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11 January 2017

Mr Andrew Hall
Deputy Chief Inspector of Rail Accidents
Cullen House
Berkshire Copse Rd
Aldershot
Hampshire GU11 2HP

Dear Andrew,

RAIB Report: Class investigation into rail breaks on the East Coast Main Line

I write to provide an update[1] on the action taken in respect of recommendation 1 addressed to ORR in the above report, published on 13 November 2014.
The annex to this letter provides details of the action taken regarding this recommendation, the status of which is now '**Implemented**'. We do not propose to take any further action in respect of this recommendation, unless we become aware that any of the information provided becomes inaccurate, in which case I will write to you again.

We will publish this response on the ORR website on 12 January 2017.

Yours sincerely,

Oliver Stewart

[1] In accordance with Regulation 12(2)(b) of the Railways (Accident Investigation and Reporting) Regulations 2005

Recommendation 1

This recommendation is intended to reduce the risk of rail breaks by taking advantage of technological developments in the UK and elsewhere, not restricted to ultrasonic techniques, to allow detection of smaller cracks in rails.

Network Rail should undertake or commission research to identify any opportunities for reducing the size of cracks and defects which can be identified in rails in circumstances likely to be associated with rail breaks. The research should be targeted at providing reliable information using equipment capable of operating routinely throughout its infrastructure

ORR decision

1. Network Rail have undertaken research into new technologies, both domestically and from overseas, to improve their detection of cracks in rails and used it to inform their processes for detecting such defects.

2. After reviewing the information provided ORR has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, Network Rail has:

- taken the recommendation into consideration; and
- has taken action to implement it.

Status: Implemented.

Previously reported to RAIB

1. ORR wrote to Network Rail challenging them explore the practicability of implementing solutions beyond existing knowledge, products and innovations around ultrasonic techniques, both within and outside the UK, as per the intent of the recommendation

2. ORR met with Network Rail on 6 October 2015 to review progress and agree further information required to demonstrate that Network Rail has addressed this recommendation. Network Rail summarised their approach to ensure that they have taken account of emerging technology and European knowledge, and will provide a written response to our letter.

Update

3. Following a timescale extensions, Network Rail provided a closure statement on 1 November 2016. The closure statement stated in summary:

> *The considered response of the Chief Track & Lineside Engineer concluded that the research, reviews and the number of initiatives and developments that have been implemented helped to identify any opportunities for reducing the size of cracks and defects which can be identified in rails in circumstances*

likely to be associated with rail breaks. The on-going reviews and data collection services enhancement project have looked beyond existing knowledge, products and innovations around ultrasonic techniques, both within and outside of the UK to identify whether there is other technology that could and should be adopted to improve the management of broken rails.

In addition to the work detailed earlier, Network Rail continues to focus on removing the underlying causes of rail breaks by considering a wider range of conditions that increase the risk of failures at specific locations. This type of approach, such as a focus on dip angles at joints, has shown considerable reward in the downward trend in broken rails in the past.

Further initiatives are planned as part of Network Rail's commitment to improving rail inspection systems, reducing the reliance on pedestrian inspection and the way data is used to provide improved information to maintenance staff.

Further developments are planned for the future, with the next generation ultrasonic systems being trialled at present. These systems incorporate multilevel defect data processing based on the system's ability to combine ultrasonic, electromagnetic, vision and other systems into the overall suspect I defect identification and classification process.

The next generation train-based systems will also be able to process and accept data from other inspection technologies (i.e. Track Geometry, Ground Penetrating Radar, eddy current and other measurement technology) using the new high speed data network systems.

This also has the potential to impact on the reduction in the requirement to measure manually and verify UTU suspects, due to the improved rail defect recognition process developed by Sperry. In the longer term, there should also be additional benefits in the new Sperry system, with an automatic track feature recognition process which would reduce the requirement for offline analysis and help towards achieving improvement in the management of broken and defective rails.

Therefore it is considered that the intent of this recommendation has been addressed and can therefore be CLOSED.

'Network Rail, Chief Track & Lineside Engineer, has addressed the intent of this recommendation by completing a number of specific actions and identifying further improvements to be introduced to reduce the size of cracks and defects which can be identified in rails in circumstances likely to be associated with rail breaks.

This work has resulted in a number of improvements to defect detection processes which have been targeted to find smaller defects more reliably, with a higher probability of detection without increasing the number of false suspects. Network Rail will continue to look for opportunities to improve the detection and prevention of defects that could lead to a broken rail.'

4. Network Rail provided information on the track inspection technologies they reviewed and initiatives taken to improve the detection of defects:

- Data Collection Service Enhancement (DCSE)
- Introduction of fourth and fifth (spare) UTU to increase the extent of ultrasonic testing
- On-going review of defective and broken rails
- On-going improvement to bolt hole and rail end testing using Distance Amplitude Correction on UTUs
- Research into the ultrasonic identification of potential of rail foot defects
- Revisions to the UTU analysis procedures
- Improved UTU probe guidance
- Improved couplant systems
- Development and implementation of Eddy Current surface crack detection equipment

More information about these initiatives can be found in Network Rail's closure statement

20161031 ECML rec 1 closure statement s

Previously reported to RAIB

Recommendation 1

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Network Rail should undertake or commission research to identify any opportunities for reducing the size of cracks and defects which can be identified in rails in circumstances likely to be associated with rail breaks. The research should be targeted at providing reliable information using equipment capable of operating routinely throughout its infrastructure (paragraph 121d).

Steps taken or being taken to address the recommendation

1. On 19 February 2015, Network Rail provided the following information:

Network Rail has undertaken work to identify any opportunities for reducing the size of cracks and defects which can be identified in rails in circumstances likely to be associated with rail breaks. This work has resulted in two ultrasonic detection processes.

Improved detection of small bolt hole and horizontal defects at rail ends.

Detection of cracks at rail ends and bolt holes at the earliest stages of growth is predominately determined by the sensitivity of the 370 channels. The DAC system (Distance Amplitude Correction) enables the sensitivity to be increased in areas where crack signals are likely to occur.

Identify small surface defects on the head of the rail

Train based eddy current inspection will be used to identify RCF. The existing process depends on the RCF sites being initially identified by visual inspection (which then generates a targeted ultrasonic test programme).

The eddy current system (which is not an ultrasonic process) will allow us to better understand and predict the actual depth and deterioration of RCF, allowing detection of surface defects from 0.1mm to 5mm deep. Eddy current effectively measures depth, rather than surface length, of the cracks.

The eddy current system will be fitted to all four UTUs. Geographic coverage will be as existing UTU coverage.

Work is progressing to finalise an automated report to enable Sperry to process the eddy current data. The output will give a validated pocket depth / depth of crack result in a practical and efficient way.

Revised procedures are required to make use of this more accurate and consistent data. These procedures will be revised and briefed to all appropriate staff.

Network Rail will also explore the possibility of providing pedestrian eddy current testing (new equipment/process required) and implement the results of this work.

Timescale: 15 December 2015

2. On 10 August 2015, Network Rail provided the following additional information:

Network Rail is working to initiate improvements to its ultrasonic rail management processes and against this background of research introduced a number of initiatives that have provided opportunities for improved rail management; specifically:

Introduced an additional (fourth) UTU to improve the extent of ultrasonic testing

The fourth UTU was primarily introduced to enable train based ultrasonic inspection of lower category track to be carried out at the required frequencies. Previously the UTUs were focussed on defect detection in higher speed, higher tonnage routes and only operated on Track Categories 1A, 1, 2 and 3. The fourth UTU enables this programme to be extended to cover the remaining lower speed, lower tonnage track in categories 4, 5 and 6. The additional vehicle also provides additional spare shifts which are used to free up other vehicles for planned maintenance and to implement and trial new measuring and inspection techniques which is more difficult if all vehicles are fully utilised for compliant testing.

Improved the identification of rail foot defects, or indicators that there is a relatively high risk of such defects, using improved testing equipment mounted on the UTU (i.e. testing the full depth of the rail but acknowledging that irregularities on the foot underside may both prevent crack identification but permit recognition of corroded areas liable to cracking).

Network Rail has undertaken initial trials of a modified ultrasonic procedure to enable the foot of the rail to be scanned to try and detect any transverse defects that may initiate in the middle of the rail foot. This has been refined to improve the results with all four UTUs now modified to allow the deep 37 degree probe data to be captured routinely. Current work is validating the results from initial runs carried out on ECML between London and Peterborough and on West Coast Main Line south of Rugby.

Work is currently underway to understand the capability of the new process and to assess the potential for introducing this technique on all Routes.

If the procedure is validated and shows a benefit in reducing the risk of rail breaks further work is required to develop analysis procedures to process the data and determine new minimum action codes to target the removal of at risk rail before failure is likely to occur.

Revising how rail head ultrasonic data is processed to increase the likelihood of detecting rail head defects…

Revisions to the analysis procedures have been put in place since September 2013 to improve the detection of longitudinal defects in the head of the rail based on repeated sections of rail with a loss of rail bottom signal. These types of defect are difficult to detect with conventional ultrasonic testing due to their orientation and small cross sectional area. This has improved the early detection of a number of vertical longitudinal split defects that would have not been detected previously.

Fitted additional equipment to the UTU trains intended to improve the detection of cracks on the rail head

Eddy Current based wheel probes have been developed, installed and operational on all UTU vehicles to measure the length and depth of surface defects such as rolling contact fatigue. Since February 2015 test data has been gathered from all vehicles and work is ongoing to validate surface crack length with depth through the removal of samples of rail tested in track.

Initial comparisons using rails removed from West Coast Mainline show that both the vehicle-mounted and pedestrian Sperry Eddy Current Systems measured crack depths with sub-millimetre accuracy when compared to the definitive milling results. Further samples, which have been measured by the UTUs, are currently being gathered and will also be sectioned to provide a larger population of results from a wider range of rail conditions. Benchmarking of measured data is also difficult and time consuming as a range samples of rails measured in track need to be removed and sectioned to provide a definitive answer on the depth of real defects being measured.

The system has been developed to be fully automated and is mounted to existing inspection vehicles to minimise the potential for human error or operator appraisement errors which were significant with the existing visual inspection process. Initial results show a step change improvement in the reliability and repeatability of the data being collected by the eddy current technology which has identified new sites which had not been identified at all and given depth data which was only ever estimated in the past. The system is intended to replace the current visual assessment of surface length which was used to give an approximate indication of crack depth and replace it with a direct measurement of crack depth and thus much more accurate results compared to what has been used for the last 13 years. It is already providing better data than was previously available. Work is currently underway to make the data accessible to the Routes whilst upgrades are being made to the rail defect management system RDMS to allow eddy current data to be automatically loaded and managed within the system.

Other work not previously provided to RAIB:

Improvements to the current UTU procedures to improve the detection of smaller defects at bolt holes and rail ends (results of trials and developments since April 2014).

Sperry ultrasonic systems use ultrasonic pulses directed at 37 degrees to the vertical to interrogate bolt holes for the presence of so-called "Star Cracks". These grow at approximately any of the four diagonal directions and horizontally from bolt holes mainly where rails lengths are joined together using bolted fishplates. The fishplates cover growing cracks and prevent crack detection using visual inspection and so it is important that ultrasonic inspection is comprehensive and reliable in detecting and identifying any growing cracks. The Probability of Detection of cracks at the earliest stages of growth is determined by the sensitivity of the 37 degree channels. Unfortunately as the sensitivity is increased there is a tendency for spurious signals (noise) from various sources to degrade the quality of the signals. This usually sets a practical limit to the capability to detect cracks.

One way of overcoming this limitation is the have a system that enables the sensitivity of the system, normally expressed as Gain, to be varied as a function of time. This system enables the sensitivity to be decreased in areas that are likely to generate noise and increased in areas where crack signals are likely to occur. This functionality is called Distance Amplitude Correction (DAC).

The results of the trials showed that in all cases there is either an equal number of hits when DAC is applied but in the majority of cases there is an increase in the number. Furthermore there is no increase in spurious signals recorded by the system. The trials showed that the "hard-to-find" d cracks are detected with greater probability when DAC is used. In the comparative trial 89% of the d cracks were detected when DAC was used compared to only 27% when it was not.

The introduction of DAC means that extra sensitivity can be used in the areas around bolt holes where Star Cracks are known to originate.

In view of the successful trials DAC was implemented on all UTUs from November 2014 to improve the detection of defects at rail ends.

3. ORR wrote to Network Rail challenging them explore the practicability of implementing solutions beyond existing knowledge, products and innovations around ultrasonic techniques, both within and outside the UK, as per the intent of the recommendation

4. ORR met with Network Rail on 6 October 2015 to review progress and agree further information required to demonstrate that Network Rail has addressed this recommendation. Network Rail summarised their approach to ensure that they have taken account of emerging technology and European knowledge, and will provide a written response to our September letter.

ORR decision

5. ORR, in reviewing the information received from Network Rail has concluded that, in accordance with the Railways (Accident Investigation and Reporting) Regulations 2005, it has:

- taken the recommendation into consideration; and
- is taking action to implement it

Status: Implementation on-going. **ORR will advise RAIB when further information is available regarding actions being taken to address this recommendation.**