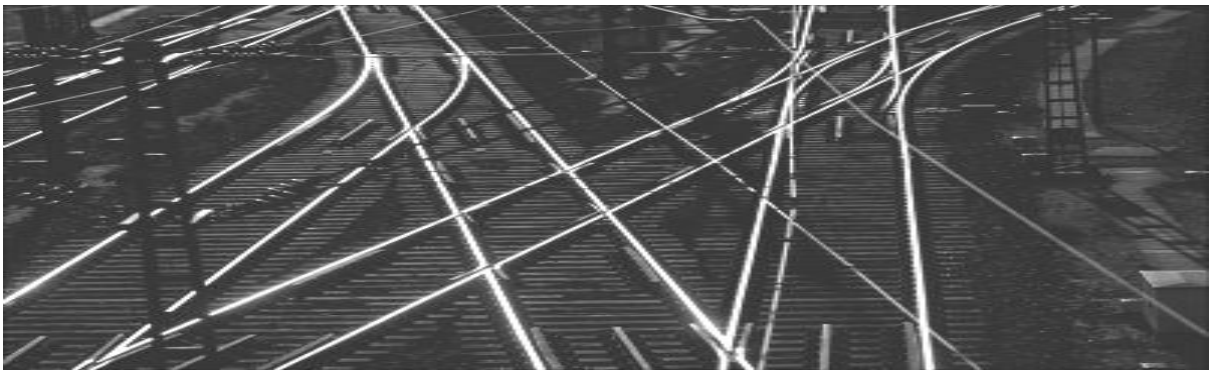
Eisenbahn-Bundesamt

**Central Investigation Office of the Federal Railway Accident Investigation Office**

# *Accident Investigation Report*



## *Train derailment*

## *Stuttgart-Untertürkheim station*

## *Line No 4720, Untertürkheim-Kornwestheim*

## *on 15 March 2010*

**Bonn, 5 July 2011**

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Federal Railway Accident Investigation Office (EUB)
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# 1. Summary

## 1.1 Sequence of events

At about 20:50, the second locomotive of double-headed freight train CFN 63051 (from Karlsruhe-Rheinbrücke Raffinerien to Stuttgart Hafen) derailed close to No 391 switch (IBW54-300-1:9-li) (which lay to the left) whilst running via track 361 to track 278 into Stuttgart-Untertürkheim station. This second locomotive became uncoupled, swung to the right and after travelling a few metres, came to rest on the ballast, leaning to the side. The first locomotive and three tank wagons derailed and rolled towards track 284. The first locomotive and the first tank wagon toppled on their sides diagonally across the direction of travel. The tank wagon was pushed by the following train and wedged against lattice mast No 2/3 supporting the catenary.

## 1.2 Consequences

The driver was slightly injured.

The derailment damaged or destroyed some 250 track metres of track and switch and crossing work together with a lattice mast and the catenary. Fuel oil escaped from two places of leakage in the tank of the first tank wagon which had overturned and was wedged. Some 300 to 400 litres [of fuel oil] escaped into the ground. Three tank wagons and two locomotives of class 140 were severely damaged.

## 1.3 Causes

The cause of the derailment is to be attributed to deficient tamping and alignment work carried out over the night of 14/15 March 2010 as part of permanent way renewal.

On the curve between No 391 and No 394 switch a cant of 40 mm was created. There was no cant at that point before the work began.

For reasons related to the design of tamping machines, tamping and alignment work through switches and crossings can only be done with a switch and crossing tamping machine and not with a plain line tamping machine. Although the resulting gradient due to cant run-off was close to No 391 switch, the

tamping and alignment work with the plain line machine had to be stopped before the toe of No 391 switch.
In this way, a steep gradient with a twist of some 8.2 ‰ was created. The limiting value for the 'twist' parameter in accordance with Module 821 'Inspection of the Permanent Way' was exceeded (it was 153 % where the limiting value is set at 130 %). Since readings were not taken up to at least 20 m beyond the end of the work of the plain line tamping machine (as required by Module 824 'Carrying out work on the permanent way'), the fact that the limiting value had been exceeded was not recorded.

# 1. Preliminary remarks

## 2.1. Those involved

The event was investigated on site by the Federal Railway Accident Investigation Office. Comments by technical specialists and expert statements from the following bodies were factored in when verifying the facts and researching the causes:

- Deutsche Bahn Systemtechnik, Minden
- Deutsche Bahn Gleisbau [track work] GmbH (DBG), Augsburg

## 2.2. Organisational note

Directive 2004/49/EC on safety on the Community's railways (the Railway Safety Directive) obliged EU Member States to set up independent investigating bodies to investigate particular dangerous events. This Directive was transposed into national law in Germany by the Fifth Railway Regulations Amendment Act of 16 April 2007, and the Federal Railway Accident Investigation Office [Eisenbahn-Unfalluntersuchungsstelle des Bundes (EUB)] was established. The Railway Safety Directive was further transposed in the Railway Accident Investigation Regulation [Eisenbahn-Unfalluntersuchungsverordnung (EUV)] of 5 July 2007.

The management of the Federal Railway Accident Investigation Office is the responsibility of the Federal Ministry of Transport, Building and Urban

Development [Bundesministerium für Verkehr, Bau und Stadtentwicklung (BMVBS)]. The management of the Federal Railway Accident Investigation Office can call on the Central Investigation Office within the Federal Railway Authority to help it carry out investigations. For technical matters, the Central Office reports exclusively and directly to the director of the Federal Railway Accident Investigation Office. Further details of these arrangements are given in the Internet under >> www.eisenbahn-unfalluntersuchung.de << [only available in German].

### 2.3. Aim and purpose of rail accident investigation

The aim and purpose of the investigations is to establish the causes of dangerous events and hence to derive ways of improving safety. Investigations by the Federal Railway Accident Investigation Office do not serve to establish fault or to clarify issues of liability or other claims in civil law. They are conducted independently of any judicial investigation.

Investigation includes collecting and evaluating information, drawing up conclusions including establishing the causes and, as appropriate, issuing safety recommendations. The Investigation Office's proposals for avoiding accidents and improving the safety of rail traffic are notified to the safety authorities and, as necessary, to other bodies and authorities and other EU Member States in the form of safety recommendations.

## 2. The event

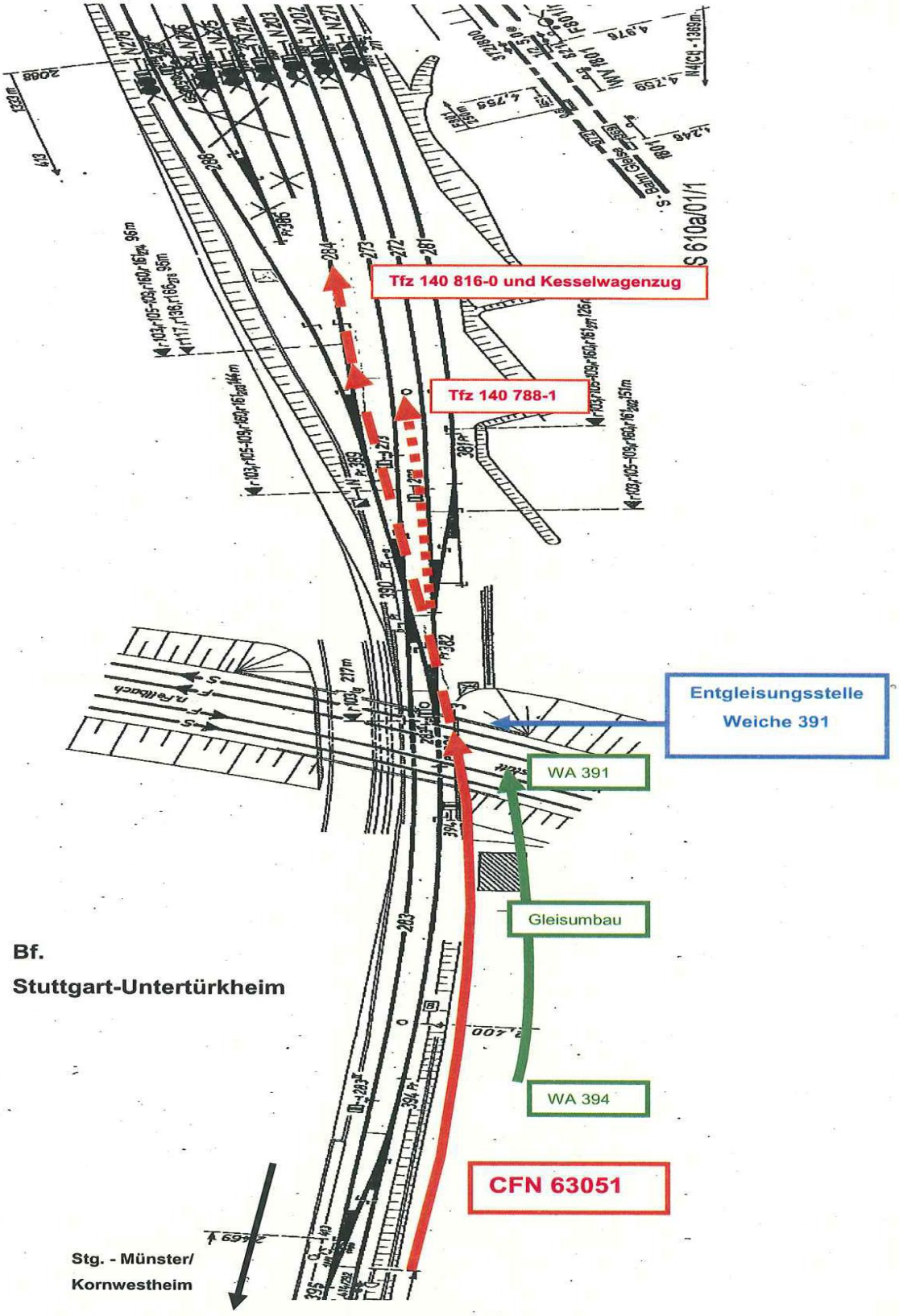
### 3.1. Sequence of events

Freight train CFN 63051 was double-headed with two locomotives of class 140. The first locomotive was 140 816-0 and the second 140 788-1; together they hauled a train of twenty bogie tank wagons. The approach to Stuttgart-Untertürkheim station from the Kornwestheim direction was via the route set up from track 361 to track 278 using right-line working.

The second locomotive became uncoupled on No 391 switch at a speed of 45 km/h, it swung to the right and after some three vehicle lengths came to rest on the ballast, leaning slightly to the side. The first clear signs of the derailment,

marks which were caused by the second locomotive, could be seen close to the distance blocks of the right-hand switch blades.

Having derailed, the first locomotive 140 816-0 and three wagons of the tank wagon train initially rolled together in a line swinging off towards the left of No 391 switch and then rolled further onto other switches and crossings. The derailed locomotive forced No 389 switch across to lead to track 284. The locomotive subsequently fell on its right-hand side, slid over the tracks and came to rest some 100 m behind No 391 switch diagonally across the direction of travel. The first three tank wagons (338078485525, 338178486118 and 338078488313) derailed likewise and the first tank wagon toppled over and came to rest lying beside the locomotive which was already lying diagonally across the direction of travel. This tank wagon was pushed by the following train and wedged against electrification lattice mast No 2/3 and its base standing on an embankment. Because of the very high point loads on the tank (caused by the edges of the solebars of the following tank wagons) two holes were pierced. Some 300 to 400 litres of fuel oil ran out through these. The holes were sealed by the fire brigade. The fuel oil that came out of the second hole was caught in plastic tanks.



***Second locomotive, 140 788-1, derailed first***


***First locomotive 140 816-0***

***First tank wagon No 338078485525 overturned***

***First tank wagon, transfer of tank contents due to leakage***

### 3.2. Fatalities, injuries and damage to property

Fortunately there were no fatalities. The driver was slightly injured in the incident and suffered shock. Damage to property may be summarised as follows:

| | | |
|---|---|---|
| Locomotives | approx. | EUR 200 000 |
| Tank wagons | approx. | EUR 43 000 |
| Track | approx. | EUR 493 000 |
| Control and safety equipment | approx. | EUR 64 000 |
| Electro-mechanical equipment | approx. | EUR 83 000 |
| Environmental damage | details not yet available | |
| Operating difficulties | no details | |

### 3.3. Weather conditions

The accident happened in darkness. The temperature was cool.

## 3. Investigation report

### 4.1. Summary of statements

Statement made by the driver of train 63051 to the team leader of DB Schenker Rail:

'On 15 March 2010 my duties on shift 9111 were to drive train 63051 from Karlsruhe Miro [refinery] to Stuttgart-Hafen. For this, I took locomotives 140 816 and 140 788 in multiple from Karlsruhe marshalling yard stabling point into the refinery. There, after coupling up to the train, a full brake test was made. I was able to leave five minutes before time. I was checked in Durlach station by a preceding S-Bahn train and followed it to Wilferdingen-Singen where I came to rest on the passing loop. After the exit signal had cleared, I accelerated strongly so that I could start the uphill section with as much momentum as possible. During the acceleration, several traction current relays in the rear locomotive tripped because of slipping so I had to stop again in the departure area of the station. The relays closed but that caused approximately five minutes further delay. The continuing journey to Stuttgart-Untertürkheim was without operational or technical incident. The signal giving access to Stuttgart-

Untertürkheim showed a “proceed at caution” [Hp2] aspect. I reduced speed to that required with a controlled service brake application. In the switch and crossing work there was a sudden pull. I had the impression that the rear part of the locomotive had derailed. After about 50-70 m the locomotive came to a stop. Shortly before stopping I felt a jerk and the locomotive tipped to right. Current was cut off and it was dark. I was able to free myself from the locomotive but I was very careful because of the risk of overhead electrification cables hanging down. After I was able to climb down the front of the locomotive, I moved to a place of safety on the road which runs parallel. As I got there, the first emergency service vehicles were already arriving. I introduced myself to a police woman as the driver of the train that was involved. She took my personal details. I notified the head of the fire brigade team of the freight being carried. Due to the earthing of the overhead electrification I asked him to make contact with the signaller. After treatment by the emergency doctor, I provided the DB Schenker emergency service with details of the sequence of events that led to the accident. After that, he arranged my return home in a taxi.’

Statement made by the signaller at Stuttgart-Untertürkheim to the work-team leader (operations) and investigation leader of DB Netz AG:

‘The route to track 278 was set up for train 63051. I saw the beginning of its arrival as the track section started to show “occupied”, then the fault alarm suddenly rang and, amongst other things, the “switch run through” indicator for No 391 switch showed. After a short wait I wanted to make radio contact with the driver of train 63051; I could not get through despite repeated attempts. Shortly afterwards the central electrical control office reported a short circuit, further reports by the operations centre followed (amongst other things a call to fire brigade control by the emergency control centre).’

## 4.2. Safety management system

### 4.2.1. Management of emergencies

In accordance with Article 4(1) of the General Railways Act [Allgemeines Eisenbahngesetz (AEG)], railways have an obligation to cooperate in fire protection and technical assistance measures. The interior ministries of the *Länder* and DB AG have agreed the procedure to be adopted. For DB Netz AG, the *Länder* legislation for defence against fire and catastrophe applies. DB AG's emergency management [procedure] is described in more detail in and governed by Group Guideline (Ril) 123.

In this case, the emergency services (fire brigade, emergency doctor) were called by witnesses who were not employed on the railway and not by DB Netz AG's emergency control centre.

### 4.2.2. Investigation of processes and procedures for railway operations, works management and administrative law

Background in terms of works contracts:

The South-West Region of DB Netz AG, (the client) concluded **works contract 0016 / EKT / 92159287** with the general undertaking (the contractor), for track and switch renewal in Stuttgart-Untertürkheim station. Prequalification certification for this task was supplied; it was issued after a review of suitability and certifies the skills, capacity and reliability necessary for work on the DB Group's lines. The same applies to the subcontractors listed in the list of subcontractors. The company employed for the tamping and aligning work over the weekend of 13/14 March 2010 is not listed here since apparently it was only brought in as a replacement for a subcontractor whose machine had failed.

Furthermore the South-West Region of DB Netz AG, (the client) concluded **engineering consultancy contract 234715** with an independent engineering consultancy (the contractor) for monitoring the work on site.

In this contract, amongst other things, the client tasked the contractor with:

- Technical services for engineering works contracts and in traffic installations in accordance with Appendix 1.1. These include, for example:

- ➔ checking that all the authorisations necessary, including those to be obtained by the contractor$_{works}$, are to hand at the time the work is to be done, and are complied with;
- ➔ notifying all the measures affecting railway operations, the timescales and circumstances to the bodies responsible for rail operations;
- ➔ detection of irregularities on site whilst the works are ongoing;
- ➔ immediate checking of the content of all paperwork and reports etc. coming from the contractor(s)$_{works}$ or third parties and forwarding them as agreed with the client;
- ➔ visual inspection of the implementation plans as made available to check for consistency with circumstances on the ground, and supervision of the execution of the work to ensure it is in accordance with the contract, is consistent with the documents available, with the contract for the works, generally recognised technical principles and the regulations applicable;
- ➔ taking part in the contractor$_{works}$ inspections and acceptance procedures and recording the inspections in accordance with the catalogue of inspections;
- ➔ assessing the condition of parts of the work in accordance with Article 4(10) of the German Construction Tendering and Contract Regulations (technical acceptance) [part B of the Vergabe- und Vertragsordnung für Bauleistungen (VOB/B)] ;
- ➔ preparing for and participating in the handover of the installations to the person responsible for them in DB AG;
- ➔ participating in the preparation and execution of partial and complete putting into service.

- Railway operational services and safety supervision in accordance with Appendix 1.2. These include for example:
  - ➔ carrying out the duties of the authorised technical officer in accordance with point 4.2 of the Advice of work in progress [Betriebs- und Bauanweisung (Betra)] such as, for example,

making reports to the signaller, including the report of suitability for traffic, and assessing operational safety before release to traffic;

- ➔ drawing up proposals for the Advice of work in progress in accordance with Guideline 406 and submitting them to the body responsible for operations planning;
- ➔ ensuring complete coordination of operations and operational safety issues within engineering possessions in accordance with the Advice of work in progress;
- ➔ ensuring safe and punctual rail operations, amongst other things, compliance with possession times, within the bounds of the contractor's tasks.

- Services under the VV BAU/BAU-STE administrative regulations [regulations for the supervision of works including signalling and telecommunications works] in accordance with Appendix 1.3. These include for example:
  - ➔ carrying out the duties of the works supervisor in accordance with the provisions in the current administrative regulations for works (VV BAU). Amongst these, in particular, are the organisation, execution and documentation of all intermediate acceptance and [final] acceptance necessary under VV BAU whilst taking account of the EBA's project-specific procedural specifications.

The supervisory activity includes the technical areas of running lines, overhead electrification equipment, other electro-technical installations, control and safety technology and health and safety coordination [SiGeKo – Sicherheits- und Gesundheitsschutzkoordinator]. In addition, the contract lays down that the contractor will only engage staff who, depending on their tasks and qualifications, are entitled to the designation of rail works supervisor [Bauüberwacher Bahn (BÜB)], specialist supervisor [Fachbauüberwacher (FBÜ)] or works supervisor [Bauüberwacher]. Likewise, it is agreed that during the time the works contractor is working, the works supervisor responsible must be continuously present on site.

The certificates of competence for the rail works supervisor and specialist supervisor are to hand (including for supplementary training such as, for example, on evaluation of multi-channel plotter records and evidence of regular further training). There is evidence that the DB Netz AG head of operations for the area briefed the rail works supervisor on local features affecting the work in accordance with Betra No F 644061 and No F 644062 on 4 March 2010.

Advice of work in progress, description of the works:

The description of the works and preliminary remarks on the specifications reveal that conventional track renewal of the section of track between No 394 and No 391 switch was planned. This involved removal and replacement of track panels supplied from a storage area at the side and transport from the assembly area in the station. Possessions for the work were notified to operations departments for the following periods: from 08:00 on Saturday 13 March 2010 to 04:00 on Monday 15 March 2010.

Possessions for the removal and re-installation of No 391 switch in the old location were notified to operations departments for the following periods:
from 00:00 on Saturday 20 March 2010 to 00:00 on Monday 15 March 2010.

Advice of work in progress No F 644062 with corrections 1 and 2 came into effect at 22:00 on Sunday 7 March 2010. It expired at 17:00 on Friday 26 March 2010.

The possession of Nos 394, 391 and 382 switches and track 292 (between entry signal F361 and clearance marker Ra 12 to No 202 switch) took place in accordance with Advice of work in progress point 2.2 from 08:00 on Saturday 13 March 2010 to 04:00 on Monday 15 March 2010 and from 08:00 on Saturday 20 March 2010 to 04:00 on Monday 22 March 2010. In each case, the track under possession was identified as a being worked on in accordance with Module 408.0902.

According to the Advice of work in progress, reduction of the permitted speed at the site to 70 km/h should just have applied after conclusion of the overhead

electrical work during the period from 04:00 on 22 March 2010 to 07:00 on 27 March 2010 from km 2.4 to km 1.2 and from km 2.1 to km 2.4.

The authorised staff were listed in Advice of work in progress No F 644062:

- under point 4.1, the signaller at Stuttgart-Untertürkheim for all operational arrangements;
- under point 4.2, (inter alia) the 'authorised technical officer' named in accordance with the engineering consultancy contract for all operational agreements and reports to the signaller.

Before the beginning of the work and at every shift changeover, the authorised technical officer reports to the signaller on duty who registers this in the register of telephone calls. At all times, the authorised technical officer must be known by name to all those involved and be continuously available to the on-site signaller on duty. To keep an audit trail of instructions and reports to the signaller and the person overall in charge, the authorised technical officer keeps a record book analogous to the register of telephone calls.
The signaller gives possession of the line for work under Advice of work in progress point 5.3.4 in accordance with Module 408.0902 with the agreement of the authorised technical officer once the appropriate conditions on site have been created (for example, setting up protective signals).
The report that the line is clear and that the line under possession may be used is made under Advice of work in progress point 5.3.10. In accordance with that point, the authorised technical officer reports that work has finished, that the line under possession is clear and that it may be used (and that the normal loading gauge is available) to the signaller on duty. This report has to be made promptly once the appropriate conditions on site have been created (for example, removing protective signals) so that the signaller on duty can lift the possession before the time set down in Section 2.2 of Advice of work in progress. After receiving the report from the authorised technical officer that the line under possession is clear and that it may be used, the signaller on duty lifts the possession.

Scheduling of the works

In accordance with the works schedule dated 26 January 2010, the following stages were planned for the work in the areas around track 282 and No 391 switch:

➔ Track 282 = section between No 394 switch (described as km 2.402) and No 391 switch (described as km 2.318). Length for renewal 84 m:

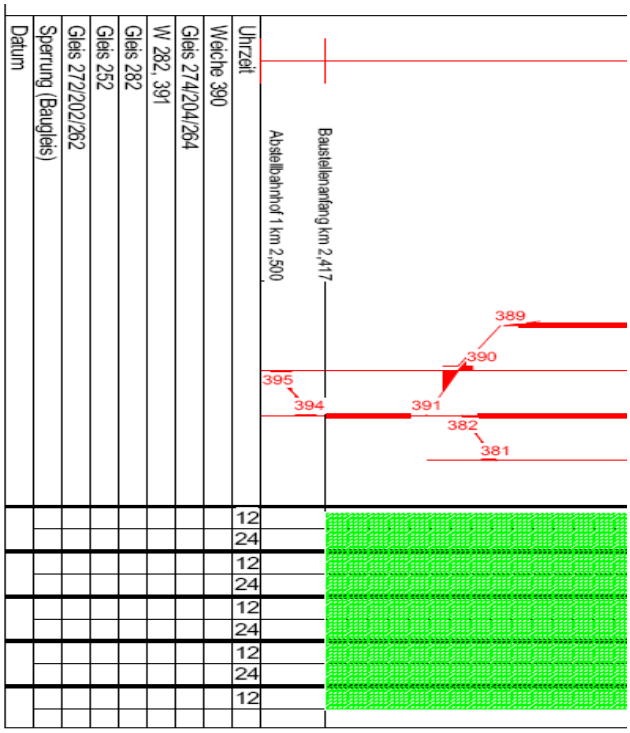
- beginning of work at 08:00 on 13 March 2010 with specialist work, removal of sections of track, search for [unexploded] munitions;
- removing the ballast bed loading material supply wagons from the front with a loading station;
- placing the bottom ballast;
- levelling the ballast;
- installing track panels (to approx 01:00 on 14 March 2010);
- changing rails (from temporary rails to final rails);
- ballasting the section of track;
- tamping work: lifting and packing pass (from approx 05:00 on 14 March 2010) with **overlapping** on No 391 switch;
- tamping work: first consolidation;
- ballasting the section of track;
- tamping work: second consolidation (up to approx 10:00 on 14 March 2010);
- rail welding;
- creating of the track bench;
- remaining work, specialist work (to 04:00 on 15 March 2010).

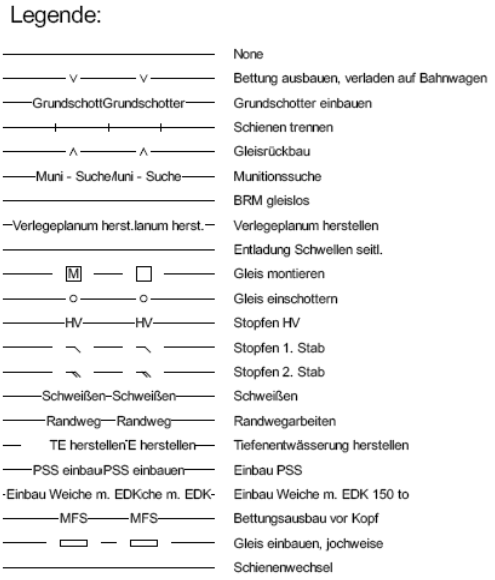
➔ No 391 and 282 switches:

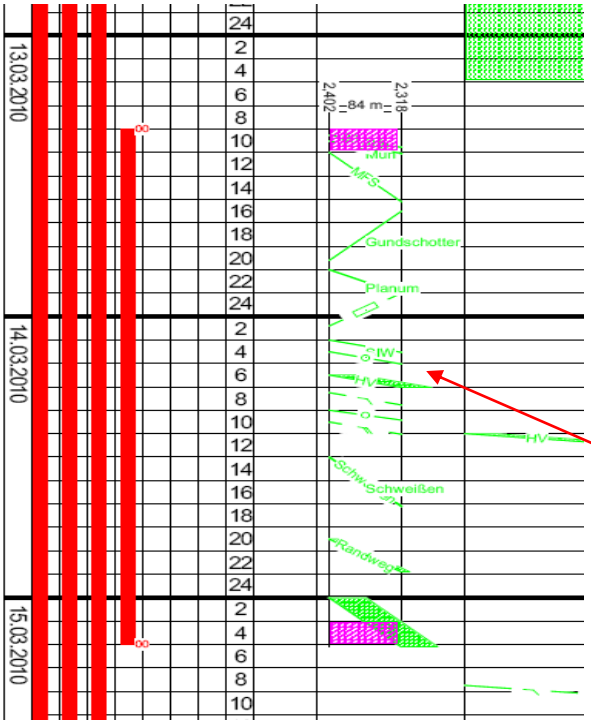
- Beginning of work at 08:00 on 20 March 2010 with specialists, removal of a section of track and switch, search for [unexploded] munitions;

According to the daily report produced by the company carrying it out, the work to renew the track between No 391 and 394 switches was started on 13 March 2010. The tamping work began with plain line tamping machine 09/32 CSM at 20:00 on 14 March 2010 (entry to the possession) at No 394 switch and continued towards No 391 switch. It ended at about 22:00.

Subsequently some 90 m of track was ballasted. Ballast was cleared up and the [rail] tension between No 394 and No 391 switches measured.
According to the daily report, the track between No 391 and No 394 switches and track 201 was released in accordance with Advice of work in progress point 4.2 at 03:00 on 15 March 2010 by the authorised technical officer on behalf of the company carrying out the work.




Overlapping of the tamping work from the plain line area to the area of No 391 switch was planned (only possible with a switch and crossing tamping machine)

***Works schedule***

Investigation of the operational activities linked to Advice of work in progress No F 644062:

The report from the authorised technical officer (specialist supervisor) that track 292 (section under possession from entry signal 361 to colour light 394) and the adjoining switch and crossing area (from clearance point No 382 switch to colour light 394) were clear and useable was given at 04:04 on 15 March 2010. The signaller at Stuttgart-Untertürkheim cancelled the possession of the line at the same time.

In the period after 04:04 but before the accident, the following trains ran over the entry section F 361 to No 394 switch:

| **Train number** | **Time** | **Locomotive** |
|---|---|---|
| 56099 | 05:03 | 152 168-1 |
| 47769 | 06:20 | 185 316-1 |
| 47787 | 06:32 | 151 018-9 |
| 56123 | 06:38 | 290 633-7 |
| 56101 | 07:09 | 185 229-2 |
| 63054 | 10:51 | 152 049-3 |
| 68575 | 11:13 | 140 013-4 |
| 68580 | 16:41 | 185 294-6 |
| 68565 | 17:37 | 185 089-0 |
| 58338 | 18:00 | 290 633-7 |
| 68203 | 19:06 | 152 166-5 |
| 68231 | 20:43 | 155 257-9 |

According to an excerpt from the record of telephone calls, possessions of the following sections of line which would later be used by the train involved in the accident were taken during the period from 04:04 to 17:55:

- Entry signal 361 to colour light 394
- Clearance point No 382 switch to colour light 394

- No 394 switch to colour light 394
- Colour light 394 to No 382 switch
- No 391switch to colour light 272
- No 391 switch

These possessions were taken to finish the work defined in the Advice of work in progress. All the subsequent entries in the record of telephone calls related to operational issues after the time of the accident.

Administrative law procedures and background:

The line in question is shown in the infrastructure register as being part of the conventional rail TEN-Network (Trans-European Network). To fulfil all the conditions necessary to meet the requirements to put rail installations on the TEN-Network into service on time and in accordance with technical and quality standards, the [German] Regulation on the interoperability of the trans-European rail system [TEIV (Verordnung über die Interoperabilität des transeuropäischen Eisenbahnsystems)] and the Administrative provisions of the Federal Railway Authority for the procedure to put structural sub-systems of the trans-European rail system into service to form fixed installations [VV IST (Verwaltungsvorschrift des Eisenbahn-Bundesamtes für die Verfahrensweise bei der Inbetriebnahme struktureller Teilsysteme des transeuropäischen Eisenbahnsystems für den Bereich ortsfester Anlagen)] this requires the employment of a 'person responsible for putting into service'.

In accordance with the VV IST, the person responsible for putting into service is responsible for carrying out the process for putting civil engineering projects on the TEN-Network into service, including presenting all the papers relevant to putting into service to the safety authorities. This person is responsible for the completeness and auditability of the papers to be submitted in terms of timescales, technical requirements and the specification as well as putting new, extended or altered railway installations on the TEN-Network into service in operational safety in accordance with the requirements of the TEIV and VV IST. In making his submission, this person confirms on behalf of the project promoter that all the evidence relevant to putting the installation into service has been fully and correctly supplied and that nothing prevents the Federal Railway Authority from issuing an authorisation to put the installation into service. A

'putting into service' file is to be submitted with the application for the issue of an authorisation to put the installation into service in accordance with Article 6 of the TEIV. As a rule, this application should be submitted to the safety authority four weeks before the installation is put into service. Information on the following topics, inter alia, is included:

- on the installations to be put into service;
- on the staff taking part in the work;
- on the records of technical checks made and test reports;
- on certificates of acceptance;
- on the track geometry (record of track geometry, multi-channel plotter record, for example).

*More detailed explanation: even if the authorisation to put the installation into service is not available in time, installations in the existing network may be accepted for traffic immediately after the report that the track is clear and useable in accordance with Article 4(1) of the General Railways Act (self-authorisation).*

Likewise, a 'Declaration by the person responsible for putting into service' is to be submitted with the application for the issue of an authorisation to put the installation into service. In this document, the person responsible for putting into service certifies that they have checked the papers relevant to putting into service in accordance with Appendix 1 of the VV IST (the 'putting into service' file) and that these are complete and correct. This person also declares that nothing stands in the way of putting the installation into service. This declaration is also signed by the competent person responsible for the installation and the rail works supervisor. As a rule, handover of the definitive constructional papers by the person responsible for putting into service to the person responsible for the installation takes place within two days. It is to be noted, however, that the person responsible for putting into service is not required to have competency in evaluating multi-channel plotter records.

In accordance with Article 9 of the TEIV, comprehensive re-equipment or renewal of a structural subsystem, which goes beyond replacement in the context of maintenance work, requires an authorisation to put into service in accordance with Article 6 of the TEIV and Article 8 of the VV IST. This authorisation is issued by the safety authorities on application by the operator of the structural subsystem. Notice has to be given to safety authorities in accordance with Article 9(2) of the TEIV.
In accordance with Appendix 3 of the TEIV and Appendix 4 of the VV IST, comprehensive re-equipment or renewal are said to exist, inter alia, if:

- the costs of the works exceed EUR 1 million;

or, if the costs of the works are less than EUR 1 million;

- an increase in speed of at least 10 % should be possible as a result of changing the alignment.

In the course of the works, the cant was increased from 0 mm to 40 mm. In accordance with the track layout plan, this represents an increase of speed from 85 km/h to 100 km/h (an increase of more than 10 %). However, the infrastructure manager, DB Netz AG, did not intend to seek an authorisation to put into service or to employ a person responsible for putting into service. The production management of DB Netz AG gave the reason that it was a like for like replacement of the switches and the new cant of 40 mm was below the limit of 75 mm. Furthermore it was not planned to increase the speed to 100 km/h in the short term.

*More detailed explanation: the 75 mm dimension is simply a guideline in Appendix 5 to VV IST and signifies that reinstatement of the design condition and the optimisation of the existing track geometry with lifting of up to 75 mm in a vertical direction is regarded as remedial work not requiring authorisation.*

In accordance with the list of locally permitted speeds, the renewed section of track is used to date at 80 km/h (from km 2.4 to km 1.4). For timetable year

2012, however an increase in speed to 90 km/h for this section of line is proposed. **This represents an intended increase of more than 10 %.**

DB Netz AG however sees the project as not requiring authorisation. The competent approval authority (Federal Railway Authority, outstation Stuttgart/Karlsruhe, Section 2) has not been involved in this civil engineering project.

The task of supervising the work:

The specialist supervisor employed before the accident took the 'Exam for employment as a works supervisor with operational duties and as a safety supervisor (authorised technical officer), requirements in accordance with the Railway Construction and Operating Notice (EBO) Articles 47, 48 and 54 focusing on running lines' on 2 July 2002 (163 hour course).

In accordance with his certification, the specialist supervisor was also entitled:

- to prepare and submit works planning applications and Advice of work in progress applications;
- to carry out the duties of the authorised technical officer in accordance with point 4.2 of Advice of work in progress for running lines and civil engineering;
- to carry out safety supervision duties and to protect himself;
- to carry out the duties of the person responsible for precautions against electrocution on electrically-operated sections of lines in accordance with Advice of work in progress point 6.

The specialist supervisor employed qualified as a 'State Certified Technician (specialising in engineering and construction)' at the State School for Technicians in Berlin in 1976. Since 2002, he has undertaken supervisory activities for DB Netz AG in addition to construction and works management activities in various rail-related private companies.

The certificate of competence required by Guideline 809 with appropriate current entries, inter alia in respect of additional training, specific training and

regular continuing training, is available. His certificate of competence was issued for ‘permanent way and civil engineering’.

Authorisations under Article 6(1) of the VV BAU in respect of activities as a rail works supervisor for the ‘running line’ activity are available in part. (After completion of each project, the original of the authorisations has to be sent back to the issuing office). These authorisations from DB Netz AG, South West Area [RB Südwest], however all show the issuing date of 24 August 2006.

The following specific evidence of activities undertaken was available as an appendix to the specialist supervisor’s certificate of competence (supplied by his employer):

| Tätigkeitszeitraum | Tätigkeit, Beschreibung des Bauvorhabens | Einsatzbereich nach örtlicher Einweisung | örtliche Einweisung durchgeführt am | Einweisung durch Mitarbeiter (DB AG) | genehmigt druch (Stelle der DB AG / Unterschrift) | Ing.-Vertrags-Nr. Bestellschein-Nr. |
|---|---|---|---|---|---|---|
| 06.10.07.02 | Bauüberwacher mit betrieblichen Auf- | Strecke Nr. | | | | |
| | Gaben nach 4.2 für Bau | 1720 | 16.07.2002 | | | |
| | GSM-A Infrastrukturmaßnahmen | | | (Hohensee) | | |
| 12.01.03 – | BAUÜBERWACHER NACH 4.2 MIT | GÖTTINGEN | | | | |
| 03.02.03 | BETRIEBLICHEN AUFGABEN | STRECKE 3600 | | | N-N-8831 BJG | |
| | GLEISERNEUERUNG BEBENAUSN- | VON KM 219 | | | | |
| | TUNNEL + WERRABRÜCKE | BIS KM 227 | | | | |
| 27.01.03 – | BAUÜBERWACHER NACH 4.2 MIT | STRECKE 3600 | 1732 | | | |
| 31.01.03 | BETRIEBLICHEN AUFGABEN | BHF EINBECK- | | | N-N-8831 BJG | |
| | LÜCKENSCHLUSS W 40 + 41 | SALZDERHELDEN | | | | |
| 31.02.03 – | BAUÜBERWACHER NACH 4.2 MIT | STRECKE 3600 | 1732 | | | |
| 11.03.03 | BETRIEBLICHEN AUFGABEN | BHF. EINBECK- | | | N-N-8831 BJG | |
| | GLEISERNEUERUNG GL. 3 + 4 | SALZDERHELDEN | | | | |
| 24.03.03 – | BAUÜBERWACHER NACH 4.2 MIT | STRECKE 3600 | | | | |
| 06.04.03 | BETRIEBLICHEN AUFGABEN | BHF. OBERN- | | | N-N-8831 BJG | |
| | GLEISERNEUERUNG BHF. OBERN- | JESA | | | | |
| | JESA GLEIS 2 | | | | | |
| 19.05.03 – | BAUÜBERWACHER NACH 4.2 MIT | STRECKE 3600 | | | | |
| 27.05.03 | BETRIEBLICHEN AUFGABEN | km 243,4 | | | N-N-8831 BJG | |
| | GLEISUMBAU GRONE-ROßDORF | bis 244,9 | | | | |
| 28.05.03 – | BAUÜBERWACHER NACH 4.2 MIT | STRECKE 3600 | | | | |
| 22.06.03 | BETRIEBLICHEN AUFGABEN | km 233,3 | | | N-N-8831 BJG | |
| | GLEISUMBAU OBERNJESA GL. 1, | bis 238,2 | | | | |
| | OBERNJESA-FRIEDLAND, FF GL. 1 | | | | | |
| 22.06.03 – | BAUÜBERWACHER NACH 4.2 MIT | STRECKE 3600 | | | | |
| 6.07.03 | BETRIEBLICHEN AUFGABEN | km 226,5 | | | N-N-8831 BJG | |
| | GLEISUMBAU BHF EICHEN- | bis 228,2 | | | | |
| | BERG GLEIS 3 | | | | | |
| 12.09.05-28.10.05 | BÜ Fb für WE Bf Waldhof W86,67,68 | Bf RMW km 10,8-12,5 | 22.08.05 | Enders Paul I.NBI-SW L31 | | |
| 04.10.-16.12.05 | BÜ Fb für WE W392, 395 und Gleisemeuerung Gleis8 | Bf Ludwigshafen Hbf | 22.05.07 | Enders Paul I.NBI-SW L31 | | |
| 10.10.05-28.10.05 | Bauüberwacher, Technisch Berechtigter nach 4.2, Sicherungsüberwachung GE Wilferdingen-Grötzingen Strecke 4200 km 9,9 bis 7,0 | 4200 9,9 - 7,0 | 10.10.05 | KIENAST | I.NBI-SW-L31 UHR IH | |
| 16.03.-31.05.06 | GE Bf Schwetzingen Gleis 005/055/105 Technisch Berechtigter nach 4.2 Sicherungsüberwachung Bauüberwachung | | 16.03.06 | Heidenreich I.NIA-SW 13 | | |

***Evidence of activities undertaken taken from the certificate of competence***

Evidence of activities undertaken after 31 May 2006 was not available in the certificate of competence.

| | | |
|---|---|---|
| 2002 – 30.11.2007 | [redacted]<br>Bauüberwacher Betrieb/ Fahrbahn<br>- Infrastruktur GSM-R im Auftrag DB Telematik GmbH<br>- Weichenerneuerung W 52, 53, 54 Abzw. Wustermark - Falkenhagen DB Netz NL Ost<br>- Weichenerneuerung W 525, W 535 u. Kr. , W 537 Rbf. Osnabrück/ Anlaufberg (Förderanl.) DB Netz NL Nord<br>- Oberbauarbeiten Bebenrothtunnel – Werrabrücke DB Netz NL Nord<br>- S-Bahn RheinNeckar 4-gleisiger Ausbau Ludwigshafen-Mitte und Umbau Mannheim Hbf - Westkopf, DB ProjektBau GmbH NL Südwest; ARGE INGE<br>- DB Netz AG NL Südwest – Durchführung von Instandhaltungsarbeiten in Gleisen und Weichen<br>- DB Netz Karlsruhe – Erneuerung von Gleisen und Weichen im Netzbezirk Ludwigshafen, Mannheim und Karlsruhe; u. a. Umbau von Förderanlagen Rbf Mannheim<br>- DB Netz AG NL SW - GE Gl. Heitersheim – Bad Krozingen<br>- GE Meckesheim-Hoffenheim und Ma. Rbf – Abzw. Ziehbrunnen | |
| 01.12.2007 - | [redacted]<br>Bauüberwacher<br>- DB Netz AG NL Südwest – Durchführung von Instandhaltungsarbeiten in Gleisen und Weichen | |
| 2008 | DB Netz AG NL Südwest:<br><br><br>DB Netz NL Nordwest | - Bf Ulm; Weichenerneuerung<br>- GE Bf Aulendorf<br>- GE Bf Plochingen<br>- GA Schladen – Wolfenbüttel<br>- GA Othfresen – Salzgitter Ringelheim |
| 2009 | DB Netz AG RB Südwest: | - GE Orschweier – Herbolzheim<br>- WE / GE Bf Kehl u. Bf Riegel |

***Further areas of activity undertaken shown on the CV***

There are authorisations under Article 6(1) of the VV BAU from DB Netz AG, South West Area, all showing the issuing date of **24 August 2006** for the following 'running line' work:

- renewal of No 1, 2, 40 and 114 switches at Worms;
- Wilferdingen – Grötzingen project
  - ➔ (discrepancy: time of activity 10-28 October 2005 according to the evidence of activities undertaken);
- track renewal Karlsruhe – Knielingen track 52;
- track renewal Weidental track 132;
- track renewal Freudenstadt – Alpirsbach;
- track renewal Heitersheim – Bad Krotzingen;
- track renewal Horb track 5;

- renewal of No 1, 2, 3, 4 and 5 switches Horb;
- track renewal Gottenheim – Breisach.

There was no such official authorisation under Article 6(1) of the VV BAU for the civil engineering work in Stuttgart-Untertürkheim. The employer did not have evidence of activity after May 2006.
In the letter dated 27 September 2006 introducing Guideline 809 there was a reference to the agreement with the Federal Railway Authority providing that in the case of 'simple civil engineering work which does not require a submission or advance notice', rail works supervisors with master [craftsman] or technician qualifications may be employed to allow significant savings to be made compared with the employment of a professionally qualified rail works supervisor [with an engineering qualification]. In accordance with Guideline 809.0301 Section 1(4), work which under VV BAU is regarded as simple technical or operational civil engineering work in the overhead electrification and level crossing areas not requiring notice may be supervised by specialist supervisors (FBÜ) with the appropriate speciality.

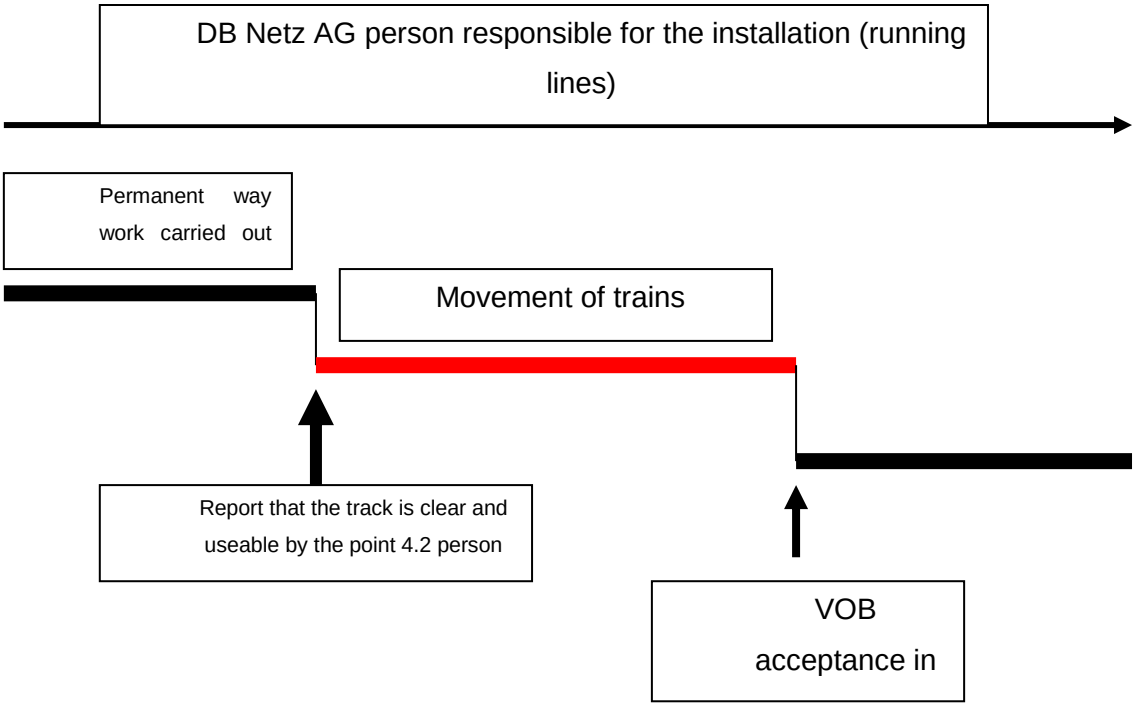
Acceptance of permanent way work:

In the course of the investigation of the accident, the following issues relating to the acceptance of permanent way work were raised:

1. Does the person responsible for the installation remain fully responsible for the track work throughout the three phases (execution of the work, train movement before VOB acceptance, train movement after VOB acceptance)?
2. Where does the division of responsibility arise from (responsibility for the installation) after the person designated under point 4.2 reports that the track is clear and useable for operations (signaller)?

3. After release to traffic, does the point 4.2 person only take on the responsibility for the installations affected by the works or for the totality of the infrastructure necessary for operations?
4. From the time that the point 4.2 person reports that the track is useable, does the person responsible for the installation [Anlagenverantwortliche (Alv)] automatically have responsibility for the complete installation (including for the newly created or reinstated parts of the installation, although the person responsible for the installation is not present as a rule)?
5. If question 4 can be answered with 'yes', how is it ensured that the person responsible for the installation is informed that his installation is compliant and that he can thus fulfil his responsibilities?

6. The completion of the permanent way work is only formalised by the VOB acceptance – therefore for example after 1.5 million gross tonnes or after eight weeks (Guideline 824.8110). That means that only at that point in time will DB Netz AG receive all the safety-relevant papers from the contractor. How is the safety of the infrastructure up to VOB acceptance ensured? Is it just left to the rail works supervisor and specialist supervisor?




DB Netz AG made the following comments on these questions:

Re. 1. Responsibility for the installation cannot be delegated and invariably remains with the person responsible for the installation. What can be delegated, however, are the tasks resulting from the responsibility for the installation. The contractor to whom the work is entrusted does this by commissioning and employing rail works supervisors (BÜB). This approach is not only found in DB Netz AG's internal regulations (Guideline 809.0301), but also in the Federal Railway Authority (EBA) administrative instructions that are relevant, for example the VV BAU.

The more important points of substance in these administrative instructions are mirrored in DB Netz AG Guidelines (Guideline 809). According to Guideline 809.0301 Article 1(9), the following duties and responsibilities are listed as being amongst the tasks of works supervision:

Works supervision must ensure in particular that:

- the safety of railway operations is not compromised by the civil engineering work;
- auditable reports that the track is useable are to be provided (authorised technical officer in the context of the Advice of work in progress) if the civil engineering work is carried out in stages;
- changes to the sequence of construction which lead to changes in operational regulations must be notified immediately to works planning and works coordination.

The technical competence of the rail works supervisor is to be confirmed each time by checking his certification and prequalification and verifying it in accordance with Guideline 809.0301 Article 1 (6) 'check on activities carried out'.

Re. 2+4. The so-called 'point 4.2 person' is named after the chapter heading in the Advice of work in progress. This is the authorised technical officer. Within the meaning of Guideline 406.1201 Section 4(11), authorised technical officers are 'authorised officers to whom the works supervision or the responsibility for carrying out civil engineering work is entrusted in accordance with a Advice of work in progress and who report as such to the signaller'. Appendix 02, the 'Advice of work in progress checklist' from the same module of the Guideline accordingly defines the authorised technical officer as 'the person who has sole responsibility for operational agreements and reports (for example, for removing all grounds for closing a line, for reporting that the track is clear and useable) to the signaller'. The operating communication between the work site and signaller via the authorised technical officer is therefore carried on independently of the tasks and responsibilities

for the civil engineering works and the declaration of usability for rail operations after the work is complete. This declaration is made by the rail works supervisor who has already been mentioned. He ensures that the infrastructure installations comply with the technical and operational specifications after they are put into service and may be used without restrictions so that they can subsequently be handed over without any restriction/qualification to the inventory of the person responsible for the installation. In practice, the two functions (authorised technical officer and rail works supervisor) are normally and legitimately combined in one person. At no point does the authorised technical officer alone carry responsibility for the installation.

As described under point 1, responsibility for the installation always remains with the person responsible for the installation. This person has handed over the task of ensuring that the conditions in which the civil engineering work is being done and that the results of the work are operationally safe to the rail works supervisor.

Re. 3. The rail works supervisor (here being also the authorised technical officer) takes over the responsibility for the tracks and installations directly affected by the civil engineering work. Insofar as additional activities affecting existing installations are necessary for the civil engineering work to be done (such as, for example, adjustments to adjoining areas in the form of cant run-off), he is responsible for supervising that this work is done properly. The supervisory responsibilities of the rail works supervisor thus extend to infrastructure installations which could be affected directly or indirectly by the civil engineering work.

Re. 5. Assignment of the task of supervising the work presupposes that the company to undertake the work and its staff are chosen properly. In making a choice between companies, their suitability, capacity, technical knowledge and the quality of their performance is evaluated and guaranteed by means of the prequalification procedure which has

already been mentioned. In the on-site briefing of the rail works supervisor (see Guideline 809.0301 Section 1(8)), which is given by the person responsible for the installation, the rail works supervisor is informed about the location and, if appropriate, of any local features there may be, so as to ensure he can complete his tasks. Ensuring that the civil engineering work is done in accordance with the regulations so that the end-product can be used for operations is the task of the rail works supervisor. Relevant points of non-compliance which restrict or exclude a use are to be notified to the person responsible for the installation by the rail works supervisor as part of his supervisory activity.

Re. 6. In civil law as between the client and contractor, VOB acceptance establishes whether the contractor has properly carried out the work with which he was entrusted. For approval of an installation for example, multi-channel plotter records, the results of the IT assisted switch inspection, records of adjustment of the tension [in the rails], comparisons of the values of design and actual measurements must be provided. Approval is only given if the results of the readings ensure that operations can take place in safety. In the course of their training, rail works supervisors qualified for the permanent way have to pass, amongst others, course 046.2552 on ‘evaluating plotter records’ and 046.2553 ‘IT assisted inspection or approval after maintenance’ in accordance with Guideline 821.2005 (switches and crossings). In this way, rail works supervisors are in a position to recognise any dangers noted during measurement runs taken before approval, and to take counter measures or refuse to report that the track is useable. Therefore safe operations can be ensured before the VOB acceptance. All further documents (for example, thickness of the sub-layer, thickness and profile of the ballast, approvals for the material) are not safety-relevant before the time of acceptance and are only supplied by the contractor on VOB acceptance.

Findings:

Essentially, responsibility for the installation cannot be delegated and remains with the person responsible for the installation. Until complete handover, all papers are successively devolved to the person responsible for the installation. Not all these papers are available to this person at the time the installation is approved, thus evaluation of approval and the decision to approve must be taken by the rail works supervisor.

## 4.3. Investigation of the infrastructure and signalling systems

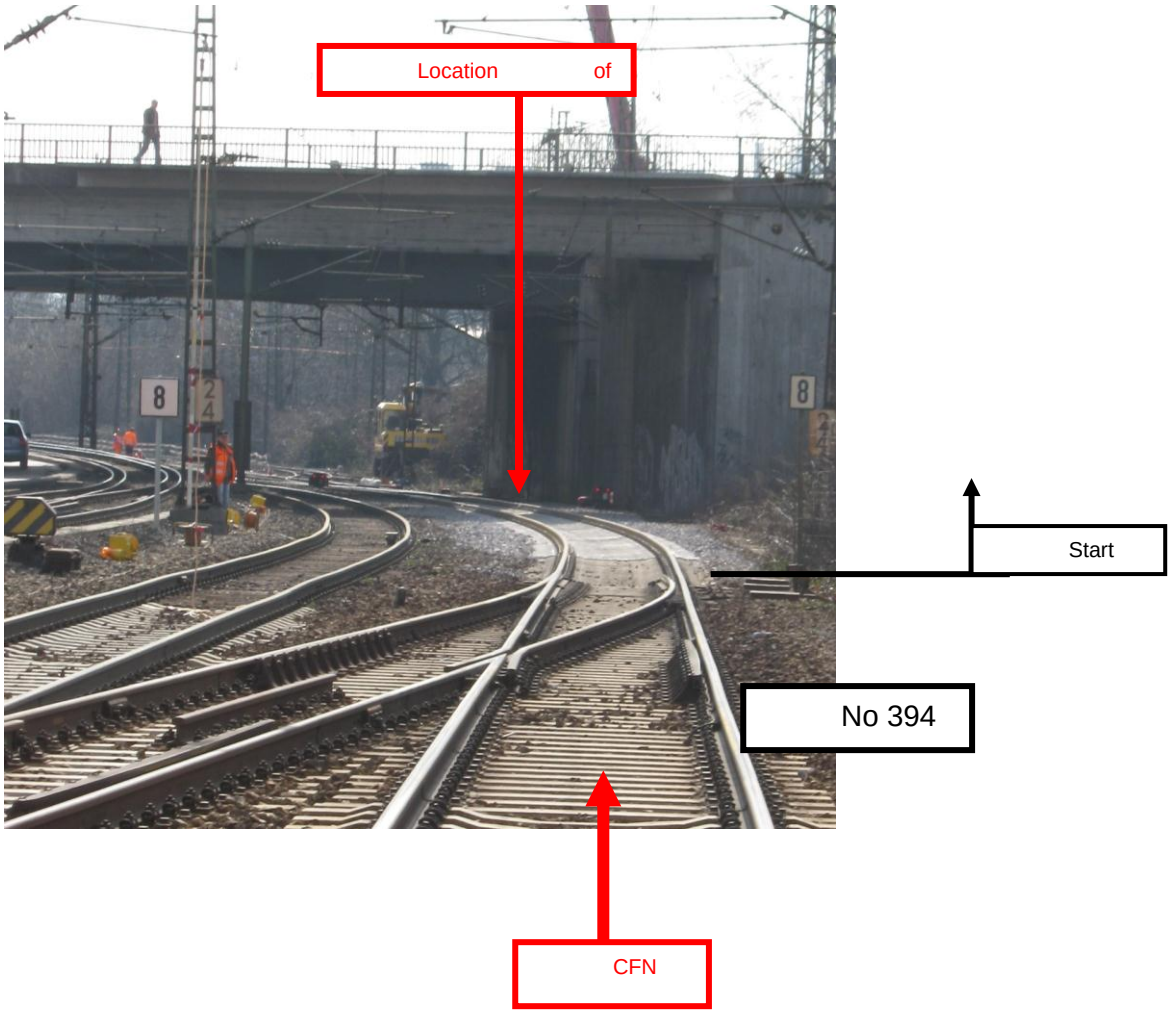
### 4.3.1. General

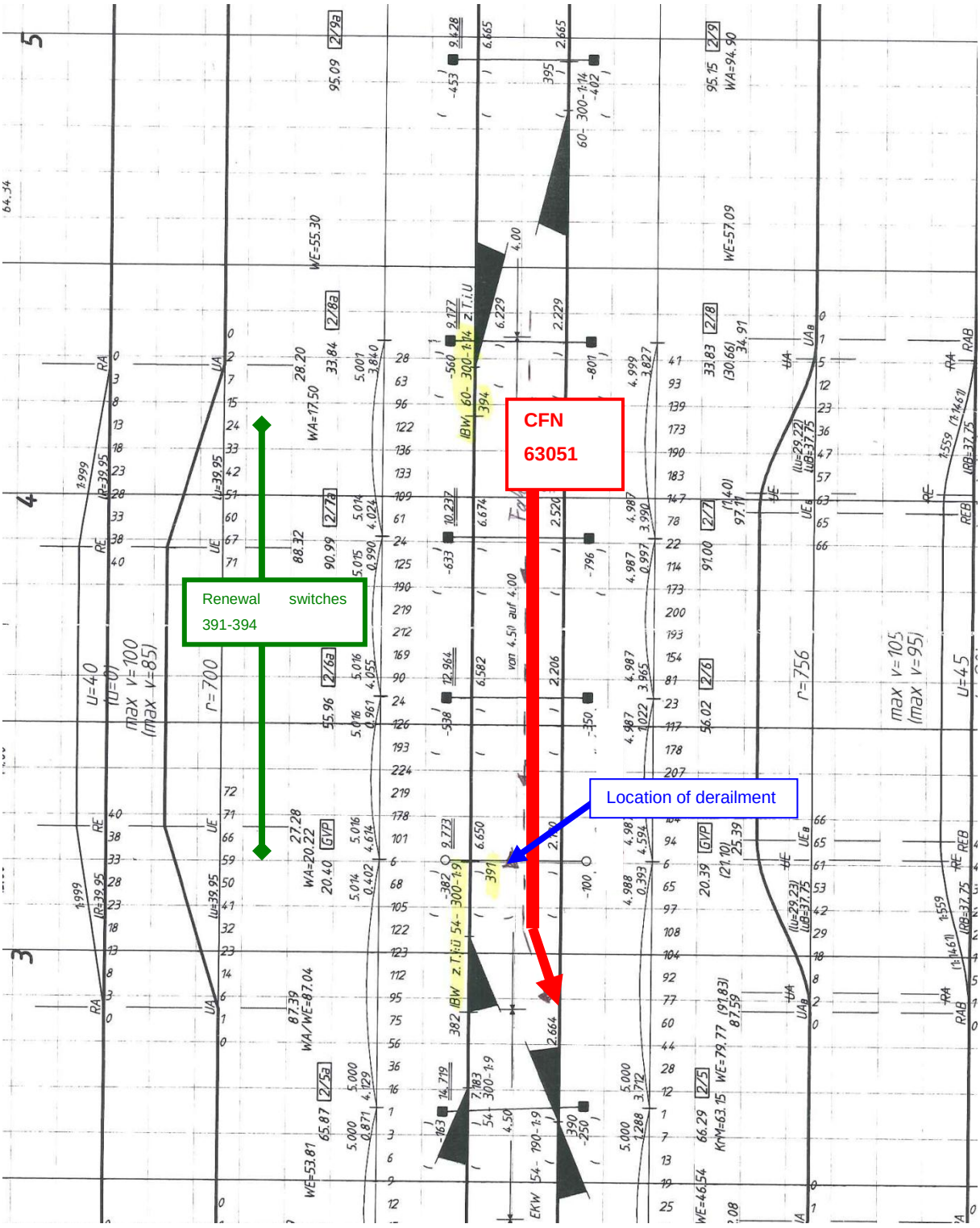
The section of line 4720 from Stuttgart-Untertürkheim (No 041 switch) to Kornwestheim passenger station (No 453 switch) concerned is a double track electrified main line. According to the list of locally permitted speeds, the maximum speed is 90 km/h. According to information from the infrastructure register, the line loading limit is D4 with the maximum axle load 22.5 tonnes and the maximum longitudinal load 8 tonnes per linear metre. The infrastructure register also records that the section of line in question is part of the 'conventional TEN-Network'.

Line 4720 comes from the Kornwestheim direction to arrive in the reception section of Stuttgart-Untertürkheim station in a straight line. At about km 2.428 (start of transition) this leads into a transition curve with a following circular curve (right-hand curve from km 2.388 with radius r = 700 m) and another transition curve from km 2.327 (end of transition) to km 2.287 (start of transition). According to the track layout plan, the transition curves coincide with the cant gradients in which the cant increases in a linear fashion up to the maximum target value of cant = 40 mm in the circular curve (uniform cant gradient). Switch No 394 (switch type IBW 60-300-1:14) lies partially in the first transition curve with the toe of the switch at km 2.4175. Switch No 391 is situated in the area of the second transition curve (toe of the switch at km 2.3202). This switch is an internal curve switch [IBW] IBW 54-300-1:9-li. Approaching from the Kornwestheim direction, the switch is passed over in the facing direction.

The radius of the diverging line rz is 287 m, that of the principal line rs 6786 m. The components of the switch are screwed to hardwood sleepers by type 'K' rail fastenings. Between the toes of switches No 391 and No 394 the permanent way is supported by conventional sleepers with 54E4 rail (formerly S54) including transition rails from 54E4 to 60E2 rails (formerly UIC60) and concrete B70 and B90 sleepers in stone ballast.

Speeds on the section of track under review are kept to a maximum of 80 km/h by means a permanent fixed indicator of type Lf 7 (indicating 8) situated at km 2.400. Movements to the diverging route are permitted operationally by signal type Hp2 [stop signal showing proceed at caution] (without an additional indicator) at a maximum speed of 40 km/h. For reasons of driving dynamics, running over No 391 switch in the diverging direction (left-hand) with radius r = 300 m is limited to 50 km/h.






***Track layout plan – renewed track section***

### 4.3.2. Technical condition of the permanent way

No 391 switch was last subject to a regular inspection in accordance with Guideline 821.2005 'Inspection of Switches, Crossings, Joints and Derailing Devices' by means of the 'MessReg' system on schedule on 3 February 2010. There was no evidence at all that the evaluation yardstick SR (stimulus/reaction ratio) had been exceeded. In particular the blade test with the No 1 gauge gave the result 'good'. There were no cracks worth mentioning on the blades, frog or other running rails or other safety relevant defect on the components. There were likewise no comments on the support for the switch, comprising timber sleepers. The frictional tensioning of the rails and the rail fastenings in the plain line and switch areas and the consequential ability to keep to gauge were fully compliant. All the sleeper cribs in the plain line and switch areas were fully filled. The section across the track bed was correct with at least 40 cm of ballast outside the sleeper ends. Wear (for example, on the railhead) can be disregarded when considering the risk of derailment.

The last check on the track geometry took place on 23 November 2009 with the track measurement unit in accordance with Guideline 821.2001 'Checking of track geometry by means of track measurement vehicles'. Under Table 1 of this guideline, lines with a speed limit of between 80 km/h and 120 km/h (as shown in the list of locally permitted speeds) are to be inspected every twelve months (in exceptional cases, every sixteen months). This inspection rhythm was respected.

In the last two passes of the track measurement vehicles, no safety-relevant cases of exceeding the evaluation yardstick SR (stimulus/reaction ratio) which would had the consequence of limiting the safety of traffic were noted. Only a slight SR-100 excess of some 11 mm which had no safety relevance was noted at km 2.355. In any event, because of the ongoing renewal work, that record and value for the area immediately before the toe of No 391 switch is no longer relevant.

After the derailment, the geometric layout of the switch and the condition of the switch blades (gauge 1) was checked. No faults were found. The exact track geometry between the frog end of No 394 switch and the frog end of No 390 EKW [simple crossing switch] was measured by using the 'Krabbe' measuring system. A depression in the outside rail of the curve before No 391 switch is apparent here (see the illustration below). This measurement reveals that there is a twist of some 8.2 ‰ in the area of the toe of No 391 switch. This constitutes a percentage factor of 153 % compared with the standard limit value of 130 % or the SR-100 value of 100 %: the measurements of 3.0 m or 3.5 m from the 'Krabbe' system are the criteria for this process. The slightly different twist fault of 8.41 ‰, given in the DB-Systemtechnik report and derived by spline interpolation, relates to a wheel base of 3.40 m. This wheel base is the same as that of the bogie of class 140 locomotives.

Findings:
In accordance with Guideline 821.2001, a twist of greater than 130 % or 7 ‰ exceeds the limiting value. The limiting value is the value which requires the line to be closed in accordance with Guideline 821.1000.

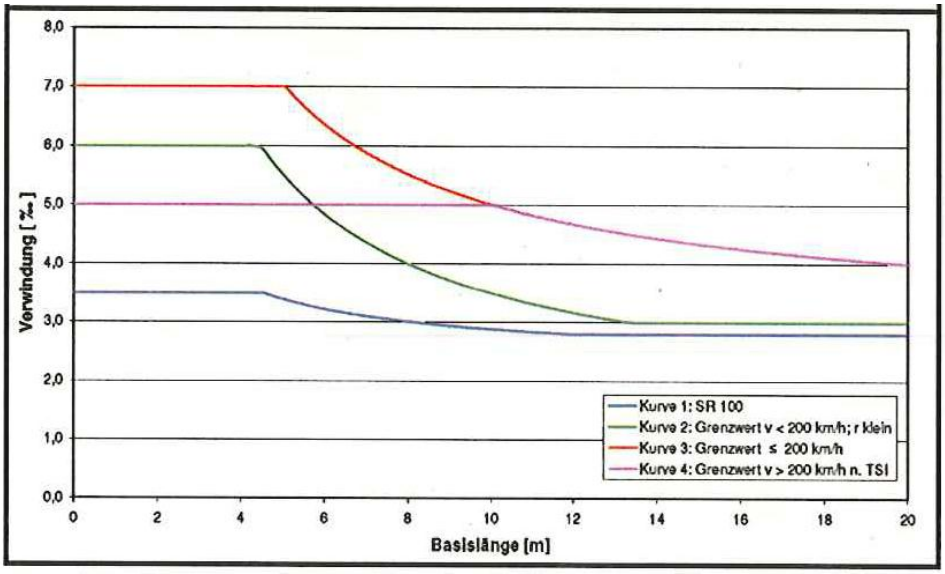

***Depression in the outer rail of the curve by the toe of No 391 switch (end of the tamping work)***

In principle, track twist arises from differing heights for the outside and inside rails of a curve. In transitional curves, the outside rail continuously rises to reach the cant planned in the circular curve. A twist in the track is artificially introduced by the cant gradient. This necessarily leads to a twist in the vehicle. Technical theory indicates that there is an enhanced risk that the outer wheel on a curve climbs the rail when coming out of a circular curve. In circular curves, the outer wheel is more heavily loaded if the lateral acceleration is not balanced. At the same time, a higher guiding force (Y) operates on the outer wheel. The depression of the outer rail of the curve relieves the force on the wheel, whilst the guiding force is about equal. Hence the quotient Y/Q increases. As the model is conceived, the wheel cannot climb, as long as:

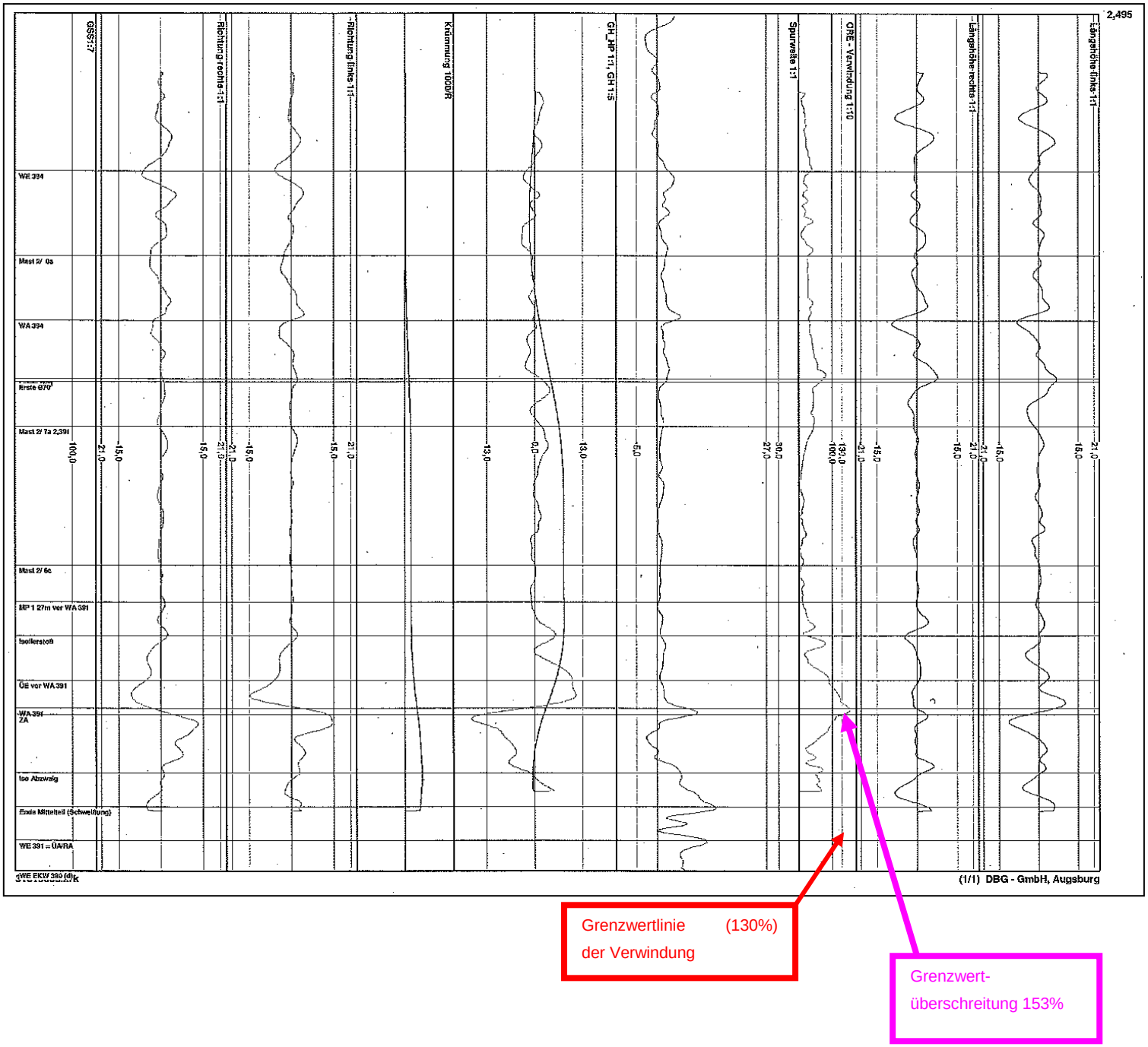
$$Y/Q \leq (\tan \varphi - \mu) / (1+ \mu * \tan \varphi)$$

Y = lateral guiding force
Q = wheel load
φ = flange angle (70° in this case)
μ = coefficient of friction between rail and wheel (0.36 in this case)

For the case in question, the limiting value for Y/Q = 1.2.




***Assessment criteria for twist taken from Guideline 821.2001***




Grenzwertlinie (130%) der Verwindung

Grenzwert-überschreitung 153%

***'Krabbe' record after derailment***

### 4.3.3. Consideration of how the works were done and the circumstances that resulted

From the remark on the track layout plan from 2005, it is apparent that the design track geometry is shown (here with cant = 40 mm). Furthermore it is noted on the plan that 'Current measurements are given in brackets (here with cant = 0 mm) for the event that design values or actual values following renewal are missing'. According to the track layout plan, the cant of 40 mm shown permits a maximum speed of 100 km/h through the curves. Without the cant, a maximum permitted speed of only 85 km/h is indicated.

The cant was increased from 0 mm to 40 mm in the circular curve between switch No 391 and switch No 394 by the tamping and aligning work undertaken at the time as part of the renewal work in Stuttgart-Untertürkheim station. This work was carried out by means of a plain line tamping machine of type GSM 09-32 during the night possession from 14/15 March 2010. The following basic steps in the work should be distinguished:

a) Compaction pass: the track is aligned crudely in direction and height. In this process, the lift should be about 30 mm-40 mm and must not exceed 60 mm per pass. The lateral realignment per compaction pass should not be greater than 30 mm. After the compaction pass, the design track geometry should be laterally within a maximum of +/- 20 mm and vertically 40 mm (tolerance: +/- 10 mm) below the final position. The ballast loosely distributed under each sleeper is compacted by pushing the tamping tine to its lowest setting at least twice so that a firm support is created under the sleepers.

b) First stabilisation: before the first stabilisation the sleeper cribs are to be adequately refilled with ballast. In the stabilisation pass the tines are only buried so that the distance between the top surface of the tine plate and the bottom of the sleeper is 20 mm. The maximum lift should not exceed 30 mm. After the first stabilisation, the design track geometry should be

laterally within a maximum of +/- 10 mm and vertically 15 mm (tolerance: +/- 10 mm) below the final position.

c) Second stabilisation: before the second stabilisation the sleeper cribs are to be adequately refilled with ballast. The design track geometry should be achieved as far as possible in the second stabilisation. The normal section across the track bed is also to be created.

In the case in question, a compaction pass, the first stabilisation and the second stabilisation were carried out. If a line is to be brought into use temporarily, i.e. at a defined stage of the work on the permanent way but before its completion (for example, after the first stabilisation), then in accordance with Guideline 824.2310, Section 4(36), the following acceptance values in the multi-channel plotter record for the permanent way may not be exceeded:

| | |
|---|---|
| 'Direction' assessment parameter | 20 mm |
| 'Twist' assessment parameter | 9 mm or 3 ‰ |

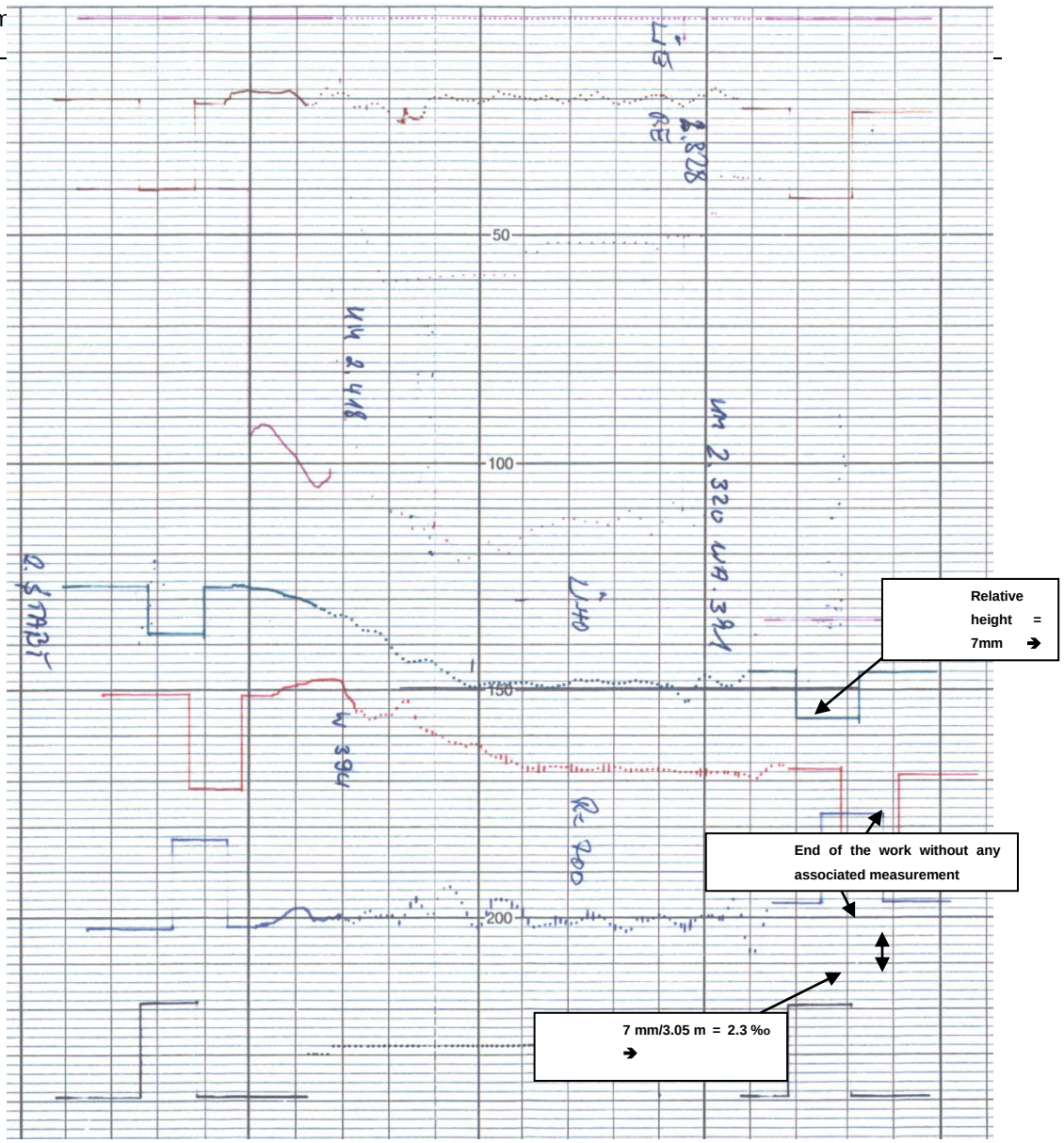
To put a line into service (here putting the line into service after completion of all permanent way work is meant, for example after the second stabilisation) then, in accordance with Guideline 824.2310, Section 4 (37), the following acceptance values in the multi-channel plotter record for the permanent way may not be exceeded:

| | |
|---|---|
| 'Longitudinal profile' assessment parameter | 20 mm |
| 'Direction' assessment parameter | 20 mm |
| 'Relative heights' assessment parameter as the difference between elevations (only for MKS-8) [MKS – multi-channel plotter] | 7 mm |
| 'Relative heights' assessment parameter as the cant (for MKS-6) in scale 1:2 | 7 mm |

Evaluation of the multi-channel plotter records showed that **no values exceeded the limits** shown in Guideline 824.2310 Section 4. These results were also confirmed on the multi-channel plotter record by signatures on 14 March 2010 of both the supervisor of the work/operator of the plain line tamping machine and the person named as specialist supervisor/authorised technical officer in accordance with Advice of work in progress point 4.2.

In accordance with Guideline 824.2310 Section 3(8), the contractor must ensure, inter alia, that plotter records for the section of line being worked on begin 20 m before the start of the work (including the cant gradient) and extend to 20 m after the end of the work in every case. In that way it can be verified that the transition from the old infrastructure to the renewed section of line conforms to the regulations.

Finding:
This extension, going 20 m beyond the end of the work, is not shown in the multi-channel plotter record to hand. In consequence, it was not possible for this multi-channel plotter record to provide a properly measured check of the transition section. There may then be values, for example for twist, that exceed the limits and that potentially go undetected.




***Multi-channel plotter record plain line tamping machine, second stabilisation pass, all assessment parameters respected***

### 4.3.4. Condition of the components to operate and secure No 391 switch

In accordance with Guideline 892, (Installing and maintaining switch operating and securing components) the following values were obtained from tests on No 391 switch:

Travel of the blades: 153 mm (left) and 155 mm (right). Design value: 160 mm +/-10mm;

Flangeway gap: > 58 mm (left and right): compliant;

4/5 mm test: compliant;

Cover over the locking mechanism: fully compliant;

Resistance against movement of the switch for traffic to the left: 2200 N;

Resistance against movement of the switch for traffic to the right: 2700 N;

Actuating force available to throw the switch for traffic to the left: 5300 N;

Actuating force available to throw the switch for traffic to the right: 5900 N;

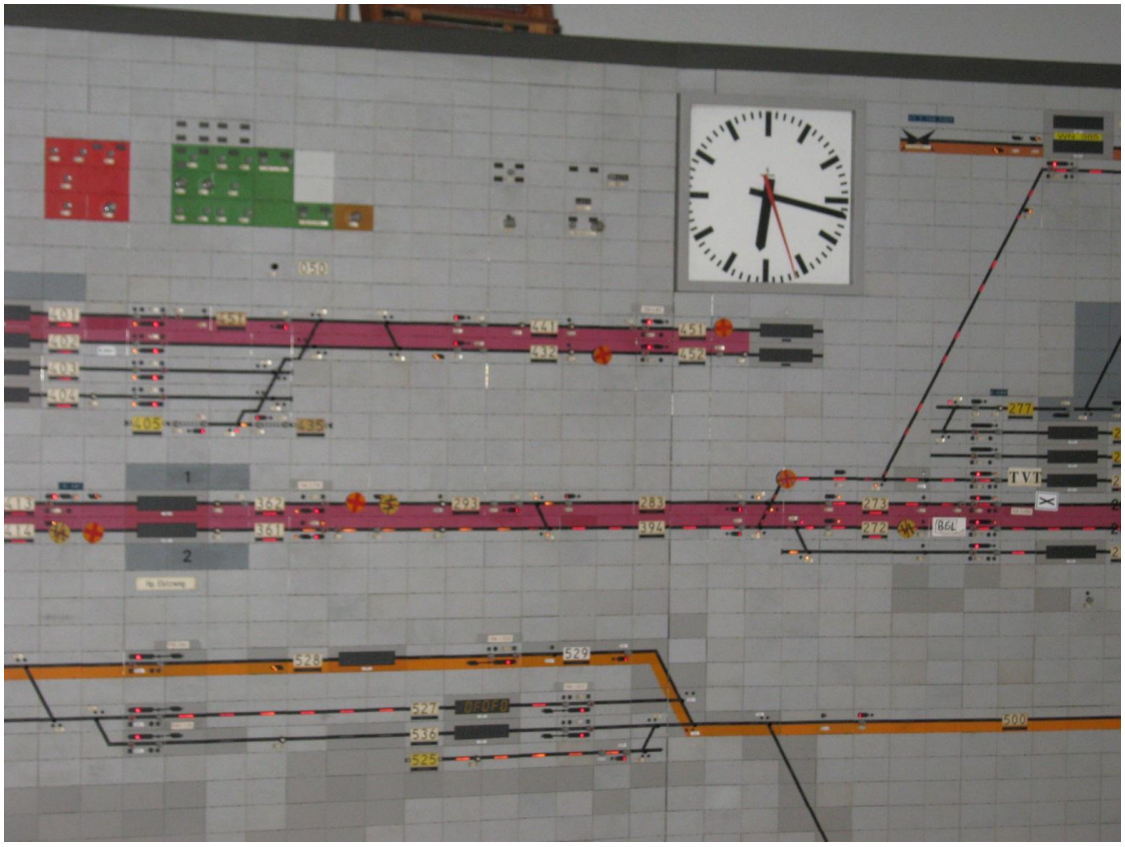
The measurable actuating force if the motor is locked does not therefore reach the standard sliding force setting of 5.5 +/- 0.5 N for the clutch and therefore lies within the tolerance laid down in Guideline 892.

When making the periodic inspection on 3 December 2008 which resulted in the test values above, no values in excess of the limits laid down in Guidelines 892.9302 and 892.9303 of any type were noted. The inspection periodicity of 24 months in accordance with Guideline 892.03 was respected. The testing and maintenance team undertook the last operation and securing inspection, maintenance and operation test on 2 March 2010. There were likewise no faults found.

### 4.3.5. Signal system:

The approach to Stuttgart-Untertürkheim station from the Stuttgart-Kornwestheim direction is via the route set up from track 361 to track 278 using right line working. The signaller in Stuttgart-Untertürkheim signal box controls train operations. The signal box is of type Spurplan DrS60. The signal box equipment may be excluded as a cause of the event.

Furthermore, the head of control and signalling technology confirms that the track magnets at signals Vf361, F361 V278 and S278 were operating correctly.



***Signaller's panel at Stuttgart-Untertürkheim***

### 4.4. Investigation of rolling stock and technical installations

Investigation of the tamping machine:

The then current periodic test of two-sleeper tamping machine 09-32 CSM (built in 1996) in accordance with Guideline 931 (ancillary and special rolling stock) was in July 2009. As a result of that examination by the DB Netz AG testing engineer, the vehicle was approved for operation until 23 July 2010. The testing engineer examined the record of test tamping. No faults were found. Appropriate documentation is to hand.

The customer service department of the manufacturer, Deutsche Plasser, undertook a BR 1 overhaul and an overhaul of the 'Servogor' [trade name] plotter in June 2009. Documentation is to hand.
The tamping mechanism was put into service by the customer service department of the manufacturer in January 2010, the pendulum and levelling unit adjusted, the tamping depth of the tines set. A short test-tamp was carried out. Documentation is to hand.
Monthly checklists internal to the [contracting] firm 'Commissioning, decommissioning and checking tamping machines by the master mechanic before and after work' are to hand for January and February 2010.

Investigation of the locomotives which derailed:
DB Systemtechnik experts from Minden were commissioned by the Federal Railway Accident Investigation Office to undertake the expert investigation of the locomotives that had derailed. Investigation of the locomotives took place in Kornwestheim in the presence of and under terms of reference set by an EUB Federal accident investigator. In the process, the following aspects in particular were inspected and checked:

- Wheelsets and wheelset measurements;
- Primary springs, axlebox guides, wheel travel limitation;
- Secondary springs and damping;
- Bogie pivot bearings;
- Traction motor suspension;
- Bogies and locomotive body.

After inspection of the running gear components and measuring the flange depth (sh), flange width (sd), the active face of the flange (qR), tyre thickness (Rd) and the distance between the internal surfaces of the wheels ($A_R$), no defects which could have caused a derailment were noted. All the values were within operational limits. The last inspections of the two locomotives took place on 25 January 2010 (locomotive 140 788-1) and on 24 November 2009 (locomotive 140 816-0).

***Results from measuring the wheel profile – locomotive 140 788-1***

| Maß | | Radsatz 1 | | Radsatz 2 | | Radsatz 3 | | Radsatz 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | links | rechts | links | rechts | links | rechts | links | rechts |
| Sd | | 30,5 | 30,0 | 30,5 | 29,5 | 29,5 | 30,5 | 30,0 | 30,0 |
| Sh | | 30,0 | 30,0 | 30,0 | 30,0 | 29,5 | 29,5 | 30,0 | 30,0 |
| qR | | 10,0 | 9,5 | 9,5 | 8,5 | 8,5 | 10,0 | 9,0 | 9,0 |
| Rd | | 74,0 | 74,0 | 77,0 | 76,0 | 74,0 | 74,0 | 72,5 | 73,5 |
| $A_R$ | 1.Messung | 1360,6 | | 1359,7 | | 1359,8 | | 1361,5 | |
| | 2.Messung | 1360,4 | | 1360,3 | | 1360,0 | | 1361,4 | |
| | 3.Messung | 1360,0 | | 1360,5 | | 1360,7 | | 1361,4 | |

***Results from measuring the wheel profile – locomotive 140 816-0***

| Maß | | Radsatz 1 | | Radsatz 2 | | Radsatz 3 | | Radsatz 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | links | rechts | links | rechts | links | rechts | links | rechts |
| Sd | | 30,5 | 28,5 | 30,0 | 29,5 | 28,0 | 29,0 | 27,0 | 27,5 |
| Sh | | 30,5 | 31,5 | 30,5 | 30,5 | 31,0 | 31,0 | 31,5 | 30,0 |
| qR | | 10,0 | 8,5 | 8,0 | 8,0 | 8,0 | 8,0 | 8,0 | 8,5 |
| Rd | | 73,0 | 73,0 | 73,0 | 72,5 | 75,5 | 76,0 | 75,5 | 74,0 |
| $A_R$ | 1.Messung | 1359,8 | | 1360,0 | | 1360,8 | | 1360,3 | |
| | 2.Messung | 1359,6 | | 1360,3 | | 1361,0 | | 1360,4 | |
| | 3.Messung | 1360,6 | | 1361,5 | | 1360,3 | | 1360,2 | |

Investigation of the bogies of the derailed tank wagons:

The pattern of the damage clearly rules out the first three derailed tank wagons (type ‘P’ and numbered 3380 7848 552-5; 3381 7848 611-8; 3380 7848 831-3) as the cause of the event. The damage is simply consequential damage. No attempt was therefore made to undertake a thorough examination of the bogies and running gear. The pattern of the damage to the overturned tank wagon in particular, did not facilitate any further evaluation of these bogies. All the vehicles however were within their permitted maintenance intervals.

Examination of the leaking tanks:

The following trailing load forced the first overturned tank wagon (3380 7848 552-5) against electrification mast No 2/3 and against its concrete base, standing on an embankment. One corner of the buffer beam of the second tank wagon pierced the rear-facing tank wall of the overturned wagon. Hence a 4 cm hole was made in the tank wall. A further leak occurred on the opposite side, close to the forward right-hand fillet between the tank and its

cradle. Most of the diesel fuel which escaped did so through the damaged bottom valve, the outlet pipe and the filling valve. The tank was within its 'next maintenance' date. All the damage which had led to the leakage was due to the high forces (in part selective) imposed by the following trailing tank wagons.

***Leakage from the rear tank end – first tank wagon***

***Leakage from the tank cradle fillet front right***

***Damaged outlet pipe and filling valve***

Composition of the train:

Block train 63051 was composed of:

- Class 140 816-0 (leading locomotive) with 4 axles
- Class 140 788-1 (following locomotive) with 4 axles
- 20 bogie tank wagons with 80 axles in total
- Weight of locomotives: 168 t / 166 t
- Total train weight: 1 892 t / 1 90 t
- Locomotive brake weight: 122 t / 108 t
- Total train brake weight: 1 196 t / 1 182 t
- Least brake percentage: 63
- Available brake percentage: 63

The data for the trailing load was:

- Length of trailing load: 328 m
- Weight of the consignment: 1 250 t
- Weight of the trailing load: 1 724 t
- Trailing load brake weight: 1 074 t

Brake regime ‘G’ was selected on the locomotive. The first five tank wagons were in brake regime ‘G’, the remaining fifteen tank wagons were in brake regime ‘P’. This arrangement complies with Guideline 408.0721 ‘Running trains, brakes in trains, selecting the regime’ for freight trains with a trailing weight of over 1 200 t.

The ‘Report to the train driver on the preparation of the train’ for train 63051 on 15 March 2010 is to hand. Amongst other things it certifies that:

- the wagons were coupled up in accordance with the regulations;
- the wagons had undergone a technical examination;
- a brake test had been made;
- the tail lamp had been attached;
- securing devices had been removed and the hand/stop brakes released.

### 4.5. Evaluation of documentation from the scene of the accident and records from individual pieces of control equipment

Evaluation of the electronic journey recording equipment [Elektronischen Fahrten-Registrierung (EFR)] for the leading locomotive 140-816:

The locomotive was fitted with an inductive train safety system of the I60/ER 24 type. That system has the PZB 90 intermittent automatic train control [Punktförmige Zugbeeinflussung (PZB)] operating system installed. Brake type 8 and a brake percentage of 66 (rapid application) had been input to the system.

The leading locomotive passed entry signal F361 at km 2.776 (showing proceed at caution [Hp2] and radiating an electromagnetic field of 1 000 Hz) at 20:43:55 (data cassette time). The speed at this point was 44 km/h. An electromagnetic signal of 1 000 Hz and normal operation of the vigilance button was registered. As the journey continued, the speed increased slightly to 47 km/h. No 391 switch at km 2.320 was traversed by the leading locomotive diverging to the left (diverging route) at 45 km/h. At km 2.291, speed started to be reduced from

45 km/h. At 20:44:39, at 32 km/h and at km 2.231 a fall in the pressure of the main brake-pipe to below 2.2 bar was recorded. The cause of this could have been a rapid brake application by the driver or the consequence of a divided train as the result of the derailment.
The end of the EFR record at 20:44:59 was at about km 2.206. At the location with the first signs of derailment (the toe of No 391 switch) the EFR did not record anything exceptional that would have pointed to a derailment. It is possible that the distance indicator gave incorrect readings after km 2.246 because of the derailment.

Finding:
The speed signalled was exceeded by up to 7 km/h. However, since the dynamics in principle permit No 391 switch (radius of diverging line 300 m) to be traversed at 50 km/h, this excess speed does not constitute a cause of the derailment nor a circumstance contributing to it.

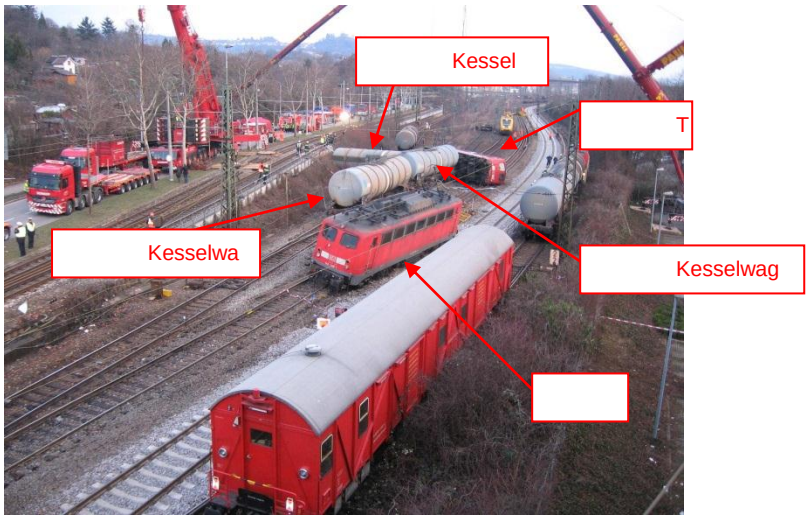
Evaluation of the electronic journey recording equipment (EFR) for the second locomotive 140-788:
The locomotive is fitted with an inductive train safety system of the I60/ER 24 type. That system has the PZB 90 intermittent automatic train control operating system installed. Brake type 8 and a brake percentage of 66 (rapid application) had been input to the system. Since that locomotive was not being used to drive the train, the electromagnetic signals from the lineside PZB equipment were not captured.
To allow the records from both locomotives to be compared, they were both aligned to the times and distances recorded for the leading locomotive 140-816.
At about km 2.296 speed started to be reduced from 45 km/h. At 20:44:40 and at about 33 km/h a fall in the pressure of the main brake-pipe to below 2.2 bar was recorded. The cause of this could have been a rapid brake application by the driver or the consequence of a divided train as the result of the derailment.
The end of the EFR record at 20:44:55 was at about km 2.216.

At the location with the first signs of derailment (distance blocks of No 391 switch) the EFR did not record anything exceptional that would have pointed to a derailment.
It is possible that the distance indicator gave incorrect readings after km 2.246 because of the derailment.

Evaluation of the fault log [in the signal box]:
The last record on the fault log was at 20:51. The routing assistance 'all' button [Fahrstraßenhilfstaste (FHT)] [to delete routes that have been set up] had been operated in switch area 50 (west side). The time recorded by the fault log is not actual time. Operation of the FHT was not connected with the route set up for train 63051.
Other operations recorded in the fault log were not undertaken by the signaller for this movement.

Evaluation of the train describer printout:
The arrival of train 63051 was properly recorded in the train describer. Arrival was shown as at 20:48 on tracks 414/278. The time recorded by the train describer is not actual time.

## 4.6. Interpretation of the evidence from the accident




***Overall view showing the damaged vehicles***

The evidence from the derailment and the position of the vehicles involved point to the sequence of events being as follows:

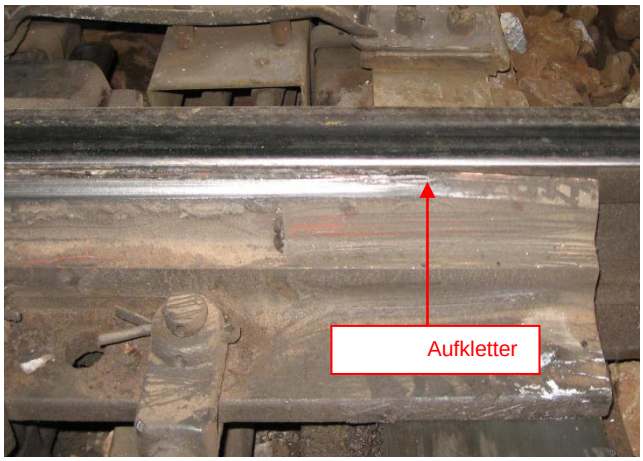
- First of all one wheel set on the leading bogie of locomotive No 2 derailed on No 391 switch towards the right in the direction of travel.
- As a consequence of the derailment, locomotive No 2 veered off to the right. Both couplings became undone in consequence. Locomotive No 1 became derailed together with tank wagons one to three. The main brake-pipe was separated and the brakes applied automatically.
- The trailing load collided with locomotive No 1 and caused locomotive No 1 and the first tank wagon to tip over.
- Locomotive No 2 finished some 100 m beyond the first point of derailment.
- Overturned locomotive No 1 and the overturned tank wagon finished some 150 m beyond the first point of derailment.

The first signs of climbing the rail are on the side of the right-hand switch blade shortly close to the toe. Disturbance of the layer of rust provides evidence of running on the tops of the blades. Further signs of derailment can be noted on the distance blocks of No 391 switch. In this case it is the impression of the wheel flanges. Some rail fastenings were also damaged by the locomotive. All further damage beyond No 391 switch is to be regarded as the consequence of the derailment.

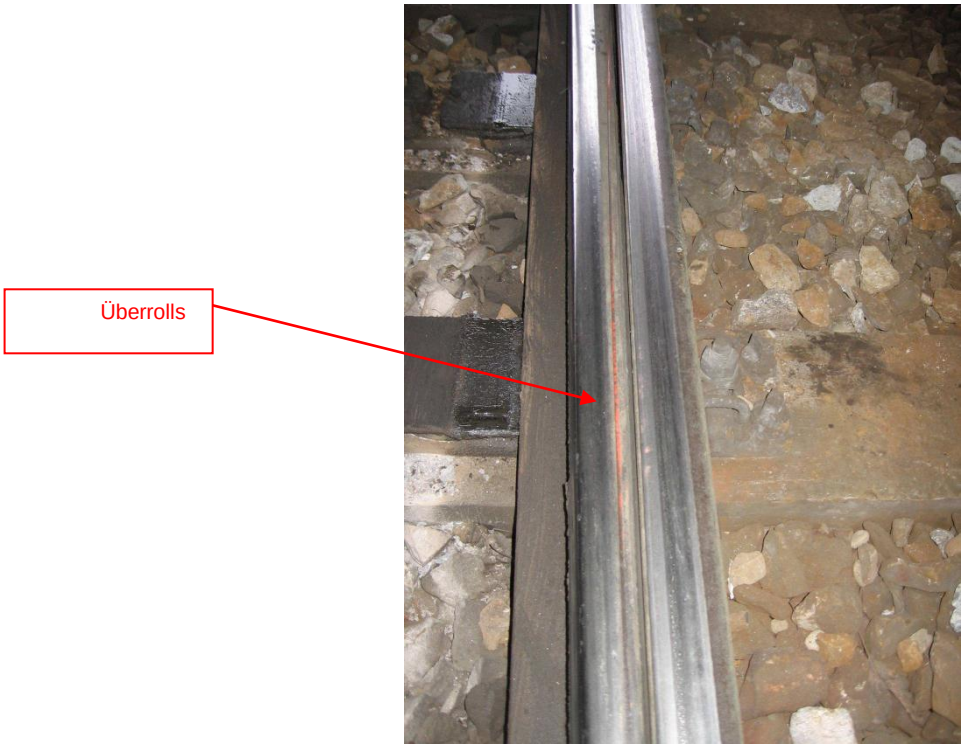
***Signs of derailment – distance blocks No 391 switch***

***Signs of derailment – anti-creep anchor No 391 switch***

***Longitudinal markings – right blade of No 391 switch***




***Signs of climbing - right blade of No 391 switch***




***Signs of over-running - right blade of No 391 switch***

## 5. Analysis and conclusions

Because of the fact that tamping and alignment work through a switch can only be done with a switch and crossing tamping machine and not with a plain line tamping machine, the plain line tamping machine that was set to work had to finish its work in the area close to the toe of No 391 switch. (A plain line tamping machine does not have, for example, the ability to lift the third rail nor extended options to align or individual control of tamping tines.)

**The cant gradient which had been provided for in the plans was not constructed in its entirety and as a consequence, an unnoticed twist - made necessary by the possession - was introduced.**

The twelve train movements made after the line was released to traffic make it apparent that twist does not necessarily lead to derailments. Basically, a derailment can arise when limiting values (only derived empirically on the basis of technical tests on wagons and various measurements of track) come together in an unfavourable combination. Statistically, we can be 95 % confident that vehicles will not derail on twisted track with the limiting values laid down for

permitted cant, permitted twist and the limiting values which have to be met by vehicles in tests.

Where switches are on transition curves or cant gradients, as a rule the complete transition curve or cant gradient is tamped right through with a switch and crossing tamping machine.
Alternatively, the plain line tamping machine used on site could initially have worked on the section of line between No 391 and No 394 switches without a cant up to the toe of No 391 switch. Also a 'flatter' build up of the cant gradient with the cant approximately equal to zero at the toe of the switch would have been conceivable. The full cant could have been created using a switch and crossing tamping machine at a later date (for example on the renewal of No 391 switch the following weekend). This method of working was not adopted. In particular, the overlapping in the works schedule points to the assumption that originally a switch and crossing tamping machine rather than a plain line tamping machine would have been used between No 391 and No 394 switches.

**There are clear inconsistencies between the way the use of plain line and switch and crossing tamping machines was planned and the way the work was actually and practically carried out.**

In accordance with Guideline 824.2310 Section 3(8), the contractor must ensure, inter alia, that plotter records for the section of line being worked on begin 20 m before the start of the work (including the cant gradient) and extend to 20 m after the end of the work. In that way it can be verified that the transition from the old infrastructure to the renewed section of line conforms to the regulations.

**This extension going 20 m beyond the end of the work is not shown in the multi-channel plotter record to hand. Values, for example in twist, can then exceed the limits and go undetected. Despite the tamping and alignment work not being done properly, the specialist supervisor and authorised technical officer on duty reported that the track was clear and useable.**

In accordance with Appendix 3 of the TEIV and Appendix 4 of the VV IST, comprehensive re-equipment or renewal are, inter alia, said to exist, if an increase in speed of at least 10 % should be possible as a result of changing the alignment. In accordance with Article 9 of the TEIV, comprehensive re-equipment or renewal of a structural subsystem which goes beyond replacement in the context of maintenance work requires an authorisation to put into service in accordance with Article 6 of the TEIV or Article 8 of the VV IST.

**Despite an intention to increase the speed by more than 10 %, the safety authorities were not involved with the work: no application for authorisation to put into service was made nor was notice in accordance with TEIV Article 9(2) given.**

In accordance with Guideline 809.0301, Section 1(4), measures which under VV BAU are regarded as simple technical or operational civil engineering work in the overhead electrification and level crossing areas not requiring notice may be supervised by specialist supervisors (FBÜ) of the appropriate speciality.

**Since the project was one which required notice to be given and authorisation to be given, a rail works supervisor (trained as an engineer) rather than a specialist supervisor (trained as a technician or master craftsman) ought to have been employed.**

The speed signalled was exceeded by up to 7 km/h.

**Since the dynamics in principle permit No 391 switch (radius of diverging line 300 m) to be traversed at 50 km/h, exceeding the speed limit is not to be regarded as contributing to the derailment.**