THE AIR FORCE FLIGHT TEST CENTER ARTIFICIAL ICING AND RAIN TESTING CAPABILITY

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ABSTRACT

The Air Force Flight Test Center has the charter to conduct All-Weather testing on Air Force weapon systems. This includes testing in airborne icing conditions and in rain. To date, a high speed (180-300 knots) NKC-135 modified for artificial ice/rain testing has been used. This system is currently being upgraded to provide a more reliable, technically adequate cloud simulation. The Palletized Airborne Water Spray System (PAWSS), utilizing a C-130 cargo aircraft, will complement the NKC-135 with a speed range of 100-180 knots (100-250 knots using a C-130H model). The PAWSS is self-contained and is built on a cargo pallet and requires no modifications to its carrier aircraft.

BACKGROUND

General

In 1971, the Air Force Flight Test Center, located at Edwards AFB, CA, acquired the Air Force charter for All-Weather testing from Wright-Patterson AFB, OH. All-Weather testing includes artificial inflight ice and rain testing. This testing is necessary to assure that Air Force weapon systems have the capability to operate to design specifications (MIL-STD-210B, Climatic Extremes for Military Equipment, and MIL-STD-810C, Environmental Test Methods) in icing and rain environmental conditions.

NKC-135

To date the primary tanker used to create the necessary artificial icing and rain clouds has been a modified NKC-135. A wide variety of aircraft and missiles have been tested behind this tanker for ice/rain evaluations. These include: AV-8, F-111, A-7D, SRAM, Concorde, T-38, C-130, B-52, F-14, EA-6B, F-15, F-4, A-10, E-3A, T-39, F-16, F-18, Canadair Challenger CL-601, Boeing 757, AGM-86, and AGM-109. The NKC-135 is well suited for higher airspeeds, but cannot be used at approach airspeeds which are typically below 180 knots.

System Description

Bleed air is tapped from the sixteenth stage of the two inboard J-57 engines. The air is routed in 2" diameter pipe through the wing leading edges to a heat exchanger located in the fuselage. Using ram air through the heat exchanger, the bleed air is cooled from approximately 900° F to 400° F. The air is then routed in 4" diameter pipe aft to a pressure regulating valve and then through the standard aerial refueling boom to a nozzle array. Air pressures, temperatures, and metering are monitored from the boom operator's station.

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Nozzle Array

The nozzle array, shown in Figure 1, consists of parallel water and air feed lines joined by sheet metal strips and formed into a circle. The array contains five of these rings configured concentrically. The largest ring is 44 inches in diameter and the smalled is 12 inches. One hundred nozzle elements are welded into the concentric rings. Water is pumped through these to the nozzle elements. Bleed air is routed through the boom (around the water line) down to the air feeder tubes in the manifold, which in turn distributes air to the nozzle elements for water atomization and for heating to prevent nozzle freezing.

The nozzle element currently in use is an off-the-shelf Spraying Systems 1/4 J, setup 22, nozzle. Of 100 nozzle elements, only 49 are used for water spray. The remaining 51 are used for anti-icing the array and are bleed air only. A study is underway to design a replacement array with better flow/lower drag characteristics.

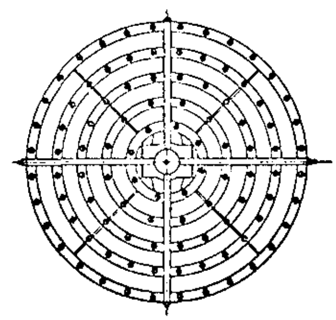

Figure I
CIRCULAR ICING ARRAY

Calibration

Calibration results were obtained in November and December 1982 with a Cessna Citation I outfitted with an instrument package designed to evaluate tanker performance. The instrument complement included two laser probes to measure droplet size, two liquid water content (LWC) instruments, a frost point measuring instrument, plus instruments for temperature, altitude, and air speed. A trisponder system was used to measure distance between the tanker and Cessna. A summary of the calibration follows in Table 1. A representative plot of the drop distribution can be seen in Figure 2. Liquid water content variation with separation distance is shown in Figure 3.

The cloud shape for the USAF KC-135 tanker was reconstructed using the survey data from all tests to obtain statistical significance. The horizontal survey data indicated a cloud core width from 55 to 80 percent of the visible cloud as shown in Figure 4 while the vertical survey data indicated a maximum LWC below the cloud