

Emissions Measured in the Exhaust of a CFM-56 Engine on a DC-8



Instrument rakes behind the DC-8 engine.

A very extensive set of gaseous- and particulate-emissions data from an inservice commercial aircraft engine was obtained by a team of researchers from NASA, the Environmental Protection Agency, and the Department of Defense. The program was led and organized by Dr. Chowen Wey of the UEET Project Office at the NASA Glenn Research Center and was dubbed the Aircraft Particle Emissions eXperiment (APEX). Testing was done at the NASA Dryden Flight Research Center. The main object of APEX was to identify particulate emissions from commercial-aircraft engines.

Measurements were made in the exhaust of a CFM-56 engine on the Dryden DC-8. Two engines were run on three different fuels: (1) JP-8 as the baseline, (2) JP-8 doped for high-sulfur content, and (3) a fuel having relatively high aromatic content. The engines were run over a full range of power settings--including takeoff, climb-out, approach, idle, and several simulated cruise conditions. Two of the four inboard engines were used to maintain torque balance on the aircraft. Two of Glenn's instrument rakes were installed on stands specifically designed for this test and located about 1 and 10 m from the engine-exhaust plane. The 1-m station is shown in the photograph. Each instrument rake had six particle probes, with probe-tip dilution built in, and six gaseous-sampling probes. The 1-m rake had three additional gas-sampling probes added to either side.

The Glenn contingent measured gaseous emissions by two different methods. The primary gaseous system had standard analyzers, as recommended by the International Commercial Aviation Organization (ICAO) and the Society of Automotive Engineers (SAE). The results from these measurements were used to check engine performance and provided the basis for reducing all the other test data. The other Glenn system was composed of a multigas analyzer that is based on the Fourier transform infrared spectroscopy (FTIR) method. This analyzer is being evaluated as a possible alternate

method for gaseous-emission measurements. Both analyzer systems were fed the exhaust extracted from gas-sample probes from each stand location.

The gaseous emissions measured in this test compared well with the certification data for the CFM-56. Particulate measurements, taken by two other research groups, contained both volatile and nonvolatile particles. The nonvolatile particles consisted primarily of solid carbon. The volatile particles included sulfur compounds and various organics from the fuel-combustion process. The volatiles were usually in the vapor state at the engine exhaust plane and tended to condense onto the solid particles in the plume. Other researchers in the test project measured and tracked this process.

This test represents the most thorough exhaust sampling ever conducted, especially for particulate measurements. When this article was written, the data were still being analyzed. Results were reported at the APEX Conference held in Cleveland, Ohio, November 8 to 10, 2004 (ref. 1).

Reference

1. Chowen C. Wey, ed.: Aviation Particle Emissions Workshop. NASA/CP--2004-213398, 2004. <http://gltrs.grc.nasa.gov/cgi-bin/GLTRS/browse.pl?2004/CP-2004-213398.html>

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