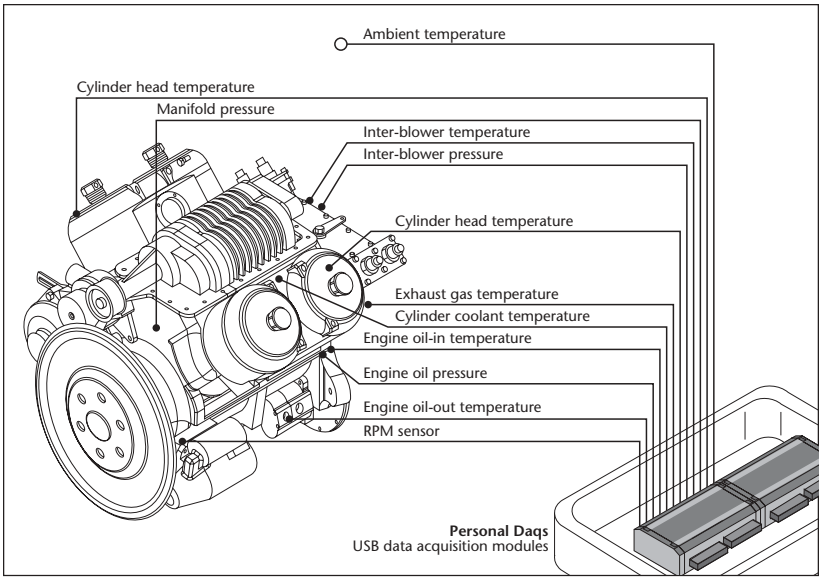
Diesel Aircraft Engine Testing
using the Personal Daq™

Aircraft

Application Note #79

Application Summary
Before a new engine can be approved and commissioned for general and experimental aircraft, it must log hundreds of operating hours on a dynamometer test stand without failure. This verifies its design and ensures that the engine is highly safe and reliable. Unfortunately, the work needed to successfully carry out such an undertaking can be daunting for the crew. They must be present during the entire test, even when the event runs around the clock. The problem became quite acute for the various teams of engineers, technicians, and volunteers at DeltaHawk Engines, LLC, in Racine Wis., when they began endurance testing a new 160 hp, four-cylinder diesel engine late last year. The observers must be ready at all times to make minor adjustments or fine tune the setup on the fly when a measured variable from one of the numerous sensors placed around the engine exceeds a preset limit. And the equipment had to be relatively easy to program and operate by people with a wide-range of skill levels.

Potential Solution
Conventional temperature, pressure, and flow gages had been used in the past, but this approach did not provide the trend data that may need to be analyzed at a later time. A large, expensive data gathering system was employed during initial tests, and although it worked well, the desktop computer and rack-mounted hardware were too large and bulky to use on the aircraft for in-flight tests. Moreover, the equipment was relatively difficult to program and maintain during a test; it runs most reliably under the hands of a programmer and other skilled technicians. Although this equipment was tolerable for the highly experienced, it was not practical for the scores of less skilled volunteers who manned the tests at odd hours of the day and night.



Two Personal Daq USB data acquisition modules are installed in a carrying case for convenience when performing in-flight tests or connecting to an aircraft engine and dynamometer assembly in the field lab. The engine and dynamometer are mounted in a trailer so the rig can be moved around DeltaHawk's test facility at John Batten Airport in Racine, Wis., and tested outdoors in a wide range of temperatures and weather. Field-testing is also carried out in several remote locations where the engine may be put through its paces without soundproofing restrictions.

IOtech's Solution
Rip Edmundson, information manager for DeltaHawk, decided to try the more compact IOtech Personal Daq™ data acquisition system connected to a laptop computer to collect the data from an engine and dynamometer on a trailer. Edmundson programmed the Personal DaqView™ software package to display virtual gages on the laptop screen with lower limits set in blue and upper limits in red. When a variable crossed over the limit line it was quite obvious to all operators.

One critical variable to measure is the oil pressure, which normally runs between 20 and 100 psi over a specific range of engine speeds during extensive tests. "For long runs, we just pack on the hours," says Edmundson. "We monitor oil pressure and numerous temperatures, look for component wear and cracks, and eventually take the engine apart and put it back together again." One engine usually runs in an airplane while another runs on the trailer. In the plane, the Personal Daq charts 10 channels of sensor data with a laptop computer. "On the trailer, we are able to collect data through 20 channels using the Personal Daq/55 and expansion modules," says Edmundson.

"Typically, we run the USB lines from the engine area to the laptop computer on a table, over 25 feet away to keep out of the line of flying parts," says Edmundson, "if such a thing should ever happen." The only electronic components on the engine are the sensors collecting the data. The engine is a diesel, so simple and straightforward that it doesn't require sophisticated electronic ignition systems or computers. Even the fuel pump is mechanical. "But we use an alternator to charge the battery that runs the boost pump," says Edmundson. "And it's perfectly safe. If the system should lose power in flight, the pilot's instruments are the only components that fail. The plane flies just as easily and reliably without them."

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The engine is a four-cylinder V-configuration. DeltaHawk engineers monitor the engine speed and each cylinder head temperature in the water jacket, which is divided into two sections between the one/three cylinder bank on one side and the two/four cylinder bank on the other side. A water temperature sensor in each bank monitors the respective temperature. "Because the engine has both a turbocharger and a super charger," says Edmundson, "we monitor the exhaust gases with a sensor in the inner blower, between the two chargers. We also use pressure sensors to record inner blower pressure and manifold pressure under the supercharger. Finally we measure the oil temperature going into the engine and another at the output to the heat exchanger."

On the plane, engineers also monitor static and dynamic pressures. The static pressure is the ambient pressure, and the dynamic pressure is the air pressure inside the air scoop on the bottom of the plane — the air over the heat exchanger. And they don't always keep the sensors in the same location during a test program, they move some of the sensors around, and add or delete a few. Edmundson performs no analysis on the site with the software; he prefers to put it into a spreadsheet format indicating the length of the run and rpm level. On certain runs, he charts all the variables. And he archives the charts so he can compare all the runs made with one engine or several engines. "So far," says Edmundson, "we have collected about 40 CDs worth of data. We also run an expensive data collection system with a controller on the dyno, but we selected the IOtech for running on both the plane and the trailer. It is much less expensive, runs on 12 VDC, and is portable – exactly the features we need."

The other system sits on a large desk, burdened by a 64-pin connector and can't go anywhere. Also, the IOtech Personal Daq connects conveniently with the removable terminal block, a first-rate feature. Edmundson also says that he uses the DaqView software to program the meters, and he appreciates the way he can easily program any analog meter, bar graph, or digital display. The instructions are so easy to use and the equipment so easy to set up, that his volunteers have no problem with it, regardless of their skill level. And the USB hook up is especially convenient. He is now using an IOtech WaveBook and WBK17™ eight-channel counter and encoder module to measure instantaneous rpm to detect any possible jitter in the crankshaft. "We wanted to try some design changes, but needed a way to measure jitter to see if the changes were having the proper effect. So far, the data provided by the Personal Daq look great, but we still have a few tests to complete before obtaining final certification."

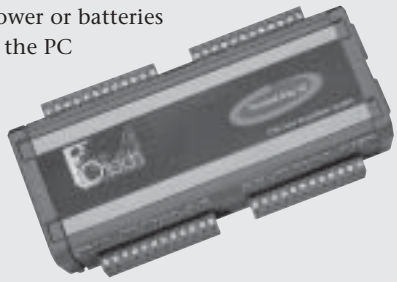
Conclusion

DeltaHawk engineers selected an IOtech Personal Daq to collect test data from new, experimental diesel engines intended for aircraft. The equipment they had used previously was too large and heavy for in-flight tests compared to the Personal Daq which is smaller, portable, runs with 12 VDC input, and costs less. The Personal Daq is easy to program and use by both skilled technicians and a wide variety of volunteers working around the clock who monitor the sensors and adjust the speed of the operating engines during a test.

Personal Daqs

Designed for high accuracy and resolution, the 22-bit Personal Daq™ data acquisition systems directly measure multiple channels of voltage, thermocouples, pulse, frequency, and digital I/O. A single cable to the PC provides high-speed communication *and* power to the Personal Daq. The Personal Daq modules are a family of low-cost, USB-based products from IOtech. Because of the strict power limitations of the USB, the modules incorporate special power-management circuitry to ensure adherence to USB specifications.

Features



- Multi-function data acquisition modules attach to PCs via Universal Serial Bus (USB 1.0 and 2.0 compatible)
- Ultra low-power design requires no external power or batteries
- Can be located up to 5 meters (16.4 feet) from the PC
- High-resolution, 22-bit A/D converter offers reading rates from 1 to 80 Hz
- Built-in cold-junction compensation for direct thermocouple measurements
- Frequency/pulse, or duty-cycle measurements up to 1 MHz
- Convenient removable screw-terminal signal connections
- 500V optical isolation from PC for safe and noise-free measurements
- Programmable inputs from ±31 mV to ±20V full scale
- Digital I/O lines with open collector output for direct drive applications
- Expandable up to 80 channels of analog and digital I/O
- Up to 100 Personal Daq modules can be attached to one PC using USB hubs, for a total capacity of 8,000 channels
- Digital calibration—no potentiometers or adjustments required

Software

- Personal DaqView™, spreadsheet-style software for *Out-of-the-Box*™ setup, acquisition, and real-time display
- eZ-PostView™, for post-acquisition data viewing
- Support for Visual Basic®, C/C++, LabVIEW®, and DASYLab®

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