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Electrical testing on rail systems is essential for safety and reliability

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Title	Electrical testing on rail systems is essential for safety and reliability
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Abstract

Standard ohmmeters are inadequate to accurately determine the resistance of high-current connections and a digital low resistance ohmmeter should be used. Modern TDRs can locate cable faults at distances up to 20 km from the point at which the instrument is connected and some types feature dual channel operation, which allows faults between cables to be rapidly localised.

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In rail-related applications, electrical testing is not only essential to prove the safety and reliability of new and modified electrical systems, it can also be a valuable tool for the prediction and prevention of costly failures. This article explores some of the test techniques that are most applicable to the rail sector, and explains their usefulness.

Electrical test instruments that are of particular value in railway applications include insulation testers, battery testers, low resistance ohmmeters and time-domain reflectometers (TDRs). Such instruments are widely available and most organisations involved in railway projects are likely to have access already to some if not all of them. However, it is worth noting that older instruments in particular may not offer the full benefits that are provided by the latest products.

The best 1kV insulation testers, for example, provide an extended measuring range. Instead of simply indicating 'infinity' for insulation resistances above few tens of megohms, these testers give accurate and dependable readings up into the tens of gigohms range. This may not seem to matter, as an infinity reading surely confirms that the insulation is in satisfactory condition.

That much is true, but an accurate measure of insulation resistance can provide valuable input for a preventative maintenance programme. Suppose, for example, that a test on, say, a traction motor shows that its insulation resistance is 10 gigohms, but that another test a month or two later shows that this figure has fallen to 1 gigohm.

While both of these values are almost certainly satisfactory, such a dramatic fall indicates that a problem is possibly developing, and that further attention is needed. This early warning, in many cases, can allow simple remedial action to be taken before a costly and inconvenient breakdown occurs. For the higher voltage equipment used in the rail industry, the use of 5 kV and even 10 kV insulation testers is worth considering. A study by GM Electromotive Division in the USA has shown that routine testing at these voltages can reveal a significantly higher proportion of incipient faults in traction equipment than testing at 1kV. This reduces the risk of early failures in equipment returned to service after routine testing.

Another area where regular testing with modern test equipment can provide big benefits is in the maintenance of storage batteries, which are employed to perform a wide range of safety and other essential functions in the rail industry.

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It is notoriously difficult to determine the condition of storage batteries, but without this knowledge it is impossible to be sure that they will perform properly when called upon to supply power. This is a particular problem in standby applications, when the shortcomings of the battery installation may not be apparent until it's too late.

The traditional method of battery testing is load cycling, where the battery is taken out of service and fully discharged to determine its true capacity. This method is the most accurate indicator of capacity, as it replicates the conditions experienced by the battery under load. Traditionally, it has been necessary to take the battery out of service to perform this type of test but, by limiting the depth of discharge to 80%, the latest testers can provide accurate results while the battery remains on line.

Nevertheless, testing batteries by load cycling is undoubtedly time consuming. For regular routine testing, therefore, impedance test techniques, which can provide an excellent indication of battery condition, are often preferred. The best battery impedance testers measure float and ripple current, as well as impedance, cell voltage and intercell connection resistance. Used in conjunction with battery database management software, this data provides an accurate and dependable indication of battery health, quickly and with-out the need to take the systems off line. Because battery impedance testers, which are usually handheld, are so easy and fast to operate, they are ideal for regularly checking the condition of the batteries in rolling stock and fixed installations. The data obtained from regular testing provides a reliable indication of problem areas, and also allows the end-of-life point for the batteries to be accurately determined.

Many areas of railway operation, not least the provision of traction supplies, involve large currents. This means that good, low resistance connections between busbars, power rails and similar conductors are essential. The introduction of even a modest amount of resistance in these areas will lead to rapid heating of the connections, resulting in dangerous hotspots and failures.

Standard ohmmeters are, however, inadequate to determine accurately the resistance of high-current connections, not least because the test currents they use are orders of magnitude different from the operating currents of the connections. To address this problem, a digital low resistance ohmmeter should be used. Modern instruments of this type deliver test currents that are continuously variable over a wide range – typically from 10 A to 200 A – thereby eliminating the need to use different test sets for different currents. They also use a four-terminal test method that effectively cancels out the resistance of the test leads, which, in these applications, can easily be greater than the resistance value that is actually being measured.

Often, digital low-resistance ohmmeters offers a choice of testing modes, including a continuous mode where the result displayed is updated every two seconds. This is invaluable for detecting and evaluating joints where heating is taking place, or where an intermittent fault is suspected. Railway installations, whether they are for signalling or power, are notorious for the complexity of their cabling. When a fault occurs, locating it can be exceedingly time consuming and trouble-some, especially if long cable runs in trenches or conduits are involved. An invaluable way to tackle these issues is to use a time domain reflectometer (TDR).

TDRs work by applying a brief pulse to the cable and measuring the time it takes for this pulse to be reflected back to the instrument. From this time, the instrument can calculate the distance to the point in the cable where the reflection occurred. If there is no fault on the cable, the reflection will come from the remote end. If, however, the cable has a short or open circuit fault, the reflection will come from this, and the instrument will indicate the distance to the fault.

While this principle of operation is simple, designing an instrument that will consistently deliver good results in practice is far from straightforward. Current instruments from leading suppliers are however, not only fast and easy to use, but are also capable of locating cable faults at distances up to 20 km from the point at which the instrument is connected. Some types also feature dual channel operation, which allows faults between cables to be rapidly localised.

Efficient and effective electrical testing in railway installations is the sure route to minimising downtime, and to detecting incipient faults before they develop into full-blown breakdowns. To maximise the benefits of testing, however, it is important to choose dependable instruments of the right type for the application, a task for which this article has hopefully provided some useful guidance.

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