AVIATION
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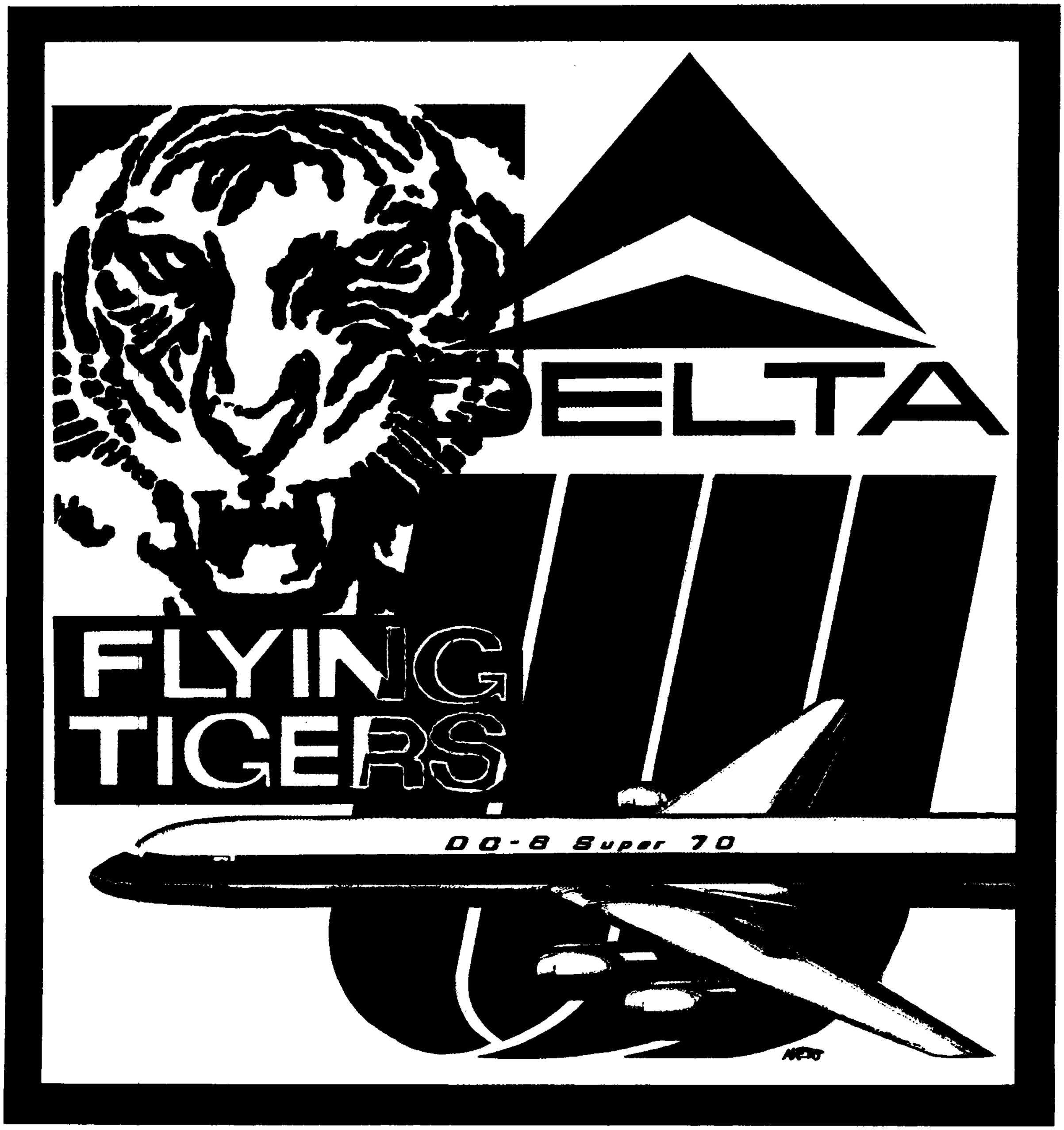

Monitoring Engine Vibration

The case for piezoelectric accelerometers in the test cell.

Reprinted for Endevco

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A check of several engine overhaul and repair facilities indicates major improvements in test cell instrumentation are being made. The resurgence of purchases of sophisticated test equipment over the last 12 months is a strong indication that many engine maintenance facilities have recognized the need to upgrade their engine test cell capabilities. State-of-the-art equipment available for checkout, data collection, validation and engine diagnostics are at the top of many other maintenance organizations' capital equipment investment lists. According to several industry sources, the resurgence is due to a realization that new test equipment available today can achieve increased accuracy, better repeatability, provide real-time display capability and offer improved diagnostics. Computer based equipment, video analyzers and improved vibration signal analysis instrumentation appear to be the most sought after test instrumentation. Equipment that is compatible with sensors used for inflight monitoring of engines installed on commercial transports and high performance military aircraft is setting the minimum requirements for all buyers. Another factor affecting equipment selection relates to overcoming economic factors that are driving up the costs of operating and maintaining test cell facilities.

A major U.S. trunk carrier, who is also a leader in engine repair and overhaul, has already developed sophisticated instrumentation for its CF6 and JT9D test cells. The improvement in test capability this has provided convinced the airline to re-equip its JT3D and JT8D test cells to the same high degree of sophistication. The added capability will allow them to test standard-body engines more cost effectively and provide better diagnostics and validation. In an example where an engine is prematurely removed from a wing for some performance reason, the added test capability will allow the airplane to runup the engine before teardown to accurately determine which part of the engine needs to be repaired, thereby avoiding unnecessary teardown and repair.

A leading designer and producer of test cells, Aero Systems Engineering of St. Paul, Minnesota, thinks that new computer controlled instrumentation systems are within the reach of every test cell operator. "Computer based scanning and recording equipment that display upper and lower limits and the dynamic data of the engine in real-time are cost effective," claims Lars Broberg, executive vice president at Aero, "and within the reach of any company today," he added. Three dimension, real-time monitoring systems which display vibration, amplitude and engine RPM are available for under $50,000. Broberg claims the key to engine maintenance today is modular overhaul, and a company's test cell instrumentation should be sophisticated enough to analyze an engine and diagnose a discrepancy down to the module level. "To achieve this," says Broberg, "you need computerized instrumentation that can analyze engine data to the module level."

In military aviation, Air Force has taken several steps to enhance their engine test capabilities and to achieve cost savings by upgrading its three major engine overhaul and test centers in the U.S. At the Oklahoma Air Logistics Center, Air Force recently completed two new 100,000 pound thrust test cells that are outfitted with computer controlled instrumentation. The new systems can automatically runup and checkout the most sophisticated engines. Real-time displays and automatic logging of data is routine. Special diagnostics built into the instrumentation evaluate each overhauled engine and if a discrepancy is detected the system automatically determines the problem area of the engine which needs rework. This sophisticated capability is saving millions per year in unnecessary rework. The Oklahoma City facility is the forerunner of similar test cells being constructed at the San Antonio Air Logistics Center and the Air Force's research center at Edwards AFB.

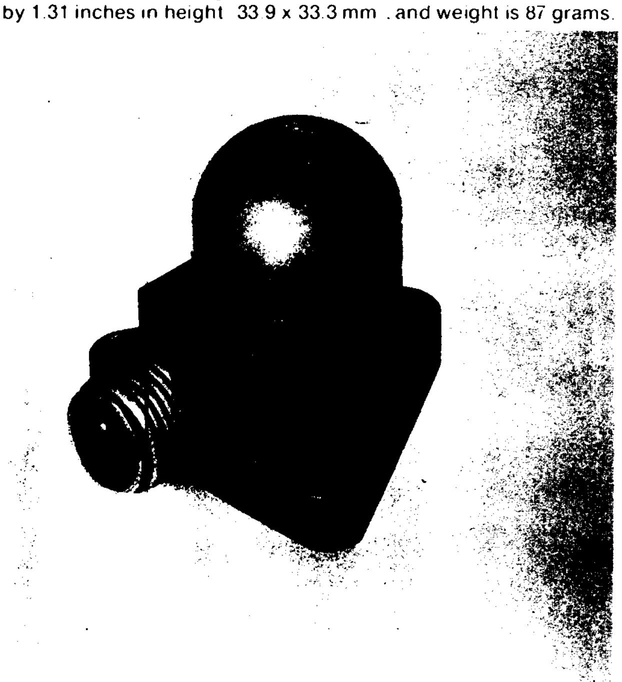
Engines used on wide-bodies and a growing number of standard-body commercial transports are now equipped with extensive vibration monitoring, pressure and temperature sensing devices to monitor the performance and health of installed high bypass turbofan engines. Inflight monitoring equipment installed on high performance military engines, such as the modular F-100 which powers the U.S. Navy's F-14 and Air Force's F-15 and F-16, can analyze 32 different engine parameters. This expanded monitoring capability can also be used during test cell runup to evaluate discrepant engines and to validate repaired or overhauled engines. Instrumentation for test cell applications should therefore be configured to interface with the many types of engine sensors installed on commercial and military engines in use today.

A major difficulty in achieving reliable engine data in test cells has been the quality of engine sensors and the test instrumentation. Improvements in accuracy and repeatability of temperature and pressure sensors at cost effective prices are needed to match the improvements in test instruments. Another difficult parameter to measure has been engine vibration, but improvements in vibration sensors and the advent of microprocessor based real-time analyzers in the $6000 to $10,000 category available today have overcome this difficulty.

Both piezoelectric accelerometers and velocity transducers are available for measuring engine vibration. In the past, velocity transducers (which use a moving coil in a magnetic field to generate a voltage proportional to the engine vibration) had been used extensively in test cell applications. However, the use of piezoelectric accelerometers on wide-body engines has changed that, and instrumentation being selected today must accommodate both types of vibration sensors. According to Endevco, a leading manufacturer of piezoelectric accelerometers, older vibration equipment installed in test cells may not be compatible with piezoelectric devices. New vibration monitoring instruments can accommodate magnetic or piezoelectric pickups. Therefore, new vibration monitoring equipment for test cell applications should be configured to accept velocity or accelerometer type engine vibration sensors.

Piezoelectric accelerometers have been selected over velocity transducers for inflight vibration monitoring applications because they have an inherently longer life span and they are more durable. These benefits, plus others, make them equally desirable for test cell applications. Piezoelectric accelerometers generate a signal proportional to the magnitude and frequency of the engine vibrations. They contain no moving parts and use a bolted mounting system. They provide high sensitivity, excellent signal-to-noise ratio and are less susceptible to electrostatic and electromagnetic pickup. They are undampened, operate well below their first resonance and can measure acceleration over a wide frequency range. Typical piezoelectric accelerometer devices provide a flat response from five to 7000 hertz. High, low and passband filters can be used to selectively monitor vibrations from various rotational elements of an engine. The devices are connected to the input of real-time analyzers through a charge amplifier using low noise cables. In addition to long life and broad dynamic range, they can operate over wide temperature ranges (-270 to +650°C), have a small size (Figure 1), low mass and negligible sensitivity to the external environment. ■

Figure 1: Shown here is a differential output accelerometer for measurements up to 20 kHz. It features mounted resonance frequency of 50 kHz, standardized output of 20 pC/g ±5%, 260°C operating temperature and hermetic seal. Case is grounded to structure. Size is 1.33 inches wide by 1.31 inches in height (33.9 x 33.3 mm), and weight is 87 grams.



DC-8 RE-ENGINING

The cover design for this issue illustrates the re-engining of the "stretched" DC-8 aircraft and the airlines which are already committed to the program. The new Super 70 Series aircraft will meet the 1985 federal noise regulations and will be as fuel efficient as the same class aircraft coming on the market today.

The new engines are being designed and developed by General Electric Company USA and SNECMA of France. The CFM 56 engine may eventually be used to re-engine smaller DC-8 aircraft as well as the 707, AMST and KC-135.

Four Endevco® accelerometers have recently completed re-testing after 229 hours of successful operation in and on the official certification engine. These units are mounted on the No. 1 bearing, fan frame, turbine frame and gear box. The sensors are designed for high sensitivity and maximum ruggedness and reliability.

The CFM56 engine is designed for on-condition maintenance and modular maintenance. Vibration is one of the key parameters which will make these concepts work to optimize maintenance for the airlines.