



## Preliminary statement – updated version.

Translation - the Danish version is the valid version

### IC4 train set passed signal in position "stop" at Marslev on 7 November 2011.

The preliminary recommendations in this statement are based on the data and facts now available.

The investigation of the incident made by Havarikommisionen (Accident Investigation Board Denmark) will be continued.

#### Information

On Monday 7 November 2011 at 15:55 the operator informed the railway unit of Havarikommisionen that train 47 had passed a signal at Marslev station at high speed and had stopped directly behind a freight train (G9233) brought to standstill at the subsequent the entry signal (I signal). Train 47 was IC4 train set (MG5627).

Havarikommisionen initiated an investigation of the incident.

#### Sequence of incident

After having passed Ullerslev station the engine driver observed "kør igennem" (passage) (2 green lights) on AM signal 2133 (automatic block signal on free line), i.e. it could be expected that there would be free passage of the next AM signal 2153. The train passed the ATC track magnet at the AM signal at 15:15:58. The ATC information stated a permitted speed of 180 km/h and free line 4000 metres ahead.

The next AM signal (2153) showed "kør" (drive) (one fixed green light showing that the next signal – here the AM signal 2173 – would be expected to show "stop"). The engine driver initiated a light braking at 15:16:34, approx. 220 metres before reaching the AM signal 2153.

When passing the ATC track magnet in front of AM signal 2153 at 15:16:38 the speed of the train was recorded to be 177 km/h, and the distance to the next signal was stated to be 2000 metres.

The brake force of the train was gradually increased until 15:17:01, where a full braking of the train was performed. An emergency braking of the train was performed at 15:17:08.

At 15:17:25 the train passed the AM signal 2173 in position "stop". As the wheels were blocked, it was not possible to determine the actual speed of the train. The speed is therefore calculated to be approx. 131 km/h at the time, when the train passed the ATC track magnet.

The train stopped at 15:18:00, 651 metres after the AM signal 2173 and 542 metres after the danger point. The train stopped 374 metres behind freight train G9233 ahead.

## **Investigations made by Havarikommissionen**

The train set applied about 2800 metres for braking from 180 km/h to standstill. Such slackening of speed should under normal circumstances be possible at a distance of less than 2000 metres.

### Surroundings/environment

As to the environment/rail conditions the weather was humid (misty/high atmospheric humidity, no rain). The air temperature was 8° C. The line is a heavily trafficked main line without any special slope-up or slope-down.

The incident took place during the leaf fall period. Around the place of the incident there were some trees, primarily on the north side of the track. However, no forest was found. On 8 November 2011 in the morning the line was inspected visually (from the driver's cab of another train), and a physical inspection was made on Friday 11 November 2011. Only a limited quantity of leaf fall was ascertained (few leaves) on or at the track.

### Traffic conditions

Marslev is daily passed by 45 - 50 trains from Nyborg to Odense.

Banedanmark (Rail Net Denmark) informed that there were 3 planned overtakings in Marslev that day and that according to the plan freight train G9233 was to be overtaken in Marslev.

Banedanmark has not received any messages concerning slippery rails on the line prior to the incident. Banedanmark has no recordings of irregularities concerning signals or tracks on the line immediately prior to the incident.

In connection with the inspection of the line around Marslev on 1 December 2011 coating of limited rail sections was indicated. The coating was manifested by water pearls on the top of the rail. This could be an indication of grease. Subsequently, samples have been taken from the rails. These samples have been analysed by Teknologisk Institut (Danish Technological Institute). The analysis results did not demonstrate any unexpected material on the rails. This e.g. means that there was no indication of grease, oil or lubricants.

As for freight train G9233 ahead, which had run on the same line immediately before train 47, no problems were established in connection with slackening of speed. However, attention is drawn to the fact that the freight train performed a slow slackening of speed towards the I signal to Marslev station and that the braking was initiated closer to the I signal. The freight train transported empty return packaging to Fredericia brewery. Both the locomotive and the wagons of freight train G9233 have subsequently been controlled, and no irregularities have been found which could explain the indications of the coating on the rails.

### Investigations of the train set

Immediately after the incident data of the logging systems of the train have been scrutinised. These data i.a. showed that the train due to whole/partial wheel blocking had not recorded the distance covered correctly. Between the AM signals 2153 and 2173, where the physical distance is 2000 metres, the DLU of the train has recorded that the train had covered a distance of 1400 metres. It was ascertained

that the magnetic rail brake of the train was disconnected (normal operation is not conditional on the magnetic rail brake being connected). Logging data of the incident still form part of the analysis work.

In the period 9 November 2011 - 11 November 2011 technical investigations were made (visual inspection and control of physical assemblies) of MG 5627 in DSB's workshop in Aarhus. The technical investigations did not reveal any defects and shortcomings explaining or making possible the sequence of incident on 7 November 2011.

From 16 November 2011 until 18 November 2011 a number of static tests were carried out. The tests i.a. included components and communication connections as to the function of the brake system of the train. The static tests revealed no defects or shortcomings explaining or making possible the sequence of incident on 7 November 2011.

After mounting of diagnostic, monitoring and soap equipment a number of dynamic brake tests were carried out on 2 December 2011 – 5 December 2011 on the test line between Vojens and Rødekro. The tests i.a. consisted in "speed-up" test from 120 km/h to 180 km/h on dry rails and on soapy rails.

Based on the UIC standard brake test (brake test on dry rails and on soapy rails) which normally forms the basis of approvals in respect of braking properties of rolling stock it was not possible to recreate abnormal brake sequences.

In order to induce a corresponding or a similar reaction as the one occurring in connection with the incidents on 4 and 7 November 2011 brake tests were performed on rails covered by oil with the purpose of simulating slippery rails with a coefficient of friction approaching zero. Approx. 2000 metres of the rails were covered by oil, and braking from 180 km/h was performed immediately hereupon. By brake tests on oily rails a braking distance corresponding to the braking distance in connection with the incident on 7 November 2011 could be recreated.

### **Similar incidents**

After the incident on 7 November 2011 it was established that an incident with an IC4 train set (MG 5643) had occurred on 4 November 2011 at Høje Tåstrup. In respect of braking conditions this incident reminds of the incident of 7 November 2011.

The investigation of this incident showed that also here the distance actually covered and the data recorded by the train differ. During slackening of speed the DLU of the train recorded that the train had covered a distance of 1019 metres instead of the 1418 metres physically and actually covered by the train.

The same static tests were made for MG 5643 as the ones made for MG 5627. The tests i.a. included components and communication connections as to the function of the brake system of the train. The static tests revealed no defects or shortcomings explaining or making possible the sequence of incident on 4 November 2011.

### **Supplementary brake tests on 10 and 11 January 2012**

On 10 and 11 January 2012 supplementary brake tests with another IC4 train set (MG 5660) than the train sets involved in the incidents on 4 and 7 November 2011 and with an IC3 train set (MF 5011) were carried out.

The brake tests were carried out in two phases:

1. Brake test on dry rails according to UIC standard brake test (limited part of UIC standard brake test).
2. Test on oily rails.

Re 1.

By brake test on dry rails abnormal brake sequences could not be recreated, neither for the IC4 train set nor for the IC3 train set.

Re 2.

Brake test on oily rails resulted in a braking distance corresponding to the braking distance in connection with the incident on 7 November 2011 for both IC4 (MG 5660) and IC3 (MF 5011).

IC3: By the brake tests (oily rails) with activated magnetic rail brakes where the difference between the distance recorded and the distance covered was biggest, the DLU of the IC3 train set recorded 2380 metres out of the 2396 metres covered.

IC4: By the brake tests (oily rails) with activated magnetic rail brakes where the difference between the distance recorded and the distance covered was biggest, the DLU of the IC4 train set recorded 261 metres out of the 2174 metres covered.

### **Revealed conditions**

In connection with tests and analyses the following conditions have been revealed concerning the brake system of IC4:

- the blocking system of the IC4 train set (WSP system) can under very slippery conditions not protect against whole/partial wheel blocking
- whole/partial wheel blocking will result in insufficient recording of the distance actually covered when braking under these special conditions and in missing recording of the actual speed
- whole/partial wheel blocking can result in the safety system (ATC) not being able to bring the train to standstill within the safety distance, i.e. before a danger point
- at the IC4 train set the serial connection between the TC and ATC is not established. A serial connection will i.a. ensure information to the ATC system in case of an acute reduction of the braked weight percentage (loss of braking ability) during braking
- fault in the Danish version (translation) of the English precaution for the fault indication text can have resulted in the magnetic rail brake having been disconnected in connection with the incident on 7 November 2011
- in connection with the incident in Marslev the wheel diameter of axle 5 (where the speed sensor for ATC is situated) was in the brake computer of the train recorded to be 860 millimetres. In the ATC system the wheel diameter was correctly recorded to be 849 millimetres.

### **Assessments / preliminary analyses**

Havarikommissionen has together with attached external experts analysed data from the incidents, the static and dynamic tests performed as well as information available about the individual components of the brake system of the train.

The wheel blockings recorded in the DLU of the IC4 train set from brake step 2 to brake step 8 relating to the slackening of speed in connection with the incident in Marslev can make possible that in some areas the rails have been very slippery.

The missing data of the safety system (ATC system) concerning the actually covered distance and the correct speed have resulted in the safety system of the train having released an emergency braking later in the brake sequence than was actually required.

If the safety system have contained valid data concerning the position and the speed of the train in connection with the incident on 7 November 2011, it would have resulted in the train, at a speed of 180 km/h and with a braked weight percentage of 170, having reached the ATC monitoring curve earlier and in the ATC sound indicator having given alarm approx. 170 metres before the AM signal 2173.

The disconnected magnetic rail brake of MG 5627 has contributed to the train passing the AM signal 2173 in position "stop" by 651 metres. The tests made show that in general an active magnetic rail brake can minimize the braking distance. This is also confirmed by test results from abroad.

The ATC system takes into account an eventually reduced braking ability as for instance on slippery rails. The safety factors of ATC system permit a reduction of the braking ability up to approx. 17 %.

### **Preliminary conclusion**

Havarikommissionen assesses that especially slippery rails combined with the functionality of the WSP system, disconnected magnetic rail brakes and the missing data (actual speed and distance covered) to the ATC system have been the most important causes of the incident on 7 November 2011.

### **Preliminary recommendations**

In the light of the observations made and the preliminary assessments Havarikommissionen recommends that Trafikstyrelsen (Danish Transport Authority) considers the conditions stated below in connection with putting IC4 into service again:

- that the wheel blocking system of the IC4 train sets (WSP system) under very slippery conditions cannot not protect against whole/partial wheel blocking
- that whole/partial wheel blocking will result in insufficient recording of the distance actually covered and the actual speed when braking under these especially slippery conditions
- that missing data to the ATC system about the actually covered distance and the actual speed can result in the safety system (ATC) not being able to react as expected.

### **Further investigations**

Havarikommissionen continues the investigation together with attached external experts, the operator, the supplier and sub-suppliers.