Abstract

An airliner (passenger aircraft) is suitable for regularly collecting air samples in the upper atmosphere all over the world. Such sampling makes it possible to quantify the spatiotemporal distributions of the concentrations of trace gases in the upper atmosphere over a long period of time. During the first phase of the CONTRAIL project (1993–2005), a sampling device, the Automatic air Sampling Equipment (ASE), was developed and deployed to collect air samples from a Boeing 747-200 operated by Japan Airlines (JAL). The ASE could automatically collect 12 air samples into titanium flasks using a metal bellows pump during each flight. The ASE development project was a collaboration between the Meteorological Research Institute (MRI), the JAL Technical Development Institute, and the JANS Corp. in Japan. The air samples were collected from the air-conditioning duct upstream of the recirculation fan. A test flight confirmed that the sampled air was useful for precise measurements of trace gases such as CO_2 and CH_4. A cabin pressure sensor in the ASE was used to start the collection of air samples without any assistance of crew members on board the aircraft. The automated sampling operation was controlled by specially designed control boards attached to the ASE. A security system was included to abruptly stop sampling if necessary. Airworthiness inspections by the Federal Aviation Administration (FAA) of the United States and the Civil Aviation Bureau of Japan (CAB) led to licensing of the operation of the ASE on passenger aircraft. An analytical system was established to precisely measure the concentrations of trace gases in the ASE samples at MRI.

Continuation of the observations after 2005 (the second phase of the CONTRAIL project) required that a new ASE be installed on a newer plane, the Boeing 747-400. The basic design of the new ASE for flask air sampling is similar to that of the previous ASE model, but all of the old components have been replaced with new ones. One of the most significant advancements in the new ASE instrument is the sampling operation system, which can be automatically controlled using real-time monitoring of flight navigation data through the ARINC-429 data bus of the aircraft. The new ASE is installed on the rack in the forward cargo compartment of the aircraft, and the air-sampling bypass intake is mounted on the air conditioning duct. JAMCO-Tokyo and JAMCO-America have performed various tests in accord with the environmental conditions and test procedures for airborne equipment specified in the Radio Technical Commission for Aeronautics document RTCA/DO-160D. Deployment of the ASE in a JAL Boeing 747-400 aircraft has been approved by the aviation regulatory agencies of the FAA and CAB through the issuance of a Supplemental Type Certificate (STC). The instrument can thus be used by any airline that flies any Boeing 747-400 series aircraft and thus provides a powerful observational platform for collecting samples for measurements of trace gas concentrations high in the atmosphere on a global scale.

In this report, details of not only the techniques used in the CONTRAIL project but also the background of the development of the ASE for passenger aircraft are described so that it will be easier for readers unfamiliar with this field to understand how we were able to overcome difficulties and restrictions to develop the ASE. We hope that this report will facilitate the advance of a next-generation airliner observation program.