DEMONSTRATION OF THE
TRAINSAFE RESEARCH CLUSTER MECHANISM
IN THE CONTEXT OF
“ADHESION MANAGEMENT”
WITHIN THE
“SAFE INFRASTRUCTURE” RESEARCH CLUSTER

STAGE 1

ISSUE HIGHLIGHTED IN THE STATE OF THE ART REPORT

This resulted in the topic of "adhesion management" being included in the agenda for the "Safe Infrastructure" workshop.

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

4.2.1.3. The Wheel-Rail Interface: Adhesion Management

In order to minimise emergency braking distances, it is important to maintain good adhesion between the wheel and the rail. The organic residues associated with autumn leaf fall have been found to accumulate on rails and have the effect of lowering the coefficient of friction/adhesion at the wheel-rail interface to the extent that train braking and acceleration efficiency is seriously impaired. Some 2000 track miles (4000 miles of rail) are affected in the UK alone and the problem is known to affect many other European countries. In the worst affected areas of the UK, there is a risk that the reduced level of adhesion can compromise passenger safety and consequently remedial measures are taken through the application of 'Sandite' (a gelatinous suspension of sand) or grinding[9] to ensure satisfactory wheel-rail adhesion. Alternative methods include applying chemical or organic treatments that breakdown the residue, although the implementation of such methods is very limited. The organic residues range from 'heavy leaf mulch' to nano-thick layers and both their fundamental nature and their behavioural characteristics with respect to friction changes are not clearly understood. It is therefore necessary to undertake a programme of fundamental investigations to develop suitable methods that can predict or measure adhesion in order that a warning message can be communicated to the train driver. This will allow the driver to take appropriate actions and mitigate the risks of signals passed at danger (SPADS) or in the worst-case scenario, train collision. Furthermore, the resulting increased understanding will also assist in the development of effective preventative solutions.

One example of such technology has been developed by AEA Technology Rail BV. A low adhesion warning system was delivered to the Dutch Railways in October 2003. It consists of 15 trains that send low adhesion warnings to a central computer by GSM. These warnings are then converted to SMS messages and sent to drivers, who can adjust their braking accordingly. It is anticipated that this system will improve both safety (reduced SPADs) and train availability (reduced wheelflats).

4.2.1.4. Line Side Equipment

In the event of a derailment, the design of line side equipment can play a significant role in determining the ultimate severity of the incident. There is currently an ongoing debate with respect to the most effective safety role for line side items such as electrification pylons. On the one hand, if such pylons were made to be very strong they could help to contain a derailed train and save it from further risk (water, bridges, buildings, etc.). The argument against this is that if the pylons were designed to fail at a predetermined force level, they could act as energy absorbing devices to control the deceleration of the vehicle. This would also reduce damage to parts of the train not designed for impact (sides and roofs). For example, as described in Section 4.1, one of the carriages in the Hatfield crash suffered extensive damage due collisions with line side pylons.

Further investigation is needed in this area.

4.2.1.5. Collision Protectors

Collision protectors can be used to protect line side constructions (e.g. bridge columns) from being damaged by a derailed train. Rigid ground constructions are often unsuitable for absorbing large amounts of energy. Therefore, solutions such as the one shown in Figure 4.12 have been developed. This consists of a block of steel or concrete that is attached to the ground with anchors. In the event of a collision, the anchors are pulled out of the ground at a predetermined force level to decelerate the vehicle.

STAGE 2

DISCUSSION PRESENTATION FROM AN ADHESION MANAGEMENT EXPERT

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

Management of Adhesion within the Railway

Kerry Schofield

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Definition relates to railhead adhesion - μ

- Low $\mu \Rightarrow$ extended braking distances
- Needs to be > about 0.15 to give little/no problems
- Can be as low as 0.01 – wet leaves
- High $\mu \Rightarrow$ high creep forces (RCF initiation)
- Can be as high as 0.7 – US measurements

Management of Low μ

- High pressure water spray
- Sandite
- Trainborne sanders
- Optimised WSP
- Vegetation management
- "Defensive" driving

For High μ - lubrication

Problem – how to manage $0.15 < \mu < 0.4$ all year?

<u>RSSB Research</u>

•ERTMS & Adhesion

•Laserthor

And deferred:

•PaMLA – Predicting & measuring low adhesion

•TAMOS – Total adhesion management & optimisation strategy

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STAGE 3

RESULTS OF FACILITATED DISCUSSION AT THE SAFE INFRASTRUCTURE WORKHSOP

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

Adhesion Management

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

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

- Low adhesion for UK and similar latitudes in northern Europe - seasonal.
- SPADs of up to a mile have been recorded due to low adhesion – Train out of control!
- Causes of low adhesion;
  - Leaf film;
  - Oil Spillages; Moisture exacerbates the situation.
  - Rust;
  - Post Stoppage.
- Low adhesion. Safety issue or availability issue? (Wheel flats)
- Track circuit issues. Causes:
  - Leaf film contaminant
  - Excessive sanding.
- Issues with existing solutions
  - Can be short term (Cleaning, Sandite, grinding, laser)
  - Removal of trees – Destabilisation of embankments, Green issues
  - Sanding – wear initiation, track circuits
- High Adhesion
  - High temp, Low humidity = RCF initiator
- Perceptions of (high/low) adhesion may vary by country.

2. What are the issues relating to standards?

- Require target range for coefficient of friction (μ).
  - Associated cost/benefit;
  - Train focus / track focus.
  - Standardised method for measuring μ.
    - Continuous;
    - Discrete;
- How should the information be managed?
  - "Rough and ready" train mounted warning system
  - Scientific measuring test for research.
- New standard required
  - UK base "Code of practice" – UK- RSSB
  - For European interoperable operations TSI
- Wheel-slide protection (UIC standard – product acceptance)
  - Contains water/soap solution test . Experience shows doesn't work well.

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

- Low Adhesion
  - In service head conditioning/cleaning e.g Laser-Thor
  - Alternative braking technologies (non-adhesion dependant)
  - Better management of information.
  - Local climatic condition measurement/estimation
  - Air deflectors
  - Microwaves – Breaks down film.
  - Ultrasonics
  - Friction modifiers
  - Modified rail profile – increase contact pressure
- High adhesion
  - Modified rail material – e.g. Ni Coating.
  - Modified rail profile – reduce contact pressure
  - Misting systems

4. What are the priorities for future research activity? (a)

Low Adhesion

- Development of a reliable adhesion measuring technology.
- In-service cleaning technologies.
- Fundamental understanding of leaf films.
  - Chemical/mechanical/electrical fundamentals
  - Environmental conditions
- Standard adhesion condition substances.
- Rough and ready train mounted low adhesion warning system.
- Evaluation of non-adhesion braking systems
- Feasibility study into alternative rail profiles/coatings/topography.
- Prediction management of adhesion
- Definition of what level μ is "Low adhesion"

4. What are the priorities for future research activity? (b)

High Adhesion

- Optimum adhesion metallurgy/coatings/profiles
- Solid lubricants – chemical development
- Prediction management of adhesion management
- Definition of what level μ is "High adhesion"

STAGE 4

FINAL CHAPTER FOR CLUSTER REPORT

Describing the problem, its magnitude, the limitations of existing solutions, and the business implications. Making recommendations for new standards, technical solutions and future research activity.

N.B. Current document is still in draft form.

ADHESION MANAGEMENT

Prepared by the Advanced Railway Research Centre and the Rail Safety & Standards Board (RSSB)

Introduction

Adhesion management relates to the control of the coefficient of friction, μ, at the railhead. The challenge is to consistently maintain a value of μ between approximately 0.15 and 0.40, although the exact boundaries of the desired range are open to debate

Low adhesion (μ less than approximately 0.15) can lead to extended braking distances and failure to stop at signals. Indeed, in the UK, incidents have occurred in which sliding trains have over-run signals by up to a mile. A recent study by AEA Technology found that in a five year period between June 1997 and June 2002, there were 140 adhesion related SPAD* incidents in the UK. Annually, the breakdown of these SPADS was as follows:

Category	Severity	Average Annual Occurence
1	0-25 yd over-run	12.4
2	25-200 yd over-run	10.0
3	200 yd+ over-run	5.0
4-8	Damage to people / equipment	0.8

Analysis of UK SPADS, June 1997 – June 2002

As well as being a safety issue, low adhesion can also impact upon the availability of rolling stock. This is because sliding generates wheel flats, leading to the withdrawal of vehicles from service for repair.

The most common causes of low adhesion are leaf films, oil spillages, and rust†. Moisture generally exacerbates the situation. Wet leaves can result in values of μ as low as 0.01. Consequently, chronic low adhesion is both a regional and a seasonal problem. The worst affected areas are the UK and similar latitudes in Northern Europe, during periods of autumnal leaf fall.

High adhesion (μ greater than approximately 0.4) can lead to high creep forces and the initiation of rolling contact fatigue. Again, it is predominantly a regional issue, particularly in climates with high temperatures and low humidity. In the US, μ values as high as 0.7 have been recorded.

High adhesion is usually treated through lubrication.

Current Technical Issues Relating to Adhesion Management

Current approaches to managing low adhesion tend to involve one of the following:

- Cleaning the rail (e.g. using high pressure water spray or grinding).
- Adding substances to the track to raise the coefficient of friction (e.g. sand).
- Vegetation management (e.g. clearing trackside foliage so that leaf-fall is no longer an issue).

The problem with the former two approaches is that they are only short term solutions. In extreme circumstances, their effectiveness can diminish within a matter of hours. The addition of sand can also interfere with track circuits and initiate wear.

The main drawback of clearing trees and other trackside vegetation (aside from the environmental implications) is that it can lead to the destabilisation of embankments. Trackside foliage can also act as an effective noise barrier.

To a certain extent, drivers can also modify their driving style to accommodate low adhesion (e.g. through the use of earlier braking). However, drivers obviously need to be aware of the existence of low adhesion conditions for this approach to be effective.

Current Issues Relating to Standards and Adhesion Management

There are currently no mandatory legal standards relating to adhesion management. A UIC product acceptance standard for wheel-slide protection does exist (Leaflet 541-05), and this is based on a water / soap solution test. However experience shows that this test is not particularly useful. Therefore:

> *The TRAINSAFE consortium recommends that a new standard for adhesion measurement should be developed. For European interoperability, this should be through a TSI.*

However, before such a regulation could be introduced, it would first be necessary to develop standardised approaches to the measurement of μ and the management of this data. Consequently:

> *The TRAINSAFE consortium recommends that a standardised system for the measurement of μ should be developed.*

> *The TRAINSAFE consortium recommends that standardised systems for the management of adhesion information should be devised and implemented.*

Further consideration needs to be given to both of the above recommendations. For example, should μ be measured on a continuous or discrete basis? Should any measurement system be train-based or track-based? Is more than one measurement system required? (e.g. a highly accurate scientific measurement

* "Signal passed a danger" – an incident in which a train passes a stop signal without authority to do so.

† A particular problem when a section of track has been out of service for a period of time

system for calibration and research purposes and a more robust, less refined, cost-effective system for in-service use).

Solutions for Improved Adhesion Management

Any new solutions for adhesion management should clearly aim to overcome the limitations of existing approaches. Therefore, they should:

- Be long-term or ongoing solutions.
- Not interfere with track circuits or other systems.
- Not have detrimental side effects (e.g. the initiation of wear).
- Be able to accommodate existing trackside vegetation.

In terms of low adhesion, one approach might be to employ new, cost-effective, non-contact rail cleaning devices that could be fitted to all in-service rolling stock. Potential technologies might include:

- Laser treatment (e.g. Laserthor).
- Microwave or ultrasonic devices.
- Aerodynamic devices that deflect air so as to clear fallen leaves from the track.

Alternative, or complimentary, approaches to the problem of low adhesion might involve technologies that don't rely on modifying μ directly. For example, non-adhesion dependant braking devices (e.g. air brakes). Or the use of modified rail head profiles to increase contact pressures.

As low adhesion is a transient problem, it might also be worthwhile to develop improved techniques for forecasting its onset, perhaps using local climatic condition monitoring / prediction tools. Contingencies for dealing with low adhesion could then be implemented in advance.

For high adhesion, the following solutions could be considered:

- The use of modified rail materials, e.g. nickel coatings.
- The use of modified rail profiles to reduce contact pressures.
- In-service misting systems.

The Business Benefits of the Proposed Solutions

It has been estimated that the total annual cost of low adhesion in the UK is some £20 - 40 million (approximately €30 - 60 million). This represents the revenue lost due to "leaves on the line" service disruption, the revenue loss / repair cost of wheel flats, and the cost of accidents caused by SPADS (although the latter are fortunately extremely rare).

Clearly, when the Europe-wide situation is considered, together with the additional costs associated with track damage due to high adhesion, the total cost of adhesion-related issues to the European rail industry is likely to be into the hundreds of millions of Euros per year. Consequently, any technologies that can help to address the problems surrounding adhesion have the potential to yield significant cost savings.

Recommended Priorities for Future Research into Adhesion Management

In order to facilitate the proposed solutions, the following primary recommendations are proposed:

The TRAINSAFE consortium recommends that the following programmes of research into adhesion management should be prioritised:

- *The development of reliable adhesion measurement technologies.*
- *Improved fundamental understanding of leaf films in terms of their chemical, mechanical and electrical properties.*
- *The development of track cleaning technologies that can be implemented within existing in-service rolling stock.*
- *For high adhesion, a study of optimum rail metallurgy, coatings and profiles.*

Other, secondary, research priorities that would also usefully contribute to the knowledge base include:

- The definition and development standard surfaces, with calibrated levels of adhesion, as a tool for research.
- Cost-effective, train-based, low adhesion warning systems.
- The evaluation of braking systems that don't rely on adhesion.
- Tools for the forecasting and prediction of adhesion.
- Accurate definition of threshold levels for "low adhesion" and "high adhesion".
- The chemical development of solid lubricants to counteract high adhesion