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Laboratory Evaluation of Aircraft Ground De/Antiicing Products

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ABSTRACT

An icing laboratory facility has been set up at Université du Québec à Chicoutimi to evaluate the ice holdover times and the aerodynamic performances of commercial ground de/antiicing products. Ice holdover and aerodynamic performances of deicing and antiicing fluids are established through three standard laboratory tests: the Water Spray and High Humidity Endurance Tests, carried out in a climate chamber, and the Flat Plate Elimination Test, conducted in a cold wind tunnel. UQAC facility qualifies for certification of commercial products under these AMS and AEA standard tests. This paper aims to describe the testing procedures recently implemented at UQAC icing laboratory for de/antiicing fluid evaluation and other research activities in this area.

INTRODUCTION

All precipitation below 0°C tends to produce solid deposits on the aircraft body. These deposits are known to modify the aerodynamic performance, reducing lift and increasing drag (Zierten and Hill, 1987). To prevent these ill effects on aircraft, various deicing and antiicing schemes have been developed. The purpose of deicing is to remove all forms of ice deposit while the aircraft is on the ground waiting for takeoff. This is achieved by a combination of mechanical, thermal and chemical actions: projection of hot water, sometimes mixed with ethylene and propylene glycols. The object of antiicing is to prevent formation of ice deposit. Antiicing fluids are much thicker than deicing fluids as a result of the introduction of large polymers to the water-glycol solution. However, the work of Boeing Company in collaboration with the NASA Lewis Research Center (Nark, 1983; Hill, 1990) and the Von Karman Institute for Fluid Dynamics (Carbonaro, 1986 and 1987) has demonstrated that significant amount of the thickened fluid was left on the wing at the time of liftoff, and consequently, aerodynamic penalties were, once again, detected. The importance of non-Newtonian or pseudo-plastic behaviour was therefore acknowledged for antiicing fluids. The fluid viscosity had to be markedly shear stress dependent, in order to flow more easily during ground acceleration. In a joint effort among Boeing (Hill, 1990), VKI (Carbonaro, 1990) and UQAC (Laforte et al., 1992c), an evaluation procedure for fluid flowoff behaviour was defined, set up, and is now routinely performed at VKI and UQAC.

This paper describes UQAC facilities and research activities related to ground de/antiicing products. The task is carried out within the Groupe de Recherche en Ingénierie de l'Environnement Atmosphérique (GRIEA), including four senior investigators and a staff (technicians, research assistants, graduate students) of about 30 persons, approximately 15 of whom are actively involved in de/antiicing work. GRIEA has been, for more than 20 years, involved in experimental simulations of cold precipitation and started work in 1988 on de/antiicing fluids. The laboratory received, in April 1992, recognition from the Aerospace Industries of America (AIA) and the Association Européenne des Constructeurs et de Matériel Aéronautique (AECMA).

ICE HOLDOVER EVALUATION

Methodology

The purpose of ice holdover evaluation is to assess the antiicing effect of de/antiicing fluid. The assessment is made in laboratory, since actual weather conditions are unpredictable and variable. In principle, laboratory conditions are meant to reproduce actual conditions. This optimistic view will be discussed later. Two laboratory situations have been selected to study ice holdover. First, the Water Spray Endurance Test, WSET, which is defined as representative of freezing rain during queuing time before takeoff. The rate of precipitation in WSET is set at $5 g/dm^2h$, the air and surface temperatures are at –5.0° C (Laforte et al., 1990). Second, the High Humidity Endurance Test, HHET, which is defined as representative of frost accumulation, typically during longtime parking. The rate of ice condensation in HHET is set at $0.3 g/dm^2h$, the air temperature at 0°C, the surface temperature at –5°C and the air humidity at 96% (Laforte et al., 1992b).

The environmental icing conditions indicated above are reproduced in a climactic chamber (Fig. 1) controlled to provide the required air temperature and flow. An independent refrigerated support, housing eight 10 cm x 30 cm, flat, thin aluminum plates, simulates the wing surface condition. The support is inclined at 10° to provide the gravity effect due to the wing slope. The precipitation is obtained from an oscillating nozzle above the support for the WSET, and from a humidity generator for the HHET. The design and control of precipitation systems are delicate, to obtain (2% to 9%) uniform distribution of ice catch on 10 cm x 10 cm plates as shown in Fig. 2.

The test procedure is basically identical for both tests. A film of the candidate fluids is applied on three plates; at least three plates are left blank for ice precipitation rate measurement. The required precipitation is turned on after a 5-min period of settling so the fluid can reach a stable thickness. The time when ice, forming from the top of the plate, has reached a 25-mm length is recorded as the standard holdover time for the test. De/antiicing fluid, with a holdover performance above 30 min in WSET and 240 min in HHET, is classified as type II. Below that, but above 3 min in WSET and 20 min in HHET, a fluid is classified as type I. A list of

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KEY WORDS: Atmospheric icing, ground wing deicing, deicing/antiicing fluids.