)	mg/kg	468888	08/03/2010	NF EN 1899-1 (3)
9	COD	mg/kg	719826	08/03/2010	NF T 90-101 (4)
10	COD/BOD_5	-	1,54	08/03/2010	
11	Biodegradability 20 °C 10 % 50 % 90 %	hours	5 20 44	11/12/2010	NF EN ISO 9888 (5)
12 12a 12b	Acute toxicity for Daphnia CE 50i - 24 hours CE 50i - 48 hours	g/L	6,54 (5,04-8,39) 5,15 (4,65-5,70)	08/20/2010	NF EN ISO 6341 (6)

Product effectiveness

N°	Name	Unit	Values	Date	Normative references
13	Product freezing point as a function of mass percentage (%) Mass percentage : 5 % Mass percentage : 10 % Mass percentage : 15 % Mass percentage : 20 %	°C	-3,2 -6,8 -11,2 -17	10/25/2010	Determination by spectroscopy



Test 13 : Product freezing points as a function of mass percentage

3 - Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
4 - Water quality – Determination of chemical oxygen demand (COD) – February 2001.
5 - Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
6 - Water quality – Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) – Acute toxicity test – May 1996 – The values in brackets correspond to the confidence interval at 95 % of the EC50 % (Effective concentration creating an effect on 50 % of the population after 24 hours or 48 hours).

RUNWAY DEICER HOLDOVER TESTS - COMPARISON OF RUNWAY DEICERS

This report is part of the ongoing tests performed by the STAC, on the functional properties of runway deicers which are traditionally used at airport infrastructures. It provides a summary of the results of the analyses carried out on glycerol, potassium and sodium formates and acetates.

LIQUID FORMULATIONS

Potassium acetate based formulations
- Clearway 1 (Kemira)
- Cryotech E36 (Cryotech)
- Safegrip (Abax Industrie)
- Safeway KA HOT (Clariant)

Potassium formate based formulations
- Clearway F1 (Kemira)
- Safegrip FR (Abax Industrie)
- Safeway KF HOT (Clariant)

Glycerol based formulation
- Estorob BIO D-ICER (Novance)

SOLID FORMULATIONS

Sodium acetate based formulations
- Clearway 6S (Kemira)
- Cryotech NAAC (Proviron Industries NV)

Sodium formate based formulations
- Safeway SF (Clariant)
- Clearway SF3 (Kémira)

This document is mainly aimed at airport operators in charge of runway deicing operations. It is a baseline of technical knowledge, enabling the following:

(1) the completion and precision of the data which already exist on the subject, particularly that released by suppliers of runway deicers for the attention of airport operators,
(2) the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,
(3) the support of airport services in the definition of the criteria used for product sourcing.

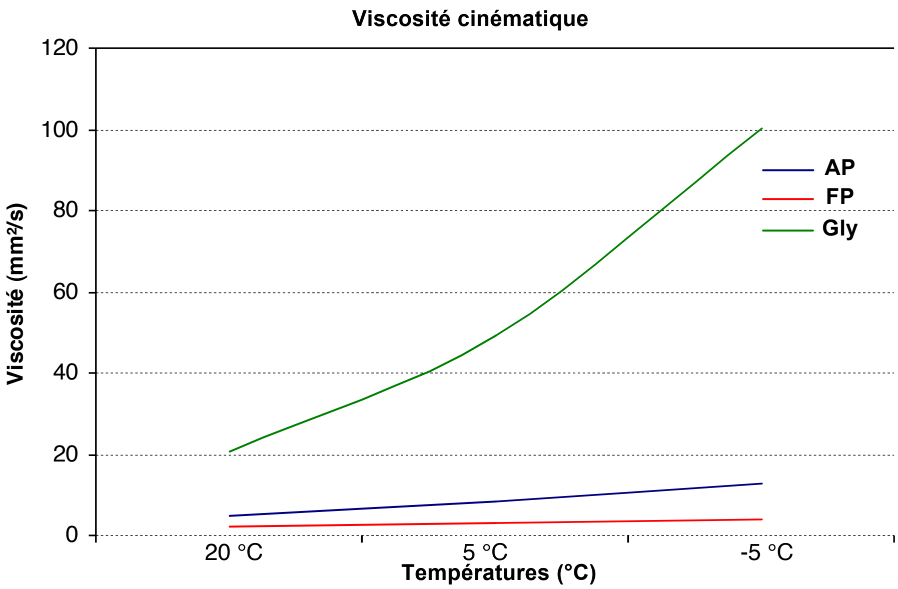
The information presented in this document also contributes to the current thought processes at both national and international levels, concerning the air safety and environmental problems surrounding the use of runway deicers, and the changes in the standards in force on the subject.

The runway deicer holdover tests were organized by the "winter maintenance – engineering and equipment" resource team at the Laboratoire regional de Nancy, under the auspices of the STAC.

Physical and chemical properties of the product

Name	Unit	PA	PF	Gly.	SA	SF
State (liquid/solid)	-	Liquid	Liquid	Liquid	Solid	Solid
Color (visual)	-	Colorless	Colorless	Colorless	+/- irregular pellets	
Density	g/L	1281,75	1348	1177	830*	1050*
Kinematic viscosity						
20 °C	mm²/s	4,68	2,08	20,53	-	-
5 °C	mm²/s	8,19	3,03	49,21	-	-
-5°C	mm²/s	12,79	4,08	100,30	-	-
pH	-	10,62	10,79	7,77	8,40	10,70
Refractive index at 20 °C	-	1,39538	1,38813	1,42560	-	-
Active principle	of the mass	53	52	69	in progress	in progress
Conductivity	mS	105,35	229,23	2,70	-	-
Flash point	°C	> 90	> 90	> 90	-	-
Auto-ignition point	°C	> 500	> 500	> 500	> 500	> 500
Particle size						
0,2 mm	%	-	-	-	0,2	0,15
0,8 mm	%	-	-	-	0,35	0,95
1,25 mm	%	-	-	-	0,70	2,35
2 mm	%	-	-	-	6,9	13
5 mm	%	-	-	-	99,8	98,20
8 mm	%	-	-	-	100	100

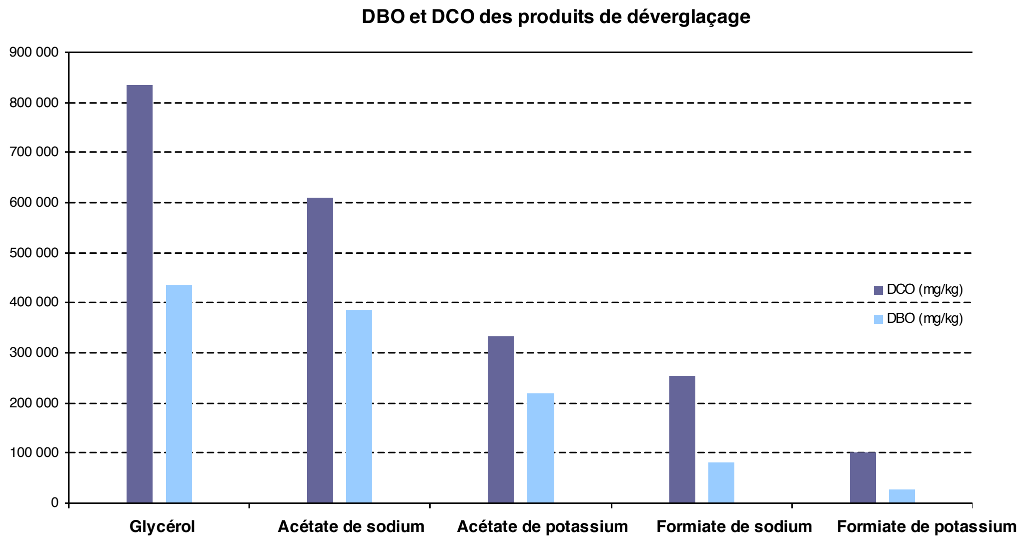
The values shown in the table correspond to mean values calculated using 4 potassium acetates (PA), 3 potassium formates (PF), 1 glycerol (Gly), 2 sodium formates (SF) and 2 sodium acetates (SA).
** Values in kg/m3.*

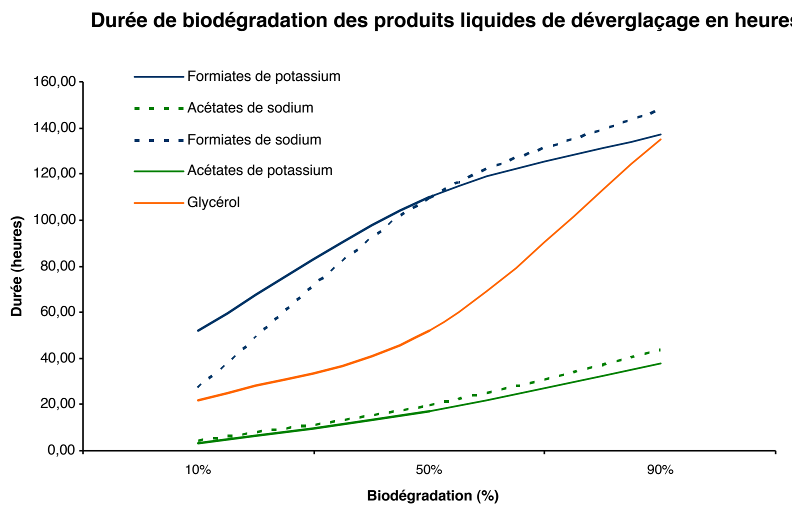


Product toxicity and environmental data

Name	Unit	PA	PF	Gly.	SA	SF
BOD_5	mg/kg	220428	27325	437317	386631	79762
COD	mg/kg	333317	101365	833402	610200	255518
COD/BOD_5	-	1,52	8,76	1,91	1,59	3,28
Biodegradability						
10 %	Hours	3	52	22	4,5	27
50 %		17	110	52	19,5	109,5
90 %		38	137	135	43,5	148
Acute toxicity for Daphnia						
CE 50i - 24 hours	mg/L	2560	2646,7	57600	9320	4585
CE 50i - 48 hours		2432,5	2513,3	22800	7675	3170

The values shown in the table correspond to mean values calculated using 4 potassium acetates (PA), 3 potassium formates (PF), 1 glycerol (Gly), 2 sodium formates (SF) and 2 sodium acetates (SA).

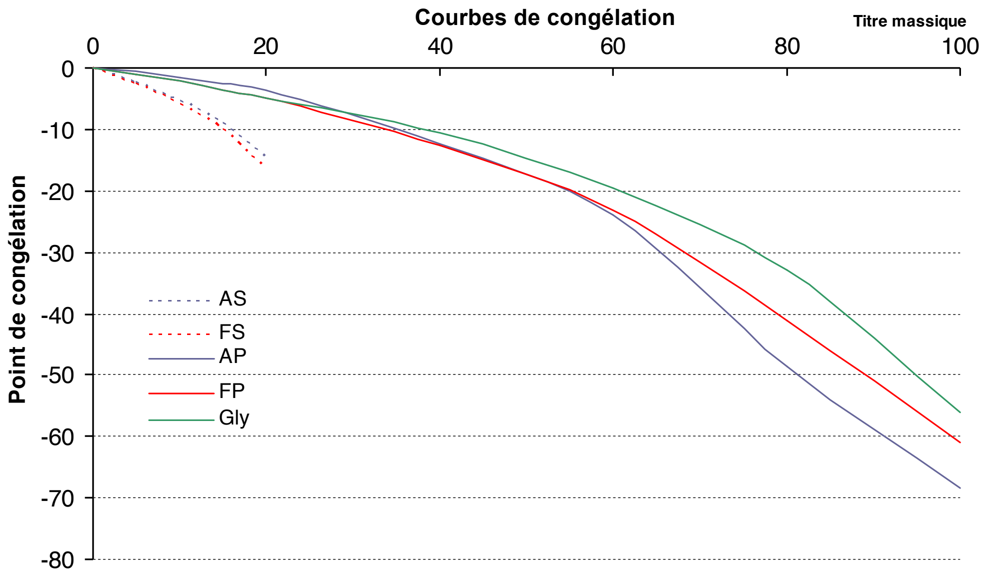




Product effectiveness

Name	Unit	PA	PF	Gly.	SA	SF
Product freezing point as a function of mass percentage						
Mass percentage: 5 %		-	-	-	-3	-3,4
Mass percentage: 10 %		-	-	-	-6,4	-7,2
Mass percentage: 15 %		-	-	-	-10,5	-11,7
Mass percentage: 20 %	°C	-3,5	-5	-5	-15,7	-17,4
Mass percentage: 40 %		-12,3	-12,7	-10,5	-	-
Mass percentage: 60 %		-24	-23,2	-19,5	-	-
Mass percentage: 80 %		-48,5	-41,2	-33	-	-
Mass percentage: 100 %		-68,5	-61	-56	-	-

The values shown in the table correspond to mean values calculated using 4 potassium acetates (PA), 3 potassium formates (PF), 1 glycerol (Gly), 2 sodium formates (SF) and 2 sodium acetates (SA).



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December 2011

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