

# Automated engine harness testing

For electrical wiring there is no more arduous environment on an aircraft than an engine. The testing of engine harnesses in a thorough and efficient manner is therefore of paramount importance. Graham Osborne of CK Technologies explains.




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To some it may come as a surprise to discover that many modern fighter aircraft can contain in excess of 20 miles of wiring where the equivalent figure for a large commercial airliner will be closer to 100 miles. While the amount of wiring installed on an aero-engine represents only a small percentage of these totals, it is fair to say that on no other part of an aircraft will the wiring be subjected to such harsh environmental conditions.

Excessive vibration, extreme changes in temperature, atmospheric pressure and humidity, along with possible contamination and degradation from fuel, lubricants and hydraulic fluids, all contribute to the most hostile conditions imaginable for the conductors, insulation and connection devices (connectors, contacts and so on) that make up these harnesses. With the introduction of significantly more complex electronic engine management and fly-by-wire systems increasing the complexity of engine (and entire aircraft) wiring, it is becoming increasingly important to use test methods that will reliably identify the problems created in such environments.

The testing of any harness should ideally be performed after manufacture, after installation to the engine (and airframe) and in an on-going manner throughout the in-service life of the aircraft. However, most airframe and engine manufacturers have chosen to outsource the manufacture and testing of their harnesses and have decided to discontinue further testing after installation of these harnesses, reasoning that no additional benefits will be derived. This is primarily a cost driven decision that disregards the real possibility of defects and damage being introduced during the installation process which might not be discovered until final functional testing of aircraft systems. Much more serious are those defects, such as insulation damage, that are not detected by functional testing but instead cause systems failures when operational conditions start to take their toll.

Not only is this approach of minimal testing tempting fate, but also the process of locating and rectifying wiring problems when they do occur is far more time consuming and costly on operational aircraft than after wiring



wire or connector through connection at different current levels. Furthermore, with manual testing it is impossible to cover all the combinations and permutations that must be tested to ensure that no short circuits or insulation breakdown paths exist in the harness. Also, manual testing is time consuming, with the cost/benefit calculation being skewed considerably toward the cost side.

Manual testing disadvantages can be eliminated by the use of a suitable automatic wiring analysis system, more commonly referred to as a cable/harness testing system. CK Technologies has worked closely with several leading companies in the engine overhaul field to integrate this test equipment into their production programmes. For example, KLM Engineering and Maintenance has been using CKT1160 and CKT1175 systems since 1996 to test CF6-50 and -80 series engine harnesses both on and off the engine. Similarly, Bombardier Shorts in Belfast has been using CKT test systems since 1989 to test harnesses for the V2500A1 and A5, BR710, and CF34-8C1/8C5 subsequent to manufacture. Other recent projects include the testing of Tay and CFM56 engines.

Indeed, an automatic system can be used to test any engine harness whether it is military or civil and whether it is installed on an engine or being rebuilt on the bench. Smaller, more portable test systems, such as the CKT1175-10 can also be utilised to perform limited harness testing on engines still installed on the wing. Such systems can be supplied as basic test systems or as turnkey solutions that include all adaptation hardware and all engine-specific test programs. The systems can be readily upgraded to test additional engine types and this normally only requires the addition of engine specific test programs and appropriate adapter cables.

### *Manual versus automatic testing*

Manual testing relies on the test technician probing the correct connector contact. However, there is always a possibility of probing an adjacent contact (especially in the

installation. And, while post-installation wiring testing will provide a high level of confidence in the integrity of the assembly, there is no guarantee that all problems associated with insulation breakdown will be found, as these can be compounded by environmental conditions, as previously mentioned.

Despite the recent attention given to ageing aircraft wiring problems, there is still ongoing debate concerning the testing of wiring for in-service airframes, and for several reasons most wiring generally remains out of sight and out of mind. Fortunately, engine harnesses, both new and rebuilt in an MRO environment, are less problematic in terms of the testing that is carried out in varying degrees by most engine overhaul facilities. This testing is often simple, manual, pin-to-pin wiring verification using either a hand-held ohmmeter or buzzer/light combination that will locate an open circuit or a high resistance wire, but it will not qualify the overall integrity of the harness.

The manual testing method has the serious limitation of not being able to accurately quantify the resistance of a

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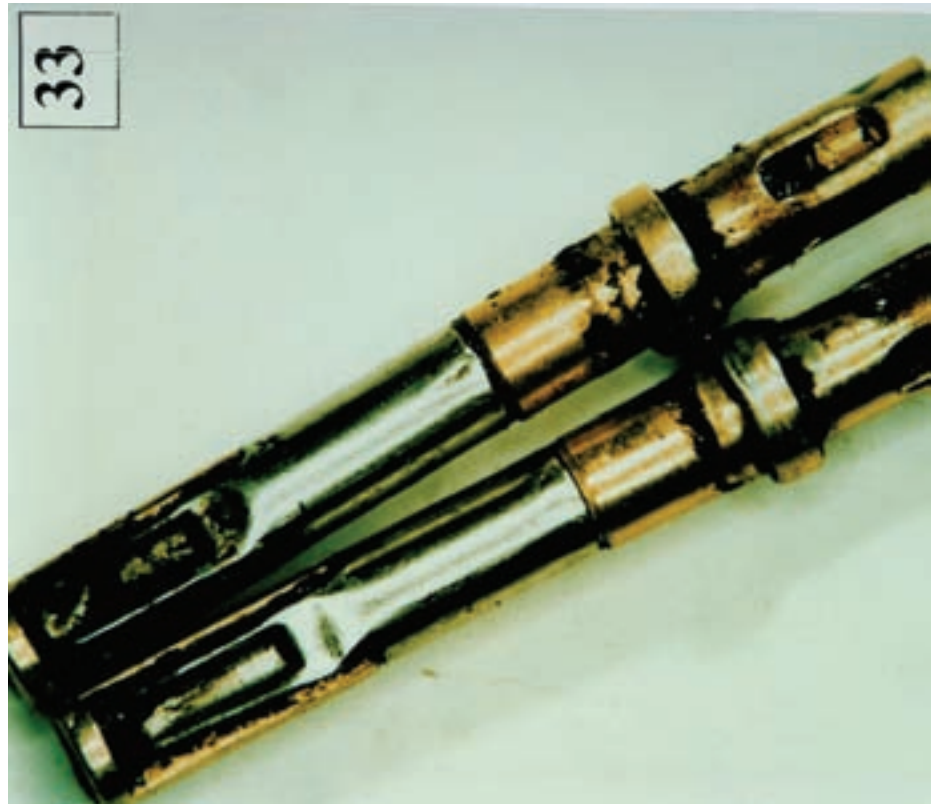
case of male connector contacts) and, in the case of a wire reversal there is a possibility of receiving a pass continuity indication. Furthermore, there is a higher probability of receiving a false passing continuity indication when using a lamp or buzzer, since such devices provide continuity indications even when high-resistance circuits (a bad crimp or cold solder joint) are encountered. Even more importantly, manual testing will never locate high or low resistance short-circuits as will be discussed in more detail later. Finally, manual testing is extremely time intensive and relies on the integrity of the test technician, with no means of verifying that a 100 per cent continuity test has been performed.

Automatic testing utilises proven software (test programs) and adaptor cables that eliminate the possibility of errors and 'missed tests'. Limits are set within the software that specify the pass/fail thresholds of each wire or accessory under test, eliminating the requirement for human judgment. Additionally, the voltage and current used to perform each test step are programmable, providing complete flexibility over the conditions of each test, even to the point where stressing of the harness and its connectors beyond normal operating limits can be accomplished in order to ensure additional safety margins.

### *Insulation resistance testing*

Insulation resistance (IR) testing is used to detect damage or insulation breakdown in wires or connectors. The test requires that each wire or connector contact is tested against all others, the metallic harness braiding (shield) and the body of the engine (ground). To perform an IR test, each wire or connector contact is checked (usually at elevated voltage) against all other wires, or contacts in the harness. This involves an arithmetic progression of tests which is impossible to perform manually except with very small test articles.

However, such a test is readily performed by an automatic cable/harness test system that has the

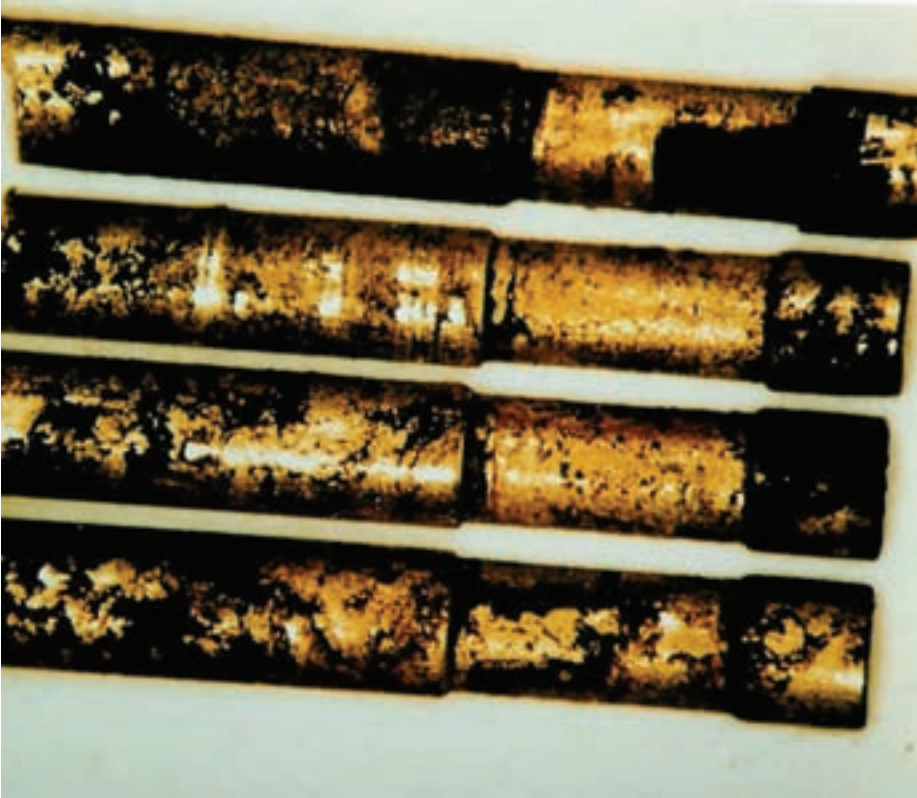


capability of comparing one wire or contact simultaneously against all others. It is then possible to isolate those wires or contacts that do not comply with the IR specification using a process called scanning. A system such as the CKT1175 can perform a 100 per cent IR and continuity test on a 1,000-wire harness in less than one minute with a 100 per cent confidence level.

### *Damage to the harness*

Another problem with manual testing is mechanical in nature. Probes used to contact the engine connector contacts may not be of the proper type and this can result in damage to the contacts, even when confirming a correctly wired circuit, so that high resistances can result after the engine harnesses are mated to the engine components.

Furthermore, a sharp pointed probe can 'break through' contact contamination or corrosion, producing a valid connection. But the mating connector on the engine might not have the ability to do this, which will mean that the defect will only be found when



the engine is in an operational environment.

Testing with an automated test system eliminates these potential problems. Dedicated adapter cables are used to connect the engine harness to the test system and these adapter cables are fitted with the correct connectors thereby eliminating the problems of incorrect mating and improper probing.

#### *Traceability of results*

Another potential problem with manual testing is that the operator is

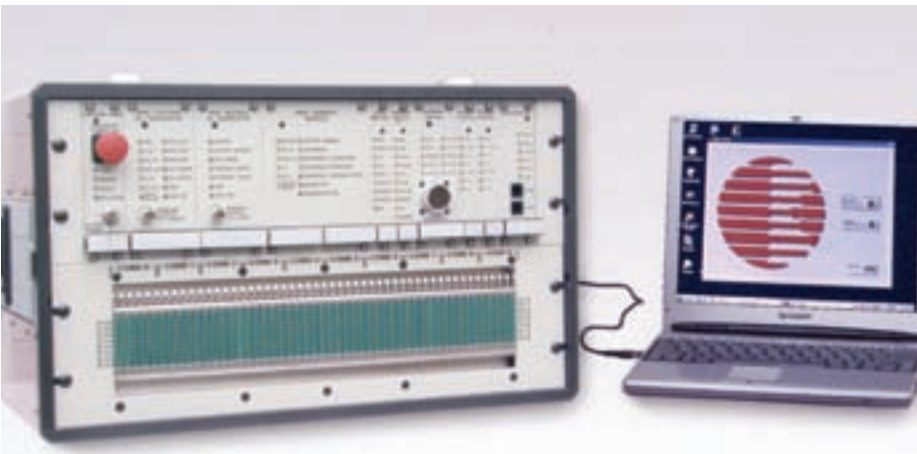
relied upon to record the results of the test and any other relevant information specific to the test. In comparison, automatic testing will produce comprehensive test reports which, with the use of a suitable test system such as the CKT1175, can be customised to satisfy the requirements of a number of different quality control directives.

For example, some users may only require the details of the individual test failures while others may require the recording of test information for every test performed, irrespective of the result. The level of information made available for each test should be as brief or detailed as the user requires. For instance, for some applications it may be sufficient to record the connectors and contacts tested and the corresponding measured values of each test. In other circumstances additional information such as the accessory/circuit name, the tolerance, the stimulus values used and fault tracing information may also need to be reported.

Test results and relevant instructions to the operator must be capable of being displayed on the system monitor and/or through an output to a printer. Also it may be desirable to have the ability of saving this information to disk, or recording it onto a CD in a text or spreadsheet format. The capability to generate extensive test reports not only increases the integrity of the test, it also improves quality monitoring procedures and bolsters customer confidence.

#### *Testing accessories*

With a properly instrumented automatic cable/harness test system it becomes possible to measure the parameters of some engine accessories using resistance, capacitance and voltage measurements. Additional instrumentation can also permit the measurement of inductance and impedance. Furthermore, when the test system is configured with appropriate power supplies, the outputs of which can be distributed to the required points in the engine harness, the testing



of valves, solenoids, actuators, ignition boxes and so on can also be accomplished in conjunction with the testing of the harness wiring.

### *Time saving*

Engine harness testing using an automatic cable/harness test system provides a much more comprehensive and competent test result than manual testing is able to achieve. It also results in significant time saving per engine.

Ideally, in an overhaul environment a harness should be tested whilst it is still installed on the engine during incoming inspection. It should also be tested in the workshop subsequent to modification and repair and again after engine build-up, but prior to test cell running.

Experience has shown that automatic testing can reduce the time to test a complete engine harness from 15-20 man-hours when testing manually to less than 2 hours. If the harness is tested three times this will result in a test time reduction of more than 40 man-hours per engine. And a much better test will result!

Comment from Dolf Schouten, engineer, KLM Engineering and Maintenance:

"For us, the main benefit of using the CKT test system is the considerable saving on labour. Also, having accurate, recorded measurements — especially where 4 wire (Kelvin) measurements are required — is a significant factor. Engineering uses the test report data as a guideline for work-scope determination and to inform our customer if components need to be repaired or replaced.

Currently, we use the system for classic and FADEC 1 aircraft engines, testing the entire harness and accessories at incoming and outgoing inspections. For FADEC 2 /3 engines, we plan to use the system in a slightly different manner. We will use the output data from the Engine Electronic Control Unit (ECU) and make the (CKT) test programs per ARINC label / manual fault isolation section. This further reduces the test time, because only the defects identified by the ECU output will be checked."

The benefits of testing engine harnesses with a suitable automatic test system can be summed up by one word — CONFIDENCE — a mnemonic coming from:

- Complete 100 per cent test every time;
- Operator error elimination;
- No need to refer to wiring diagrams etc;
- Functional testing of accessories included in basic harness test;
- Improved quality control and monitoring processes;
- Damage to connectors and contacts is eliminated;
- Easily upgrades to test additional engine types;
- Number of testing man-hours considerably reduced;
- Certified, detailed, user formatted error reports; and
- Enhanced customer satisfaction.



*Accounting says you're already over budget.*

*The supplier tells you it's on back-order.*

*Maintenance has replaced the same part three times.*

*The engineers don't think it can be done.*


*You think that there has to be a better way.*

# Unison has the solution


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