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15. Supplementary Notes (Funding programs, titles of related publications, etc.)

Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada. These are available from the Transportation Development Centre (TDC). Several reports were produced as part of this winter's research program. Their subject matter is outlined in the preface. The work described in this report was, in part, co-sponsored by the Federal Aviation Administration (FAA).

16. Abstract

This objective was met by conducting a series of full-scale tests using the NRC open circuit wind tunnel to examine the flow-off properties of anti-icing fluids contaminated with various forms of simulated freezing precipitation to investigate several recent industry operational concerns; this work was completed in conjunction with the ice pellet research being conducted at the NRC PIWT.

- SURFACE ROUGHNESS AND HEAVY CONTAMINATION: For dry wing cases, the smooth light freezing rain adhered contamination did not have a significant impact on aerodynamic performance, however the addition of ice pellets generated a much rougher surface which translated to larger lift losses. In the case of testing done with fluid, the results indicated that when severe levels of contamination are present, this can result in significant aerodynamic penalties.
- CLEAN LEADING EDGE: The test results demonstrated that the lift loss improved slightly as a result of the fluid being removed from the leading edge. However, it should be noted that in an operational scenario, the leading edge heater may result in "cooking" the fluid on the leading edge, and may cause residues to form. This potential residue may have a measurable thickness and roughness, and a resulting effect on lift loss.
- APPLYING INADEQUATE AMOUNTS OF FLUID: The visual observations supported the lift loss data which did not indicate significant differences in aerodynamic performance whether 2L or 16-20L were used. The results indicate that the improvement in aerodynamic performance when applying less fluid is not significant enough to offset the potential lift losses incurred from contamination due to early fluid failure.
- EFFECTS OF RAMP-UP TIME: For fluid only cases, PG fluids demonstrated approximately 0.1% decrease in lift loss per extra second in ramp-up time. For EG fluid, this was approximately half (0.04%). For the contamination cases, the PG fluids demonstrated a 0.1% and 0.64% decrease in lift loss per extra second in ramp-up time. This result indicated that in the case of contamination runs, the extra ramp-up time could have a more significant impact on resulting lift loss.
- MIXED PRECIPITATION CONDITIONS: The tests indicated a potential for an allowance times for Mixed Light Ice Pellets, Light Rain, and Snow, for Mixed Light Ice Pellets, Light Freezing Rain, and Snow, and for Mixed Light Freezing Rain, and Snow, however further testing would be required. The flap positioning during the test may play an important role on the development of the guidance, as a requirement to maintain flaps in a stowed position for as long as practical may be necessary.
- SNOW OR RAIN ON AN UN-PROTECTED WING: The dry snow test demonstrated that even with the cold wing skin temperature, the snow would not easily be blown off the wing during the ramp up. The majority of the snow was removed, however a thin layer was still present at the time of rotation. During the test, it seemed difficult to ascertain the level of adhesion of the snow and difficult to predict whether it would be removed at rotation. The rain test however demonstrated an excellent flow off of the rain present on the wing during the ramp-up.
- HEAVY SNOW: In general, the heavy snow testing results demonstrated similar visual and aerodynamic results (when compared to the moderate snow tests) for equivalent amounts of contamination, regardless of exposure time. These results indicate a potential to develop guidance material for heavy snow conditions, however a more extensive analysis of this and previous years data, along with flat plate testing data is required.
- MULTIPLE FLUID COMPARISON: It should be noted that although similar amounts of residual fluids were present in all the thickened fluid cases, the fluid dye provided a different visual indication as to how much fluid was present. For example, EG106 and AD-49 both use a very bright dye. If comparing these fluids to ABC-S+ or Launch, one might misinterpret the bright fluid remaining on the wing as an indication of poor fluid flow off, whereas all fluid generate similar residual thicknesses on the wing.

17. Key Words	18. Distribution Statement
Ice Pellet, Allowance Time, Fluid Adherence, Fluid Flow-Off, Wind Tunnel, Surface Roughness, Contaminated Flap, Inadequate Anti-Icing Application, Mixed Precipitation, Snow on an Un-Protected Wing, Heavy Snow	Limited number of copies available from the Transportation Development Centre

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