

Two Response Sensors with different resonant frequencies are sown inside of wheel.

their own magnetic field. For displacement/rotation measurements, the response recorder uses the sensor's response amplitude, which is dependent on the distance from the antenna. The

recorder's antenna orientation and position are kept fixed, and the sampling period is constant.

A sensor with fixed frequency and fixed orientation with respect to the response recorder antenna can be used for position and displacement measurements. If the sensor's orientation is not fixed, but its trajectory is known, it may be possible to calibrate the response amplitude variation with trajectory. For rotational motion such as wheel speed, identifying the number of times the response amplitude exceeds threshold amplitude in a fixed time duration can be used to determine rotation rate. A wheel speed sensor is shown in the figure. The sensor is a thin-film circuit

placed inside the wall of a tire. As the sensor approaches the antenna, the amplitude increases. The amplitude peaks at the closest point to the antenna then decreases producing changes in amplitude that are cyclical. When two sensors with different respond frequencies are used inside the wheel, rotation direction can be determined by identifying which sensor's amplitude increases first. In addition, there is no mechanical wear because no gears are used in the design.

This work was done by Stanley E. Woodard of Langley Research Center and Bryant D. Taylor of Swales Aerospace. Further information is contained in a TSP (see page 1). LAR-16848-1

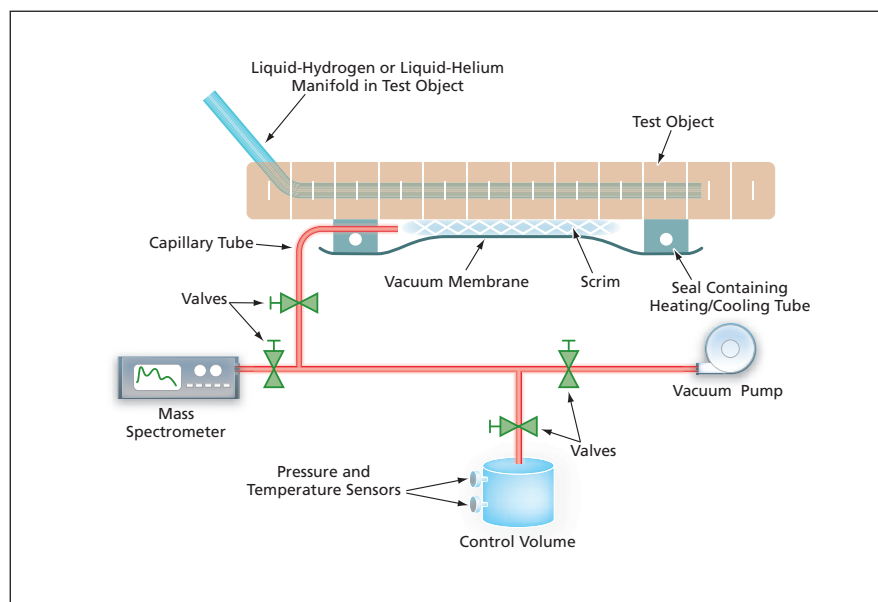
Portable Microleak-Detection System

Heating or cooling of a vacuum seal enables testing over a wide temperature range.

Langley Research Center, Hampton, Virginia

The figure schematically depicts a portable microleak-detection system that has been built especially for use in testing hydrogen tanks made of polymer-matrix composite materials. (As used here, "microleak" signifies a leak that is too small to be detectable by the simple soap-bubble technique.) The system can also be used to test for microleaks in tanks that are made of other materials and that contain gases other than hydrogen. Results of calibration tests have shown that measurement errors are less than 10 percent for leak rates ranging from 0.3 to 200 cm³/min.

Like some other microleak-detection systems, this system includes a vacuum pump and associated plumbing for sampling the leaking gas, and a mass spectrometer for analyzing the molecular constituents of the gas. The system includes a flexible vacuum chamber that can be attached to the outer surface of a tank or other object of interest that is to be tested for leakage (hereafter denoted, simply, the test object). The gas used in a test can be the gas or vapor (e.g., hydrogen in the original application) to be contained by the test object. Alternatively, following common practice in leak testing, helium can be used as a test gas. In either case, the mass spectrometer can be used to verify that the gas measured by the system is the test gas rather than a different gas and, hence, that the leak is indeed from the test object.



The **Portable Microleak-Detection System** includes components in common with prior microleak-detection systems, plus a seal-heating/cooling subsystem that enables testing over a wide temperature range.

The flexibility of the chamber makes it adaptable to test objects having a variety of simple or complex shapes. The flexible vacuum chamber includes an aluminized polyethylene terephthalate vacuum membrane that is sealed to the outer surface of the test object by a flexible, adhesive seal material. A scrim is placed between the inner surface of the membrane and the outer surface of the test object to maintain a gap to accommodate the flow of any leaking gas. A capillary tube that passes through the

seal connects the gap volume with the plumbing that leads to the mass spectrometer, the vacuum pump, and a control volume described next.

The control volume has a known size and is instrumented with pressure and temperature sensors. In use, the control volume is evacuated, then disconnected from the vacuum pump, and then the pressure and temperature are measured as the leaking gas flows into the control volume. By use of the ideal-gas law, the rate of leakage can be calculated from

the temperature and measured rate of increase of pressure.

An unusual feature of this system is a heating/cooling subsystem that includes a tube embedded in the flexible adhesive seal. A heating or cooling liquid can be circulated through this tube to maintain the seal at or near room temperature, where it is most effective,

regardless of the temperature of the test object or the environment. The heating/cooling subsystem is essential, for example, for maintaining an effective seal for testing a tank, pipe, valve, or other object that contains liquid hydrogen or other cryogenic fluid. The heated/cooled seal enables testing at temperatures from -455 to $+350$ °F

(about -271 to $+177$ °C), even in the presence of distortions caused by mechanical and thermal loads applied to the test object.

This work was done by H. Kevin Rivers and Joseph G Sikora of Langley Research Center and Sankara N. Sankaran of Lockheed Martin Space Operations. Further information is contained in a TSP (see page 1). LAR-16139

Free-to-Roll Testing of Airplane Models in Wind Tunnels

Causes of, and cures for, wing-drop/rock behavior can be evaluated.

Langley Research Center, Hampton, Virginia

A free-to-roll (FTR) test technique and test rig make it possible to evaluate both the transonic performance and the wing-drop/rock behavior of a high-strength airplane model in a single wind-tunnel entry. The free-to-roll test technique is a single degree-of-motion method in which the model is free to roll about the longitudinal axis. The rolling motion is observed, recorded, and analyzed to gain insight into wing-drop/rock behavior.

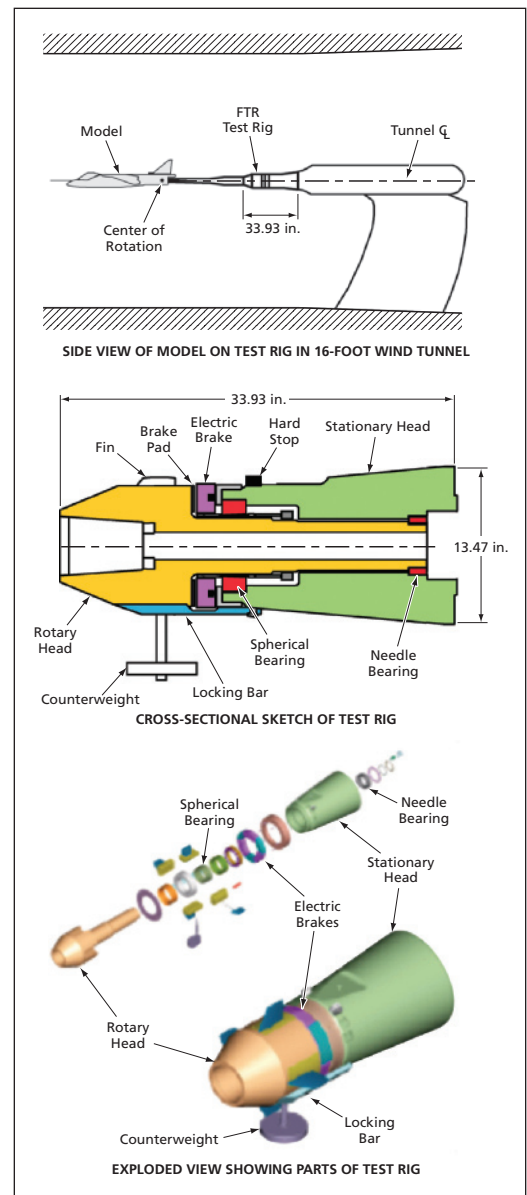
Wing-drop/rock is one of several phenomena symptomatic of abrupt wing stall. FTR testing was developed as part of the NASA/Navy Abrupt Wing Stall Program, which was established for the purposes of understanding and preventing significant unexpected and uncommanded (thus, highly undesirable) lateral-directional motions associated with wing-drop/rock, which have been observed mostly in fighter airplanes under high-subsonic and transonic maneuvering conditions. Before FTR testing became available, wing-rock/drop behavior of high-performance airplanes undergoing development was not recognized until flight testing. FTR testing is a reliable means of detecting, and evaluating design modifications for reducing or preventing, very complex abrupt wing stall phenomena in a ground facility prior to flight testing.

The FTR test rig was designed to replace an older sting attachment butt, such that a model with its force balance and support sting could freely rotate about the longitudinal axis. The rig (see figure) includes a rotary head supported in a stationary head with a forward spherical roller bearing and an aft needle bearing. Rotation is amplified by a set of gears and measured by a shaft-angle resolver; the roll angle can be resolved to within 0.067° at a

rotational speed up to $1,000^\circ/\text{s}$. An assembly of electrically actuated brakes between the rotary and stationary heads can be used to hold the model against a rolling torque at a commanded roll angle. When static testing is required, a locking bar is used to fix the rotating head rigidly to the stationary head. Switching between the static and FTR test modes takes only about 30 minutes. The FTR test rig was originally mounted in a 16-ft ($\approx 4.0\text{-m}$) transonic wind tunnel, but could just as well be adapted to use in any large wind tunnel.

In one series of tests on the FTR rig, static and dynamic characteristics of models of four different fighter airplanes were measured. Two of the models exhibited uncommanded lateral motions; the other two did not. A figure of merit was developed to discern the severity of lateral motions. Using this figure of merit, it was shown that the FTR test technique enabled identification of conditions under which the uncommanded lateral motions occurred. The wind-tunnel conditions thus identified were found to be correlated with flight conditions under which the corresponding full-size airplanes exhibited uncommanded lateral motions.

This work was done by Francis J. Capone, D. Bruce Owens, and Robert M. Hall of Langley Research Center. Further information is contained in a TSP (see page 1). LAR-17153-1



The FTR Test Rig allows free rotation of the airplane model around the centerline. Optionally, brakes can hold the model at a commanded roll angle, or the rig can be locked against rotation for conventional static testing.