TRAINSAFE
SAFE INFRASTRUCTURE
WORKSHOP

DEMONSTRATION OF THE RESEARCH CLUSTER MECHANISM FOR "INSPECTION TECHNOLOGIES"

STAGE 1

ISSUE HIGHLIGHTED IN THE STATE OF THE ART REPORT

This resulted in the topic of ‘Inspection Technologies’ forming part of the agenda for the ‘Safe Infrastructure’ workshop.

The following is the relevant extract from the State of the Art Report

Track inspection technologies

There are a multitude of commercial systems that are based around surface visual inspection. These commonly offer detection of rail surface and sleeper anomalies as well as missing fastening elements and deviations in the contour of the ballast at inspection speeds up to 200km/h. One of the most high profile rail maintenance systems is the Central Japan Railway Company's “Doctor Yellow” inspection train. This inspection vehicle is a 7 car EMU that inspects track geometry, catenary, signalling and telecom systems at speeds of up to 270km/h.

Ultrasonic testing of railway tracks is currently limited to approx 70km/h. The test speed is limited by the travel time of the ultrasound in the rail, and by the distance required between measurements. Ultrasonic testing has good penetration but poor near surface resolution. More recently, the use of guided ultrasonics, acoustics, and refined hand-held ultrasonic measurement devices has been evaluated.

Eddy current testing is becoming a more common mechanism of inspection. When an AC current flows in a coil close to a conducting surface, the magnetic field of the coil will induce circulating (eddy) currents in that surface.

The magnitude and phase of the eddy currents will affect the loading on the coil and thus its impedance. Any cracks in the material of the railhead will interrupt, or reduce, eddy current flow, thereby reducing the load on the coil and increasing the impedance. It is the monitoring of the voltage across the coil that, when calibrated correctly, can actively monitor the rail condition. However, a limitation of eddy current examination is that cracks parallel to the circular eddy current flows may not cause sufficient interruption to be detected. Also, eddy current density decreases exponentially with depth into the test material. Where eddy currents excel is in surface scanning. Eddy currents will pick up surface breaking cracks that ultrasonic testing will not detect at all.

Overall, to meet the ERRAC objectives of increased traffic volume and lower maintenance times, the strategic solution may be to allow inspection vehicles to run seamlessly alongside passenger or freight vehicles, actively monitoring rail wear and crack propagation.

STAGE 2
DISCUSSION PRESENTATION FROM AN INSPECTION TECHNOLOGY EXPERT

A brief five minute presentation to introduce the topic to the workshop delegates. This defined the topic scope and highlighted the key specific issues to be addressed.

INSPECTION TECHNOLOGIES - Rails

Alumino-thermic welds

Every railway system has problems with Alumino-thermic weld breakage.

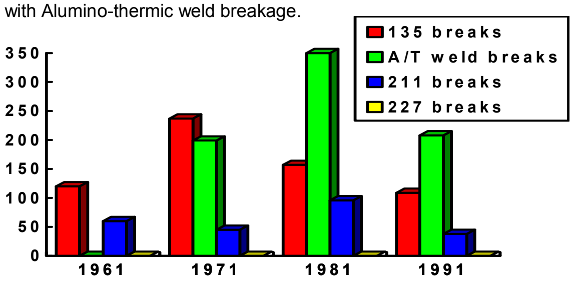


Fig 1. Historic British rail breakage statistics

In 1970, there were estimated to be 300,000 A/T welds in Britain, mostly Thermit SmW's, and about 200 breakages

In 2002-03, there were of the order of 3 - 4 million A/T welds in place, the majority the more reliable SkVf, but welds still accounted for 26% of all breakages, the vast majority of those being A/T welds.

Historic research indicated that the overwhelming cause is manufacturing defects, principally lack of fusion defects in the foot (1).

[1] Lack of fusion defects occur elsewhere but have not been considered a comparable risk to rail integrity. In addition, more recently gross porosity has become more prominent as have hot tears. However the primary concern remains large defects in the foot.

Thus to eliminate the majority of suspect welds we only need to inspect once and we are looking, not for tiny defects, but for major flaws in a specific area, the foot[1].

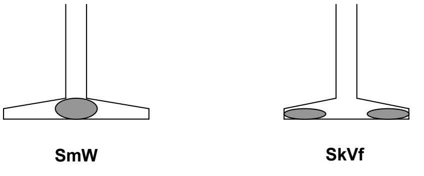


Fig.2 Lack of fusion defect location in A/T welds

PROBLEM - we have 3 - 4 million welds to inspect and they are being added to at a rate of the order of 150,000 per year.

TIMESCALE - If the inspection of each weld requires, say 5 minutes, then with one 4 hour possession per day, and working 365 days per year, it will take about 230 years to get round the system. To make a useful impact on the problem, we need to consider speed.

POSSIBLE SOLUTIONS - we need a point and shoot system, preferably vehicle mounted. Any system requiring a measure of rail or site preparation is simply not going to be quick enough. Nothing subtle is required; we are looking for big defects and simply require a yes/ no answer.

RECOMMENDATIONS - Low frequency ultrasound, Conventional U/T but using ACFM with magnetic saturation.

Flash butt welds

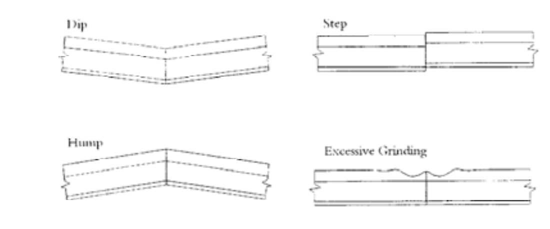
Historically, factory made flash welds have had a very good reliability record in Britain.

The traditional quality test is the bend test but

- it's insensitive to strip quality, which has a huge effect on fatigue strength
- it's destructive
- it can only be used on a small sample of welds
- when site welding is involved, the answer is not quickly available and testing can be quite expensive

We need quick tests, that can be applied to every weld & that provide assurance of strip quality and internal soundness. However this isn't purely an inspection issue; we also need to understand more about how the strip affects the fatigue strength and about what is tolerable in terms of internal defects.

How then do we evaluate the severity of a discrete top fault such as a joint?



Flash Butt Wleds

One option is to let the train take the strain. If you look at the axlebox's vertical velocity over a dipped joint, you get a trace something like Fig.4 and it is straightforward to show that the effective dip angle is equal to the change in vertical velocity over the joint divided by the train speed.

Unfortunately, historic work indicates that the results show little reproducibility (4) [1], which is unhelpful from the point of view of establishing compliance with any specified track standard. They also show little relation to what might be measured on the ground using a straight edge and void meters. **Do we have other options?**

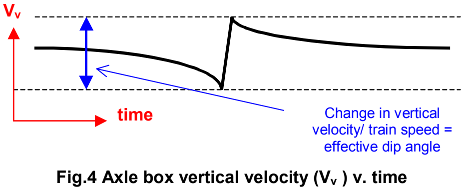


Fig.4 Axle box vertical velocity (V_v) v. time

[1] In the author's view this is a real effect, not a fault in the measuring system; if you repeatedly run similar vehicles over the same track fault, the scatter in rail stress is substantial, e.g.(5).

Head checks

The critical thing with rolling contact fatigue defects is where they are going. Are they growing at a shallow angle, or have they branched down?

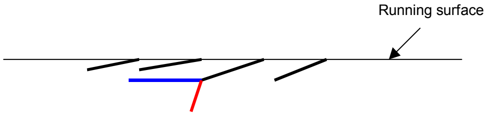


Fig.6 Schematic diagram of rcf defects

If they have branched down (red) and are of substantial size, we may find the branch using ultrasonics. Electrical methods, at present, will usually tell us the surface length with great accuracy, but at best will currently give us an estimate of the total crack length (Black section plus red or blue branch). We've nothing to pick up a downward branch at an early stage.

High speed inspection systems

There are enormous advantages if ultrasonic test trains can run as normal traffic but if you go too fast you will miss defects and the restrictions for wheel probes (with a longer sound path) are greater than those for sliding probes. So much one gleans from talking to system manufacturers. ***What are the real limitations? How can they be overcome?***

STAGE 3

RESULTS OF FACILITATED DISCUSSION AT THE SAFE INFRASTRUCTURE WORKSHOP

The output from a two hour session, which was then presented to the other workshop delegates for comment.

INSPECTION TECHNIQUES

Safe Infrastructure Workshop
29th – 30th October 2003
Leamington Spa, UK

1. What are the critical passive safety issues relating to the topic?

- Passive rail break detection systems
- Characterisation and measurement of loading conditions
- Measuring rail alignment
- Residual rail stresses
- Contact bending stress and bending stress
- Reliability of the human interface
- Good quality defect data
- Development of technologies to actually gather the data, i.e. collection of information on crack sizes.
- Rail adhesion measurement
- Environmental temperatures/conditions/wet/dry etc…
  - Humidity
  - Ice formation on third rail

1. What are the critical passive safety issues relating to the topic?

- Inspection periodicity
- Measurement of alignment of rail welds
- Staff safety, i.e. trackworkers
- Data integration/dissemination/handling
- Decision making, i.e. what do we do with the data when we have it?
- Vehicle characteristics and their effect on the track
- Rail/wheel profiles
- Reaction time from initial defect identification until rectification
- Material types
- Crack lengths
- Rate of crack growth

2. What are the issues relating to standards?

- Does the TSI for conventional interoperability include all the issues that we are raising today?
- Does the revision of the high speed TSI include the issue we are discussing today?
- 'Local' (business driven) maintenance standards v's 'Group' standards
- Terminology standard
- Defect definition standard – NR and UIC standards exist – are these current?
- Wide range of practices for managing defects across EU – difficult to harmonise? What is an acceptable risk of trains running over broken rails?
- Are standards too prescriptive and therefore taking away personal involvement?

3. What are the overall recommendations (solutions) for addressing the critical passive safety issues identified in slide 1?

- Need technology which immediately gives the ability to decide whether to replace a rail.
- On-line processing of video imagery
- Reproducability of inspection results when using axle box movement, when considering discrete track faults?
- Measurement of residual stress are generally destructive. Need a technique to measure these non-destructively and quickly. These are currently being worked on by MMU/Sheffield/DB/Chalmers (modelling of residual stresses development. Chalmer are also considering the question, 'Where are the critical stress points in the rail profile?').

4. What are the business benefits of the proposed recommendations?

- Availability of track
- Prevention of disruption
- Optimisation of maintenance (technically and economically)
- What is the cost of safety?
- It maintains rail as being the most effective mode of land transport.

5. What are the priorities for future research activity?

- Reliability of input data
  - Rail break detection
  - Ability to non-destructively test rails in-situ
  - Remote monitoring
- Definition of safety limits
- Data integration and modelling
- Effects of vehicle types