

REVIEW OF RAIL-TESTING PRACTICES AND TECHNOLOGIES — OVERSEAS

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Summary

A review of overseas rail-testing technology and practices has revealed signal analysis and processing techniques that may increase productivity and accuracy of rail-flaw detection. The study focused on three testing modes — manual, semiautomatic, and fully automatic high-speed test systems. The first two modes included such test systems as "walking sticks," push carts, and self-propelled trolleys.

For high-speed systems, the emphasis has been to increase speeds and improve accuracy of testing and detection of hidden defects which often differ from North American defects. Higher operating speeds of 40 to 60 mph are routinely achieved. Signal-analysis approaches include off-line processing and development of exception reports that prioritize defects to improve remedial actions.

The ability to test continuously represents a major difference in testing approaches between Europe and North America. High test-vehicle speeds allow European railways to operate with significantly fewer test units, supplemented by a large number of manual units. Data-collection systems also allow for on-line and off-line analysis of defects. European regulation allows prioritization of defects by severity and risk, determination of optimal remedial action, and scheduling of action based on available forces.

Finally, there is a significant difference in testing philosophy from the point of view of standards, standardized training, and certification. Many European systems attempt to simulate ISO certification practices, and include use of "traceable" standards (to a "reference" standard). They also provide for regularly scheduled testing and recertification of ultrasonic operators. This ensures standardization of practices and verification of skill levels.

This survey is a part of the joint effort by the Association of American Railroads (AAR) and Federal Railroad Administration to improve the reliability of rail-flaw detection, and was conducted under the Track Integrity Strategic Research Initiative. A companion Technology Digest (TD — 98-015) describes findings from a North American survey on the same subject matter.

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INTRODUCTION AND CONCLUSIONS

As part of a Strategic Research Initiative on Improved Rail Integrity, the Association of American Railroads sponsored a review of rail-flaw testing technologies and practices in European and other technologically advanced countries. A major focus of this report is on European technology, which represents some of the most advanced non-North American technology (see TD-98015). In the area of rail testing, overseas technology focuses on three primary testing modes — manual, semiautomatic, and fully automatic high-speed test systems.

In the first two modes, improvements in walking-stick detection units, carts, and self-propelled trolleys have increased the productivity and accuracy of these lower-speed testing resources. These technological improvements utilized improved signal-analysis and processing features.

In the case of high-speed testing, the focus has been similar to that in North America. This has included higher speeds, improved accuracy of testing, and enhanced detection of hidden defects. Because of the ability to test continuously, higher speeds are routine, together with high levels of productivity. Thus, testing speeds of 40 to 60 mph are achieved. This has led to signal-analysis approaches which include off-line processing and development of exception reports that prioritize defects to allow for improved remedial actions. It has also led to high productivity of test vehicles (up to 100 miles per day) which allows European railways, as compared to North American practice, to operate with significantly fewer test units supplemented by manual units.

Finally, there is a significant difference in testing philosophy in the use of standards, standardized training, and certification. Many European systems attempt to simulate ISO certification practices, and include use of traceable standards (to a "reference" standard). They also provide for regular scheduled testing and recertification of ultrasonic operators. This allows for standardization of practices and verification of skill levels.

CURRENT STATE OF THE ART

Because of differences in philosophy, operations, and even failure mechanisms, the technological focus of overseas railways differ from those of

North American railways. Because of the lighter axle loads used in Europe, the classes of defects that are of major concern to the European Railways are noticeably different than those of the North American railways.

Another major difference in technological focus is evident from the heavy use of manual inspection techniques, which represents a major mode of inspection overseas, including Europe and South Africa. It is also used as the primary inspection mode by major European railways, such as Railtrack in the United Kingdoms, even though these railways own and operate their own high-speed test trains.

This extensive use of walking inspections is evidenced by the limited number of test vehicles and contractors in operation overseas. In Europe there is only one major testing contractor, Speno International. In addition, several of the railways which own test vehicles operate them on a contract basis. This includes the Netherlands Railways and the Germany Railways. In addition, Railtrack (UK), Société Nationale des Chemins de Fer Francois (France), and the Ente Ferrovie dello Stato (Italy) own test vehicles for their own use. Elsewhere, only Australia has active testing contractors and suppliers. The rest of the world relies on United States testing contractors for services and equipment.

In Europe, the three major types of equipment used are manual "walking stick," push cart, and self-propelled cart (trolley). These systems are often equipped with multiple transducers, real-time signal analysis, and data-recording capability, in some cases approaching that of onboard test cars.

Because of the less restrictive legal and regulatory environment overseas, test cars are generally operated in a high-speed continuous-testing mode with testing capabilities up to 60 mph (100 kmh) and test coverage of more than 100 miles per day. For example, Speno International's US 6-1 can inspect approximately 90 miles (150 kilometers) per day at an average testing speed of 36 mph (60 kmh). The new UST-96 vehicle in the Netherlands is designed to test at speeds of 60 mph (100 kmh).

The European approach to analysis of ultrasonic signals has paralleled that previously reported for North America¹. This includes the evolution of signal processing from analog processing to

digital processing with pattern-recognition logic. One major difference is the use of off-line processing in Europe, where the continuous testing philosophy includes follow-up off-line analysis of signals and identification of defects. For example, the off-line reports prepared by the Dutch test car Report Generation System are²:

- Defect-exception report
- Thermite weld and joint report
- 2-D defect-image report
- Rail-height report
- Inspection-quality reports, including backwall echo disappearance and water-film thickness

Key defects for testing and analysis purposes include:

- Tache ovales (Called "kidney failures," these defects are caused by hydrogen flaking and are similar to transverse defects)
- Vertical splits of the head and web
- Bolt-hole cracking
- Squats
- Defective thermite welds
- Engine burns

These defects are generally found in the center of the railhead and web. This eliminates the need for testing in the "corners" of the railhead which is so important in North American applications. Exhibits 1 and 2 illustrate the areas of coverage and detectability criteria for Railtrack. Exhibit 1 shows detectability criteria and coverage for Tache Ovales defects. The "defect detection/rejection" criteria for this type of defect is 6 mm (.25 inch) with an "accuracy" of 4 mm (0.16 inch).

Exhibit 2 illustrates the detectability criteria for horizontal web defects. As can be seen in this exhibit, defects of 12 mm × 12 mm (0.5 inch × 0.5 inch) are required to be detectable.

RAILROAD PRACTICES

Overseas rail systems which own or contract high-speed test cars/trains operate these systems in a

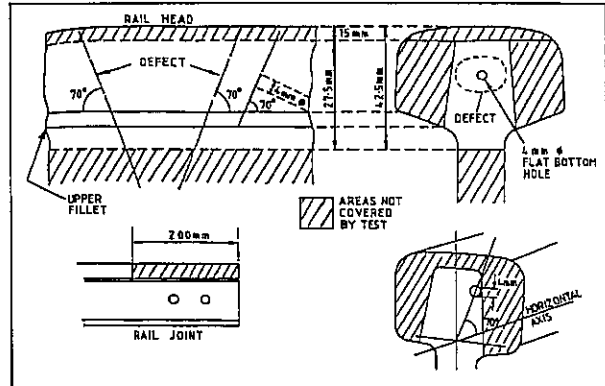


Exhibit 1. Detectability Criteria and Coverage for Tache Ovales Defects

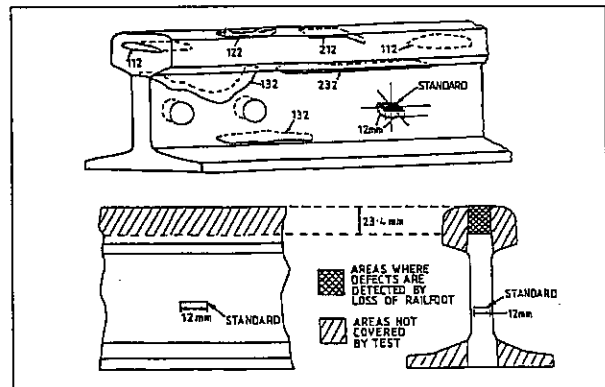


Exhibit 2. Detectability Criteria for Horizontal Web Defects

continuous, "non-stop" test mode. Because of significant differences in both the regulatory and legal environment, the "stop-and-verify" approach used in North America is not necessary. Therefore, European rail systems can take advantage of the high testing speeds and work within a traffic block to achieve more test miles per day when compared to North American practices.

In this continuous test mode, the test car generates a series of reports which include:

- Real-time "exception" reports
- Detailed exception reports with prioritization of the defects
- Off-line summary reports with an increased level of detail
- Off-line selective reports for key defect types (e.g. joints)



A key difference with North American practice is in the prioritization reports which allow railways to react to detected defects at a level of urgency commensurate with the severity of the defect. In fact, many European railways allow even significant defects to remain in track for up to 36 hours. Other defects are allowed to remain in track for up to 90 days, depending on defect type, size, and level of risk.

Inspection frequency is generally based on fixed time or tonnage intervals. European railways have not yet introduced the concept of risk-based testing frequency. This may be because their defect growth rate is significantly lower than that experienced in the heavier-axle-load environment of North America.

As an example, one European railway tests on a fixed-cycle basis as follows:

- Main lines with more than 7.5 million gross tons per year — test twice yearly
- Other main lines — test once yearly

Railtrack uses a graphical-based scheduler for its testing based on speed and tonnage levels. The ultrasonic tests can include both manual and semi-automated, or high-speed test cars.

Finally, it is noted that European railways make extensive use of standards, certification, and formal "test tracks." Many of the European test cars, as well as smaller trolley and cart units, carry "standards," generally a section of rail with a predrilled "defect." These standards are used as part of a daily calibration. For example, the use of standards on the Railtrack car has been credited with the addition of 2 dB of gain in signal strength. In addition, the use of standards is part of the European goal of achieving ISO 9000 certification as part of an overall quality-control program.

Most European railways have formal ultra-

sonic operator testing and certification programs. In the case of Railtrack, all operators are recertified every two years with formal retesting. These must be completed and documented. These results are part of the operator's permanent record. This operator certification is in addition to regular, periodic checks of each set of ultrasonic equipment at a centralized maintenance facility to check for wear, accuracy, and functionality.

Finally, several of the major European railway systems, particularly those that do not own their own test cars, maintain a rail-flaw calibration track for the evaluation of test vehicles supplied by the contractor. These test tracks contain known defects which have been premapped and which represent a range of defect types, sizes, and configurations. Contractor test vehicles must be tested on this calibration track. Once upon entry onto the railroad prior to testing, and a second time upon leaving the property and conclusion of testing.

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