NASA TECH BRIEF

Diffusion of Trace Gases for Leak Detection: A Study

Various leak detection techniques are used when searching for leaks in aerospace pneumatic systems. One common technique is the injection of Freon-22 ($CHClF_2$) or helium (U.S. Bureau of Mines, Grade A) into the system to be tested and location of leaks with detection devices, such as a halogen detector, which senses Freon, and a helium mass spectrometer. Pure Freon or helium is seldom used because of the expense, unless maximum sensitivity is required. Good practice in leak detection would normally specify Freon or helium concentrations in air or nitrogen ranging from 1 to 10 percent by volume. The method of inserting the trace gas into a system under test is usually slug injection; i.e., at some point or points during the pressurization cycle, a specific amount or slug of pure trace gas is inserted in the system. The accuracy of the test depends on the extent to which the trace gas diffuses throughout the system to form a homogeneous mixture of known concentration. An experimental study was therefore undertaken to obtain quantitative measurements of the diffusion of trace gases (Freon and helium) injected into systems by different methods.

A Freon concentration in air of 1 percent by volume was used for the Freon experiments, as this concentration is widely used in leak detection. Two methods of Freon injection, slug injection and premixing of Freon and air by means of a special Freon injector, were used. The tests were made with a nonspecific system consisting of spherical volumes and interconnecting tubing with sampling ports at five locations in the system. Samples were analyzed with a mass spectrometer in order to measure the Freon concentration at each location. The various slug injection modes tested did not produce the desired uniform mixture of Freon and air. Much of the system had little or no Freon, while other portions had considerably more than the desired concentration. Suitable diffusion of the Freon was obtained using the Freon injector. Some dilution occurred at the dead end of the system as a result of the air in the system being partially compressed and only partially mixed with the pressurizing gas mixture. The dilution can be prevented, however, by venting the dead end during fill.

A helium concentration of 10 percent by volume in air was used for the helium tracer experiments. The common slug-injection technique was used in conjunction with the nonspecific system described above having sampling ports at 5 locations and with a 12,500-cubic-foot tank with sampling ports at 6 locations. A helium mass spectrometer was used to measure the concentration of helium sampled from each of the ports. The various slug-injection modes for the nonspecific system did not produce the desired uniform mixture of helium and air. The slug injection modes which were tested in conjunction with the large tank produced varying results. However, after a period of 4 hours, the helium diffused uniformly throughout the entire tank volume.

The test results for both Freon and helium show that uniform mixing of the trace gas does not always occur; some portions of the system are likely to be completely void of the trace gas. Thus it is mandatory that not only the method of trace gas injection be established to ensure uniform distribution, but also the system under test must be evaluated to determine the optimum fill locations and the required vent points.

(continued overleaf)

Note:

Documentation is available from:

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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

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