Cold Regions Science and Technology 138 (2017) 57–62

Contents lists available at ScienceDirect

Cold Regions Science and Technology

journal homepage: www.elsevier.com/locate/coldregions

Comparative evaluation of the anti-icing protection time of runway deicers using infrared thermography

Caroline Laforte *, Marc Mario Tremblay [1]

Anti-Icing Materials International Laboratory, University du Québec à Chicoutimi, Chicoutimi, QC G7H 2B1, Canada

ARTICLE INFO

Article history:
Received 25 August 2016
Received in revised form 18 November 2016
Accepted 5 March 2017
Available online 18 March 2017

Keywords:
Icing
Runway deicers
IR thermography
Anti-icing performance

ABSTRACT

This study presents a new method, based on infrared (IR) thermography, to evaluate and compare the anti-icing performance, i.e., the ability to delay the reformation of ice, of runways and taxiways deicing/anti-icing fluids (RDF) under icing precipitation. In summary, the test consists of applying on a standardized concrete pavement sample, a given quantity of a candidate de-icing fluid. Following the application, the concrete sample is submitted to low intensity freezing drizzle simulated in a cold chamber. Thermography picture is taken every 30 s intervals until the concrete becomes completely iced. The measurement of anti-icing performance of different concentrations of propylene glycol (PG) and potassium-formate (KFOR) solutions are shown when assessed using the new IR method at −5 °C, −8 °C and −11 °C.

1. Introduction

It is known that transportation vehicles and associated surrounding infrastructure can all be detrimentally affected by undesirable ice accumulation. Achieving an efficient, safe, and environmentally sustainable transportation infrastructure in cold climates requires an innovative, yet practical, approach. Current airport practices require the use of significant quantities of de/anti-icing chemicals applied on aircraft and runways, to remove or prevent the accumulation of snow and ice.

In North America, large quantities of the runway deicing products (up to ten million kilograms per year) are applied to airport runways to ensure safe aircraft takeoff and landing in adverse conditions. Following applications, some of the chemicals can somewhat be recovered, but are generally dispersed to the airport's surrounding environment through aviation operations. Limited focus has been given into assessing and determining optimal quantities of deicer to be spread on runways, to achieve at the same time a high degree of safety. Any reduction in this amount of chemicals used would contribute to reducing the risk of contamination to the environment in areas surrounding transportation infrastructure.

Runway deicing chemicals have detrimental effects on the surrounding environment such as soil, flora and fauna, human (Fay and Shi, 2012) and the airfield pavement (Goh et al., 2011; Giebson et al., 2010). Urea has become less popular due to its significantly higher ecological impact. The use of alkali acetates and formates, the successors of urea, has led to new corrosion problems; especially in the case of the maintenance of the aircraft carbon brakes material which require more frequent replacement due to reduced service life. Catalytic carbon brake oxidation is presently considered as a serious safety concern that affects aircraft transportation. To address this problem, chemical manufacturers are currently developing new runway deicers; namely hybrid and non-alkali products, which are much less corrosive, but with equivalent or better anti-icing performance. These new fluid generations still have environmental concerns, challenged by, in some cases, relative changes in biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Research on the impact and development of most effective runway deicers remains necessary. More efficient runway deicers could lead to lower quantity of products use to achieve the same result, thus minimizing the release of potentially detrimental chemicals into the environment.

It is sought to develop tools, whether through application methods or complementary new technologies that could assist the aviation sector in the overall improvement of deicer effectiveness; a practice that has worked well and continues to do so for aircraft ground de/anti-icing fluids. Actually, a better assessment of their deicing and anti-icing performance will help in the development of the next generation of runway de/anti-icing chemicals. Improved performance tests would

* Corresponding author at: AMIL, Applied Sciences Faculty, 555 Blv. Université, Chicoutimi, Canada.
E-mail address: claforte@uqac.ca (C. Laforte).
[1] Fluid Testing Manager, AMIL, Applied Sciences Faculty, 555 Blv. Université, Chicoutimi, Canada.

http://dx.doi.org/10.1016/j.coldregions.2017.03.003

Table 1
AIR test results for RDFs tested at AMIL since 2011.

After 30 min, −10 °C	KFOR based (7 RDFs)	Hybrids (9 RDFs)	KAC[a] based (14 RDFs)
AIR6170 ice melting ice melted ± SD[b] g	6.6 ± 0.5	7 ± 2	6.2 ± 0.6
AIR6172 ice undercutting ice undercutting ± SD mm^2	56 ± 15	58 ± 29	41 ± 16
AIR6211 ice penetration penetration depth ± SD mm	2.6 ± 0.4	1.3 ± 0.3	1.8 ± 0.6

[a] Potassium-acetate.
[b] Standard deviation.

allow the development of more environmentally sustainable deicers, through their improved performance.

The main objective of this paper is to present a new laboratory test procedure to assess the anti-icing performance of runway deicers, specifically in liquid form (RDF), when submitted to icing precipitation. The anti-icing performance is determined by mean of the infrared thermography analysis. This purpose of this new method is to be used as a comparative tool during a development process of the new generation of RDF.

2. Runway deicing/anti-icing fluids testing

2.1. Deicing performance

Many attempts have been made in recent years to develop performance evaluation tools for airport runways and taxiways deicing/anti-icing fluid (Muthumani et al., 2014). In 2002, Scientific Material International (SMI), and the Federal Aviation Administration (FAA) started adapting the Strategic Highway Research Program (SHRP) performance tests for roads (SHRP, 1992a, 1992b, 1992c, 1992d, 1992e, 1992f) to airport applications. This work was summarized as the SHRP tests, where they evolved as the adapted SHRP tests (SHRP, 2002a, 2002b, 2002c).

Indeed with newer high performance and/or sustainable deicers, there was a renewed interest in developing the performance standards to prove their effectiveness. For example, a research group of Montana State University worked on the adapted SHRP methods using differential scanning calorimetry (DCS) technology in combination with artificial neural network (ANN) in order to assess and model deicer performances (Muthumani et al., 2014; Akin and Shi, 2012; Shi et al., 2013). In 2008, the Runway Deicer Performance Working Group (RDPWG) of the SAE G-12 subcommittee was mandated to develop such tests; the first task was to develop runway deicer performance test methods based on the adapted SHRP tests of 2002. This task involved three tests: one for ice penetration, another for ice melting capacity, and a third for ice undercutting. Then in 2012, these new SAE Aerospace Information Report (AIR) test methods AIR6170, AIR6172 and AIR6211 (SAE International, 2011a, 2011b, 2012), applicable for runways and taxiways de/anti-icing chemicals, were published and included in the Aerospace Material Specifications (AMS) AMS1431 for solid products and AMS1435 for liquid products (SAE International, 1992, 1995).

Table 1 presents AIR test results of the three types of, experimental or commercial RDFs ready-to-use or 50% w/w solution tested at the Anti-Icing Materials International Laboratory AMIL since 2011 (Tremblay et al., 2012). Potassium formate based fluids (KFOR) have a slight advantage with ice penetration efficiency. But overall, no significant difference between the three types of RDF was observed, the deicing capability being similar within experimental error.

2.2. Anti-icing performance

There is an increasing interest around the development of new expanded methods, based on tests used to generate Anti-icing Endurance Time (AET) or Holdover Time (HOT) similars to those developed for aircraft deicing/anti-icing fluids (ADF) (Koefod and Tremblay, 2013). As for ADF, RDF efficiency depends on several factors such as meteorological conditions: air and pavement temperatures, wind, humidity, solar radiation, icing type and intensity, traffic, fluid application method, and pavement conditions including surface profile and chemical contamination. The simulation of these conditions in a laboratory and their correlation with field results are difficult to accurately reproduce due to the presence of those fluctuating factors related to the runways. For these reasons, in this study, the anti-icing performance time will labelled as Icing Protection Time IPT for doing a distinction with AET or

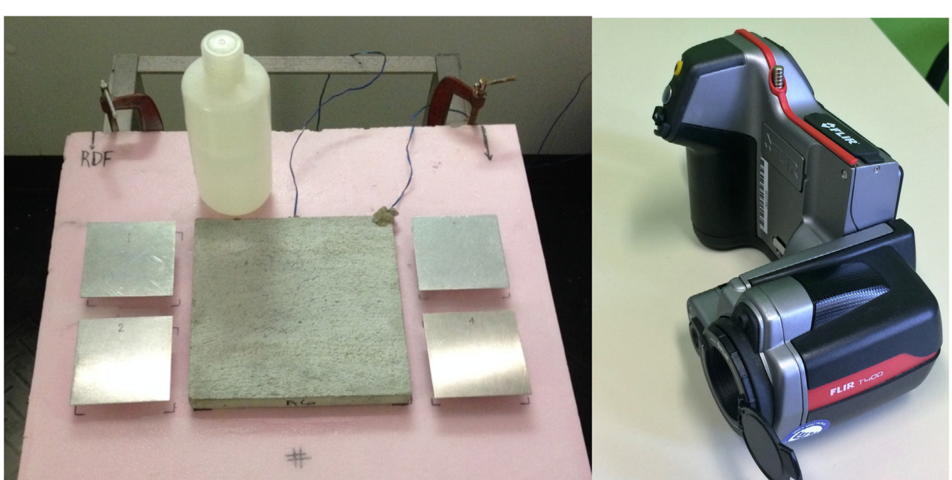

Fig. 1. Left) RDF, concrete sample and ice catch panels before the icing test in the cold chamber; right) FLIR T400 IR camera.