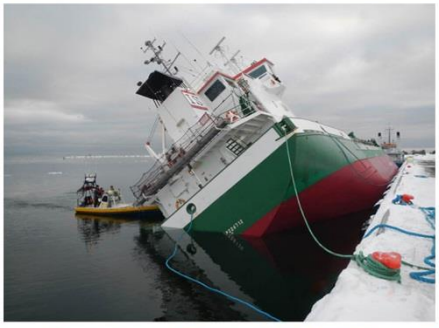
Statens haverikommission
Swedish Accident Investigation Authority



Final report RJ 2015:02e

Incident for collision between train 44660 and train 1859 in Bjuv, Skåne county, on 22 July 2014

File no. J-33/14

2015-06-30

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se

ISSN 1400-5719

This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

Postadress/Postal address
P.O. Box 12538
SE-102 29 Stockholm
Sweden

Besöksadress/Visitors
Sveavägen 151
Stockholm

Telefon/Phone
+46 8 508 862 00

Fax/Facsimile
+46 8 508 862 90

E-post/E-mail
info@havkom.se

Internet
www.havkom.se

Content

General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event occurring in the future, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

The investigation

SHK was informed on 23 July 2014 that an incident involving a near collision had occurred at the station Bjuv, Skåne county, the previous day at 19.15 hrs.

The incident has been investigated by SHK represented by Mr Mikael Karanikas, Chairperson, Mr Rickard Ekström, Operations Investigator and, until 18 November 2014, Investigator in Charge, Ms Eva-Lotta Högberg, Operations Investigator and, from 19 November 2014, Investigator in Charge, as well as Mr Claes Hedbom, Technical Investigator.

The investigation was followed by Mr Per Almqvist and Ms Diana Guarda Canet of the Swedish Transport Agency.

Investigation material

The data used in the investigation have been obtained from TX Logistik AB, TX Logistik AG, Arriva Sverige AB, NetRail AB, Interlink Logistik AB, Ahus-Alstätter Eisenbahn AG, the Swedish Transport Administration, the Swedish Transport Agency and the Accident Investigation Board Norway (Statens havarikommisjon for transport, AIBN).

SHK has conducted interviews with the driver of freight train 44660, the driver of the oncoming passenger train, the brake tester, the mechanic and representatives of the stakeholders stated in the above paragraph. SHK has also visited

the sites in Bjuv and Helsingborg, investigated the hose in question and reviewed documents.

A fact finding presentation meeting was held on 11 March 2015. During this meeting, SHK presented all the factual data available at that time.

Statens haverikommission
Swedish Accident Investigation Authority

Final report RJ 2015:02e

Report completed 2015-06-30

Train 44660	
Train type, train no./operation:	Freight train 44660 consisting of 18 loaded wagons.
Railway vehicle:	Freight wagon Sdggmrs 37804993805-3.
Railway undertaking:	TX Logistik AB.
Company hired for maintenance:	NetRail AB.
Company assisting in shunting:	Interlink Logistik AB.
Vehicle owner:	Ahus-Alstätter Eisenbahn AG.
Vehicle keeper:	Ahus-Alstätter Eisenbahn AG.
Entity in charge of maintenance:	Ahus-Alstätter Eisenbahn AG.
Lesser of wagon:	TX Logistik AG.

Train 1859	
Train type, train no./operation:	Passenger train 1859.
Railway vehicle:	X61.
Railway undertaking:	Arriva Sverige AB.
Passengers on board:	Yes.
Infrastructure manager:	The Swedish Transport Administration.

Time of occurrence:	22 July 2014, at 19.15 hrs.
Place:	Station Bjuv, Skåne county.
Speed at the time of the incident:	Slight deceleration curve from 100 km/h.
Maximum permitted speed:	130 km/h.
Injuries to persons:	None.
Damage to railway vehicle:	None.
Damage to railway infrastructure:	None.
Other damage:	None.

SUMMARY

On 22 July 2014, there was an incident involving a near collision between train 44660 and train 1859 in Bjuv, Skåne County. When the driver of train 44660 was to brake in preparation of crossing train 1859, the brakes in the wagons behind wagon 3 engaged so slowly that the train could not be stopped within the expected stopping distance. The train stopped when the locomotive was approximately 40 metres beyond the route stop lantern. Shortly after the train had stopped, train 1859 arrived at Bjuv and stopped at the platform to drop off and pick up passengers. The total braking distance for train 44660 was approximately 2,000 metres, and if the freight train had continued for another 80 metres before stopping, it would have compromised the route for train 1859, and in unfavourable conditions a collision might have occurred between the two trains involved.

The immediate cause of the incident was the abnormal amount of time it took for the brakes to engage, which was due to a constriction of the train pipe in wagon 3.

The constriction occurred because a fixed hose coupling in the train pipe had been refitted in a way that introduced a twist in the hose which affected the flow area. The constriction was not identified by the technical post-inspections, nor by the subsequent brake test.

The underlying cause was that the maintenance contractor had not identified the risk that the hose might become twisted when re-fitting it to the vehicle, this in turn due to a lack of guidance, from the railway undertaking (RU) or the entity in charge of maintenance (ECM), regarding the correct procedure for fitting and performing a function check of the hose in question, in conjunction with repairs on the vehicle. Neither the ECM nor the RU had noted this state of affairs.

Safety recommendations

Ahus-Alstätter Eisenbahn AG is recommended to:

- ascertain that any maintenance carried out on vehicles, for which they are the entity in charge of maintenance, is carried out in accordance with the pertinent instructions and, if the need is identified, highlight any particular hazards that may be associated with maintenance operations on vehicles or their subsystems (see section 3.2). *(RJ 2015:02 R1)*

1. FACTUAL INFORMATION

1.1 Sequence of events

Trains 44660 and 1859 were involved in a collision incident on 22 July in Bjuv. As train 44660 was approaching Bjuv, it was given a restrictive signal by the home signal (Bjuv 22), due to oncoming traffic in the form of passenger train 1859 (Pågatåg). When engaging the brakes to adjust the speed and stop the train at the route stop lantern 82, the driver experienced that there was in principle no or very weak braking action. He then emptied the train pipe using the driver's brake and an emergency brake valve.

The train stopped with the engine approximately 40 metres beyond the route stop lantern 82, but without passing section signal, Bjuv 32. Shortly after the train had stopped, passenger train 1859 arrived at Bjuv and stopped at the platform to drop off and pick up passengers. The driver of the passenger train did not experience anything abnormal when entering Bjuv but thought, however, that the freight train was standing unusually far ahead when he passed the home signal. The total braking distance for train 44660 was approximately 2,000 metres, and if the freight train had continued for another 80 metres before stopping, it would have compromised the route for train 1895, and in unfavourable conditions a collision might have occurred between the two trains involved.

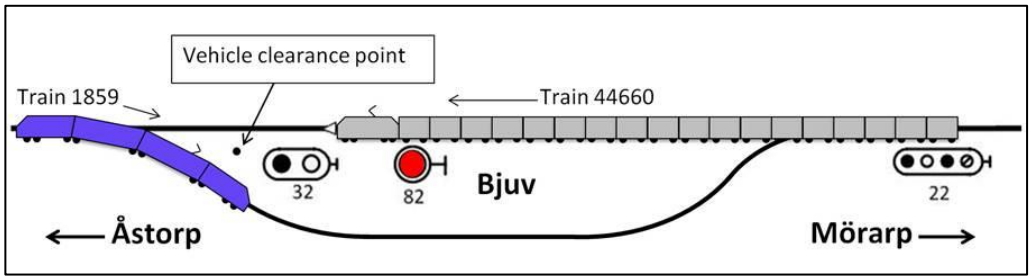


Figure 1. Schematic drawing of the approximate position of train 44660 when it came to stop after passing route stop lantern 82. Shortly thereafter train 1859 arrived to the platform at Bjuv station.

Once the incident site manager arrived at the site, a brake test was conducted, which showed that the brakes had only engaged on wagons 1 and 2, as well as on the four axles in wagon 3, which were closest to the engine. However, there was air through the whole train, which was determined by opening the train pipe on the last wagon.

After fault isolation, it could be determined that the train pipe hose in wagon 3 was twisted and did not let enough air through for the brake system to function in the intended manner beyond this hose, as viewed from the locomotive. Once the wagon manager of TX Logistik AB arrived at the site, the problem was rectified, and the train could then continue on with fully functional brakes.

Earlier that day, a mechanic at NetRail had been assigned to perform maintenance on a class Sdggmrs freight wagon, which was located at

the Interlink Logistik terminal in Helsingborg. The mechanic went to the location and, via the "blue card" (trouble report) that drivers and others fill in when they discover a fault, was informed of a leak in the brake system.

The mechanic connected air to the wagon to perform fault isolation and localised the leak to a coupling in the line to the middle bogie brake cylinder (arrow 1 in Figure 2). To obtain access in order to repair this, it was necessary to remove the hose (arrow 2 in Figure 2) that transfers the air between the two parts of the articulated wagon. As can be seen from Figure 2, it is otherwise difficult to access the coupling.

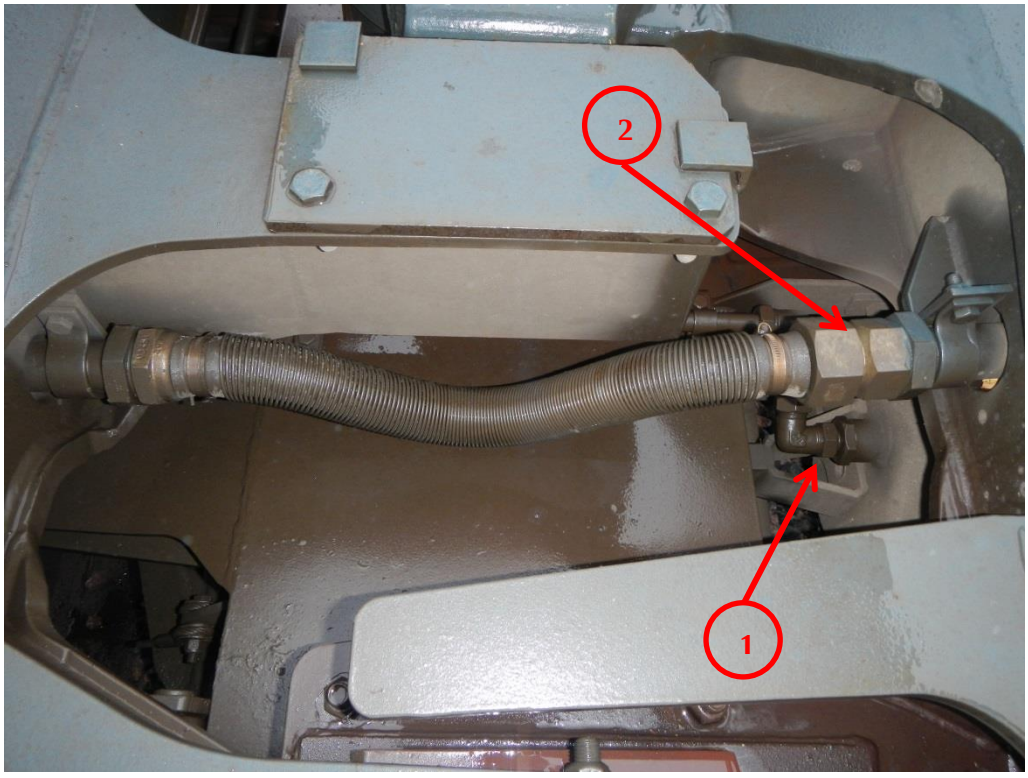


Figure 2. The wagon's middle bogie. (Not the actual wagon involved in the incident). In order to access the mounting at the brake cylinder (1), the mechanic had to take off the main line for the brake system (2).

When refitting the hose after the repairs, the mechanic noted that it was difficult to install without it twisting, but that it was finally possible to put back in place. The mechanic then conducted a post-inspection that included testing for leaks and checking the movement of the brake blocks and the brake regulators.

The wagon was then placed as number 3 out of 18 loaded wagons in freight train 44660, which was to go from Helsingborg to Bro, departing at 19.06. The driver from TX Logistik AB conducted a brake test (initial terminal inspection) together with a brake tester from Interlink Logistik prior to departure. The train then departed slightly ahead of schedule, and the driver intended to carry out a deceleration check somewhere between Mörarp and Åstorp, where the track is sufficiently level and straight. Before the deceleration check had been

carried out, the restrictive signal was received at the home signal (Bjuv) 22 due to the oncoming passenger train, and the driver engaged the brakes.

1.2 Deaths, injuries to persons and material damage

None.

1.3 Rescue operation

Not applicable.

1.4 Background data

1.4.1 Personnel involved, contractors and other parties and witnesses

The driver of freight train 44660 has been employed by the hour at TX Logistik AB, where he also did his work placement during his train driver training, as of 1 May 2014. His train driving licence from the Swedish Transport Agency was issued on 11 June 2014. Over the summer, he had driven the route in question on several occasions.

The brake tester has been employed by Interlink Logistik AB since September 2012. In October 2012, he underwent training as hand signaller, including wagon inspection and brake testing. He has been trained by TX Logistik in TXF 9.1.500 Brake regulations and refreshed his training every year.

The mechanic has been employed with the maintenance company NetRail in Helsingborg since the beginning of 2014. He has roughly 10 years' experience as a mechanic, completed general freight train training in 2013 and brake training in 2005.

1.4.2 Trains and their composition

Freight train 44660 consisted of the engine and 18 trailer-type freight wagons. The wagon now in question was running as wagon number three. The railway undertaking was TX Logistik AB, which leased the wagons from TX Logistik AG, which in turn leased them from Ahus-Alstätter Eisenbahn AG (AAE), which was both the vehicle owner and the entity in charge of maintenance (ECM[1]).

The railway undertaking for the oncoming passenger train 1859 was Arriva Sverige AB.

1.4.3 Infrastructure and signalling system

The Swedish Transport Administration is the infrastructure manager for the route. The line is supervised by centralised traffic control. The maximum permitted speed is 130 km/h.

[1] ECM – Entity in Charge of Maintenance. See also Section 2.3.1.

1.4.4 Means of communication

The driver and the brake tester were communicating via radio.

1.4.5 Works on or near the site

The investigation has not revealed that any ongoing works on or near the site have influenced the sequence of events.

1.5 External circumstances

According to SMHI, the weather at the site in question on 22 July at 19.15 was clear to half-clear, with no precipitation and a temperature of 25 degrees (Celsius). Wind around east 2–4 m/s, visibility more than 10 km. The elevation angle of the sun was 17 degrees and the azimuth 282 degrees.

According to the driver's account and drawings, the topography is such that the track from Helsingborg to Bjuv is mainly on an upward slope.

2. CONDUCTED INVESTIGATIONS

2.1 Interviews

SHK has conducted interviews with the driver of freight train 44660, the driver of the oncoming passenger train, the brake tester and the mechanic.

SHK has also posed questions to representatives of TX Logistik AB, NetRail and Interlink Logistik in managerial positions, as well as to Ahus-Alstätter Eisenbahn AG, TX Logistik AG, the Swedish Transport Administration, the Swedish Transport Agency and the Accident Investigation Board Norway.

Data from these interviews are presented in 1.1 Sequence of events, as well as in relevant sections later in the report.

2.2 Technical facilities and rolling stock

2.2.1 Signalling and traffic management systems

The interlocking system in Bjuv has functioned in the intended manner. Bjuv is a station where the interlocking system has been set up for simultaneous entry, with the model ESIK (single track, simultaneous entry, short station). An entry route (in the event of simultaneous entry) then has its end point at a route stop lantern and the section signal is then approximately 100 metres further out and at a short distance from the clearance point of the switch (HIP). The distance from the end point of the entry track to HIP is thus only a little over 100 metres, which requires ATC-10. Train 44660 was travelling northwards on track 2, the main/straight track. The distance from the route stop lantern 82 to section signal 32 is 100 metres, and from section signal to

HIP it is 22 metres. From the home signal 21 to HIP, where 1859 was driving, the distance is 280 metres. The maximum permitted speed of the line, up to the home signals, is 130 km/h. In the case at hand, 1859 had received a restrictive signal aspect, as the route was set for the siding and accordingly had to use lower speed.

2.2.2 Infrastructure

Not investigated.

2.2.3 Communication equipment

Not investigated.

2.2.4 Rolling stock

General

The wagon in question was of the type Sdggmrs 37804993805-3, a six-axle trailer and container wagon consisting of two connected wagon units with a common bogie in the middle. The hose that was constricted in this incident due to it being twisted, is a part of the train pipe that connects the two parts of the wagon, as the wagon is articulated at this point, see Figures 3 and 4.

Figure 3. Sdggmrs wagon. The picture is taken from the wagon's middle bogie.

Figure 4. The red circle in the picture shows the hose in question over the middle bogie.

Train brake

Brakes are controlled by means of a "drivers' brake valve". This valve is used to feed air to the train pipe or to allow air to escape from the train pipe. If the train pipe pressure is lowered, brakes will be applied in proportion to the pressure difference from full pressure in running conditions, 5 atmospheres. As the pressure is restored, brakes will be released proportionally, until fully released when train pipe pressure is again 5 atmospheres.

The hose

The train pipe hose in the articulated joint consists of a rubber hose with a fixed coupling at one end, which is screwed into a mating fitting in one part of the wagon and, at the other end, a flange coupling with a collared nut, which is mated to a suitable fitting in the other part of the wagon. The fixed coupling, in actual practice the entire hose, is first screwed into the corresponding outlet in the train pipe of one half of the wagon. The flange coupling is then put together and tightened using the collared nut to seal it to the train pipe coupling of the other half of the wagon. In this step, it is important for the hose not to twist, as this can cause a constriction in the hose.

The hose is made from rubber and it is protected by a tightly wound spiral of hard steel wire and it is mounted as close as possible to the articulated joint. The protective spiral makes the rubber hose somewhat difficult to see from the outside. As the hose is not mounted precisely in the centre of the joint, it must be designed to allow for a certain movement of the couplings, as the distance between them varies with the articulation of the wagon. The hose is mounted in a hanging curve to be able to absorb this movement.

Investigation of the hose

After the incident, the hose from wagon 3 was removed and sent to SHK.

There is a crease on the surface of the hose material, at about the middle of the hose, which implies that at some point it has been folded there. See Figure 5. SHK´s own tests show that if the hose is sufficiently twisted, it causes a kink, or a fold, at the area where the crease is, and in conjunction with this the flow area is reduced drastically, i.e. a constriction arises. The appearance and direction of the crease in relation to the hose is consistent with a kink that would be expected to occur if the hose was excessively twisted when fitted, which could happen as a result of, for example, after-tightening of the fixed coupling to the wagon after tightening the clamp coupling at the other end of the hose, or the hose not remaining straight when the clamp coupling is tightened, which could happen as a result of excessive friction between the collar nut and the clamp coupling flange.

Figure 5. The examined hose material has a crease on the surface.

When fitting the hose, the manner of tightening the nuts is important in order to avoid twisting the hose. Nut “B” (see Figure 6) is used to seal the line with a clamp coupling. Once nut “B” starts to pull the clamp coupling together, there is a risk of the hose twisting as the nut is turned. If any of the nuts are retightened, there is also a risk of twisting the hose. The flow area is drastically reduced in the hose already after half a turn of the hose. Almost complete constriction seems to be the result after some 270º of twist. If the friction of the clamp coupling is too high, there is a risk of the hose following along with the collar nut before the coupling is sealed tight, thereby introducing a twist in the hose. The only way to prevent the hose from twisting in that situation, is to hold the hose still, using a pipe wrench

or similar tool. There is however no really suitable place to apply such a tool on the hose.

The examination of the hose also shows that bending of the hose, the type of movement that takes place when the wagon enters a curve, has a negligible effect on the area in the hose. Tests conducted with both a straight and twisted hose show that bending does not noticeably affect the flow area, but that the clearly most important factor for reducing the area is the twisting of the hose. The bend is distributed over the length of the entire hose, while a twist is relatively quickly concentrated to one area, where the hose later buckles. Due to the shape of the hose after fitting, this area is in the middle of the hose. A deformation of the hose as shown in Figure 7 cannot occur spontaneously due to a nut being loose or coming off; it requires the mountings to be tightened using tools.

Figure 6. Examined hose. A, B and C mark the nuts.

The twist

The investigation has not been able to determine how much the hose was twisted at the time of the incident. The hose was restored by TX Logistik AB personnel before SHK had opportunity to examine it. The data available is information from the mechanic and photographs taken by TX Logistik AB, which show the hose before it was restored and the twist was completely released.

Figure 7. Image of the hose directly after the event, before it was restored by TX Logistik AB. Photo: TX Logistik AB.

As mentioned in 1.1, the mechanic experienced some trouble refitting the hose. This is not something he has experienced before. The hose was unusually stiff and fairly hard. However, according to him, it was not as twisted as he has later seen in photographs following the incident. There are not instructions for all repairs, and, according to the mechanic, you solve problems based on your basic brake training.

The mechanic did not note any deviation during the post-inspection he conducted of the wagon. There is a post-inspection checklist that includes testing for leaks, regulator testing and checking the length of stroke. The checklist states that the applicable parts are to be carried out. None of the steps carried out during the post-inspection can demonstrate a constriction of the hose with certainty. The checklist has steps named "Inspection, components checked" (4.2) and "Hose fittings, inspection and control performed" (4.4.1) which in this case were marked as "ok"[2]. The steps are not described in more detail in the checklist except references to chapters in the 84 pages long NetRail maintenance instruction for freight wagon brakes, NR-455-400-1, in which the checklist is also included. In NR-455-400-1 general instructions stating that compressed air hoses should not be bent with folds. However, nothing is mentioned of the specific hose with a protection spring covering the hose.

The checklist has another step to check the airflow in the main line (item 4.4.4 (2.4.5, see footnote 3) in the checklist), which were not taken in this case. In the event of a constriction, the flow capacity is affected as the air cannot pass through unhindered. A significant con-

[2] The checklist is referring to chapter 4.2 and 4.4 in NR-455-400-1 but from the headlines SHK draws the conclusion that the intended chapter reference is 2.2 and 2.4.

striction could have been noticed by checking the airflow. In this case, the exact scope of the constriction is unknown. According to NetRail, the equipment used when repairing wagons outside the workshop area, does not have the capacity to deliver the amount of compressed air needed to perform the airflow test.

After examination, SHK makes the assessment that the present constriction of the hose cannot arise spontaneously or be significantly affected by the movements of the wagon.

Warning text regarding the hose

This type of wagon is also used by other railway undertakings. With (at least) one of them (Green Cargo), there is a detailed description of how the main line hose is to be fitted in the hinge, where particular attention is paid to the importance of not allowing the hose to twist. In addition, the wagons are equipped with a placard containing warning text in this regard, which is placed near the wagon's hinge. The reason for this is an incident in Norway in 2008, see section 2.6, where the same phenomenon arose as in the present event.

2.3 Regulations and supervision

2.3.1 Applicable provisions and regulations at the EU and national level

Swedish railway operations are primarily regulated through the Swedish Railway Act (2004:519). Section 2 of the Swedish Railway Ordinance (2004:526) states that the Swedish Transport Agency is the supervisory body under the Railway Act, and that more detailed provisions for the implementation of the Railway Act shall be issued by the Swedish Transport Agency. In addition to the Swedish regulations, which are largely based on EU Directives, there are also EU Regulations directly applicable in Sweden.

In accordance with the Railway Act, a railway undertaking is an entity authorised, through the possession of a licence or special permit, to provide traction power and perform railway services. 'Infrastructure manager' refers to an entity that administers railway infrastructure and manages facilities that belong to the infrastructure.

Safety management system

In accordance with Chapter 2, Section 5 of the Swedish Railway Act, the operations of infrastructure managers and railway undertakings must be covered by a safety management system. The safety management system consists of the organisation that has been set up and the procedures that have been established to ensure safe operations. Sections 6 and 7 of the Swedish Rail Agency's regulations[3] (JvSFS 2007:1) on safety management systems and other safety provisions for railway undertakings state that it must be possible to manage any risks resulting from the operations, including risks involving hired contrac-

[3] As of 2009, the Swedish Transport Agency is responsible for the Swedish Rail Agency's regulations.

tors, in a satisfactory manner through the safety management system, and that such a safety management system should consist of procedures that guarantee that those who carry out safety-related tasks are suited to do so and have the appropriate expertise.

Entity in charge of maintenance

EU Regulation 445/2011[4] describes a system of certification of entities in charge of maintenance for freight wagons. According to the Regulation, all freight wagons are to be assigned an entity in charge of maintenance (ECM) before they can be put into operation. Specially appointed bodies will issue certification to these entities.
The purpose of the certification system is to show that the entity in charge of maintenance has established a maintenance management system and is able to fulfil the requirements of the Regulation, in order to ensure that all freight wagons for which the entity is in charge of maintenance are in a safe condition.

The railway undertaking should ensure, through its safety management system, the control of all risks related to their activity, including these of contractors. To this end, a railway undertaking should rely on contractual arrangements involving entitys in charge of maintenance for all wagons it operates.

The railway undertaking is still responsible for a safe operation, in accordance with the provisions of the Railway Act, regardless of who the entity in charge of maintenance is for the freight wagons used by the railway undertaking. The Swedish Transport Agency's regulations (TSFS 2012:33) regarding inspection, functional checks and maintenance of vehicles contain provisions regarding maintenance and inspection of vehicles in addition to those found in EU Regulation 445/2011.

According to the Swedish Transport Agency, a railway undertaking's safety management does not need to include verification of the maintenance of a freight wagon used in its operation if the wagon has a certified entity in charge of maintenance. It is the body that certified the entity in charge of maintenance that is to conduct an annual check to verify that the certified entity fulfils the requirements of the EU Regulation. On the other hand, the railway undertaking must manage exactly how and where the maintenance is to be performed, through an agreement with the entity in charge of maintenance.

Article 4 of the same EU Regulation states that a maintenance system must have a management function, a maintenance development function, a fleet maintenance management function as well as a maintenance delivery function.

[4] Commission Regulation (EU) No 445/2011 of 10 May 2011 on a system of certification for entities in charge of maintenance for freight wagons and amending Regulation (EC) No 653/2007.

The entity in charge of maintenance must ensure that these functions fulfil the requirements and the assessment criteria found in Annex III of the Regulation, which stipulates requirements regarding management, risk assessment, monitoring, continuous improvement, structure and responsibility, competence management, information, documentation and contracting activities.

The entity in charge of maintenance must handle its own management functions, but is allowed to outsource the other functions. Regardless of organisation format, the entity in charge of maintenance is responsible for the results of the maintenance activities it manages, and it is to set up a system to monitor performance in respect of these activities.

Annex III also states that the organisation must have procedures to ensure that important operative information is comprehensive and easily available to personnel. This applies, in particular, to technical information for railway undertakings/infrastructure managers and vehicle keepers, which is needed as maintenance instructions.

Furthermore, the organisation must have procedures to ensure that relevant information from railway undertakings or other relevant sources is processed and observed for continuous improvement.

Monitoring

EU Regulation 1078/2012[5] describes a common safety method (CSM) for monitoring, which makes it possible to effectively manage safety in the railway system during operation and maintenance activities, and to improve the management system, where applicable. The EU Regulation applies to railway undertakings, infrastructure managers and entities in charge of maintenance.

The objective of the monitoring process is to verify that all processes and procedures in the management system, including technical, operational and organisational measures for risk management, are appropriately applied, and that they are effective.

Regulations for brake tests and deceleration checks

The Swedish Rail Agency's traffic regulations (JvSFS 2008:7), JTF, contain regulations pertaining to the management of traffic and works on the railway affecting traffic safety. Appendix 11 contains provisions relating to brakes.

It states that when moving, the train unit must have a main brake system (continuous brake system within a vehicle unit) where the first and last vehicle use the main brake system to brake. The brake is then engaged automatically if there is a break in the main line.

[5] Commission Regulation (EU) No 1078/2012 of 16 November 2012 on a common safety method for monitoring to be applied by railway undertakings, infrastructure managers after receiving a safety certificate or safety authorisation and by entities in charge of maintenance.

In order to check that the brake system of a train unit is working, a brake test must be performed when the train unit is standing still before departure. This is done by a brake tester together with the driver. Once the train unit is moving, the driver shall conduct a deceleration check in order to get an idea of whether the vehicle set's actual braking capability corresponds to the calculated brake percentage. The brake percentage is to be calculated for each train unit based on train weight and brake weight.

The brake test prior to departure is to ensure that the main line is open and can control the main brake system through the vehicle unit, that the main brake system works on every vehicle with brakes connected, and that the main line is sufficiently sealed in a vehicle unit with normal pneumatic brakes.

The brake test is divided into the following types: basic test, breaking down test, shorter breaking down test, separate brake test, brake verification test. During the basic test, the brake tester is to check that the brake works on all the vehicles with a connected brake by brake testing the entire vehicle unit.

The brake test of a train unit with normal pneumatic brakes must cover charge, checking seals, checking that the brake is loosened before engagement, engaging the brakes, checking that the brake is engaged, loosening the brake, checking that the brake is loosened and reporting that the brake test is complete. During the test, the driver should consider if the time required to lower the train pipe pressure while applying the brakes, is consistent with the length of the train. The railway undertaking can introduce additional procedures or checks into the brake test process.

A deceleration check is to be carried out in a suitable location, on a horizontal track, once the train has departed from a location where one of the following has occurred: a brake test has been conducted, the train composition has been changed, the brake rigging or empty/load settings have been changed, the brake has been turned off on a vehicle or there has been a change of driver on the engine.

The deceleration check is conducted either by technical calculation or by driver assessment.

Section 6.1 of appendix 11 to JTF sets out requirements for railway undertakings to state in their safety regulations how deceleration checks are to be conducted through technical calculation; which measures to take when the check cannot be carried out in a suitable location at the stated occasions; and which measures are to be taken when the actual braking capability is less than the one corresponding to the calculated brake percentage.

The Swedish Transport Agency has not issued any provisions as guidance for application. There were previously requirements for test brak-

ing to be conducted immediately after departure, but this requirement was removed when the requirement for deceleration checks was introduced in JTF. The Swedish Transport Agency never considered requiring both types of tests, and no risk analysis was conducted at the transition.

2.3.2 TX Logistik AB's safety management system

General

TX Logistik AB has a railway undertaking licence from the Swedish Transport Agency and is thereby required to have a safety management system.

Ahus-Alstätter Eisenbahn AG (AAE) is the certified entity in charge of maintenance for the wagon in question. The wagon is owned and managed by AAE. AAE has leased the wagon to TX Logistik AG (based in Germany), which in turn has leased it to TX Logistik AB. Leasing agreements for wagons have been entered between AAE and TX Logistik AG and between TX Logistik AG and TX Logistik AB.

TX Logistik AB has a wagon maintenance agreement with NetRail AB and an agreement with Interlink Logistik AB regarding shunting, between the yard and the terminal in Helsingborg, as well as brake testing.

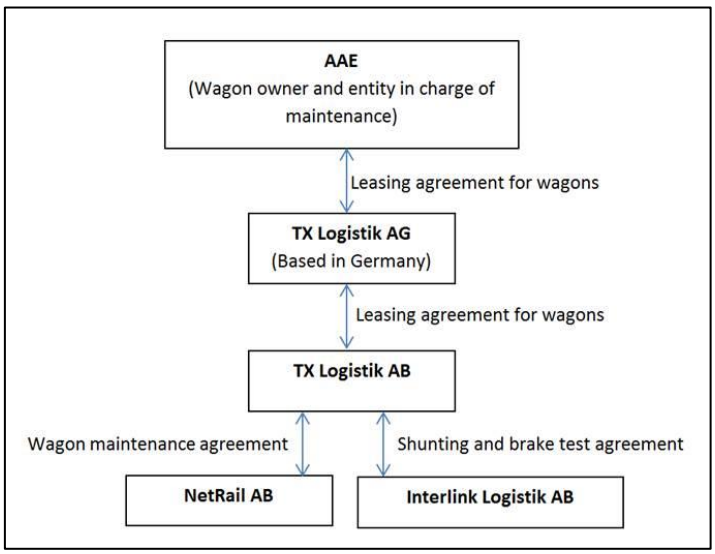


Figure 8. Contractual partners involved in the incident.

TX Logistik AB's safety management

TX Logistik AB's safety management is described in the document "*TXF 2 Säkerhetsstyrning, utgåva 24*" (TXF 2 Safety Management, 24th edition), which was valid at the time of the incident. TFX 2 describes how TX Logistik AB works with follow-up and audit of its own organisation. The audit is to be carried out in the form of planned auditing activities and planned follow-up of operative personnel. Fol-

low-up of subcontractors includes follow-up of the requirements set out by TX Logistik AB in agreements as well as delivery checks.

TX Logistik AB has been unable to produce any documentation from follow-up or audit, with the engaged contractors NetRail or Interlink Logistik, prior to the incident. The current vehicle manager/wagon manager, who is responsible for setting requirements, follow-up and verification of vehicle maintenance carried out by maintenance suppliers, took up the post on 18 June 2014 and has been unable to answer questions regarding how the company has previously worked with these aspects of the operation.

TXF 5 (4th edition) specifies how TX Logistik AB is to manage risks. The document states that TX Logistik AB is to conduct, verify and document risk analyses, or risk assessment in simpler cases, when they intend to introduce new technology, new principles, significant changes to the existing organisation or untested solutions of significance to traffic safety. The results of risk analyses and risk assessments are to give TX Logistik AB opportunity to prevent the occurrence of unwanted incidents and injuries/damage.

Prior to this incident, when entering the agreement or during the agreement period, TX Logistik AB had not completed any risk assessment to identify risks at NetRail and Interlink. According to TX Logistik AB, they have used these maintenance contractors for a long time and therefore did not deem any risk assessment to have been necessary.

TXF 7.3 "*Fordonsunderhåll godsvagnar*" (Vehicle Maintenance, freight wagons) (7th edition), describes how TX Logistik AB handles the maintenance of rented wagons owned by AAE. TXF 7.3 states the following:

> *For the maintenance of wagons owned by AAE, the AAE maintenance regulations shall be applied. The AAE maintenance regulations are updated on a continuous basis, and current instructions can be found online at: http://www.aae.ch/workshop.*

There is no closer description in TXF 7.3 of how TX Logistik AB ensures that the updates on the AAE website are incorporated into the TX Logistik AB safety management system and conveyed to contractors.

TXF 7.4 "*Mottagandekontroll av fordon*" (Checking vehicles upon delivery) (4th edition) provides regulations regarding TX Logistik AB's procedures when receiving rented vehicles from the lessor or getting vehicles back after maintenance performed by a maintenance supplier. Prior to maintenance performed by a maintenance contractor, the parties must sign an agreement. This agreement is to specify the following: handling and maintenance provisions, skills and health requirements, systems for audits and delivery notice. TXF 7.4 also states

that the wagons must undergo safety inspection in accordance with GCU[6] before the vehicle can be put into traffic.

SHK has asked TX Logistik AB if and how they have implemented the requirements stipulated in EU Regulation 1078/2012 in regard to a monitoring procedure intended to verify that the safety management system is applied correctly and achieves the desired results. TX Logistik AB has answered that this is incorporated in TXF 2.2 (1st edition) and TXF 5. SHK has not found any complete description in these documents of how TX Logistik AB incorporates the monitoring procedure in accordance with Regulation 1078/2012 to monitor their safety management system.

Wagon rental agreements

The wagon rental agreements between AAE, TX Logistik AG and TX Logistik AB had not been updated after EU Regulation 445/2011 on a system of certification for entities in charge of maintenance for freight wagons entered into force. According to the agreements, the party leasing the wagon is responsible for maintenance and remedial maintenance to the wagon between overhauls. Furthermore, the agreements specify that only authorised workshops may be used for maintenance. At the AAE website, there is a list of authorised maintenance suppliers, which does not include NetRail. However, AAE has informed SHK that TX Logistik AB is allowed to hire a maintenance contractor without informing AAE, as long as that contractor is included in the GCU. NetRail is included in the GCU.

Wagon maintenance agreement

TX Logistik AB has contracted for NetRail to conduct any planned, immediate and preventive maintenance for the freight wagons at TX Logistik AB's disposal. The agreement does not specify which type of maintenance measures are included, other than a reference to a price list with various maintenance activities. TX Logistik AB has stated that it is implied that NetRail may carry out all types of maintenance on the wagon type in question, despite this not being specified in the agreement. NetRail is certified as an ECM, but not for the vehicle concerned here, for which AAE is the ECM. See section 2.3.3.

The framework agreement (regarding freight wagon maintenance in 2014) states that the client (in this case TX Logistik AB) is responsible for providing NetRail with the appropriate maintenance instructions for the wagon type in question.

According to NetRail, they have not received any instructions or documents for the wagon type in question (Sdggmrs) from TX Logistik AB regarding how maintenance is to be performed on the wagons. Instead, NetRail used its own document NR-455-400-1 (version 1) for the maintenance of the freight wagon, which contains instructions and a checklist for work on freight wagon brake systems. The document

[6] General Contract for Use of Wagons.

provides an overall, general level of maintenance for different types of brake systems on freight wagons, and is not linked to specific wagon types. The document shows that when repairing the pneumatic parts of the brake, the checklist is implemented in applicable parts.

For the repair in question, it was the same person who alone carried out the repairs and post-inspections that he deemed applicable from the checklist.

NetRail also has a document for *Bromsarbeten på fordon* (Brake works on vehicles) (document 14.2, 1st edition). This document contains items involving brake works, a few of which are listed below.

- Carry out works according to order.
- Follow the checklist for each step.
- After work and inspection according to the checklist are completed, document and report.

NetRail has stated that they only after the incident have gained information of the AAE website with maintenance instructions. TX Logistik AG does however claim, that NetRail had been given information about the AAE website an also a unique login for website access, prior to the incident. This is purported to have taken place in 2010 - 2011, during a period when TX Logistik AG supported TX Logistik AB, as the latter lacked a fleet manager for some time.

TX Logistik AB has stated that they do not conduct any special inspection of how NetRail carries out maintenance and fulfils safety requirements in the agreement, but assume that the agreement is adhered to.

SHK has found no information regarding operations on pneumatic parts of the brake system in the agreement. Nor has SHK found any information in the agreement relating to requirements for follow-up, inspection or risk management. The agreement does not contain any of the requirements pursuant to TXF 7.4 mentioned above. TXF 7.3, which contains maintenance instructions, is not mentioned in the agreement with NetRail.

TX Logistik AB has stated that they consider the maintenance conducted by NetRail not to be covered by the requirements that are applicable to entities in charge of maintenance in accordance with Regulation 445/2011.

Procedures for deceleration checks and brake tests

TX Logistik AB has established procedures for deceleration checks and brake tests in collaboration with the Association of Swedish Train Operating Companies. These procedures are described in TXF 9.1.500 "*Bromsföreskrifter*" (Brake Regulations), 5th edition, and are used together with JTF, appendix 11.

Section 10 of TXF 9.1.500 "*Kontroll av broms till och broms loss för fordon med normal tryckluftbroms*" (Checking brakes on and brakes off for vehicles with normal pneumatic brakes) provides the following instructions.

> *Brakes on:*
> *The check is carried out by pressing with the foot or using an appropriate tool and checking that the brake blocks engage the wheels with force.*
>
> *On a two-axle wagon, it is normally sufficient to only check one of the axles. However, if the wagon has double brake cylinders, both axles must be checked.*
>
> *On wagons with bogies, at least one axle of each bogie must be checked.*
>
> *Brakes off:*
> *The check is carried out by pressing with the foot or using an appropriate tool and checking that the brake blocks on all axles are movable.*

In the case in question, the vehicle unit was divided on two tracks, 12 wagons on track 4 and 6 wagons on track 54. The engine driver arrived and connected the engine to the wagons and replenished the air. The brake tester went out after about 15 minutes to start the brake test. He asked the driver to apply the brakes and went down along the wagons on track 4. He discovered that the angle cock between two wagons was closed, which he reported to the driver. He then opened the angle cock and asked the driver to charge the system and then brake again, whereby the brakes engaged. The brake tester then continued with the rest of the wagons. He and the driver then shunted over the wagons from track 54 and also carried out the same tests on them. Nothing abnormal was noted. He stated that, with the experience he has, he should have noticed if something was not as it should. If that had been the case, he would have reported it to the driver. The brake tester has stated that he was not familiar with the details in the instruction regarding how the brake test was to be conducted, but based the implementation of the test on his experience. The brake tester conducted these tests in slightly different ways: at times he would push down on the brake block with his foot to see that it was applied with force, and at times he only looked to see that the blocks were in contact. He has not been able to remember in detail how he performed the test on the day in question.

The agreement between TX Logistik AB and Interlink Logistik AB states that TX Logistik AB is to provide training and continuing training for Interlink personnel, which they have done. After the incident, Interlink Logistik has received the following instructions from TX Logistik AB:

No cycling is allowed during brake testing
Kick every other wagon
Kick all the brake blocks on the last wagon
Release "a lot of air on the last wagon"

According to Interlink Logistik, this means that it takes 15–20 minutes longer to complete the brake test, but they resolve this by having the railway undertaking bring the vehicle unit earlier.

TXF 9.1.500, section 11 "*Retardationskontroll*" (Deceleration check) states the following.

In the event that the JTF regulations require a deceleration check, but no suitable location to perform such a check can be found sufficiently soon, the driver is to test brake the train unit when it is suitable to do so.

Note: The driver decides independently how to interpret "sufficiently soon", taking into consideration the occurrence of main signals etc. on the train's route where the train may have to stop.

Test braking is done as operational braking, which is continued for as long as the deceleration is clearly noticeable.

If the driver perceives the braking action to be worse than expected, the train unit must be stopped and the cause investigated.

When a suitable location for a deceleration check is found, this is to be carried out even if test braking has taken place earlier.

During an interview with the driver, it became apparent that the driver was unaware of TXF 9.1.500 "*Bromsföreskrifter*" (Brake Regulations). The TX Logistik AB document TXF 4.2.1 shows that there must be 56 hours of theoretical training on company-specific regulations and procedures. The training column of the driver's time report shows that two hours of theoretical training and 18 hours of line training were held with the driver in May. According to TX Logistik AB, the safety manager and the instructor still made the assessment that the driver had the knowledge required in accordance with TXF 4.2.1.

During the interview with the driver, it also emerged that test braking is not perceived to be suitable on an upward slope. The driver usually conducts the deceleration check in Bjuv, as the track levels out after the home signal to Bjuv.

2.3.3 Entity in charge of maintenance Ahus-Alstätter Eisenbahn AG

Ahus-Alstätter Eisenbahn AG (AAE) is the entity in charge of maintenance for, and also owner of, the wagon in question. AAE is based in Switzerland and was certified as the entity in charge of maintenance by SCONRAIL AG on 31 August 2012.

As mentioned above, the AAE website contains maintenance documentation for the wagon. These documents are set up in the form of modules for various parts or areas of the wagon. Module 22 contains an appendix 4, which deals with the measure "Separation of the wagon", where the hose is included as one part, but there is no specific instruction in this module regarding how the hose is to be fitted.

On 1 December 2008, AAE updated the maintenance documentation quality requirements due to similar events that had occurred in Norway and Germany, which could indicate a general problem for this type of wagon (see section 2.6). Since December 2008, the document (appendix 1 of TSO[7] Module 2) contains requirements for the hose to be inspected so that it has the right form, is not twisted or folded. According to AAE, this information was sent to TX Logistik AG in 2008. According to AAE the Module 2 should be used on the occasion of so called 'Servicing' which is a preventive maintenance measurement to increase the availability of the wagon.

In March 2009, AAE produced a further working instruction, which was distributed internally within AAE and was also sent to all authorised workshops that carried out maintenance on AAE's wagons, as well as to all AAE clients that, like TX Logistik AG, carried out maintenance on the wagons on their own responsibility. The document "Special wagon investigation on the articulated wagon of the AAE" was distributed to TX Logistik AG in German and Italian in 2009. The information provided to TX Logistik AG included information on the problem, its consequences and how to manage inspections and take measures. The document shows that at each inspection, preventive maintenance, overhaul, remedial maintenance or run-through prior to changing lessees, the following visual inspection is to be carried out:

- *That the hose has the correctly bent form and position.*
- *That the hose is not in contact with surrounding parts.*
- *That the hose has not been distorted, twisted or broken.*

To complete the inspection, the protective spiral must be pushed away to an end position in order to discover if the hose is distorted, twisted or broken.

AAE has stated that the document "Special wagon investigation on the articulated wagon of the AAE" was intended as an one time check, not for use after every repair.

As regards the updated requirements in the maintenance documentation, TX Logistik AG has stated that they forwarded this information to the then safety manager of TX Logistik AB. SHK has not been able to find this information in TX Logistik AB's current safety management system. TX Logistik AB has in turn stated that this is regulated through the agreement with NetRail. However, SHK has not found

[7] Technical Specification Operations. AAE´s rulebook for maintenance.

any such information in the framework agreement regarding freight wagon maintenance. The AAE website referred to in TX Logistik AB's safety management documentation for vehicle maintenance of freight wagons leased from AAE (TXF 7.3) is not mentioned in the agreement with NetRail.

2.3.4 Supervision

The Swedish Transport Agency

In the autumn of 2014, the Swedish Transport Agency carried out an inspection of TX Logistik AB, which resulted in an order to develop an overhaul plan and to document procedures for the contents and follow-up of entered agreements, as well as procedures for information exchanges between the company and any hired contractors.

The Swedish Transport Agency uses three types of audits. Type R1 is performed through a letter and does not involve verifications on site. In type R2 certain parts of a company´s safety management system is inspected. Type R3 is a system audit where the entire safety management system is audited. R2 and R3 include visits on site and random verifications. This inspection was of audit type 2, and therefore did not cover the entire safety management system of TX Logistik AB.

At the inspection, the Swedish Transport Agency did not verify whether TX Logistik AB fulfils the requirements set out in Commission Regulation (EU) No 1078/2012 of 16 November 2012 on a common safety method for monitoring to be applied by railway undertakings, infrastructure managers after receiving a safety certificate or safety authorisation and by entities in charge of maintenance. On the other hand, the Swedish Transport Agency did inform TX Logistik AB during a meeting that the upcoming five-year review of TX Logistik AB's licence in the autumn of 2015 would include the Agency verifying the implementation of Regulation 1078/2011.

AAE

In the autumn of 2013, AAE carried out an inspection of TX Logistik AG. This involved AAE asking questions regarding the documentation of everyday maintenance and the monitoring of subcontractors. TX Logistik AB was not involved in the inspection.

2.4 Operative measures

SHK has not found it relevant to investigate operative measures, such as traffic management measures, as they are not deemed to have affected the sequence of events.

2.5 Work environment and health

2.5.1 Working hours of the personnel involved

To gain an overview of the distribution of working hours, SHK has reviewed the working hours of the driver, the brake tester and the me-

chanic for the two weeks before, and until the time of, the incident. Nothing has been found that is deemed to have influenced the incident.

2.5.2 Medical and personal circumstances

The driver, the brake tester and the mechanic have undergone the prescribed health inspections without remark.

2.5.3 Other work environment factors

Not investigated.

2.6 Previous incidents of a similar nature

The Accident Investigation Board Norway has previously investigated an incident on Hovedbanen Strømmen on 07 March 2008 which has certain similarities with this incident. The hose became twisted following maintenance of a similar type of wagon. The incident concerned wagon Sdggmrs 33 68 4955 117-9 which is the same type of wagon as Sdggmrs 37 80 4993 805-3. The incident occurred 13 days after the wagons were returned from their overhaul at SweMaint in Göteborg and SweMaint reported this to AAE and informed its own personnel.

The Accident Investigation Board Norway issued two recommendations based on the incident. The first concerned whether the applicable regulations for brake testing are sufficient and have been applied as intended. In the second, the Norwegian Railway Authority was recommended to check that railway undertakings that hire in rolling stock ensure access to necessary documentation for safe use and maintenance of the wagons, and that experience is passed on to the owner of the stock and the supervisory authority.

After the incident in Norway, AAE modified the hose with two white strips down the length of the hose which are intended to help identify when the hose becomes twisted during mounting. According to AAE, the new hose shall be replaced during planned overhauls when the hose's serviceable life has been reached, which is 12 years.

AAE instructed its field engineers and CargoNet to perform a visual inspection of other wagons of the same type. As a result of the incident occurring in connection with CargoNet Norge and Green Cargo purchasing a number of wagons of the type in question from AAE, Green Cargo has since this incident mounted placards on each wagon and introduced instructions in its maintenance documentation specifying that the hose may not be twisted.

According to information from AAE, a similar event has also occurred in Germany. On 15 July 2008, a driver on a train from Nürnberg to Mannheim discovered that the brakes were sluggish and requested permission to stop the train on a siding.

The incident involved wagon Sdggmrs 31 84 4955 677-4, which is also a hinged freight wagon but newly produced. The wagon came straight from the manufacturer and was on its way out to the customer. It came to light that the manufacturer of the hose had modified the design with a thinner rubber wall. As the manufacturer was unable to answer when these modified hoses were first installed, all 317 wagons built thus far were inspected and 37 of the hoses were replaced. The wagon in the case now in question did not have the modified hose.

3. ANALYSIS AND CONCLUSIONS

3.1 Fundamental aspects of the sequence of events

When the train was to brake in preparation of the meeting in Bjuv, the brakes in the wagons behind wagon 3 engaged so slowly that the train could not be stopped within the expected stopping distance. The explanation for this is that the flow area in the hose that transfers the main line to the brake system in the middle bogie of wagon 3 had been reduced due to a twist in the hose. It was thus not possible for sufficient air for normal engagement of the brakes to pass through.

Questions that have arisen during the investigation principally concern why the hose was removed, how it was refitted, which post-inspections were performed and what these are able to detect, which instructions were available for handling the hose and how information has been conveyed between different actors.

In the case in question, the agreements on the leasing of the wagon and maintenance were drawn up before EU Regulation 445/2011 entered into force and had also not been updated thereafter. SHK has therefore chosen not to further examine the application of the ECM requirements, but has focused on relevant parts of the railway undertaking's safety management in the present investigation.

In accordance with the applicable agreements, TX Logistik AB has taken responsibility for continuous remedial maintenance and does not need to communicate this work to the lessor. The maintenance contractor hired by TX Logistik AB is not authorised by AAE, which means that information on and management of NetRail is controlled entirely by TX Logistik AB via their safety management. This also means they are responsible for ensuring information from AAE reaches the contractor.

3.2 Repairs

3.2.1 Conditions

The competence of NetRail's mechanics was not specific to the wagon type; it was of a general nature, based on general wagon and brake systems training. NetRail also used its own maintenance documentation which was not downloaded from the website where AAE makes

its instructions available since Netrail has stated that they did not have knowledge of the website before the incident. NetRail's maintenance documentation contained some general instructions stating that compressed air hoses must not be mounted with sharp bends or folds, but no specific instructions for handling the type of hose concerned here. The general instructions were not to be found directly in the checklist but in the accompanying 84 pages long maintenance document.

TX Logistik AB's safety management system expressly stated that for maintenance of AAE-owned wagons, AAE maintenance regulations shall be used, as well as instructions on where these maintenance regulations can be found. However, TX Logistik AB did not relay this information to NetRail; neither in the agreement nor otherwise, despite it being clear in the agreement between TX Logistik AB and NetRail that TX Logistik AB is responsible for ensuring that NetRail receives the correct maintenance regulations. In the view of SHK, this must be considered a serious shortcoming in the application of the safety management system which entailed that the conditions for NetRail and its mechanic to perform correct maintenance work were not optimal.

TX Logistik AG, who lets the wagon in question to TX Logistik AB, has given statement that they have informed NetRail about the AAE website a number of years before this incident. Whether such information was passed on to NetRail or not, NetRail did not use the maintenance instructions published on the website at the time of this incident.

3.2.2 Execution

The hose was removed in order to gain access to the pressure tube for the brake cylinder in the middle bogie in order to rectify an air leak in a pipe coupling. As can be seen from Figure 2, it is otherwise difficult to access the mounting. It is therefore understandable that the hose was removed. There were no specific instructions in NetRail's maintenance documentation regarding how the hose should be handled in this type of repair work.

After examination of the hose, SHK makes the assessment that the present constriction of the hose cannot arise spontaneously, nor will this condition be significantly affected by the movements of the wagon if the hose is not already twisted from the outset. The conclusion is thus that the hose was twisted when it was refitted and was not appreciably affected by the vehicle's motion. It has not been possible to establish with certainty exactly how much the hose had been twisted and how limited the air flow has been.

If special attention is not exercised, the hose may become twisted during mounting, for example when it is retightened. Detecting a twist in the hose is made more difficult by the fact that it is covered by a pro-

tective spring which follows the motion and conceals the rubber hose. This may explain why the mechanic did not detect the twist.

The difficulty in this has also been noted by AAE. When installing new hoses, hoses with two white stripes are now used in order to facilitate a visual inspection.

3.2.3 Post-inspection

After any maintenance activity that may have affected a component or system that is important to traffic safety, a function check should be performed as a matter of course. This is applicable irrespective of whether the system or component in itself was worked on, or if it was a matter of removing one part to get access to another.

In the case at hand, the proceedings were governed by NetRail's own instructions (NR-455-400-1), including an appendix, #4, *Brake examination* which listed check points after maintenance works on the braking system. This list of check points does not, however, give proper guidance to the mechanic for choosing which check points to carry out and record for the different types of repairs that may be performed. One such point is the "air flow check" on the train pipe. This check has not been carried out, even though the train pipe was affected when the hose in the articulated joint was removed. Neither the maintenance instructions themselves nor the check list (the appendix) suggests the need for checking the proper function of the train pipe after working on it. The available equipment where this repair took place could not be used for this check.

In these maintenance instructions there were general instructions about fitting and routing of compressed-air hoses (sharp bends, twists and kinks to be avoided etc). This particular hose was not mentioned though, despite the fact that its function is crucial to the entire braking system and that the construction with the tightly wound coil spring makes it difficult to inspect visually, to see if a bend or kink has occurred in it, when fitting it to the wagon. SHK is of the opinion, that an air-flow check on the train pipe could have revealed the reduced air flow in the wagon, which led to the poor brake performance of train 44660.

AAE, which is the ECM for this wagon, has not issued any particular fitting instructions for this hose, but following similar incidents they amended the maintenance instructions for the wagon type so that they came to include a few check points regarding its shape and condition. Additionally, AAE issued in 2009 a special instruction for inspecting all wagons for problems with the hose, to be carried out in conjunction with the next upcoming maintenance activity. That particular instruction mentions that the protective spiral should be moved to facilitate visual inspection of the rubber hose and it was to ensure that no hoses were mounted with a twist. This, however, was intended as a one-time activity and the instructions were not made available for general

maintenance purposes. Had there been a fitting instruction available, that included the details mentioned above, the kink in the hose, the incident may have been averted.

According to SHK, there may be good reasons to consider attaching signs to these wagons, in the area of the articulated joint, with a cautionary text about the importance of fitting the hose in the correct way, thus minimising the risks involved. Green Cargo AB has done this.

3.3 Brake test, deceleration checks and test braking

3.3.1 Brake test

One question is why the constriction in the hose was not noticed in the subsequent brake test.

The purpose of the brake test is only to ensure that it is possible to operate the brake from the engine and that it is connected in the entire train unit. The purpose is not to ensure the brake's efficiency or establish its operation time. In principle, it is possible to detect obstacles to the airflow in the train pipe during a brake test if for example, the train pipe pressure seems to drop more rapidly than expected when brakes are applied, or it seems to be taking an unexpectedly long time for the brake to engage or release. If the train unit is long, however, it takes a certain amount of time simply to go along all the wagons and perform checks of the brakes. A constriction in the train pipe can result in the brakes engaging very slowly in the part of the train “beyond” the constriction, but already at a very low brake pressure the braking mechanism will press the brake blocks against the wheels, though not with great force; it is thus not possible to determine that the brake is properly applied simply by performing a visual check of the brake blocks' position. A check must thus also be made to ensure that the blocks engage the wheels with force. This is also something that is described in TX Logistik AB's brake regulations (TXF 9.1.500) provided to Interlink Logistik, where it is specified that the check is carried out by pressing with the foot or using an appropriate tool and checking that the brake blocks engage the wheels with force. Releasing the brake will also take longer than usual if there is a significant constriction in the train pipe. The opportunities for noting actively such phenomena and drawing relevant conclusions when conducting a basic test may however be limited, as it involves personal judgements of discrepancies, and some of the steps are heavily depending on the length of the train involved.

The brake tester has stated that he was unaware of the exact content of the instructions regarding how the brake test was to be conducted, but based the implementation of the test on his experience. He has not been able to remember in detail how he performed the test. However, SHK notes that after the incident, the railway undertaking has issued new instructions on how to carry out the brake test. The wording of these new instructions gives the impression that shortcomings have

been identified in terms of how the brake tests were previously performed in practice.

3.3.2 Deceleration check

The deceleration check cannot be considered a general barrier against incidents due to poor braking action, as it must be conducted at a suitable location with proper conditions, and this can lead to the brakes having to be applied in a real situation, i.e. when the brakes are needed as in the case in question, before the check had yet been carried out. According to the Swedish Transport Agency, the barriers that are to catch any deficiencies in brake function, are the checks that are conducted before the wagon is returned to traffic operations and the brake tests that are prescribed.

3.3.3 Test braking

The internal regulations of the railway undertaking state that test braking is to be carried out if a deceleration check is not possible. However, it is up to the driver to determine when a deceleration check is not possible. In this case, the driver was not aware of the internal regulations and is also of the opinion that test braking would not have been completely suitable on an upward slope.

3.4 Implementation of the safety management system in general

In their safety management documents, TX Logistik AB describes their systematic work with risk analyses, follow-up and audit. However, this investigation indicates that these have not been fully implemented.

TX Logistik AB has not carried out any risk analyses to identify and manage risks based at the hired contractors NetRail and Interlink with the explanation that they have employed these contractors for a long time. Nor has TX Logistik AB carried out any audit or follow-up of the operations of NetRail or Interlink before the incident. In addition, the agreements do not contain the special items that must be included, in accordance with the TX Logistik AB safety management system, such as requirements regarding overhaul, system requirements for internal audits and the right of TX Logistik AB to carry out audits of the contractor (TXF 7.3 and 7.4). The agreement with NetRail contains none of the above-mentioned items, nor any description of how document management pertaining to maintenance documentation is to be handled and monitored. The agreement contains no reference to the TX Logistik AB management documents TXF 7.3 or 7.4. Nor does the agreement contain any description of exactly what parts or which type of maintenance NetRail may perform on the wagon. According to TX Logistik AB, it is instead implied that NetRail may carry out any maintenance on the wagon type in question.

The lack of risk analyses, audit and follow-up, as well as a clear regulation of this between the agreement parties, has meant that the ability

of the railway undertaking to identify deviations and risks in the work conducted by hired contractors has been very limited, thus constituting a difficulty for TX Logistik AB to manage and check the maintenance performed by these contractors.

3.5 Supervision

In the autumn of 2014, the Swedish Transport Agency carried out an inspection of TX Logistik AB, which included audits and follow-up of contractors. In the view of SHK, the results of this investigation point to the value of supervision and the importance of exercising checks not only of the existence of documented safety management, but also of how this is implemented and followed up.

There also seem to exist a need for reviewing if the existing agreements, between AAE and TX AG, TX AG and TX AB, and TX AB and NetRail AB complies with the requirements in regulation 445/2011. According to the regulation the certification body shall conduct surveillance at least once a year of those entities in charge of maintenance it has certified, to verify that the entities still satisfy the criteria set out in Annex III.

3.6 Findings

a) To obtain access in order to rectify an air leak, a hose in the train pipe was removed. After it had been removed, the hose was refitted in such a manner that it became twisted, which reduced the airflow in the hose.
b) The post-inspections carried out after rectification of the leak did not detect any reduced airflow in the hose.
c) The entity in charge of maintenance (ECM) had updated their maintenance instructions due to previous similar incidents in Norway and Germany.
d) The maintenance contractor did not use the wagon-specific maintenance instructions issued by the ECM, when working on the wagon.
e) Neither the railway undertaking nor the ECM had provided clear guidelines for the fitting of the hose to the wagon and the post-inspections that would be required after having to remove and refit this component.
f) The twist reduced the airflow, which led to very slow application of the brakes in the train.
g) The reduced air flow was not detected during the brake test carried out before departure.
h) The deceleration check that is to be performed when the train is moving had not yet been carried out when the incident occurred.

4. OTHER OBSERVATIONS

None.

5. CAUSES

The immediate cause of the incident was the abnormal amount of time it took for the brakes to engage, which was due to a constriction of the train pipe main line in wagon 3.

The constriction occurred because a fixed hose coupling in the main line had been refitted in a way that introduced a twist in the hose which caused it to twist. During assembly, the hose became twisted in a way that affected the flow area. The constriction was not identified by the technical post-inspections, nor by the subsequent brake tests.

The underlying cause was that the maintenance contractor had not identified the risk that the hose might become twisted when re-fitting it to the vehicle, this in turn due to a lack of guidance, from the railway undertaking (RU) or the entity in charge of maintenance (ECM), regarding the correct procedure for fitting and performing a function check of the hose in question, in conjunction with repairs on the vehicle. Neither the ECM nor the RU had noted this state of affairs.

6. ACTIONS TAKEN

TX Logistik AB has carried out further training for Interlink Logistik AB personnel, where emphasis has been placed on the importance of following TXF 9.1.500 *"Broms"* (Brakes), item 10, which specifies how the brakes are to be checked.

NetRail AB has gone over their procedures for inspecting completed repairs.

In order to ensure that no serious mistakes are made when repairing wagons and performing brake tests, TX Logistik AB will further expand its internal monitoring programme.

AAE has resumed discussions with the manufacturer of the hose to see whether a better design solution can be found (such as having the steel spring support on the inside instead of on the outside). AAE is also working on a modification of the maintenance documentation, TSO module 22, in order to clarify the necessary tasks when separating and coupling the two halves of the wagon.

7. SAFETY RECOMMENDATIONS

Ahus-Alstätter Eisenbahn AG is recommended to:

- ascertain that any maintenance carried out on vehicles, for which they are the entity in charge of maintenance, is carried out in accordance with the pertinent instructions and, if the need is identified, highlight any particular hazards that may be associated with maintenance operations on vehicles or their subsystems (see section 3.2). *(RJ 2015:02 R1)*

The Swedish Accident Investigation Authority respectfully requests to receive, by **30 October 2015** at the latest, information regarding measures taken in response to the safety recommendations included in this report.

On behalf of the Swedish Accident Investigation Authority,

Mikael Karanikas Eva-Lotta Högberg