French civil aviation authority

Civil aviation technical center

December 2016

Characterization of runway deicers

Study report

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Abstract

This new study corroborates the first data published in 2009 and in 2011, on the assessment of the performance of runway deicers used by airport operators for their winter activity.

17 formulations (12 liquids and 5 solids) have been studied. All the results are presented in this report, 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 edition has been revised 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
- the results are presented per product and not per product family, to facilitate their analysis using the various criteria assessed in this report,
- all the product data sheets have been updated so as to integrate the results of new products.

This study has received technical assistance from the "Winter Maintenance" team of ICE (Infrastructure Climate Environment) Group of the Regional Laboratory of Nancy (CEREMA). All product samples were made available to the STAC (French civil aviation technical center) by producers.

Keywords

Airport – runway – de-icing – deicer – winter maintenance – physical - chemical – environment - performance

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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 edition is part of the 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 de-snowing and deicing pavements, and is a baseline of technical knowledge, enabling the following:

1. the comparison of the physical, chemical, environmental, toxicological and functional specificities of the products,
2. 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,
3. the improvement of the use of products, and consequently the optimization of the operational procedures and the mitigation of air safety and environmental risks,
4. 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.

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 runway deicers and recommendations for use: commented analysis of the tests performed by the STAC. 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. Caution on the use of data

◢ 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 "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.

4. All of the criteria studied by airport managing authorities to choose a supplier are much wider than the technical and scientific approach described in this document. Indeed, requirements such as procurement lead times, costs and supplier-buyer relationships are not included in this analysis. The results obtained and described in this report cannot be used in place of the multi-criteria analysis conducted by an airport managing authority to choose a particular supplier.

◢ 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 3.1 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.

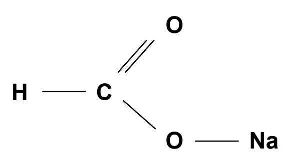
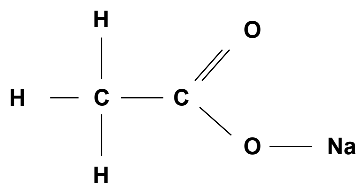
2. Runway deicers : how they are used, how they work, how they are chosen

Runway deicers are used at airports during the winter period to guarantee air traffic safety by preventing, delaying or minimizing the formation of ice accretion on the pavement (preventive treatment) or by stimulating the melting of the contaminant such as ice, snow or glaze (corrective treatment often in addition to de-snowing operations). The operating principle of these products is based on depressing the freezing point of the water on the road. Using these products helps to maintain a sufficient adherence level for the safety of vehicles operating at these airports.

2.1. Product composition

There are two distinct types of the most commonly used runway deicers at airports :

- **solid formulations** made up of sodium formates or acetates,

Sodium formate	Sodium acetate
HCOONa	CH_3COONa
	

- **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.

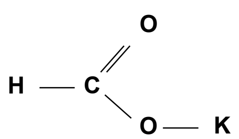
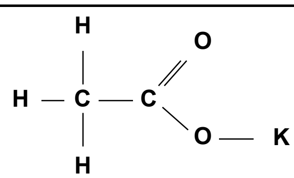
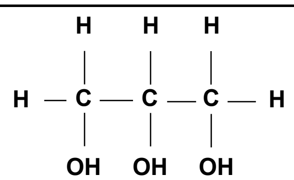
Potassium formate	Potassium acetate	Glycerol
HCOOK	CH_3COOK	$C_3H_8O_3$
		

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

17 off-the-shelf formulations used in France were analyzed as part of this study. Out of the 17 products tested, 5 were solid (3 sodium formates and 2 sodium acetates) and 12 were liquid (5 potassium formates, 5 potassium acetates and 2 glycerols).

	Traditional runway deicers				*New generation runway deicers*				
	Potassium acetate	*Potassium formate*	*Sodium acetate*	*Sodium formate*	*Glycerol*	*Potassium acetate + Glycerol*	*Propanediol*	*Potassium acetate + propanediol*	*Potassium acetate + Sodium acetate + Propanediol*
Abax Industrie	*Safegrip*	*Safegrip FR*							
Clariant	*Safeway KA Hot*	*Safeway KF Hot*		*Safeway SF*					
Proviron Industries NV	*Cryotech E36 Provifrost KA ECO*	*Provifrost KF ECO*	*Cryotech NAAC (anhydre)*				*XT 360*	*BX 36*	*EX 180*
Kemira	*Clearway 1 Clearway 3*	*Clearway F1*	*Clearway 6S (tri-hydraté)*	*Clearway SF3*					
Novance					*Estorob Bio D-icer*				
Basic solutions						*GEN 3*			
Addcon		*Aviform L-50*		*Aviform S-solid*					

The products studied in this report are in brown

Table 1: List of the main runway deicers

Each product must comply with one of the following international specifications:

- **Liquids:** AMS 1435 "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways" (SAE)
- **Solids:** AMS 1431 “Compound, Solid Runway and Taxiway Deicing/Anti-Icing” (SAE)

In addition to the previous specifications, as far as new formulations are concerned, on-site tests and the insertion of performance criteria in purchasing contracts (SHRP - Strategic Highway Research Program - Methods) are extra warranties of product effectiveness.

Potassium and sodium formates and acetates

When acetic and formic acid bases 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.)

- Composition of liquid deicers (potassium acetates and formates) : active ingredient (~ 50 %), water (~ 50 %) and additives (1 to 5 %).

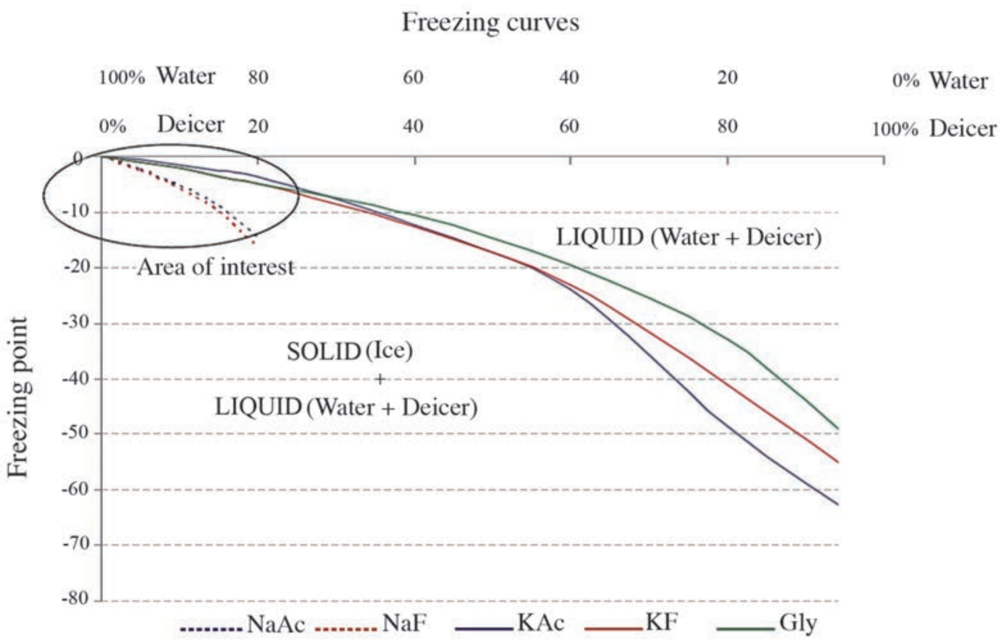
- Composition of solid deicers (sodium acetates and formates) : active ingredient (~ 100 %) and additives (1 to 5 %).

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 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.

- Composition of products of vegetable origin : active ingredient (~ 70 % (either pure or combined with an acetate or formate), water (~ 30 %) and additives (1 to 5 %)[1].

2.2. Runway deicer 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 1 shows the freezing points of solutions at different 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 percentage							
	5%	10%	15%	20%	+0%	60%	80%	100%
Potassium acetates (KAc)				-3.5	-12.2	-24	-48.5	-68.5
Potassium formates (KF)				-5	-12.6	-23.1	-41.1	-61
Glycerol (Gly)				-5	-10.5	-19.5	-33	-56
Sodium acetates (NaAc)	-2.3	-5.3	-9	-14.7				
Sodium formates (NaF)	-2.6	-5.9	-10.1	-16.5				

Figure 1 : Freezing curves for runway deicers

A contaminant (snow, glaze, rime, etc.) changes 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 quantity and temperature. A runway deicer only works properly if it is soluble (liquid).

[1] ***Percentages obtained after in-house measurements***

When a solid runway deicer is spread in the form of granules or pellets, it becomes hydrated, unlike liquid deicers which act directly. 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:

- Depressing the surface temperature by harnessing the ice melting equivalent[2]: 334 J/g (Figure 2)
- Dilution of the solution via the addition of meltwater (leading to an increase in the solution's freezing point).

If the environmental temperature is relatively low, the additional cooling may lead to a blockage in the melting process, or even to regelation.

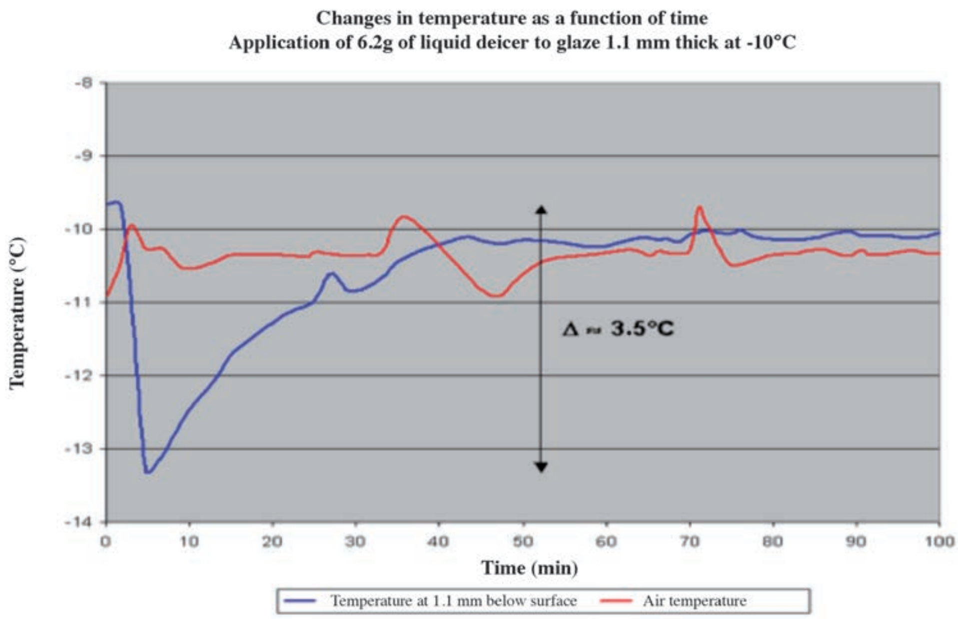


Figure 2: Changes in temperature when liquid deicer is applied to glaze at -10°C

[2] ***Energy needed for water to change from solid state to liquid state***

◢ Preventive treatment of glaze or snow

The aim of this treatment strategy is to avoid or delay the formation of ice on the pavement (small amount of water) or to minimize the adherence of ice on the pavement (large amount of water) to facilitate subsequent mechanical operations. This strategy can be used when you do not want to harness the ice or snow melting equivalent, and to therefore avoid any additional cooling of the pavement.

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

◢ Corrective treatment of glaze

▸ A liquid deicer works by progressively "eroding/melting" the glaze 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.

◢ Corrective treatment of snow (Figure 3)

Nota: Snow is only treated with such 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). If there is no mixing by the traffic, this type of treatment is usually not very effective.

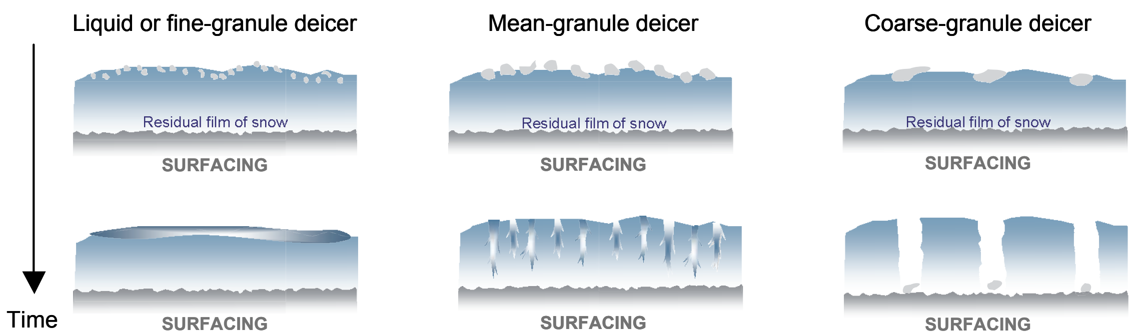


Figure 3: Runway deicer operating principles during corrective treatment

2.3. The use of mixed products (liquid-solid mixes)

In regard of the way liquid and solid deicers work, simultaneously spreading a liquid and a solid may lead to gains in effectiveness:

- Due to their typology, liquid deicers will adhere to the surface, while solid deicers will tend to bounce when they are spread, and to be swept away by wind or traffic. Under certain weather conditions and depending on the surface conditions, a mixed treatment can be used to make the solid deicer stick to the surfacing thanks to the liquid deicer.
- Spreading a mixed deicer combines the advantages of an action that is both instantaneous (liquid) and long-lasting (solid).

This technique has been demonstrated on roads, and is known as "slurry" or the "wet salt technique". It is being used at airports, even if not many use it for now.

Managing authorities are advised to contact their supplier, who is the only person able to ensure that the mixed products are compatible with the standards.

The optimum proportions depend on several aspects, mainly related to the operator's quality goals:

- Solid deicers must stick to the dry surfacing to avoid being scattered by the wind. The ratio of 80 % solid and 20 % liquid optimizes the coating of the pellets without using too much liquid (for the studied product). This type of spreading is adapted to preventive treatment. The proportions currently found go as far as 35 % solid and 65 % liquid.
- For airports with high service levels (very short time to get back to normal traffic conditions), the action of the liquid deicer must be dominant compared to that of the solid deicer, therefore reducing the time it takes to act. Solid deicers are designed to spread active molecules over a longer period of time. The proportions of the liquid deicer should be increased accordingly.

It is currently recommended to spread solid and liquid deicers in succession, and to not use the prehumidifcation technique (mixing before spreading sometimes difficult, change in the mix over time).

2.4. 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 4, 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,
- 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 (preventive or corrective treatment strategies, quality goals, time taken to get back to reference conditions, etc. with reference to the airport's snow plan),
- Air traffic control requirements (no interruption to air traffic, 24 hours a day operation, etc.),
- Procurement lead time,
- Etc.

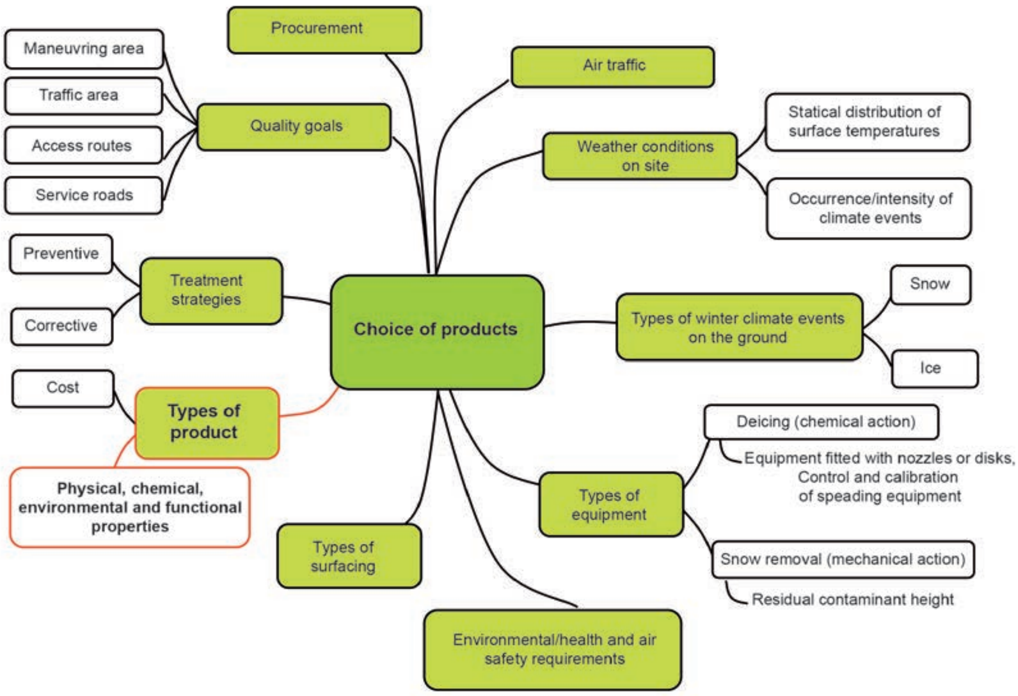


Figure 4 : Criteria for choosing runway deicers

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.

3. Performance of runway deicers and recommendations for use

The information given in this section of the report comes from the physical, chemical, environmental and performance 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.

3.1. Presentation of the runway deicer performance tests

The runway deicers have been analyzed with reference to three main groups of properties:

- physical and chemical properties
- environmental properties
- functional properties

❋ The physical and chemical properties of the deicers are defined in accordance with the following tests:

Test: Visual appearance and state

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/m^3.
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/m^3.
Test performed on solids.

Test : Kinematic viscosity

Normative reference : NF EN ISO 3 104*

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 mm^2/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 the hydrogen ions in a solution. Its measurement is used to 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*

Définition : 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 3 680*

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.*

❋ The physical and chemical properties of the deicers are defined in accordance with the following tests:

Test: Biochemical oxygen demand

Normative reference: NF EN 1 899-1*

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 chemical 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/BOD_5 ratio < 2: the effluent is readily biodegradable,
- COD/BOD_5 ratio between 2 and 3: the effluent is fairly biodegradable,
- COD/BOD_5 ratio > 3: the effluent is not readily biodegradable.

Test performed on liquids and solids.

Test: Duration of biodegradation

Normative reference: NF EN ISO 9 888

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 Daphnids

Normative reference: NF EN ISO 6 341*

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.***

✱The functional properties of the deicers are defined in accordance with the following tests:

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 with respect to the solution's mass percentage. It is completed by the deicer's freezing curve.

Test performed on liquids and solids

Test: Ice-melting

Normative reference: SHRP 205.2 method developed by SAE G12 - AIR6170

Definition: This measurement is used to express the melting capacity of a deicer, expressed in grams of melted ice per gram of applied deicer.

Test performed on liquids and solids.

3.2. Physical and chemical properties of runway deicers

3.2.1. General appearance of the products

The deicers are in two different forms: liquid and solid.

◢ Liquids

Liquid deicers must be homogenous and of uniform color (colorless or slightly colored) or bluish[3]. The visual appearance of the 12 liquid deicers studied in this report is given below (Table 2).

	Potassium formate					*Potassium acetate*					*Glycerol*	
	SAFEWAY KF HOT	*SAFEGRIP FR*	*CLEARWAY F1*	*PROVIFROST KF ECO*	*AVIFORM L50*	*SAFEWAY KA HOT*	*CRYOTECH E36*	*SAFEGRIP*	*CLEARWAY 1*	*PROVIFROST KA ECO*	*ESTOROB BIO D-ICER*	*GEN 3*
Visual appearance	*Colorless, light orange*	*Colorless*	*Colorless*	*Colorless*	*Colorless*	*Colorless*	*Colorless*	*Colorless*	*Colorless*	*Colorless*	*Colorless*	*Colorless*

Table 2: Visual appearance of liquid runway deicers

According to these results, all the deicers are colorless except for Safeway KF Hot that is slightly orange.

The viscosity of liquid deicers depends on their temperature: their viscosity increases as their temperature decreases (Figure 5). The differences within the same product family are minimal. However, the viscosity and sensitivity to temperatures vary depending on the formulation used (structure and complexity of the active molecule).

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 tend to be used at all airports, especially those exposed to harsh winter conditions entailing significant changes in temperature.

Although the quantities spread per m² may seem relatively small (20 to 50g/m²), products with a high viscosity are likely to create problems of operational adherence, particularly in the case of preventive use.

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 5).

[3] ***The colors of runway deicers are specified in section 3.1.2 of AMS 1435C "Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways"***

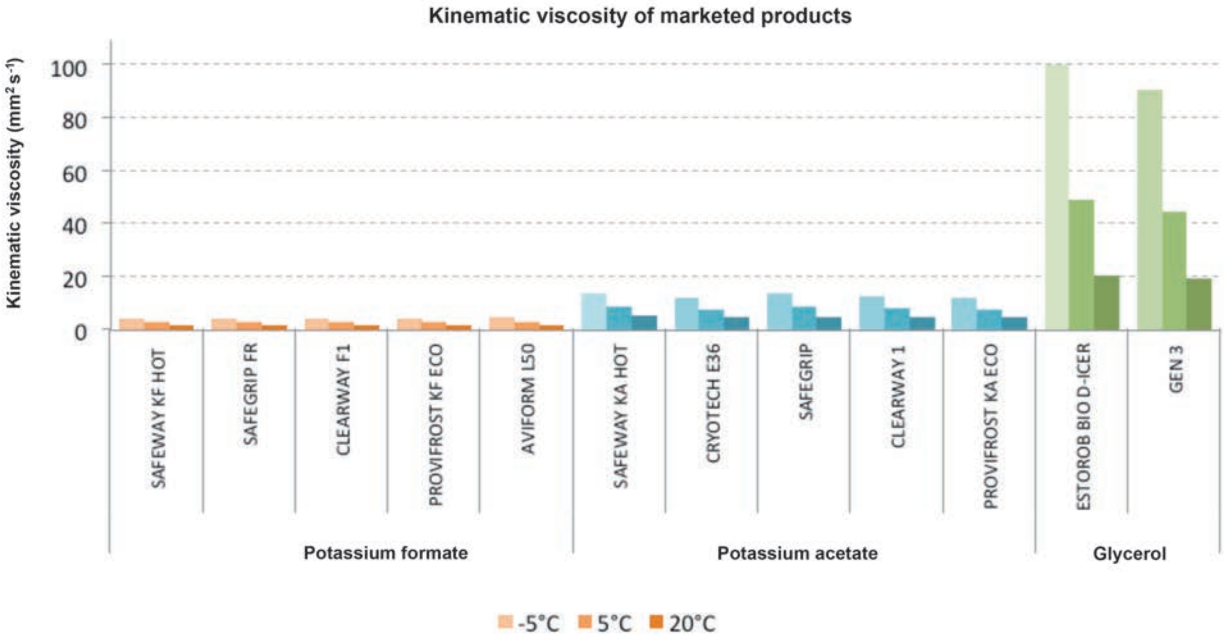


Figure 5 : Kinematic viscosity of liquid runway deicers as a function of temperature

◢ Solids

Solid deicers are in the form of white pellets. The visual appearance of the 5 solid deicers studied in this report is given below (Table 3).

	Sodium formate			*Sodium acetate*	
	SAFEWAY SF	*CLEARWAY SF3*	*AVIFORM S-SOLID*	*CRYOTECH NAAC*	*CLEARWAY 6S*
Visual appearance	*White, irregular pellets*	*White, irregular pellets*	*White, irregular pellets*	*White, regular beads*	*White, irregular pellets*

Table 3 : Visual appearance of solid runway deicers

According to these results, all the deicers are in the form of white, irregular pellets except for Cryotech NAAC that is in the form of white beads (in the middle of the figure below (Figure 6)).

Figure 6 : Visual appearance of solid deicers

The specific contact surface plays a role in the effectiveness of the products, and particularly during the hydration phase. This 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.

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 (Figure 7). Despite the size of the pellets, these products remain particularly friable and powdery. You must therefore take special precautions when using them.

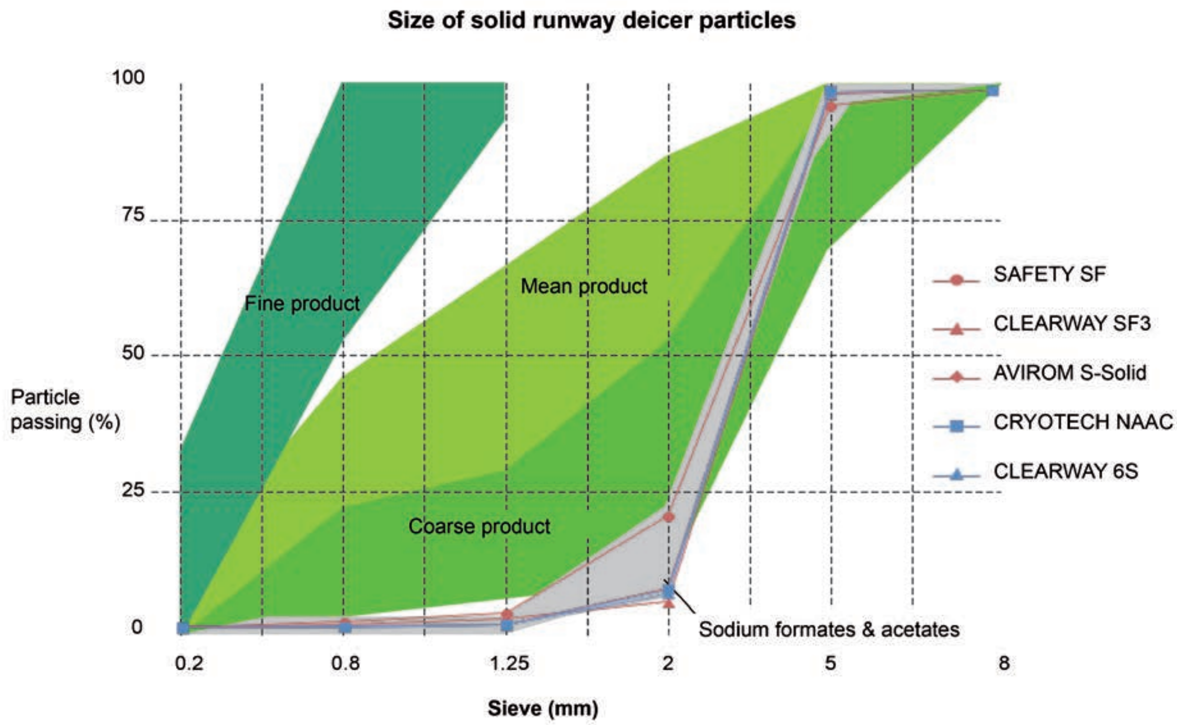


Figure 7 : Size-distribution curves for solid runway deicers – Comparison with the particle-size brackets of standard NF P 98-180

There is a close link between the fluidity of solids coming out of the spreaders, and the deicer particle size and moisture content (between 0.5 and 0.6 % of water for sodium formates, and between 1.5 and 16.5 % of water (for the trihydrate form) for sodium acetates).

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), of uniform color (colorless, or if slightly colored).

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 with the product used, 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 of personal 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.).

3.2.2. Product density

Density is an interesting lever when you need to size the technical equipment to be implemented, to provide 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 deicers is higher than the bulk density of solid deicers (Figure 8). This can be explained by the fact that solid deicers do not fill all of a given volume (space between granules), while liquid deicers fill all of the given volume.

The density of liquid runway deicers varies slightly depending on the type of products. The density of potassium formates is slightly higher than that of potassium acetates, while the density of glycerol based products is slightly lower. The variations within the same product family are minimal, except for glycerol based products. This can be explained by the difference in composition: 70 % glycerol or 50 % glycerol + 20% acetate.

There is a greater amplitude of variation of the bulk density of solid deicers between the two types of product (sodium acetates have a lower bulk density than sodium formates). This is also true for the same product family.

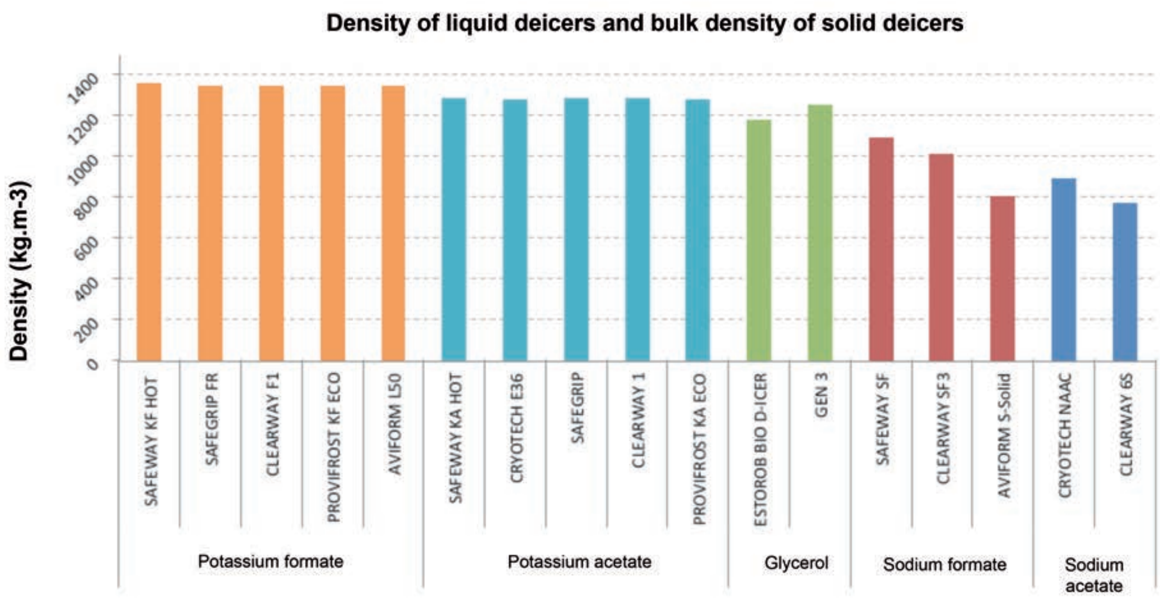


Figure 8: Density (bulk density for solids) of runway deicers

◢ 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 20 000 tons of runway deicer:

- Potassium formates require a mean available volume of 14 850 m^3,
- Potassium acetates require a mean available volume of 15 620 m^3,
- Glycerol based products require a mean available volume of 16 480 m^3,
- Sodium formates require a mean available volume of 20 640 m^3,
- Sodium acetates require a mean available volume of 24 100 m^3,

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 (Table 4), 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	20 g/m²	30 g/m²	40 g/m²	50 g/m²
	Dosage per ha (kg/ha) Dosage for 1 runway of 13.5 ha (T/runway)	200 2.70	300 4.05	400 5.40	500 6.75
Potassium formate (1350 kg/m3)	Dosage per ha (m3/ha) Volume required per runway (m³)	0.148 2.00	0.222 3.00	0.296 4.00	0.370 5.00
Potassium acetate (1280 kg/m3)	Dosage per ha (m3/ha) Volume required per runway (m³)	0.156 2.11	0.234 3.16	0.313 4.21	0.391 5.27
Glycerol based products (1210 kg/m3)	Dosage per ha (m3/ha) Volume required per runway (m³)	0.165 2.23	0.248 3.35	0.331 4.46	0.412 5.58
Sodium formate (970 kg/m3)	Dosage per ha (m3/ha) Volume required per runway (m³)	0.206 2.78	0.309 4.18	0.412 5.57	0.515 6.96
Sodium acetate (890 kg/m3)	Dosage per ha (m3/ha) Volume required per 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 required per runway (m³)	0.260 3.51	0.390 5.26	0.519 7.01	0.649 8.77

Table 4: Comparison of the volumes of deicer required to treat a runway depending on the type

For the same guidelines, the volume of product needed to treat a runway will be lower for liquid deicers. For the same form of product (liquid or solid), a formate-based treatment will require a lower volume of product. The spreaders loaded with formates will be generally more autonomous than the spreaders loaded with (liquid or solid) acetates or glycerol.

3.2.3. Flash point and autoignition temperature 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, carbon brakes, etc.). At certain temperatures, the runway deicers may self-ignite and release noxious fumes.

The tests performed as part of this study indicate that liquid and solid formulations have flash points above 90°C and autoignition temperatures above 500°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.

RECOMMENDATION

According to the safety data sheets, some deicers decompose when heated, producing noxious fumes. So, even if the flash points and autoignition temperatures 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.

3.2.4. 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 G12 "deicing" committee and by the ACRP[4] 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).

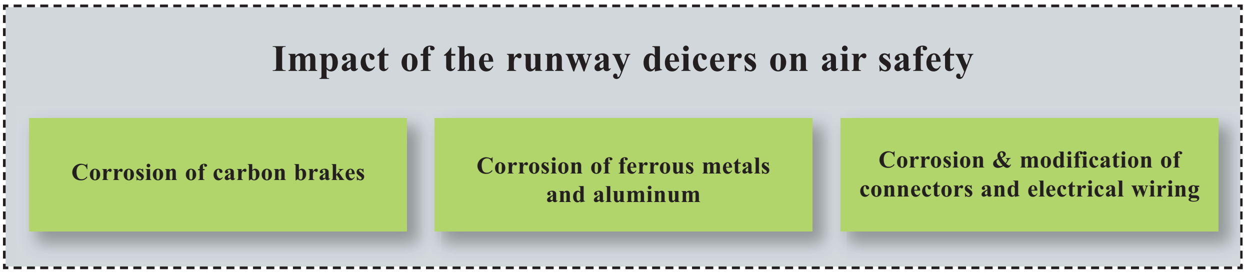


Figure 9: Main effects of runway deicers on aircraft and airport materials

Generally speaking, the salts present in water increase the electrical conductivity of a solution. This physical property contributes to corrosion[5], despite the addition of corrosion inhibitors to traditional runway deicers. So, a runway deicer with high conductivity may modify materials and cause electrical malfunctions.

[4] *Airport Cooperative Research Program (which is sponsored by the Federal Aviation Administration).*

[5] *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.*

The figure below (Figure 10) represents the conductivity of different runway deicers used in France. The conductivity of solid deicers was measured after solution heat treatment at 30 % mass percentage. It therefore cannot be compared directly with the conductivity of liquid deicers.

Generally speaking, formate-based products have a higher conductivity than acetate or glycerol-based products.

Due to the fact that the proportions of corrosion inhibitors in off-the-shelf formulations are not the same, electrical conductivity is not the same as corrosiveness. Additional investigations need to be conducted to compare the products.

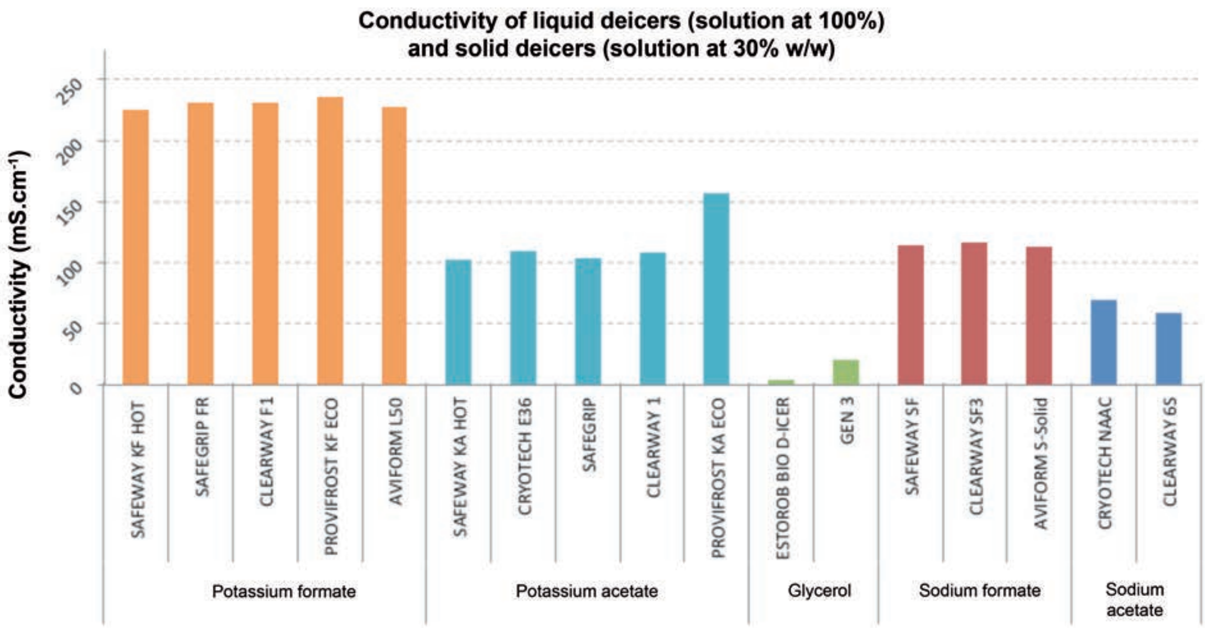


Figure 10: Conductivity of liquid runway deicers (solution at 100%) and solid runway deicers (solution at 30 % w/w)

◢ 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 runway deicers 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 depressing the temperature at which oxidation appears, and by accelerating it (Table 5).

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
700 °C	4 minutes

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

Despite the fact that all traditional products are concerned by this phenomenon, potassium formate-based formulations seem particularly incriminated in catalytic oxidation (Table 6).

	Masse moléculaire (g/mol)	Part du potassium	Part du sodium
Potassium formate ($KCHO_2$)	84	**46.43 %**	-
Potassium acetate ($KC_2H_3O_2$)	98	39.80 %	-
Sodium formate ($NaCHO_2$)	68	-	33.80 %
Sodium acetate ($NaC_2H_3O_2$)	82	-	28 %

Molecular masses (g/mol): MK: M_K = 39, M_{Na}: = 23, M_C = 12, M_H = 1, M_O = 16.

Table 6: Molecular mass of runway deicers and percentage of cations in them

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 explored. 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 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 metallic alloys), and make any test results on this subject available for consultation.

3.3. 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.

3.3.1. Acute toxicity of runway deicers

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 the acute toxicity (Figure 11) of these products on Daphnids, the off-the-shelf formulations used in France may be considered as being of relatively low toxicity (EC50[6] higher than 0.1 g/L[7], the lowest being 1.2 g/L).

The comparison of the liquid and solid formulations of acetate and formate-based deicers shows that, generally speaking, toxicity is lower for solid deicers currently used (as the EC50 is higher) and slightly higher for formate-based products.

[6] Concentration at which 50 % of the tested organisms died (or were immobile, for Daphnids).

[7] Commission Directive 93/21/EEC of 27 April 1993 adapting to technical progress for the 18th time Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labeling of dangerous substances.

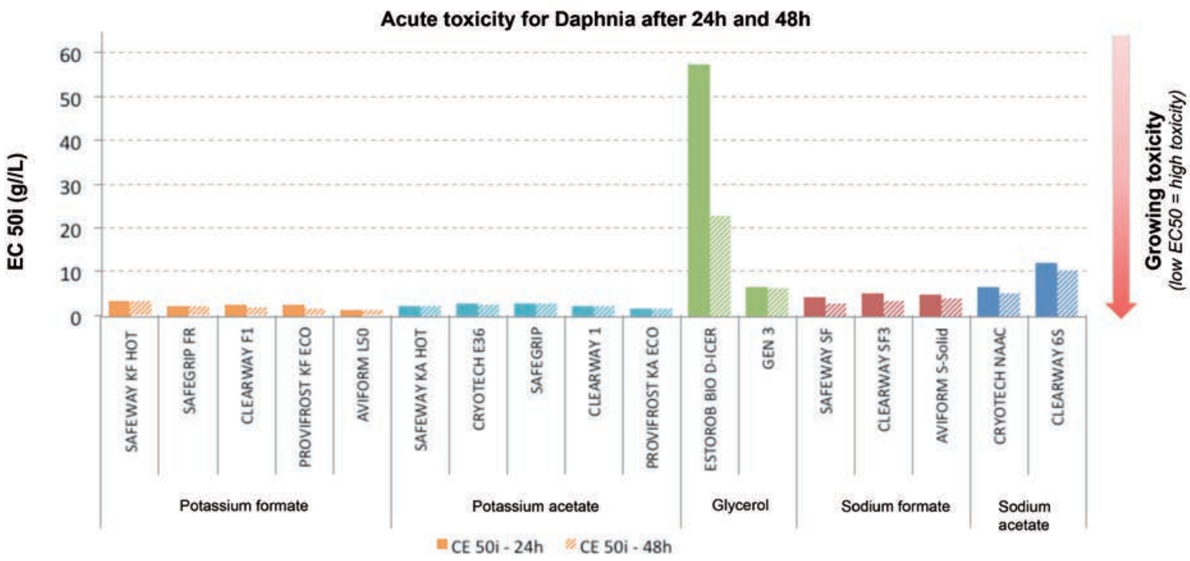


Figure 11 : Acute toxicity of runway deicers (test performed on Daphnia magna)

Glycerol-based deicers turn out to be the ones with the least impact on Daphnids.

3.3.2. 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.

◢ Organic load of the products

The organic load is identified at airports using the measurement of several parameters such as BOD_5[8], COD[9] or TOC[10], each of these parameters expresses a degree of organic and/or mineral pollution of an effluent or a solution. Generally speaking, they are used to understand the environmental impact of runway deicers.

COD represents the amount of oxygen needed to degrade organic and mineral substances thru chemical oxidation. It is related to the amount of carbon in the substance to be degraded. This is how glycerol has a higher COD than acetates and formates. Moreover, solid deicers require more oxygen to be degraded than liquid deicers for the same base (formate or acetate).

[8] ***BOD : Biochemical Oxygen Demand***
[9] ***COD : Chemical Oxygen Demand***
[10] ***TOC : Total Organic Carbon***

Likewise for the BOD_5, the longer the carbon chain of a molecule, the more biodegradable material there is. The BOD_5 in glycerol (3 carbon) is therefore higher than in acetates (2 carbon) or formates (1 carbon). Solid deicers require more oxygen to be degraded than liquid deicers for the same base (formate or acetate).

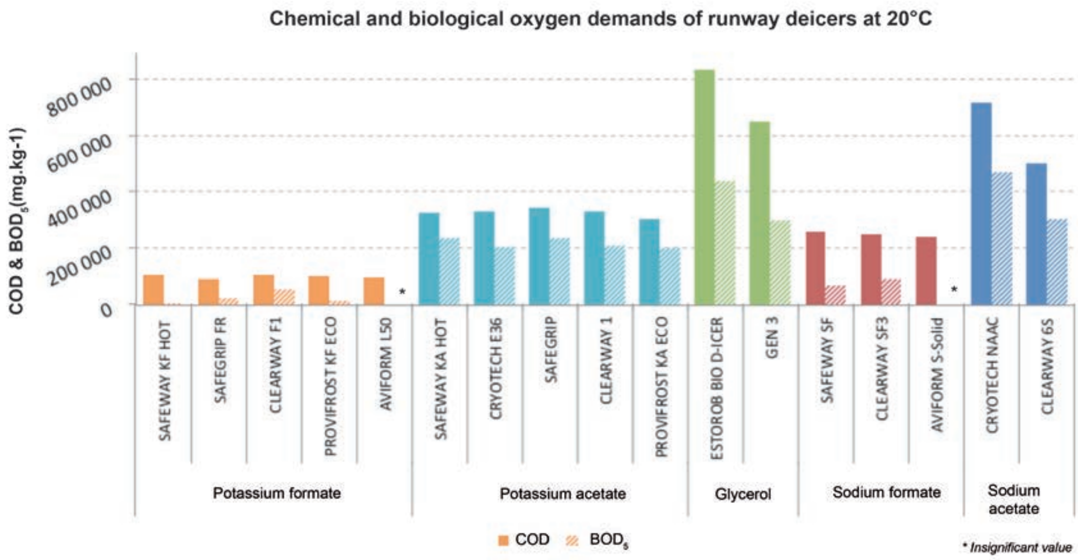


Figure 12: Chemical and biochemical oxygen demands of runway deicers at 20°C

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 as they require a lot of oxygen to be degraded (Figure 12).

◢ Biodegradability of runway deicers

The biodegradability of runway deicers can be looked at by considering two parameters: the COD/BOD_5 ratio and the biodegradation time.

The COD/BOD_5 ratio expresses the biodegradation capacity of runway deicers.

- $COD/BOD_5 < 2$: readily biodegradable effluent
- $2 \leq COD/BOD_5 < 3$: biodegradable effluent with a selected biomass
- $COD/BOD_5 \geq 3$: unreadily biodegradable effluent

According to these results shown in Figure 13, potassium and sodium acetates are readily biodegradable as their COD/BOD_5 ratio (comparable from one product to another) is less than 2 (between 1.39 and 1.62 for potassium acetates, and between 1.54 and 1.64 for sodium acetates).

Glycerol-based products are also biodegradable but may require a specific biomass (COD/BOD_5 ratio between 1.94 and 2.16).

As regards formates, the COD/BOD_5 ratio varies significantly from one product to another. In most cases, they are not readily biodegradable.

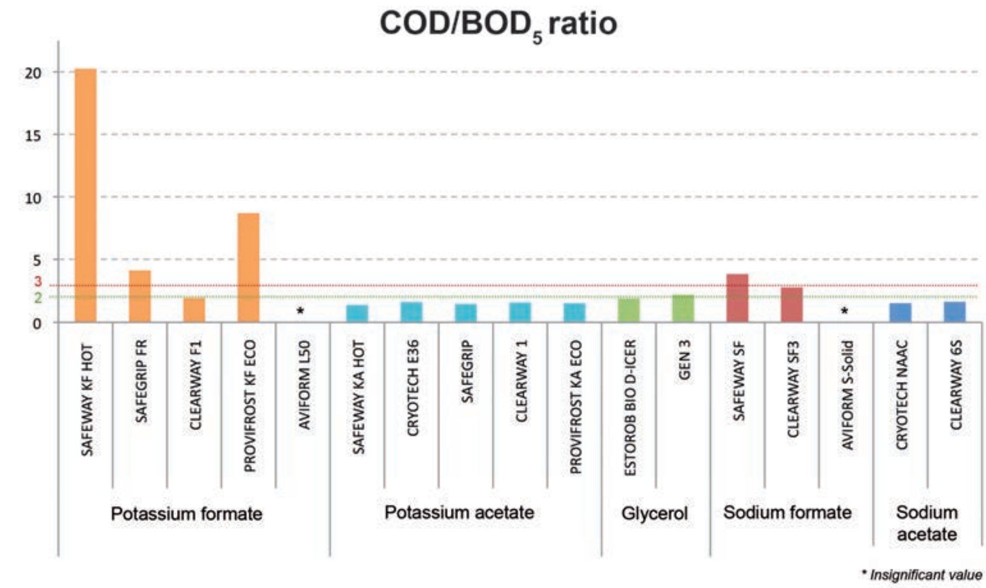


Figure 13: Biodegradability of runway deicers (tests performed at 20 °C)

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 14).

According to the results shown in Figure 14, it takes less time to degrade acetates than glycerol or formate-based products. These results therefore corroborate the comparison of the COD/BOD_5 ratios.

When taking the BOD_5 and the COD into consideration separately, the environmental impact of formates is significantly lower than that of 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:

- The biodegradability tests (COD/BOD_5 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).
- The tests performed on the biodegradation time corroborate the previous point. Formates take longer to degrade than acetates and glycerol at 20 °C.

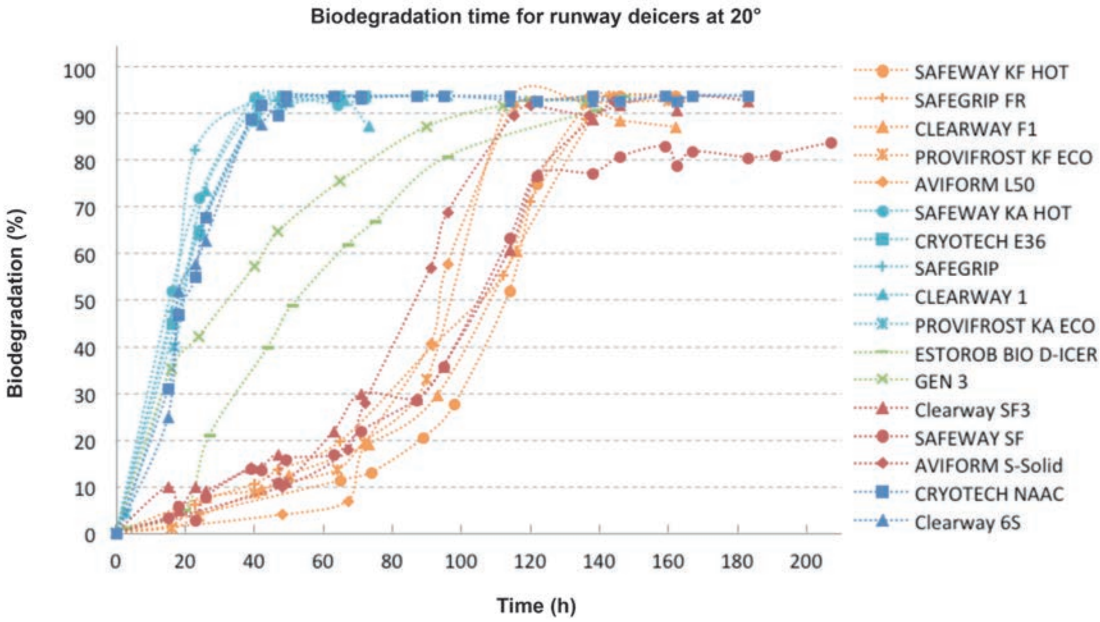


Figure 14: Biodegradation time (test performed at 20 °C) of runway deicers

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:

- 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.

- 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.

3.4. Effectiveness of runway deicers

3.4.1. Solution phase change temperatures as a function of mass percentage

The minimal freezing point (at eutectic concentration) often appears to be the reference criterium with regard to the performance of winter maintenance products. This should be taken lightly, as these products are only effective if they are in the form of a solution and as the surface temperatures encountered in France very rarely drop to -20 °C.

In order to protect a pavement at a given temperature varying between 0 °C and -20 °C, and for a determined amount of water, the amount of liquid deicer to be used is generally twice that of solid deicers. This difference between the two kinds of product is to be found in their composition. Solid products are composed of nearly 100 % active ingredient, whereas liquid products are composed of around 50 % active ingredient and 50 % water.

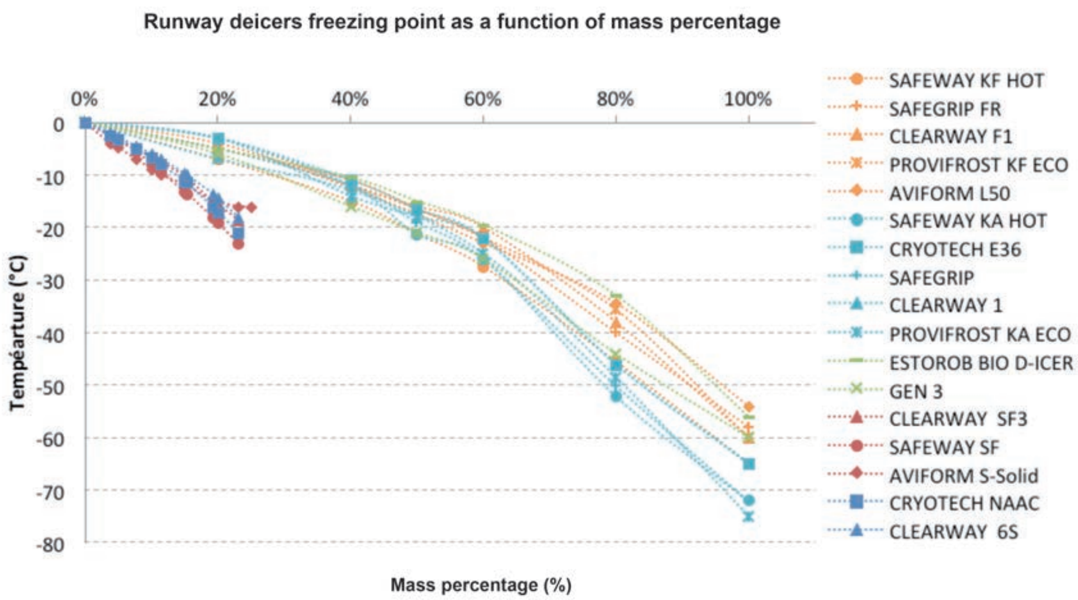


Figure 15: Runway deicer freezing points as a function of mass percentage

According to the figure above (Figure 15), freezing points are nearly equivalent for the liquid products up to dilution corresponding to a mass percentage of 50 %. Beyond this dilution, potassium acetates turn out to be more effective than potassium formates and glycerol.

The freezing points noted during these measurements are lower than the temperatures given in literature for these products (laboratory quality). The presence of "temperature depressor" type additives in runway deicers may account for this difference.

The freezing points of solid products are much lower than those of liquid products up to a mass percentage of around 20 %. These results match the off-the-shelf solid product active principle concentrations which are higher. As part of these measurements, they are more effective at temperatures that are commonly encountered during winter operations. So, in order to achieve the managing authority's quality goals, the freezing point parameter should be linked to melting kinetics and therefore to the type of contaminant to be treated.

3.4.2. Ice melting

The ice melting capacity is a parameter that characterizes the effectiveness of a runway deicer. The ice melting test is a method that has recently been updated and that can be used to measure this. The figures (Figure 16 and Figure 17) show the results of the tests performed at -5°C and -10°C.

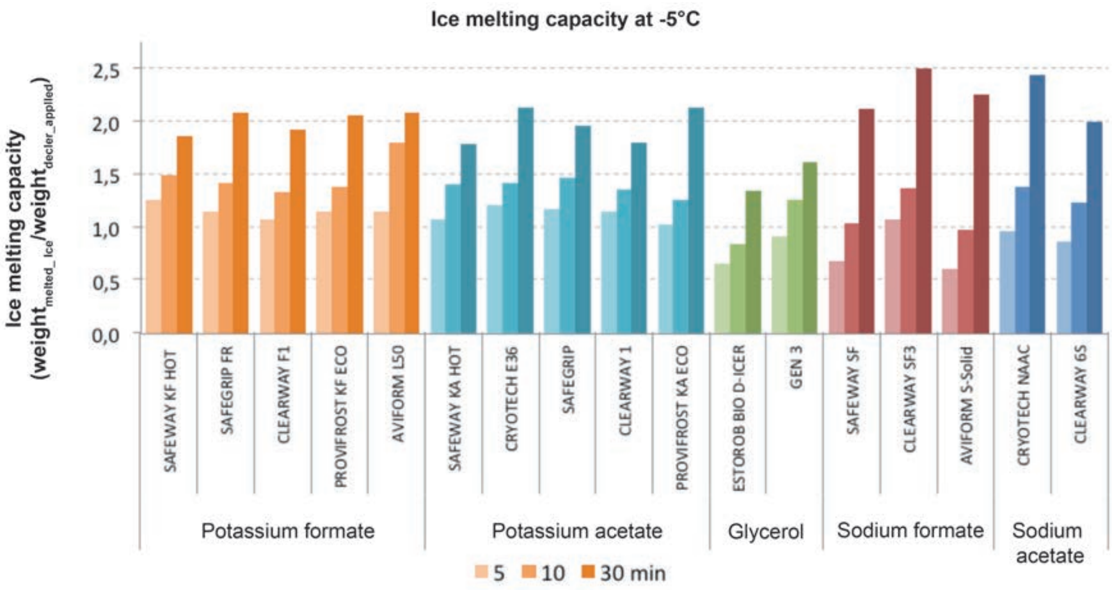


Figure 16 : Mean ice melting capacity for runway deicers at -5 °C

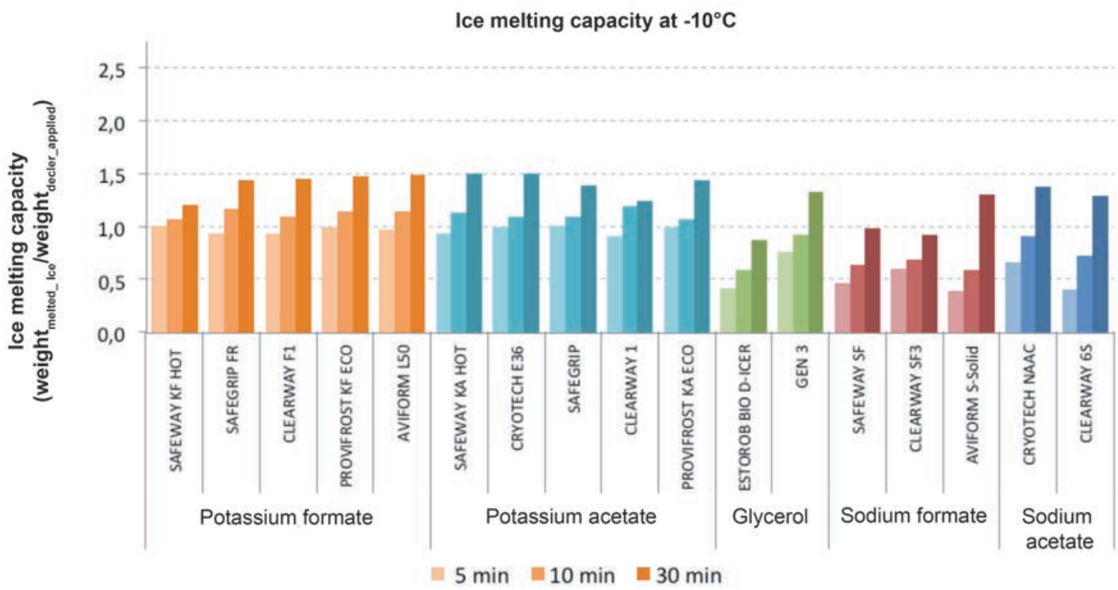


Figure 17 : Mean ice melting capacity for runway deicers at -10 °C

Generally speaking, ice melting capacities decrease with temperature: regardless of the runway deicer, its capacity to melt ice is stronger at -5 °C than at -10 °C.

The ice melting capacity of glycerol-based products at the two test temperatures (-5 °C and -10 °C) is less than that of the other liquid products studied. Potassium formates and acetates are practically identical in terms of ice melting capacity, regardless of the temperature and product dwell time.

Solid products have very similar ice melting capacities even if sodium formates seem to be a bit less effective than sodium acetates over long periods of time at -10 °C.

At -5 °C, liquid products are more effective in the short term (5 minutes), while solid products are more effective in the long term (30 minutes). At -10 °C, the mean performances of liquids are always better than those of solids. This observation can be explained by the small amount of free water available to hydrate solid products, which increases the time needed for them to act.

RECOMMENDATIONS

Solid products offer better protection at low surface temperatures, but their dwell time is longer than liquid formulations even if their action is more long-lasting. Liquid products are quick to act, enabling the requirements of airports with high service levels to be met. Solid products seem to be prescribed more at airports where the traffic requirements are more “flexible”.

4. Conclusions

Our fifth year of investigation has enabled us to improve and extend our knowledge and comparisons of liquid and solid products used as deicers at airports.

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 performed analyses can be used to characterize the performance and effectiveness of the products, on the one hand, and to compare the product families (Figure 19).

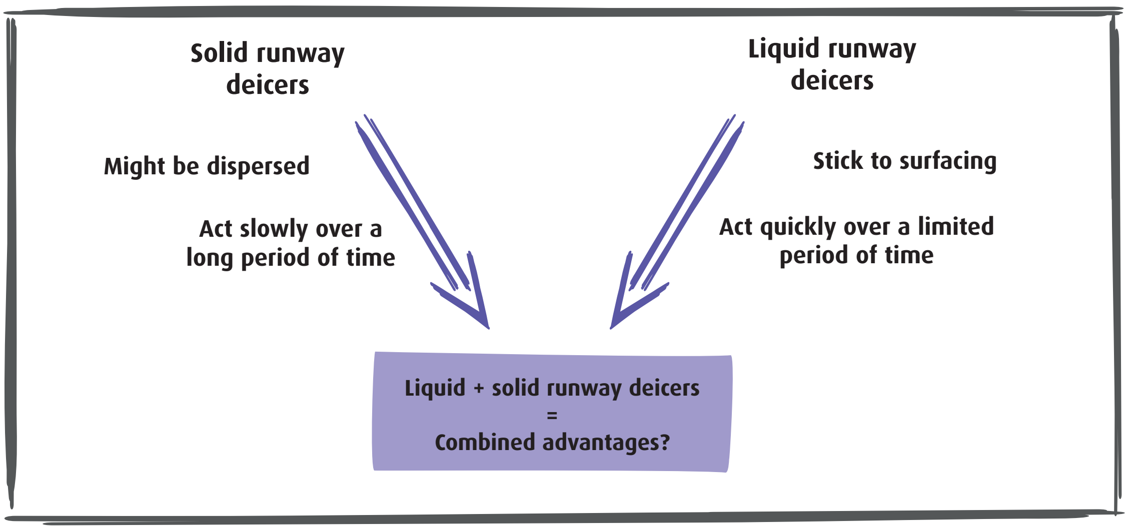
◢ Liquids, solids or mixed products ?

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.

Stronger and harsher climate events may be treated more effectively in corrective 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, in order to ensure optimum, long-lasting effectiveness of the products.

The combined use of liquids and solids is of interest in preventive treatment operations, especially on dry pavements (better adherence of deicers on surfaces), or in the management of strong climate events (combination of short-term (liquid) and long-term (solid) effectiveness) (Figure 18).

The proportion of liquid / solid deicer varies depending on the requirements of the managing authority, with a minimum of 80 % solid / 20% liquid for optimum coating of the pellets.



Liquids tend to be effective at a quicker rate than solids. However, their effectiveness is rapidly limited due to their dilution. The interest of solids lies in their holdover time ; however, they are limited by the speed of action (dissolution time). As recommended in some technical data sheets, simultaneously spreading a liquid and a solid may enable the advantages of both products to be combined.

Figure 18 : Use of solids, liquids and mixed products

The simultaneous use or mix of two products depends on prior agreement between the suppliers.

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).

Environmental impact of the products

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

When it comes to the environment, we have to admit that, despite the fact that formates have a low impact on the environment (as regards the BOD_5 and COD in particular), they are nevertheless not readily degradable (high COD/BOD_5 ratio, long biodegradation time) compared to acetates (and to glycerol, to a lesser extent), which have high BOD_5 and COD but better degradation time and biodegradability.

Product effectiveness

We cannot differentiate a product family with regard to the tests performed to date (freezing point, ice melting).

Product operating conditions

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 is often 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 of these elements must be included in the safety data sheets[11] provided by the suppliers of runway deicers.

[11] Article 31 and annex II of REACH regulation no.1907/2006 and standard 11014 of March 2009.

<table>
<tr><th colspan="6">Physical and chemical characteristics</th></tr>
<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><td>State (solid/liquid)</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 or 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 be oxidation of metals, electrical malfunctions, etc.</td></tr>
</table>

+: *positive assessment* +/-: *moderate assessment* -: *negative assessment*

<table>
<tr><th colspan="6">Toxicity and environmental characteristics</th></tr>
<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><td>COD & BOD_5</td><td>+</td><td>-</td><td>-</td><td>+</td><td>-</td></tr>
<tr><td></td><td colspan="5">Impact environmental: Formates < Acetates < Glycerol</td></tr>
<tr><td>COD/BOD_5 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>Biodegradation 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">Low toxicity of glycerol, acetates slightly less toxic than formates</td></tr>
</table>

+: *positive assessment* +/-: *moderate assessment* -: *negative assessment*

<table>
<tr><th colspan="6">Performance characteristics</th></tr>
<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><td rowspan="2">Freezing point</td><td>+/-</td><td>+</td><td>+/-</td><td>+</td><td>+/-</td></tr>
<tr><td colspan="5">Low freezing point: better protection</td></tr>
<tr><td rowspan="2">Ice-Melting</td><td>+</td><td>+</td><td>-</td><td>+/-</td><td>+</td></tr>
<tr><td colspan="5">Lower ice melting capacity for glycerol</td></tr>
</table>

+: *positive assessment* +/-: *moderate assessment* -: *negative assessment*

<table>
<tr><th colspan="6">Functional characteristics</th></tr>
<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><td>Adherence to surfacing</td><td colspan="3">+
Adhere to surfacing</td><td colspan="2">-
Adherence varies as a function of particle size and pellet shape</td></tr>
<tr><td>Speed of action</td><td colspan="3">+
Act instantly</td><td colspan="2">-
Act slowly (need to become hydrated beforehand)</td></tr>
<tr><td>Effective duration</td><td colspan="3">-
Do not act for a long time</td><td colspan="2">+
Act for a long time</td></tr>
</table>

+: *positive assessment* +/-: *moderate assessment* -: *negative assessment*

Figure 19: Summary of physical, chemical, environmental, performance and functional properties of runway deicers

5. Glossary

◢ **Autoignition temperature:** The autoignition temperature corresponds to the temperature at which a substance spontaneously autoignites in air, when there is no pilot flam.

◢ **Active principle:** The active principle of a deicer is the main component that enables the freezing point to be depressed.

◢ **Anhydrate:** Anhydrates are compounds that do not contain free water but may withhold a fraction of water of constitution, unlike hydrates. A molecule is therefore considered to be anhydrate if it does not contain H_2O molecules.

◢ **Combustible entity:** A combustible entity is any material that, in the presence of oxygen and energy, may combine with oxygen (which acts as an oxidizer) in a chemical reaction that generates heat: combustion.

◢ **Corrosion:** 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).

◢ **Daphnids:** Daphnids are small crustacea that measure between one and five millimeters, of the Daphnia genus. They live in standing fresh water, and some species can withstand slightly brackish conditions.

◢ **Endothermic reaction:** An endothermic reaction is a chemical reaction or process accompanied by heat absorption. It is the opposite of an exothermic reaction.

◢ **Eutectic:** An eutectic is the point on the phase diagram (corresponding to a given proportion) at which the mixture of two substances is at its minimal temperature in liquid phase. This temperature is unique for each mixture.

◢ **Exothermic reaction:** An exothermic reaction is a chemical reaction or process accompanied by heat release. It is the opposite of an endothermic reaction.

◢ **Flash point:** The flash point corresponds to 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 autoignition.

◢ **Fluidity:** The fluidity of a solid deicer is its ability to flow freely in a regular, constant manner in the form of individual pellets.

◢ **Hydrate / Trihydrate molecule :** Hydrates are compounds formed by the combination of water and another substance. These substances called hydrates do not contain water as such (H2O), but their elements or a combination of them : hydrogen H, oxygen O or hydroxyl OH. However, it is often said, through misuse, that hydrate compounds contain water, unlike anhydrates. A molecule is said to be trihydrate if it contains $3H_2O$.

◢ **Hydroxyde :** A hydroxide is the anion HO^-.

◢ **Hygroscopicity :** Hygroscopicity is the ability of a substance to absorb moisture from the air, by absorption or adsorption.

◢ **Latent heat of fusion :** Latent heat of fusion is the energy absorbed by a body in the form of heat, when said body's state changes from solid to liquid.

◢ **Mass percentage :** The mass percentage of a solution is the ratio of mass solute to mass total solution. It is expressed in %.

$$T = \frac{m_s}{m_s + m_w} \times 100$$

where m_s is mass solute and m_w the mass of water in which the solute is dissolved.

◢ **Solute :** A solute is a minority substance held in a dissolved state in a solution.

◢ **Specific surface :** The specific surface is used to describe the actual surface of a solid (including the irregularities of said surface) in comparison with its apparent surface.

◢ **Viscosity :** Viscosity is a fluid's resistance to uniform flow without turbulence.

6. Product data sheets

6.1. List of products analyzed

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

Product	*Corporation*	*Nature*	*State*
SAFEWAY KF HOT	***Clariant***	***Potassium formate***	***Liquid***
SAFEGRIP FR	***Abax Industrie***	***Potassium formate***	***Liquid***
CLEARWAY F1	***Kemira***	***Potassium formate***	***Liquid***
PROVISFROST KF ECO	***Proviron Industries NV***	***Potassium formate***	***Liquid***
AVIFORM L50	***Addcon***	***Potassium formate***	***Liquid***
SAFEWAY KA HOT	***Clariant***	***Potassium acetate***	***Liquid***
CRYOTECH E36	***Proviron Industries NV***	***Potassium acetate***	***Liquid***
SAFEGRIP	***Abax Industrie***	***Potassium acetate***	***Liquid***
CLEARWAY 1	***Kemira***	***Potassium acetate***	***Liquid***
PROVISFROST KA ECO	***Proviron Industries NV***	***Potassium acetate***	***Liquid***
ESTOROB BIO D-ICER	***Novance***	***Glycerol***	***Liquid***
GEN 3	***Basic Solution***	***Potassium acetate + Glycerol***	***Liquid***
SAFEWAY SF	***Clariant***	***Sodium formate***	***Solid***
CLEARWAY SF3	***Kemira***	***Sodium formate***	***Solid***
AVIFORM S-SOLID	***Addcon***	***Sodium formate***	***Solid***
CRYOTECH NAAC	***Proviron Industries NV***	***Sodium acetate***	***Solid***
CLEARWAY 6S	***Kemira***	***Sodium acetate***	***Solid***

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

6.2. 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

The following tests were performed on the runway deicers:

1. Product physical and chemical properties

LIQUIDS	
Test 1	*State*
Test 2	*Visual appearance*
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	*Autoignition temperature*

SOLIDS	
Test 1	*State*
Test 2	*Visual appearance*
Test 3	*Bulk density*
Test 4	*Particle size*
Test 5	*pH*
Test 6	*Active principle*
Test 7	*Electrical conductivity*
Test 8	*Autoignition temperature*

2. Product toxicity and environmental data

LIQUIDS	
Test 11	*BOD_5*
Test 12	*COD*
Test 13	*COD/BOD_5 ratio*
Test 14	*Biodegradation time*
Test 15	*Toxicity for Daphnia magna*

SOLIDS	
Test 9	*BOD_5*
Test 10	*COD*
Test 11	*COD/BOD_5 ratio*
Test 12	*Biodegradation time*
Test 13	*Toxicity for Daphnia magna*

3. Product effectiveness

LIQUIDS	
Test 16	*Freezing curve and point*
Test 17	*Ice-melting*

SOLIDS	
Test 14	*Freezing curve and point*
Test 15	*Ice-melting*

6.3. Rapports d'analyses

Civil aviation technical center
SAFEWAY KF HOT (Clariant)

Runway deicer: potassium formate
Date on which sample was received: 27 January 2010

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

SAFEWAY KF HOT Runway De-Icer

Clariant Produkte (Deutschland) GmbH 65926 Frankfurt am Main
Runway deicer: Potassium formate
Date on which sample was received: 27 January 2010

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. It is a baseline of technical knowledge, enabling the followingt:

(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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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.

Civil aviation technical center | Runway deicer : potassium formate

SAFEWAY KF HOT (Clariant) | Date on which sample was received : 27 January 2010

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	01/27/2010	-
2	Color (visual)	-	Colorless light orange	01/27/2010	-
3	Density	kg/m^3	1356	06/17/2010	NF EN ISO 3838[1]
4	Kinematic viscosity	mm^2/s		10/22/2010	NF EN ISO 3104[2]
	20 °C		2.154		
	5 °C		3.140		
	-5 °C		4.235		
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/cm	225.7	17/06/2010	NF EN 27 888[4]
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680[5]
10	Autoignition temperature	°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

No.	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	106 667	08/03/2010	NF T 90-101[8]
13	COD/BOD_5	-	20.3	11/12/2010	-
14	Biodegradability (20 °C)	hours		05/06/2011	NF EN ISO 9888[9]
	10 %		59		
	50 %		113		
	90 %		135		
15	Acute toxicity test on Daphnids	g/L		08/20/2010	NF EN ISO 6341[10]
	CE 50i - 24 hours		3.25 (3.11-3.66)		
	CE 50i - 48 hours		3.25 (2.98-3.52)		

[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).

Civil aviation technical center
SAFEWAY KF HOT (Clariant)

Runway deicer: potassium formate
Date on which sample was received: 27 January 2010

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	*Product freezing point as a function of mass percentage (%)*	*°C*		*10/25/2010*	*LRN in-house method*
	Mass percentage: 20 %		*-7*		
	Mass percentage: 40 %		*-15*		
	Mass percentage: 60 %		*-27.5*		
	Mass percentage: 80 %		*-45.5*		
	Mass percentage: 100 %		*-65*		
17	*Ice-melting* *T = -5 °C*	$g_{ice}/g_{product}$		*06/25/2012*	*SHRP H 205-2 method*[11]
	5 min		*1.25*		
	10 min		*1.49*		
	30 min		*1.85*		
	T = -10 °C				
	5 min		*1.01*		
	10 min		*1.07*		
	30 min		*1.20*		

[11] *SHRP H 205-2 method « Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals »*

Civil aviation technical center
SAFEGRIP FR (Abax industrie)

Runway deicer: potassium formate
Date on which sample was received: 29 January 2009

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

SAFEGRIP FR Runway Deicer

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

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
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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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Civil aviation technical center
SAFEGRIP FR (Abax industrie)

Runway deicer: potassium formate
Date on which sample was received : 29 January 2009

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	01/29/2009	-
2	Color (visual)	-	Colorless	01/29/2009	-
3	Density	kg/m³	1344	01/29/2009	NF EN ISO 3838[1]
4	Kinematic viscosity	mm²/s		10/22/2010	NF EN ISO 3104[2]
	20 °C		2.034		
	5 °C		2.943		
	-5 °C		3.948		
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/cm	231	05/11/2009	NF EN 27 888[4]
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680[5]
10	Autoignition temperature	°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

No.	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	22669	12/08/2009	NF EN 1899-1[7]
12	COD	mg/kg	93084	12/08/2009	NF T 90-101[8]
13	COD/BOD_5	-	4.11	12/08/2009	-
14	Biodegradability (20 °C)	hours		05/06/2011	NF EN ISO 9888[9]
	10 %		38		
	50 %		102		
	90 %		136		
15	Acute toxicity test on Daphnids	g/L		07/30/2009	NF EN ISO 6341[10]
	CE 50i - 24 hours		2.28 (2.01-2.55)		
	CE 50i - 48 hours		2.28 (2.01-2.41)		

[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).

Civil aviation technical center

SAFEGRIP FR (Abax industrie)

Runway deicer: potassium formate

Date on which sample was received: 29 January 2009

Product effectiveness

No.	Intitul	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%)	°C		11/09/2009	LRN in-house method
	Mass percentage: 20 %		-5		
	Mass percentage: 40 %		-11		
	Mass percentage: 60 %		-22		
	Mass percentage: 80 %		-40		
	Mass percentage: 100 %		-58		
17	Ice-melting T = -5 °C	g_{ice} / $g_{product}$		06/25/2012	SHRP H 205-2 method [11]
	5 min		1.15		
	10 min		1.41		
	30 min		2.08		
	T = -10 °C				
	5 min		0.94		
	10 min		1.16		
	30 min		1.44		

[11] *SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"*

Civil aviation technical center
CLEARWAY F1 (Kemira)

Runway deicer: Potassium formate
Date on which samples were received: 14 February 2009

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

CLEARWAY F1 Runway Deicer

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

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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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Civil aviation technical center

CLEARWAY F1 (Kemira)

Runway deicer: Potassium formate

Date on which samples were received: 14 February 2009

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	02/15/2009	-
2	Color (visual)	-	Colorless	02/15/2009	-
3	Density	kg/m³	1344	05/11/2009	NF EN ISO 3838[1]
4	Viscosité cinématique	mm²/s		08/27/2009	NF EN ISO 3104[2]
	20 °C		2.086		
	5 °C		3.018		
	-5 °C		4.047		
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	08/06/2009	LRN in-house method
8	Conductivity	mS/cm	231,0	05/11/2009	NF EN 27 888[4]
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680[5]
10	Autoignition temperature	°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

No.	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	54 039	12/08/2009	NF EN 1899-1[7]
12	COD	mg/kg	104 344	12/08/2009	NF T 90-101[8]
13	COD/BOD_5	-	1.93	12/08/2009	-
14	Biodegradability (20 °C)	hours		12/08/2009	NF EN ISO 9888[9]
	10 %		44		
	50 %		109		
	90 %		138		
15	Acute toxicity test on Daphnids	g/L		07/30/2009	NF EN ISO 6341[10]
	CE 50i - 24 hours		2.41 (2.14-2.68)		
	CE 50i - 48 hours		2.01 (1.47-2.68)		

[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).

Civil aviation technical center

CLEARWAY F1 (Kemira)

Runway deicer: Potassium formate

Date on which samples were received: 14 February 2009

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%)	°C		11/09/2009	LRN in-house method
	Mass percentag: 20 %		-3		
	Mass percentag: 40 %		-12		
	Mass percentag: 60 %		-20		
	Mass percentag: 80 %		-38		
	Mass percentag: 100 %		-60		
17	Ice-melting T = -5 °C	g_{ice} / $g_{product}$		06/25/2012	SHRP H 205-2 [11]
	5 min		1.07		
	10 min		1.32		
	30 min		1.92		
	T = -10 °C				
	5 min		0.94		
	10 min		1.09		
	30 min		1.45		

[11] *SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"*

Civil aviation technical center — Runway deicer: Potassium formate

Provifrost KF ECO (Proviron Industrie N.V.) — Date on which samples were received: 2 April 2012

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

PROVIFROST KF ECO Runway Deicer

Proviron Industries N.V. -Zone 2 – G. Gilliotstraat 60-B-2620 Hemiksem –Belgium
Runway deicer: Potassium formate
Date on which samples were received: 2 April 2012

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), under the auspices of the STAC.

Data use warnings:

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Use of data:

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Civil aviation technical center

Provifrost KF ECO (Proviron Industrie N.V.)

Runway deicer: Potassium formate

Date on which samples were received: 2 April 2012

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	04/02/2012	-
2	Color (visual)	-	Colorless	04/02/2012	-
3	Density	kg/m³	1346	07/24/2012	NF EN ISO 3838[1]
4	Kinematic viscosity	mm²/s		05/27/2013	NF EN ISO 3104[2]
	20 °C		2.072		
	5 °C		3.235		
	-5 °C		4.090		
5	pH	-	11.0	07/24/2012	NF T 90-008[3]
6	Refractive index at 20 °C	-	1.3873	05/04/2012	LRN in-house method
7	Active principle [HCOOK]	%	51 %	10/22/2012	LRN in-house method
8	Conductivity	mS/cm	235.9	07/24/2012	NF EN 27 888[4]
9	Flash point	°C	> 106.2*	05/23/2013	NF ISO 3680[5]
10	Autoignition temperature	°C	> 500	05/27/2013	ASTM E 659[6]

** the flame goes out when temperature reaches 106,2°C, but the apparatus does not detect a flash.*

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	11 888	10/02/2012	NF EN 1899-1[7]
12	COD	mg/kg	103 329	10/02/2012	NF T 90-101[8]
13	COD/BOD_5	-	8.69	10/02/2012	-
14	Biodegradability (20 °C)	hours		10/02/2012	NF EN ISO 9888[9]
	10 %		43		
	50 %		97		
	90 %		113		
15	Acute toxicity test on Daphnids	g/L		06/03/2013	NF EN ISO 6341[10]
	CE 50i - 24 hours		2.4 (2.1-2.8)		
	CE 50i - 48 hours		1.7 (1.5-2.0)		

[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).

Civil aviation technical center
Provifrost KF ECO (Proviron Industrie N.V.)

Runway deicer : Potassium formate
Date on which samples were received : 2 April 2012

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%)	°C		10/22/2012	LRN in-house method
	Mass percentage : 20 %		-5		
	Mass percentage : 40 %		-12		
	Mass percentage : 60 %		-22		
	Mass percentage : 80 %		-35.7		
	Mass percentage : 100 %		-60		
17	Ice-melting T = -5 °C	g_{ice} / $g_{product}$		06/25/2012	SHRP H 205-2 method[11]
	5 min		1.14		
	10 min		1.37		
	30 min		2.05		
	T = -10 °C				
	5 min		1.00		
	10 min		1.14		
	30 min		1.47		

[11] SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"

Civil aviation technical center
AVIFORM L50 (Addcon)

Runway deicer: Potassium formate
Date on which sample was received: 11 February 2013

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

AVIFORM L50 Runway Deicer

ADDCON Nordic AS-Tormod Gjestlands veg 16-Postboks 1138,-3936 Porsgrunn-Norvège
Runway deicer: Potassium formate
Date on which sample was received: 11 February 2013

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), under the auspices of the STAC.

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Use of data:

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Civil aviation technical center | Runway deicer: Potassium formate
AVIFORM L50 (Addcon) | Date on which sample was received: 11 February 2013

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	02/11/2013	-
2	Color (visual)	-	Colorless	02/11/2013	-
3	Density	kg/m³	1346	02/25/2013	NF EN ISO 3838[1]
4	Kinematic viscosity	mm²/s		05/27/2013	NF EN ISO 3104[2]
	20 °C		2.062		
	5 °C		2.980		
	-5 °C		4.559		
5	pH	-	11.2	02/25/2013	NF T 90-008[3]
6	Refractive inde at 20 °C	-	1.3873	02/19/2013	LRN in-house method
7	Active principle [HCOOK]	%	51	07/01/2013	LRN in-house method
8	Conductivity	mS/cm	228	02/25/2013	NF EN 27 888[4]
9	Flash point	°C	> 110.2*	05/23/2013	NF ISO 3680[5]
10	Autoignition temperature	°C	> 500	05/27/2013	ASTM E 659[6]

* the flame goes out when temperature reaches 110.2°C, but the apparatus does not detect a flash.

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	Insignificant value	07/05/2013	NF EN 1899-1[7]
12	COD	mg/kg	97 000	07/05/2013	NF T 90-101[8]
13	COD/BOD_5	-			-
14	Biodegradability (20 °C)	hours		07/05/2013	NF EN ISO 9888[9]
	10 %		68		
	50 %		93		
	90 %		111		
15	Acute toxicity test on Daphnids	g/L		06/03/2013	NF EN ISO 6341[10]
	CE 50i - 24 hours		1.4 (1.2-1.7)		
	CE 50i - 48 hours		1.2 (1.0-1.5)		

[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).

Civil aviation technical center

AVIFORM L50 (Addcon)

Runway deicer: Potassium formate

Date on which sample was received: 11 February 2013

Product effectiveness

No.	*Name*	*Unit*	*Values*	*Date*	*Normative references*
16	*Product freezing point as a function of mass percentage (%)*	*°C*		*07/01/2013*	*LRN in-house method*
	Mass percentage: 20 %		*-4*		
	Mass percentage: 40 %		*-12.5*		
	Mass percentage: 60 %		*-23*		
	Mass percentage: 80 %		*-34.5*		
	Mass percentage: 100 %		*-54*		
17	*Ice-melting* *T = -5 °C*	g_{ice} / $g_{product}$		*11/20/2013*	*SHRP H 205-2 method*[11]
	5 min		*1.14*		
	10 min		*1.79*		
	30 min		*2.08*		
	T = -10 °C				
	5 min		*0.97*		
	10 min		*1.14*		
	30 min		*1.48*		

[11] *SHRP H 205-2 method* “*Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals*”

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer : Potassium acetate
SAFEWAY KA HOT (Clariant) Date on which sample was received : 27 January 2010

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

SAFEWAY KA HOT Runway Deicer

Clariant Produkte (Deutschland) GmbH 65926 Frankfurt am Main
Runway deicer : Potassium acetate
Date on which sample was received : 27 January 2010

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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 :

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.

Service technique de l'aviation civile (Civil aviation technical center)

SAFEWAY KA HOT (Clariant)

Runway deicer: Potassium acetate

Date on which sample was received: 27 January 2010

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquide	01/27/2010	-
2	Color (visual)	-	Incolore	01/27/2010	-
3	Density	kg/m³	1284	06/17/2010	NF EN ISO 3838[1]
4	Kinematic viscosity	mm²/s		10/22/2010	NF EN ISO 3104[2]
	20 °C		4.908		
	5 °C		8.671		
	-5 °C		13.590		
5	pH	-	9.94	06/17/2010	NF T 90-008[3]
6	Refractive index at 20 °C	-	1.3966	02/04/2010	LRN in-house method
7	Active principle [CH_3COOK]	%	54	12/03/2010	LRN in-house method
8	Conductivity	mS/cm	101.9	06/17/2010	NF EN 27 888[4]
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680[5]
10	Autoignition temperature	°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

No.	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	235 694	11/12/2010	NF EN 1899-1[7]
12	COD	mg/kg	327 940	08/03/2010	NF T 90-101[8]
13	COD/BOD_5	-	1.39	11/12/2010	-
14	Biodegradability (20 °C)			05/06/2011	NF EN ISO 9888[9]
	10 %		3		
	50 %	hours	16		
	90 %		37		
15	Acute toxicity test on Daphnids	g/L		07/31/2009	NF EN ISO 6341[10]
	CE 50i - 24 hours		2.30		
			(2.18-2.56)		
	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).

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Potassium acetate

SAFEWAY KA HOT (Clariant) Date on which sample was received: 27 January 2010

Product toxicity and environmental data

No.	*Name*	*Unit*	*Values*	*Date*	*Normative references*
16	*Product freezing point as a function of mass percentage (%)* *Mass percentage: 20 %*	*°C*		*10/25/2010*	*LRN in-house method*
	Mass percentage: 40 %		*-3*		
	Mass percentage: 60 %		*-12*		
	Mass percentage: 80 %		*-26*		
	Mass percentage: 100 %		*-52*		
			-72		
17	*Ice-melting* *T = -5 °C*	g_{ice} / $g_{product}$		*06/25/2012*	*SHRP H 205-2 method*[11]
	5 min		*1.07*		
	10 min		*1.40*		
	30 min		*1.78*		
	T = -10 °C				
	5 min		*0.94*		
	10 min		*1.13*		
	30 min		*1.50*		

[11] *SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"*

Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer: Potassium acetate
CRYOTECH E36 (Proviron Industrie N.V.) — Date on which sample was received: 22 January 2009

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

CRYOTECH E36 Runway Deicer

Proviron Industries N.V. -Zone 2 – G. Gilliotstraat 60-B-2620 Hemiksem –Belgium
Runway deicer: Potassium acetate
Date on which sample was received: 22 January 2009

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), under the auspices of the STAC.

Data use warnings:

Cautions:

(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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Service technique de l'aviation civile (Civil aviation technical center)
CRYOTECH E36 (Proviron Industrie N.V.)

Runway deicer: Potassium acetate
Date on which sample was received: 22 January 2009

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquide	01/23/2009	-
2	Color (visual)	-	Incolore	01/23/2009	-
3	Density	kg/m³	1277	05/11/2009	NF EN ISO 3838[1]
4	Kinematic viscosity	mm²/s		10/22/2010	NF EN ISO 3104[2]
	20 °C		4.445		
	5 °C		7.685		
	-5 °C		11.94		
5	pH	-	10.68	05/11/2009	NF T 90-008[3]
6	Refractive index at 20 °C	-	1.394	09/30/2009	LRN in-house method
7	Active principle [CH_3COOK]	%	52	12/03/2010	LRN in-house method
8	Conductivity	mS/cm	108.9	05/11/2009	NF EN 27 888[4]
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680[5]
10	Autoignition temperature	°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

No.	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	203 524	12/08/2009	NF EN 1899-1[7]
12	COD	mg/kg	330 502	12/08/2009	NF T 90-101[8]
13	COD/BOD_5	-	1.62	12/08/2009	-
14	Biodegradability (20 °C)	hours		05/06/2011	NF EN ISO 9888[9]
	10 %		4		
	50 %		18		
	90 %		42		
15	Acute toxicity test on Daphnids	g/L		07/31/2009	NF EN ISO 6341[10]
	CE 50i - 24 hours		2.82 (2.56-3.20)		
	CE 50i - 48 hours		2.56 (2.30-2.94)		

[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).

Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer : Potassium acetate

CRYOTECH E36 (Proviron Industrie N.V.) — Date on which sample was received : 22 January 2009

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	*Product freezing point as a function of mass percentage (%)*	*°C*		*11/09/2009*	*LRN in-house method*
	Mass percentage : 20 %		*-3*		
	Mass percentage : 40 %		*-11*		
	Mass percentage : 60 %		*-22*		
	Mass percentage : 80 %		*-46*		
	Mass percentagee : 100 %		*-65*		
17	*Ice-melting* *T = -5 °C*	g_{ice} / $g_{product}$		*06/25/2012*	*LRN in-house method* [11]
	5 min		*1.21*		
	10 min		*1.42*		
	30 min		*2.13*		
	T = -10 °C				
	5 min		*1.00*		
	10 min		*1.10*		
	30 min		*1.50*		

[11] *SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"*

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Potassium acetate
SAFEGRIP (Abax Industries) Date on which sample was received: 29 January 2009

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

SAFEGRIP Runway Deicer

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

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), under the auspices of the STAC.

Data use warnings:

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Use of data:

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.
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Service technique de l'aviation civile (Civil aviation technical center)
SAFEGRIP (Abax Industries)

Runway deicer: Potassium acetate
Date on which sample was received: 29 January 2009

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquide	01/29/2009	-
2	Color (visual)	-	Incolore	01/29/2009	-
3	Density	kg/m³	1284	05/11/2009	NF EN ISO 3838[1]
4	Kinematic viscosity	mm²/s		10/22/2010	NF EN ISO 3104[2]
	20 °C		4.832		
	5 °C		8.512		
	-5 °C		13.40		
5	pH	-	10.54	05/11/2009	NF T 90-008[3]
6	Refractive index at 20 °C	-	1.3962	09/30/2009	LRN in-house method
7	Active principle [CH_3COOK]	%	53	12/03/2010	LRN in-house method
8	Conductivity	mS/cm	103.1	05/11/2009	NF EN 27 888[4]
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680[5]
10	Autoignition temperature	°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	234 271	12/08/2009	NF EN 1899-1[7]
12	COD	mg/kg	343 556	12/08/2009	NF T 90-101[8]
13	COD/BOD_5	-	1.47	12/08/2009	-
14	Biodegradability (20 °C)	hours		06/05/2011	NF EN ISO 9888[9]
	10 %		3		
	50 %		17		
	90 %		36		
15	Acute toxicity test on Daphnids	g/L		07/31/2009	NF EN ISO 6341[10]
	CE 50i - 24 hours		2.82 (2.56-3.20)		
	CE 50i - 48 hours		2.69 (2.43-2.94)		

[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).

Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer : Potassium acetate

SAFEGRIP (Abax Industries) — Date on which sample was received : 29 January 2009

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%)	°C		11/09/2009	LRN in-house method
	Mass percentage : 20 %		-5		
	Mass percentage : 40 %		-12		
	Mass percentage : 60 %		-26		
	Mass percentage : 80 %		-50		
	Mass percentage : 100 %		-72		
17	Ice-melting T = -5 °C	g_{ice} / $g_{product}$		06/25/2012	SHRP H 205-2 method[11]
	5 min		1.17		
	10 min		1.46		
	30 min		1.96		
	T = -10 °C				
	5 min		1.01		
	10 min		1.10		
	30 min		1.39		

[11] SHRP H 205-2 method "*Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals*"

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer : Potassium acetate
CLEARWAY 1 (Kemira) Date on which sample was received : 14 February 2009

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

CLEARWAY 1 Runway Deicer

Kemira ChemSolutions b.v.- P.O. Box 60 - 4000AB Tiel- NETHERLANDS
Runway deicer : Potassium acetate
Date on which sample was received : 14 February 2009

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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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Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer : Potassium acetate

CLEARWAY 1 (Kemira) — Date on which sample was received : 14 February 2009

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	02/15/2009	-
2	Color (visual)	-	Colorless	02/15/2009	-
3	Density	kg/m³	1282	05/11/2009	NF EN ISO 3838[1]
4	Kinematic viscosity	mm²/s		10/22/2010	NF EN ISO 3104[2]
	20 °C		4.549		
	5 °C		7.910		
	-5 °C		12.240		
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/cm	107.5	05/11/2009	NF EN 27 888[4]
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680[5]
10	Autoignition temperature	°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

No.	Name	Unit	Valeurs	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	208 223	12/08/2009	NF EN 1899-1[7]
12	COD	mg/kg	331 270	12/08/2009	NF T 90-101[8]
13	COD/BOD_5	-	1.59	12/08/2009	-
14	Biodegradability (20 °C)	hours		06/05/2011	NF EN ISO 9888[9]
	10 %		4		
	50 %		19		
	90 %		40		
15	Acute toxicity test on Daphnids	g/L		07/31/2009	NF EN ISO 6341[10]
	CE 50i - 24 hours		2.30 (2.18-2.56)		
	CE 50i - 48 hours		2.18 (2.05-2.43)		

[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).

Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer : Potassium acetate

CLEARWAY 1 (Kemira) — Date on which sample was received : 14 February 2009

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	*Product freezing point as a function of mass percentage (%)*	*°C*		*11/09/2009*	*LRN in-house method*
	Mass percentage : 20 %		*-3*		
	Mass percentage : 40 %		*-14*		
	Mass percentage : 60 %		*-22*		
	Mass percentage : 80 %		*-46*		
	Mass percentage : 100 %		*-65*		
17	*Ice-melting* *T = -5 °C*	g_{ice} / $g_{product}$		*06/25/2012*	*SHRP H 205-2 method*[11]
	5 min		*1.15*		
	10 min		*1.36*		
	30 min		*1.79*		
	T = -10 °C				
	5 min		*0.91*		
	10 min		*1.19*		
	30 min		*1.24*		

[11] *SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"*

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer : Potassium acetate
PROVIFROST KA ECO (Proviron Industrie N.V.) Date on which sample was received : 23 January 2013

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

PROVIFROST KA ECO Runway Deicer

Proviron Industries N.V. -Zone 2 – G. Gilliotstraat 60-B-2620 Hemiksem – Belgium
Runway deicer : Potassium acetate
Date on which sample was received : 23 January 2013

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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
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Service technique de l'aviation civile (Civil aviation technical center)
PROVIFROST KA ECO (Proviron Industrie N.V.)

Runway deicer: Potassium acetate
Date on which sample was received: 23 January 2013

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquide	01/23/2013	-
2	Color (visual)	-	Incolore	01/23/2013	-
3	Density	kg/m³	1275	01/23/2013	NF EN ISO 3838[1]
4	Kinematic viscosity	mm²/s		05/27/2013	NF EN ISO 3104[2]
	20 °C		4.466		
	5 °C		7.668		
	-5 °C		12.110		
5	pH	-	10.8	02/25/2013	NF T 90-008[3]
6	Refractive index at 20 °C	-	1.3940	02/19/2013	LRN in-house method
7	Active principle [CH_3COOK]	%	51	07/01/2013	LRN in-house method
8	Conductivity	mS/cm	157	02/25/2013	NF EN 27 888[4]
9	Flash point	°C	> 110.2*	05/23/2013	NF ISO 3680[5]
10	Autoignition temperature	°C	> 500	05/27/2013	ASTM E 659[6]

** the flame goes out when temperature reaches 110,2°C, but the apparatus does not detect a flash.*

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	200 035	07/05/2013	NF EN 1899-1[7]
12	COD	mg/kg	305 847	07/05/2013	NF T 90-101[8]
13	COD/BOD_5	-	1.53	07/05/2013	-
14	Biodegradability (20 °C)	hours		07/05/2013	NF EN ISO 9888[9]
	10 %		4		
	50 %		18		
	90 %		41		
15	Acute toxicity test on Daphnids	g/L		07/05/2013	NF EN ISO 6341[10]
	CE 50i - 24 hours		1.5 (1.31-1.7)		
	CE 50i - 48 hours		1.5 (1.3-1.7)		

[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).

Service technique de l'aviation civile (Civil aviation technical center)
PROVIFROST KA ECO (Proviron Industrie N.V.)

Runway deicer: Potassium acetate
Date on which sample was received: 23 January 2013

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%)	°C		07/01/2013	LRN in-house method
	Mass percentage: 20 %		-7		
	Mass percentage: 40 %		-13.0		
	Mass percentage: 60 %		-25.0		
	Mass percentage: 80 %		-48.5		
	Mass percentage: 100 %		-75.0		
17	Ice-melting T = -5 °C	g_{ice} / $g_{product}$		11/20/2013	SHRP H 205-2 method[11]
	5 min		1.02		
	10 min		1.26		
	30 min		2.13		
	T = -10 °C				
	5 min		1.00		
	10 min		1.07		
	30 min		1.44		

[11] SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Glycerol

ESTOROB BIO D-Icer (Novance) Date on which sample was received: 28 January 2010

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

ESTOROB BIO D-Icer Runway Deicer

NOVANCE-BP 20609-60206 VENETTE – France
Runway deicer: Glycerol
Date on which sample was received: 28 January 2010

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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:

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.

Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer: Glycerol

ESTOROB BIO D-Icer (Novance) — Date on which sample was received: 28 January 2010

Physical and chemical properties of the product

No.	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	mm²/s		10/22/2010	NF EN ISO 3104[2]
	20 °C		20.53		
	5 °C		49.21		
	-5 °C		100.30		
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/cm	2.7	06/17/2010	NF EN 27 888[4]
9	Flash point	°C	> 90*	10/22/2010	NF ISO 3680[5]
10	Autoignition temperature	°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

No.	Name	Unit	Values	Date	Normative references
11	BOD_5 (20 °C)	mg/kg	437 317	08/03/2010	NF EN 1899-1[7]
12	COD	mg/kg	833 402	08/03/2010	NF T 90-101[8]
13	COD/BOD_5	-	1.91	11/12/2010	-
14	Biodegradability (20 °C)	hours		05/06/2011	NF EN ISO 9888[9]
	10 %		22		
	50 %		52		
	90 %		135		
15	Acute toxicity test on Daphnids	g/L		08/20/2010	NF EN ISO 6341[10]
	CE 50i - 24 hours		57.6 (52.5-63.6)		
	CE 50i - 48 hours		22.8 (20.4-25.2)		

[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).

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Glycerol

ESTOROB BIO D-Icer (Novance) Date on which sample was received: 28 January 2010

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	Product freezing point as a function of mass percentage (%)	°C		10/25/2010	LRN in-house method
	Mass percentage: 20 %		-5		
	Mass percentage: 40 %		-10.5		
	Mass percentage: 60 %		-19.5		
	Mass percentage: 80 %		-33		
	Mass percentage: 100 %		-56		
17	Ice-melting T = -5 °C	g_{ice} / $g_{product}$		06/25/2012	SHRP H 205-2 method[11]
	5 min		0.66		
	10 min		0.84		
	30 min		1.34		
	T = -10 °C				
	5 min		0.42		
	10 min		0.59		
	30 min		0.87		

[11] SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"

Service technique de l'aviation civile (Civil aviation technical center)
Runway deicer: Glycerol + acetate
GEN 3 (Basic Solutions)
Date on which sample was received: 10 February 2011

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

GEN 3 Runway Deicer

Basic solutions – LNT GroupIsabella Rd., Helios 47/GarforthLeeds LS25 2DY – England
Runway deicer: Glycerol + acetate
Date on which sample was received: 10 February2011

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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.
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Service technique de l'aviation civile (Civil aviation technical center)
GEN 3 (Basic Solutions)

Runway deicer: Glycerol + acetate
Date on which sample was received: 10 February 2011

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Liquid	02/10/2011	-
2	Color (visual)	-	Colorless	02/10/2011	-
3	Density	kg/m³	1250	06/01/2011	NF EN ISO 3838[1]
4	Viscosité cinématique	mm²/s		06/08/2011	NF EN ISO 3104[2]
	20 °C		18.95		
	5 °C		44.33		
	-5 °C		90.62		
5	pH	-	10.5	06/01/2011	NF T 90-008[3]
6	Refractive index at 20°C	-	1.4219	04/05/2011	LRN in-house method
7	Active principle [$C_3H_8O_3$ + CH_3COOK]	%	Gly: 50.7 % KAc: 21.5 %	10/20/2011	LRN in-house method
8	Conductivity	mS/cm	19.6	06/01/2010	NF EN 27 888[4]
9	Flash point	°C	238	05/13/2011	NF ISO 3680[5]
10	Autoignition temperature	°C	> 500	06/08/2011	ASTM E 659[6]

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Références normatives
11	BOD_5 (20 °C)	mg/kg	301 000	08/25/2011	NF EN 1899-1[7]
12	COD	mg/kg	650 000	08/25/2011	NF T 90-101[8]
13	COD/BOD_5	-	2.16	08/25/2011	-
14	Biodegradability (20 °C)	hours		08/25/2011	NF EN ISO 9888[9]
	10 %		5		
	50 %		32		
	90 %		97		
15	Acute toxicity test on Daphnids	g/L		05/25/2011	NF EN ISO 6341[10]
	CE 50i - 24 hours		6.6 (5.9-7.3)		
	CE 50i - 48 hours		6.3 (5.8-6.9)		

[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).

Service technique de l'aviation civile (Civil aviation technical center)
Runway deicer: Glycerol + acetate

GEN 3 (Basic Solutions)
Date on which sample was received: 10 February 2011

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
16	*Product freezing point as a function of mass percentage (%)*	*°C*		*10/28/2011*	*LRN in-house method*
	Mass percentage: 20 %		*-6*		
	Mass percentage: 40 %		*-16*		
	Mass percentage: 60 %		*-26*		
	Mass percentage: 80 %		*-44*		
	Mass percentage: 100 %		*-60*		
17	*Ice-melting* *T = -5 °C*	g_{ice} / $g_{product}$		*06/25/2012*	*SHRP H 205-2 method*[11]
	5 min		*0.91*		
	10 min		*1.26*		
	30 min		*1.61*		
	T = -10 °C				
	5 min		*0.77*		
	10 min		*0.92*		
	30 min		*1.33*		

[11] *SHRP H 205-2 method* "*Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals*"

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Sodium formate
SAFEWAY SF (Clariant) Date on which sample was received: 27 January 2010

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

SAFEWAY SF Runway Deicer

Clariant Produkte (Deutschland) GmbH 65926 Frankfurt am Main
Runway deicer: Sodium formate
Date on which sample was received: 27 January 2010

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), under the auspices of the STAC.

Data use warnings:

Caution:

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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Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer: Sodium formate

SAFEWAY SF (Clariant) — Date on which sample was received: 27 January 2010

Physical and chemical properties of the product

No.	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	1090	09/06/2010	LRN in-house method
4	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		
	5		97.1		
	8		100		
5	pH (solution at 10 % w/w)	-	11.4	09/06/2010	NF T 90-008[2]
6	Active Principle [HCOONa]	%	93	10/20/2011	LRN in-house method
7	Conductivity (solution at 30 % w/w)	mS/cm	113.4	06/17/2010	NF EN 27 888[3]
8	Autoignition temperature	°C	> 500	10/22/2010	ASTM E 659[4]

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Normative references
9	BOD_5 (20 °C)	mg/kg	68 162	08/03/2010	NF EN 1899-1[5]
10	COD	mg/kg	260 065	08/03/2010	NF T 90-101[6]
11	COD/BOD_5	-	3.8	08/03/2010	-
12	Biodegradability (20 °C)	hours		11/12/2010	NF EN ISO 9888[7]
	10 %		32		
	50 %		11		
	90 %		> 150		
13	Acute toxicity test on Daphnids	g/L		08/20/2010	NF EN ISO 6341[8]
	CE 50i - 24 hours		4.18 (3.80-4.60)		
	CE 50i - 48 hours		2.90 (2.62-3.20)		

[1] Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.

[2] Water quality – Determination of pH – February 2001.

[3] Water quality – Determination of electrical conductivity – January 1994.

[4] Standard Test Method for Auto ignition Temperature of Liquid Chemicals – 2005.

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

[6] Water quality – Determination of chemical oxygen demand (COD) – February 2001.

[7] Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.

[8] 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).

Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer: Sodium formate

SAFEWAY SF (Clariant) — Date on which sample was received: 27 January 2010

Product effectiveness

No.	*Name*	*Unit*	*Values*	*Date*	*Normative references*
14	*Product freezing point as a function of mass percentage (%)*	*°C*		*10/25/2010*	*LRN in-house method*
	Mass percentage: 5 %		*-3.4*		
	Mass percentage: 10 %		*-7.9*		
	Mass percentage: 15 %		*-13.2*		
	Mass percentage: 20 %		*-19.1*		
15	*Ice-melting* *T = -5 °C*	$g_{ice} / g_{product}$		*06/25/2012*	*SHRP H 205-2 method*[9]
	5 min		*0.68*		
	10 min		*1.03*		
	30 min		*2.12*		
	T = -10 °C				
	5 min		*0.47*		
	10 min		*0.64*		
	30 min		*0.99*		

[9] *SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"*

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Sodium formate
CLEARWAY SF3 (Kemira) Date on which sample was received: 11 February 2010

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

CLEARWAY SF3 Runway Deicer

Kemira ChemSolutions b.v.- P.O. Box 60 - 4000AB Tiel- NETHERLANDS
Runway deicer: Sodium formate
Date on which sample was received: 11 February 2010

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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:

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.
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Service technique de l'aviation civile (Civil aviation technical center)
CLEARWAY SF3 (Kemira)

Runway deicer: Sodium formate
Date on which sample was received: 11 February 2010

Physical and chemical properties of the product

No.	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
4	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		0.7		
	1.25		1.9		
	2		5		
	5		99.3		
	8		100.0		
5	pH (solution at 10 % w/w)	-	10	09/06/2010	NF T 90-008[2]
6	Active Principle [HCOONa]	%	83	10/20/2011	LRN in-house method
7	Conductivity (solution at 30 % w/w)	mS/cm	115.9	06/17/2010	NF EN 27 888[3]
8	Autoignition temperature	°C	> 500	10/22/2010	ASTM E 659[4]

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Normative references
9	BOD_5 (20 °C)	mg/kg	91 360	03/08/2010	NF EN 1899-1[5]
10	COD	mg/kg	250 972	03/08/2010	NF T 90-101[6]
11	COD/BOD_5	-	2.7	03/08/2010	-
12	Biodegradability (20 °C)	hours		12/11/2010	NF EN ISO 9888[7]
	10 %		22		
	50 %		108		
	90 %		148		
13	Acute toxicity test on Daphnids	g/L		20/08/2010	NF EN ISO 6341[8]
	CE 50i - 24 hours		4.99 (4.67-5.34)		
	CE 50i - 48 hours		3.44 (3.10-3.81)		

[1] Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.
[2] Water quality – Determination of pH – February 2001.
[3] Water quality – Determination of electrical conductivity – January 1994.
[4] Standard Test Method for Auto ignition Temperature of Liquid Chemicals – 2005.
[5] Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 1998.
[6] Water quality – Determination of chemical oxygen demand (COD) – February 2001.
[7] Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.
[8] 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).

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Sodium formate
CLEARWAY SF3 (Kemira) Date on which sample was received: 11 February 2010

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
14	Product freezing point as a function of mass percentage (%)	°C		10/25/2010	LRN in-house method
	Mass percentage: 5 %		-3.3		
	Mass percentage: 10 %		-6.5		
	Mass percentage: 15 %		-10.2		
	Mass percentage: 20 %		-15.7		
15	Ice-melting T = -5 °C	g_{ice} / $g_{product}$		06/25/2012	SHRP H 205-2 method[9]
	5 min		1.07		
	10 min		1.37		
	30 min		2.50		
	T = -10 °C				
	5 min		0.61		
	10 min		0.69		
	30 min		0.92		

[9] SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer : Sodium formate
AVIFORM S-Solid (Addcon) Date on which sample was received : 11 February 2013

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

AVIFORM S-Solid Runway Deicer

ADDCON Nordic AS-Tormod Gjestlands veg 16-Postboks 1138,-3936 Porsgrunn-Norvège
Runway deicer : Sodium formate
Date on which sample was received : 11 February 2013

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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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Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer: Sodium formate

AVIFORM S-Solid (Addcon) — Date on which sample was received: 11 February 2013

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Solid in the form of irregular pellets	02/11/2013	-
2	Color (visual)	-	White	02/11/2013	-
3	Bulk density	kg/m³	807	10/10/2013	LRN in-house method
4	Particle size Sieve mesh in mm	Cumulated particle passing measured as a %		05/07/2013	NF P 98-180[1]
	0,2		0.4		
	0,8		0.5		
	1,25		0.8		
	2		7.4		
	5		99.7		
	8		100		
5	pH (solution at 10 % w/w)	-	11.8	02/25/2013	NF T 90-008[2]
6	Active Principle [HCOONa]	%	In progress		LRN in-house method
7	Conductivity (solution at 30 % w/w)	mS/cm	113	02/25/2013	NF EN 27 888[3]
8	Autoignition temperature	°C	> 500	05/27/2013	ASTM E 659[4]

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Normative references
9	BOD_5 (20 °C)	mg/kg	Insignificant value	07/05/2013	NF EN 1899-1[5]
10	COD	mg/kg	240 000	07/05/2013	NF T 90-101[6]
11	COD/BOD_5	-	-	07/05/2013	-
12	Biodegradability (20 °C)	hours		07/05/2013	NF EN ISO 9888[7]
	10 %		54		
	50 %		87		
	90 %		114		
13	Acute toxicity test on Daphnids	g/L		06/03/2013	NF EN ISO 6341[8]
	CE 50i - 24 hours		4.7		
			(3.8-6.0)		
	CE 50i - 48 hours		3.9		
			(3.0-5.0)		

[1] Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.

[2] Water quality – Determination of pH – February 2001.

[3] Water quality – Determination of electrical conductivity – January 1994.

[4] Standard Test Method for Auto ignition Temperature of Liquid Chemicals – 2005.

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

[6] Water quality – Determination of chemical oxygen demand (COD) – February 2001.

[7] Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.

[8] 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).

Service technique de l'aviation civile (Civil aviation technical center)
AVIFORM S-Solid (Addcon)

Runway deicer: Sodium formate
Date on which sample was received: 11 February 2013

Product effectiveness

No.	*Name*	*Unit*	*Values*	*Date*	*Normative references*
14	*Product freezing point as a function of mass percentage (%)*	*°C*		*07/01/2013*	*LRN in-house method*
	Mass percentage: 5 %		*-4.8*		
	Mass percentage: 10 %		*-8.8*		
	Mass percentage: 15 %		*-11.8*		
	Mass percentage: 20 %		*-15.2*		
15	*Ice-melting*	g_{ice} / $g_{product}$		*11/20/2013*	*SHRP H 205-2 method*[9]
	T = -5 °C				
	5 min		*0.61*		
	10 min		*0.97*		
	30 min		*2.25*		
	T = -10 °C				
	5 min		*0.39*		
	10 min		*0.59*		
	30 min		*1.31*		

[9] *SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"*

Service technique de l'aviation civile (Civil aviation technical center)
Runway deicer: Sodium acetate
CRYOTECH NAAC (Proviron Industrie N.V.)
Date on which sample was received: 10 March 2010

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

CRYOTECH NAAC Runway Deicer

Proviron Industries N.V. -Zone 2 – G. Gilliotstraat 60-B-2620 Hemiksem – Belgium
Runway deicer: Sodium acetate
Date on which sample was received: 10 March 2010

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), under the auspices of the STAC.

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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.
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Service technique de l'aviation civile (Civil aviation technical center) | Runway deicer: Sodium acetate

CRYOTECH NAAC (Proviron Industrie N.V.) | Date on which sample was received: 10 March 2010

Physical and chemical properties of the product

No.	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
4	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		
	8		100		
5	pH (solution at 10 % w/w)	-	8.3	09/06/2010	NF T 90-008[2]
6	Active Principle [CH_3COONa]	%	79	12/03/2010	LRN in-house method
7	Conductivity (solution at 30 % w/w)	mS/cm	68.9	09/06/2010	NF EN 27 888[3]
8	Autoignition temperature	°C	> 500	10/22/2010	ASTM E 659[4]

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Normative references
9	BOD_5 (20 °C)	mg/kg	468 888	08/03/2010	NF EN 1899-1[5]
10	COD	mg/kg	719 826	08/03/2010	NF T 90-101[6]
11	COD/BOD_5	-	1.5	08/03/2010	-
12	Biodégradabilité (20 °C)	hours		11/12/2010	NF EN ISO 9888[7]
	10 %		5		
	50 %		20		
	90 %		44		
13	Acute toxicity test on Daphnids	g/L		08/20/2010	NF EN ISO 6341[8]
	CE 50i - 24 hours		6.54 (5.04-8.39)		
	CE 50i - 48 hours		5.15 (4.65-5.70)		

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

[2] *Water quality – Determination of pH – February 2001.*

[3] *Water quality – Determination of electrical conductivity – January 1994.*

[4] *Standard Test Method for Auto ignition Temperature of Liquid Chemicals – 2005.*

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

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

[7] *Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.*

[8] *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).

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Sodium acetate

CRYOTECH NAAC (Proviron Industrie N.V.) Date on which sample was received: 10 March 2010

Product effectiveness

No.	Name	Unit	Values	Date	Normative references
14	Product freezing point as a function of mass percentage (%)	°C		10/25/2010	LRN in-house method
	Mass percentage: 5 %		-3.2		
	Mass percentage: 10 %		-6.8		
	Mass percentage: 15 %		-11.2		
	Mass percentage: 20 %		-17		
15	Ice-melting T = -5 °C	g_{ice} / $g_{product}$		06/25/2012	SHRP H 205-2 method[9]
	5 min		0.96		
	10 min		1.38		
	30 min		2.44		
	T = -10 °C				
	5 min		0.67		
	10 min		0.91		
	30 min		1.38		

[9] SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer: Sodium acetate

CLEARWAY 6S (Kemira) Date on which sample was received: 11 February 2010

ANALYSIS REPORT

This document presents the results of a series of analyses carried out on the runway deicer.

CLEARWAY 6S Runway Deicer

Kemira ChemSolutions b.v.- P.O. Box 60 - 4000AB Tiel- NETHERLANDS
deicer: Sodium acetate
Date on which sample was received: 11 February 2010

It is part of a test campaign on the assessment of the performance of the entire range of runway deicers likely to be used at national airports.
This document is mainly aimed at airport operators in charge of deicing, and at the government departments working in this field. 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 comparison of the physical, chemical, environmental, toxicological and functional specificities of the products. This is particularly useful when defining the criteria used to select service providers during the awarding of deicer supply contracts,
(4) a contribution 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 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 of the ICE (Infrastructure, Climate, Environment) group at the Laboratoire Régional de Nancy (CEREMA), 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.

Service technique de l'aviation civile (Civil aviation technical center) — Runway deicer : Sodium acetate

CLEARWAY 6S (Kemira) — Date on which sample was received : 11 February 2010

Physical and chemical properties of the product

No.	Name	Unit	Values	Date	Normative references
1	State (liquid/solid)	-	Solide	10/25/2010	-
2	Color (visual)	-	Granules irréguliers blanc	03/10/2010	-
3	Bulk density	kg/m³	770	09/06/2010	LRN in-house method
4	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		
5	pH (solution at 10 % w/w)	-	8.5	09/06/2010	NF T 90-008[2]
6	Active Principle [CH_3COONa]	%	96	12/03/2010	LRN in-house method
7	Conductivity (solution at 30 % w/w)	mS/cm	58.4	09/06/2010	NF EN 27 888[3]
8	Autoignition temperature	°C	> 500	10/22/2010	ASTM E 659[4]

Product toxicity and environmental data

No.	Name	Unit	Values	Date	Normative references
9	BOD_5 (20 °C)	mg/kg	304 373	08/03/2010	NF EN 1899-1[5]
10	COD	mg/kg	500 573	08/03/2010	NF T 90-101[6]
11	COD/BOD_5	-	1.6	08/03/2010	-
12	Biodegradability (20°C)	hours		11/12/2010	NF EN ISO 9888[7]
	10 %		5		
	50 %		19		
	90 %		43		
13	Acute toxicity test on Daphnids	g/L		08/20/2010	NF EN ISO 6341[8]
	CE 50i - 24 hours		12.1 (11.4-12.9)		
	CE 50i - 48 hours		10.2 (9.42-11.0)		

[1] Winter service – Solid sodium chloride used as a road flux – Specifications – July 2003.

[2] Water quality – Determination of pH – February 2001.

[3] Water quality – Determination of electrical conductivity – January 1994.

[4] Standard Test Method for Auto ignition Temperature of Liquid Chemicals – 2005.

[5] Water quality – Determination of biochemical oxygen demand after n days – Part 1 : dilution and seeding method with allylthiourea addition – May 19988.

[6] Water quality – Determination of chemical oxygen demand (COD) – February 2001.

[7] Water quality – Assessment of the aerobic biodegradability of organic compounds in aequous media – Static test (Zahn-Wellens method) - September 1999.

[8] 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).

Service technique de l'aviation civile (Civil aviation technical center) Runway deicer : Sodium acetate

CLEARWAY 6S (Kemira) Date on which sample was received : 11 February 2010

Product effectiveness

No.	*Name*	*Unit*	*Values*	*Date*	*Normative references*
14	*Product freezing point as a function of mass percentage (%))*	*°C*		*10/25/2010*	*LRN in-house method*
	Mass percentage : 5 %		*-2.8*		
	Mass percentage : 10 %		*-6*		
	Mass percentage : 15 %		*-9.7*		
	Mass percentage : 20 %		*-14.4*		
15	*Ice-melting T = -5 °C*	g_{ice} / $g_{product}$		*06/25/2012*	*SHRP H 205-2 method*[9]
	5 min		*0.86*		
	10 min		*1.23*		
	30 min		*1.99*		
	T = -10 °C				
	5 min		*0.41*		
	10 min		*0.73*		
	30 min		*1.29*		

[9] *SHRP H 205-2 method "Ice melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals"*

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