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Developments in Airport Ice Control Chemicals

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ABSTRACT

Icing of airstrips is a serious problem that must be addressed in light of increasing air traffic demands. In this paper current means of chemical ice control, and some problems associated with various chemicals are discussed. Research is needed in the development of effective, environmentally safe, affordable chemical controls that can be used for airstrips as well as for roadways.

Keywords: Airstrips, Chemical ice control, Deicing

INTRODUCTION

Since the earliest days of aviation in cold climates, the catastrophic effects of corrosive ice control chemicals on aircraft components have been known, and use of such chemicals has been resisted by airport operators. Aircraft landing gear can be seriously weakened due to hydrogen embrittlement by certain ice control chemicals. Corrosive chemicals have been banned from airports by all responsible airport operators, and alternatives have been sought and used for many years. There remains, however, an increasing demand for greater performance.

Prior to the use of ice control chemicals at airports, the only alternative to landing and takeoff from a slippery ice or compacted snow surface was to sand the airstrip, which also creates a difficult landing condition. In addition, sand may be ingested into jet engines, causing mechanical damage. Nonetheless, sand is still used when temperatures drop below the effective range of chemicals.

As aircraft became larger, heavier, more numerous and less tolerant to surface contaminants, the demand on airport runways increased. Ever greater available runway lengths were demanded by aircraft operators to permit them to fly heavier loads and operate in adverse weather conditions. The available length of a runway is reduced as its slipperiness increases, because the aircraft requires more distance to reduce speed under braking. The only way to increase runway available lengths under slippery conditions is to remove the ice or to apply sand. Sand can damage aircraft components and has a limited ability to improve friction. The best solution is to remove the ice. Chemicals can prevent bonding of new ice to the surface and penetrate, loosen and dissolve existing ice, allowing mechanical removal.

CHEMICAL USE FOR RUNWAY ICE CONTROL

For nearly three decades the two most common chemicals have been urea, a solid agricultural fertilizer, and a liquid urea/glycol mix. Both urea and urea/glycol have been used in the U.S. and Europe, while urea has been used almost exclusively in Canada.

With the inclusion of more complex metallurgic and synthetic compounds in aircraft components, the aircraft manufacturers and operators have lobbied hard for ice control chemicals that have minimal effects on aircraft components. In addition, the demands for products that are benign to the local environment are constantly growing. Glycol, and to a lesser extent urea, have some impact on local environments. Although these effects are usually minimal, they can sometimes be significant, depending on the local ecology. For these reasons airports have come under pressure to find new, effective, easy to use and environmentally benign ice control chemicals. Since airports are only the consumers of such products, the challenge has been passed to the suppliers: the chemical industry.

Cooperative development and testing between the chemical industry and airports research and development groups, such as Transport Canada's Airports Group Safety and Technical Services and the U.S. Federal Aviation Authority, have yielded several al-

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ternative options for ice control on airport pavements over the last seven years:

- Some U.S. sites have treated runways with urea liquefied with hot water. This is expensive but can be effective when used with very specific follow-up procudures.
- In the late 1980s sodium formate, a solid, was developed in Canada and found to be effective, but the supply of raw material was restricted soon after development. New supplies have only lately become available.
- Liquid potassium acetate was developed also in the early 1990s, tested, and found to be a good anti-icing agent.
- Sodium acetate, a solid, was recently developed in Europe and has proven effective.

SPECIFICATIONS

In Canada the results of previous independent environmental testing or a complete chemical description of the product have to be provided to Transport Canada Airports Group, before any field testing proceeds, to ensure that the product can be field tested without major environmental risk. Other countries have similar procedures. Currently in North America only those chemicals that conform to Society of Automotive Engineers, U.S. Federal Aviation Authority, and/or Transport Canada specifications are used on federally regulated or subsidized airports. Other jurisdictions have similar control and specification processes.

Prior to field testing at an airport, the manufacturer must demonstrate that the product complies with the appropriate Aircraft Material Specifications of the Society of Automotive Engineers or the equivalent specification in Europe. This ensures compatibility with aircraft components since representatives of aircraft manufacturers, airlines, chemical manufacturers, and airport regulators constitute the specification formulation and approving committees.

Transport Canada Airports Group has taken a three-stage approach to testing ice control chemicals:

1. Ice-control performance laboratory tests are performed with all variables controlled and monitored, and results documented.
2. Full-scale performance field trials are conducted at an airport over a winter, with the chemi-

Table 1. Characteristics and results of testing.

	Salt	*Urea/glycol*	*Urea*	*Calcium magnesium acetate*	*Sodiuum formate**	*Potassium acetate*	*Sodium acetate*
Solid or liquid	Solid grain	Liquid	Solid prill	Solid prill	Solid grain	Liquid	Solid grain
Environmental acceptability	Reduced	Limited	Usually	Yes	Yes	Yes	Yes
Aircraft component compatible	No	Yes	Yes	Yes	Yes	Yes	Yes
Approximate effective temperature limit (°C)	–14°	–8°	–7°	–11°	–17°	–20°	–12°
Relative effectiveness	Excellent	Good	Good	Poor**	Excellent	Excellent	Very good
Approximate cost per tonne or liquid equivalent†	$30.00	$400.00 to $600.00	$300 to $380.00	$1,100.00 to $1,300.00	$1,500.00 to $2,000.00	$1,200.00 to $1,500.00	$1,800.00 to $2,300.00
Availability	Excellent	Excellent	Excellent	Good	Good	Very good	Limited

* Recommended by Transport Canada Safety and Technical Services.

† Costs are in Canadian dollars and should only be considered as very rough approximations. The costs of the newer products are volatile, because neither the demand nor supply has stabilized.

** The reaction time for CMA on runways is high, probably due to low vehicular traffic required to break up the prills.

cal being used under operational conditions and detailed records kept of effectiveness.

3. A full-scale environmental evaluation is conducted concurrent with the performance field trials to monitor effects on the local ecosystems.

Each stage of the testing generates a report detailing the conduct of the test, findings and recommendations. The field performance evaluation will result in a recommendation to accept or reject the product for use at Transport Canada airports. Other agencies use a variety of methods to qualify a product for use. Table 1 lists the ice control chemicals, their characteristics, and the results of testing by the Transport Canada Airports Group. Currently the most effective, environmentally acceptable chemicals are sodium formate and potassium acetate. However, their associated high cost sometimes makes them an unacceptable alternative for smaller airports.

LIQUIDS VERSUS SOLIDS

Liquid and solid chemicals present not only very different challenges for storage and handling but also have different operational advantages and disadvantages when combating ice. In anti-icing modes, liquids will spread across a surface in an even film to resist the bonding of ice to the pavement. When applied as deicers, liquids will tend to spread across the ice surface, get diluted and freeze. Only when there is a very thin layer of ice or cracks in the ice that permit penetration, will the liquid be truly successful in reasonable quantities. Liquids resist wind loss well.

Solids perform well as deicers because the chemicals, concentrated in prills, release their energy in a local area and are able to "burn" through existing ice to spread out underneath and break the ice–pavement bond. In an anti-icing mode there is no resistance between the prills to the ice-pavement bond. Consequently the ice may bond before the developing chemical brine can spread and prevent it. Melting then takes additional time. In addition, solids are prone to loss because of transport by the wind and jet blast.

OTHER OPERATIONAL ISSUES

The successful operational use of any ice control chemical is dependent upon a number of factors. For example, the ability to predict the formation or precipitation of ice is important. Electronic sensing systems, forecasting, and knowledge of the local environment all contribute to an increasing ability for anti-icing before freezing of the pavement occurs, instead of deicing afterwards. At least twice as much chemical is required to deice compared to anti-icing for a given ice layer thickness. Accurate prediction of ice formation can significantly reduce costs associated with ice control.

The method of application and form of chemical used is also important. Electronic controls on application equipment can provide a very precise application rate that significantly reduces waste. Any airport can gain significantly from having both liquids and solids available. The performance of solids can be enhanced when the material is "pre-moistened" as it leaves the spreader. Wind loss is reduced, prills and grains bond to the surface quickly when moistened, and reaction time is reduced. All airports with frequent significant icing events mechanically remove (blade, broom or blow) the brine that results from chemical treatment to prevent refreezing. Airports with low risks of icing sometimes may prefer to apply large amounts of chemical to induce runoff rather than invest in fleets of mechanical equipment. Finally, good training in the use and application of sophisticated chemicals is paramount if airfield maintainers are to realize the maximum advantage.

CONCLUSION

The demands for increasing effective runway lengths in inclement weather has driven airports to seek greater performance from ice control chemicals. This demand has resulted in the chemical industry focusing relatively large resources in research, development and production of sophisticated products for a limited market. The total consumption of ice control chemicals at all Canadian airports would not exceed 20,000 tonnes in the worst of winters. Relatively higher numbers could be estimated for other countries, but the total represents a relatively small market for the chemical industry. The inevitable result is that the higher costs will be passed on to the ultimate consumer, the flying public, via the airports and airlines. Such costs can only be moderated to a small degree by competition in the marketplace. Significant cost reductions will only be realized if agencies maintaining roads, bridges and other high volume facilities also increase their consumption of products that are virtually noncorrosive and environmentally benign. Increased production volumes could then result in some reduction of price.

Research and development should now be focused on reducing the cost of the new chemicals added to our arsenal of weapons in the fight against ice on runways and roads.