De-icers storage, management and structural design: a technical guide presentation

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ABSTRACT

The deicers and anti-icers are used to improve surface status, driving and traffic conditions. They are expensive, not re-usable products and insofar there are currently no plans to their recycling. There are 20000 to 25000 storages locations in France, which quality varies from one location to the next, all having an economic impact, and an ecological one. An appropriate storage, and fitted to the need, to the stored product and to its use, allows to reduce these impacts while ensuring the spreading quality.
These considerations led the French Service of Transportation, Roads and Development (SETRA) and Technical Studies Centers (CETE) to elaborate a document dedicated to de-icers management and storage.
This technical guide aims to gather in one document legal, methodological and technical tools. It presents management procedures and strategies, and identifies possible improvements with respect to environmental issues, and to guarantee the quality of these products.

1. INTRODUCTION

Deicers use increases: the French consumption raised over the four past decades, from a few hundred thousand tons to over two millions during most severe winters. In the same time, environmental considerations are growing. Deicers are expensive (a deicers ton cost is similar to the one of a bituminous mixture ton) and considered as consumable. So, it is mandatory to use them appropriately. The storage is an indispensable step to maintain their inner qualities. Furthermore, as a result of the road network growth and the successive French reorganizations storage distribution and structural design are sometimes poorly adjusted to road manager needs.
This document “De-icers storage, management and structural design”, written by the Technical Studies Centers (CETE) and published by the French Service of Transport, Road and Development (SETRA), will be available in 2014. It is intended to all road networks managers (either urban and interurban), networks owners, architects and partners, and aims to gather legal, methodological and technical tools.
This paper provides an overview of the guide and details, in the first part, the French regulations, associated design and management recommendations. The following part describes approaches to choose the storage location and the dimensioning needs, based on previous winters. All suggested approaches in this guide are illustrated with examples. This paper then describes general principles to build or to renovate a storage, specifically with environmental considerations.

2. FRENCH CONTEXT AND REGULATION

Sodium chloride is the most commonly used deicers (99%) on the French road network and is an acceptable response to global needs of road managers. There is no specific national legislation on the environmental aspect of winter maintenance. But in the global environmental regulation, the act of throwing, of pouring, or to let pour into water […] one or many substances which action or consequences, even temporarily, are negative on health, or might damage animals or plants […] is punished by the law [1]. There are other legislations that empower road managers, with the principle that the polluter pays [02].

Chloride and sodium are clearly mentioned as evaluation criteria for groundwater quality with threshold values, of respectively 250 mg/L and 200 mg/L [4]. These thresholds can be modulated after an evaluation of the quality of groundwater body. This body shall be considered to be in poor chemical status when there is a significant increase of certain parameters (in particular chloride, sulfate and conductivity) [5]. Therefore the guide “De-icers storage, management and structural design” insists on the systematic sheltering of sodium chloride to protect it from rain and snow.

In rare cases, others products are used for treatment of specific road sections due to specific constraints. This guide presents particular storage, adapted to de-icers other than NaCl, according to their physical properties and their recommendations of use.

A paragraph is dedicated to the de-icers use in the legal REACH context [6]. The waste material treatment (de-icer no longer considered as such) is structured into the following priorities:

- the preparation for a new use, generally possible for chloride de-icers (NaCl, $CaCl_2$),
- the recycling, which may be formalized in contracts right at the material purchase,
- the disposal of waste: The French Department of Health Regulations prohibits the abandonment of waste in the public domain (wild storage), and the pouring of dangerous substances to aquatic environment (emptying of brine tanks).

With respect to the legislation, this guide suggests some design approaches to minimize environmental impacts: topography evaluation, soil permeability, dilution capacity of receiving water courses, storage surface waterproofing, implementation of halophyle resistant plants in the vicinity of the storage location, building a loading platform, etc. Other recommendations concern operations on the de-icer stock: manipulation under shelter, regular maintenance of equipments, methodic unloading on the stock, sweeping the platform, etc.

3. STORAGE LOCATION

The guide objective is to adapt equipment strategy to the road manager needs. The storage location is related to the typology of road network (linear or mesh network), it is a link in a circuit organization. It has to be near the road network, while being easily accessible for spreaders and for delivery trucks.

The storage may be located in the road operation center or isolated as a supply support point, which could also raise delivery / security problems. The location of the site is a compromise between circuit’s accessibility (distance, time required to load spreaders, existence of high traffic road sections), priority treatment and/or more frequent treatment for specific winter-sensitive points of road network (priority circuits, ramps, bridges…), and

spreader's autonomy. Site's topography, environmental sensibility or proximity of homes will be taken into account too.

To determine its location, a possible approach could be the barycenter method. Some physical points are considered (bridges, ramps, high environmental sensitivity or elementary road sections), and are weighted according to their importance (high coefficient for high service level, frequency operation, times operation, consumption, etc.). This study with barycenter method will not provide an accurate response, but is a good indicator.

A second step consists in creating, if necessary, strategic stocks to cope with supply demand peaks in the case of long winter events. This option entails road network managers logistical capacity. The barycenter method can also be applied in theses situations to optimize the location of this strategic stock.

4. STORAGE DIMENSIONNING

The storage dimensioning is based on previous consumptions. In France, the Winter Maintenance Index (IVH) [7] gives a representative picture of winter maintenance troubles. Some previous studies have shown that de-icers consumptions are correlated with this index [8].
The storage capacity defines the device size and the most important volume which can be stored. This threshold is part of a global strategy with the definition of the amount available at winter start (de-icers available before winter season), the threshold for a new supply and the threshold of the end of winter to cope with late winter events. These definitions are detailed elsewhere [9]. The size of the storage capacity reflected road manager's choices in terms of risks, which vary between two extremes:

- to minimize the storage capacity or to manage in a just-in-time way, with the risk of inventory stock-outs. This choice induces an ability to manage crisis situations.
- To maximize the storage capacity with an investment in a storage device and expensive immobilization of products.

Predictable consumptions are based on average winter and are appreciated through available data and a comparison with an average IVH (IVH_{100}.) In the absence of reliable data or for road creation, consumptions are estimated as a function to surface where de-icers will be spread on, and on the number of predictable operations, following a climatologic analysis or by contacting the person in charge of the network next to the one considered. In France, regions with coastline have a largest winter variability than continentals regions (**Figure 1**). All French territory is fluctuating between these two extremes "coastline zone" and "continental zones". This envelope is helpful for a better assessment of the risk-taking of road-managers. As an example, if the road-manager chooses a sufficient capacity to face 4 winters out of 5, or a likelihood of occurrence of 80% in continental zone, the consumption of deicers will be similar with a winter of IVH_{100}=120. Statistical data of previous winter will allow to determine the associated amounts in tons.

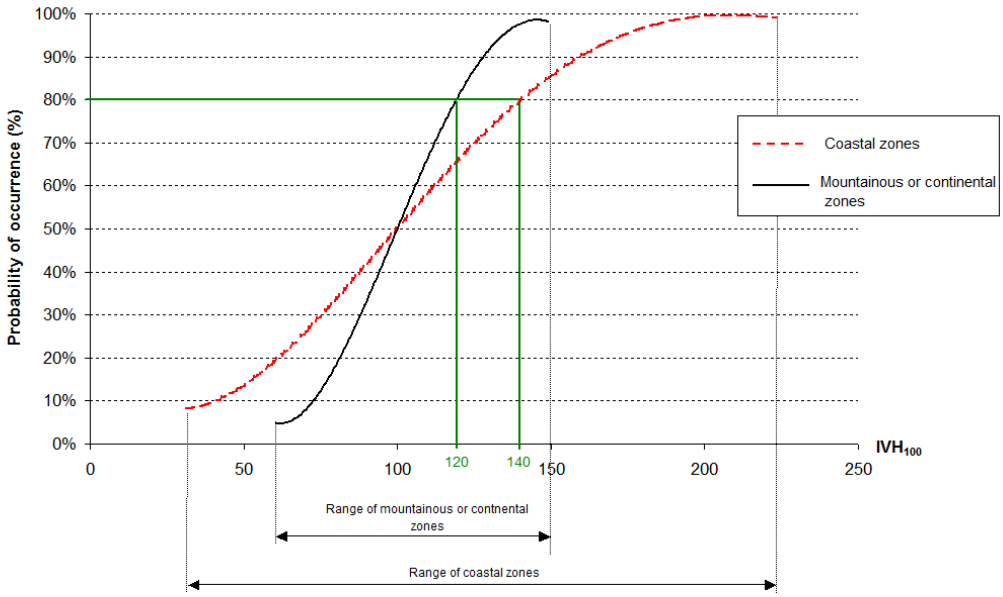

Figure 1 - Probability of occurrence of winter in France as a function of geographical zones (data 1977-2012)

Table 1 – - Maximum storage capacities as a function of French climate zones

	Mountainous or continental climate	Coastline zones
Variability ($IVH_{100\ max}$ / $IVH_{100\ min}$ ratio)	< 2 or 3	> 3
Maximum storage capacity	80% to100% of an average winter's consumption	100% to 200% of an average winter's consumption
	Compatibility with 5 or 6 days of winter weather (new supply threshold)	

Maximum storage capacities presented here (Table 1) are directly inspired from road-managers practices of urban or interurban networks [10]. However, it is possible to adjust these orders of magnitudes depending on the context: for small stocks or zones with a weak winter severity, the stock must not to be left unused over two consecutive winters, to maintain de-icers qualities. A storage beyond 200% will not be cost-effective, except in cases of strategic stock.

5. FONCTIONNALITIES

This guide presents principles to be respected to create or for the renewal of storage devices: administrative part separated from operation part, proximity of fuel supply, accessibility to deicers storage by spreaders and to supply-trucks, etc. A paragraph of the guide is dedicated to the management of runoff-waters. In particular, as a minimum, the storage center must be equipped by buffering ponds.

For existing stocks, this guide intended to avoid brine release during low-flow periods (concentration of saline effluents without dilution by receiving water courses) and during spring period (growths vegetation) [11]. Another option is to collect brine run-off for its injection into brine manufacturing devices. The objective is not to collect all run-off water, but only the most heavily concentrated brines, in general after long winter weather. A statistical study of local rainfall allows an estimate of their intensities. The tank dimensioning could also be made on the basis of the maximum de-icers amount on

platform. Over three days of winter weather, it is reasonably admitted that the staff has time to clean the platform. The maximum capacity of brine manufacturing device and of the tank storage are also a significant criterion for the dimensioning, or not considering that no additional amount than the maximum possible could be used.
In this guide, the emphase is also put on other functionalities such as the respect for drive-through, presence of loading platform. A comparison between the types of materials dedicated to loading spreader equipments is suggested (Table 2)

Table 2: comparison between the types of materials dedicated to loading spreader equipments

Equipment type	Tractor or front loader	Telescopic loader	Loading silo
Carrying capacities	0,3 to 10 m^3 (2 m^3 maximum recommended)	0,5 to 10 m3 (2 m^3 maximum recommended)	-
Estimate carrying times (spreader 6 m^3)	6 to 10 minutes	6 to 10 minutes	1 to 5 minutes
Deicers quality recommended	All type	All type	Deicers with good flowability
Investment cost	●●○○○*	●●●●○*	●●●●○
Operating cost	●●○○○	●●●○○	○○○○○
French specifications for ergonomic and safety	CACES** section 4 if > 4,5 tonnes.	CACES** section 4 if > 4,5 tonnes.	No qualification
* These equipments are also available in rental for winter maintenance			
** CACES : French safe driving aptitude certificate			

6. STORAGE TECHNIQUES

This part provides details about storage conception: working platform waterproofing, stock exposure (opposite to the prevailing winter winds) or geometric aspects (device shape, clearance with the ceiling compliant with handling equipment, useful volume, etc.). This is an international common approach. The material choice proposed is based on carbon footprint. To date there has been no formal evaluation, but some values are available [12]:

- Wood: in some conditions, carbon footprint is neutral or negative if wood exploitation is sustainable (forest re-grown) and if storage device has long-life service (around one hundred years). If all these criteria have been met, the wood carbon-footprint is –500 kg of carbon equivalent dioxide per ton (photo 1).
- Steel: 870 kg of carbon equivalent dioxide are necessary to bring a ton of steel and 300 kg of carbon equivalent dioxide for one ton of fully recycled steel.
- Concrete: 235 kg of carbon equivalent dioxide per ton.

Photo 1 – Wood shelter with two boxes

If we consider that a de-icers storage device is similar to an agricultural hangar, emission factors are 60 kg of carbon equivalent dioxide per square meter for metallic construction, compared to 180 kg carbon equivalent dioxide per square meter for a concrete one. Thus, a comparison of materials properties in terms of costs, resistance, environmental impact or esthetic is available for the reader.
Finally, different de-icers storages (salt box, large bags, silos, shelters with removable roofs, or hangars) are described to help road manager in making a choice the most adapted to his need and organization.

7. CONCLUSION

The technical guide “De-icers storage, management and structural design” presents guiding principles in the elaboration, the dimensioning, and the management of a winter maintenance center. In addition the legal aspects, it presents a comparison of de-icers products, exposes some methods to choose storage device location and its size, with a permanent goal to minimize the environmental impact. The definition of de-icers management requires an unavoidable phase: the definition of the needs. The resulting stocks spatial distribution is a conclusion of this analysis and the storage capacity. This guide interacts with several other documents (published or to be published) where road managers will find some information on French winter maintenance approach [11] [13].

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