Railway Accident Investigation Unit

Ireland

INVESTIGATION REPORT

Fog signal activation in DART driving cab, Bray, 6th March 2012

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A	09/10/2013	Paragraph 69, Alsetex changed to Lacroix

Reader guide

All dimensions and speeds in this report are given using the International System of Units (SI Units). Where the normal railway practice, in some railway organisations, is to use imperial dimensions; imperial dimensions are used and the SI Unit is also given.

All abbreviations and technical terms (which appear in italics the first time they appear in the report) are explained in the glossary.

Descriptions and figures may be simplified in order illustrate concepts to non-technical readers.

Report preface

The RAIU is an independent investigation unit within the Railway Safety Commission (RSC) which conducts investigations into accidents and incidents on the national railway network, the DART network, the LUAS, heritage and industrial railways in Ireland. Investigations are carried out in accordance with the Railway Safety Directive 2004/49/EC and the Railway Safety Act 2005.

The RAIU investigate all serious accidents. A serious accident means any train collision or derailment of trains, resulting in the death of at least one person or *serious injuries* to five or more persons or *extensive damage* to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety.

The RAIU may investigate and report on accidents and incidents which under slightly different conditions might have led to a serious accident.

The purpose of RAIU investigations is to make safety recommendations, based on the findings of investigations, in order to prevent accidents and incidents in the future and improve railway safety. It is not the purpose of an RAIU investigation to attribute blame or liability.

Report summary

On the 6th March 2012 the 08:00 hours DART service from Greystones to Malahide was stationary at Platform 2, Bray Railway Station awaiting a driver change over. The relief driver entered the driving cab at 08:10 hours, intending to drive the DART to Malahide

As the driver put his bag on the floor of the driving cab, eleven of the twelve railway fog signals that he was carrying in the bag exploded. The driver sustained injuries to his hand and suffered some temporary loss of hearing. The interior of the cab was superficially damaged.

During the investigation it was found that the fog signal supplier had changed the fog signals supplied to Iarnród Éireann to a less robust fog signal. Iarnród Éireann had not been notified of this change and had not noticed the difference in fog signals until after the accident.

Although the immediate cause of the explosion of the fog signals could not be ascertained, the RAIU identified the following causal, contributory and underlying factors.

Causal to the explosion were the following causal factors:

- The Alsetex fog signals supplied to Iarnród Éireann, by Lacroix, were not as robust as the Lacroix fog signals requested by Iarnród Éireann;
- Iarnród Éireann did not notice that the Alsetex fog signals provided to them were not the Lacroix fog signals that were ordered.

The contributory factor identified was:

- The fog signals storage tube, designed by Iarnród Éireann, allowed the fog signals to impact on one another which may have caused them to degrade over time;

The underlying factors identified were:

- Iarnród Éireann did not risk assess the storage and transportation of fog signals outside of Central Stores;
- Iarnród Éireann had not introduced any training to staff in the handling of fog signals;
- Iarnród Éireann did not have a process in place for the checking of parts when they arrive at Central Stores.

The RAIU made three new safety recommendations, related to the occurrence, as follows:

- Iarnród Éireann should ensure that their procurement and quality control processes verify that goods received are of the correct specification as those ordered.
- Iarnród Éireann should introduce appropriate procedures and standards for the safe issue, storage and transportation of fog signals.
- Iarnród Éireann drivers should receive adequate training in the safe handling of fog signals.

Contents

The occurrence

Summary of the occurrence

1 On Tuesday 6th March 2012 at 08:10 hours (hrs) the DART service from Greystones to Malahide arrived at Platform 2, in Bray Railway Station, see Figure 1 for location of the accident. A driver change was scheduled and the relief driver made his way from the staff rest area to Platform 2.

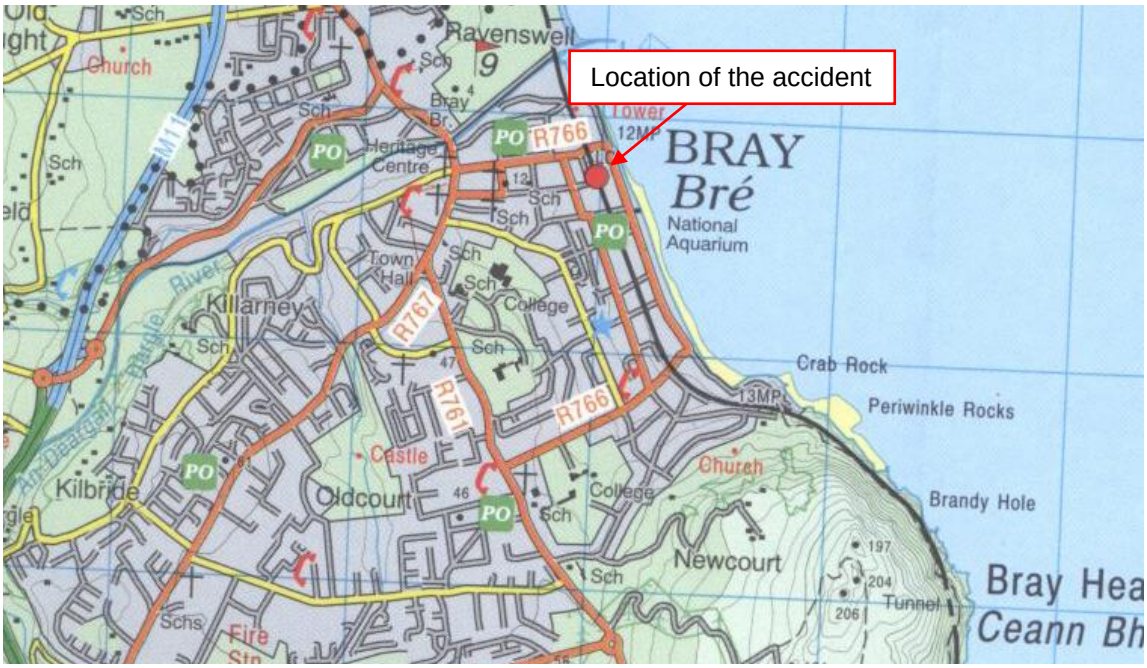

Figure 1 – Location of accident

2 Here he had a brief discussion with the driver coming off the train and he entered the driving cab, putting his leather driver's bag on the floor of the driving cab. As he did so the fog signals that were being carried in a container inside the bag exploded. The driver suffered injuries to his hand and suffered a degree of hearing loss due to his close proximity to the explosion.

3 The Emergency Services were quickly on the scene and initially the occurrence was declared a suspected crime scene by An Garda Síochána (Garda); and the Explosives Ordinance Department of the Defence Forces Ireland were tasked by the Garda to examine the scene and it was declared safe at 13:30 hrs. Subsequent enquiries by the Garda established that the explosion was not as a result of criminal act.

General description of the railway

Infrastructure

4 Bray Railway Station is 14 miles south of Dublin Pearse Station. Each platform is equipped with a signalling system that allows trains to use both platforms for arrivals and departures in both directions.

5 The railway line from Dublin Pearse Railway Station to Bray is double line. The track is flat bottom *continuously welded rail* (CWR) mounted on concrete sleepers in ballast. The Line is fitted with Overhead Line Equipment (OHLE) to supply electricity to DART trains travelling between Malahide and Greystones. No factors in relation to the condition of the track or the OHLE were found to have contributed to the occurrence.

Rolling stock

6 The train involved was the 08:00 hrs DART service (train identification number E805) from Greystones to Malahide. The service was operated by a four carriage 8600 DART *Electrical Multiple Unit* (EMU) manufactured by Tokyu, consisting of carriages 8625, 8525, 8526, and 8626. Carriage 8625 was the leading carriage at the time of the occurrence. The four carriage unit is 81 metres (m) in length with a combined weight of 143 tonnes. No factors in relation to the condition of the rolling stock were found to have contributed to the occurrence.

Signalling and communications

7 The double track route from Pearse to Bray is signalled using three and four aspect *colour light signals*, controlled by the suburban signalman based in Central Traffic Control (CTC). *Track Circuit Block* regulations apply to this route.

8 The means of communication between train drivers and the suburban signalman on this route is via train radio. Lineside signal telephones are also available. No factors in relation to the condition of the signalling and communications systems were found to have contributed to the accident.

Operations

9 The Train Driver was a qualified driver.

Fatalities, injuries and material damage

Fatalities and injuries

10 The driver suffered superficial cuts and abrasions to his left hand, and a slight temporary hearing loss due to the pressure of the explosion. His jacket and outer clothing were scorch damaged.

Material damage

11 The rear wall, floor and ceiling (see Figure 2) of the interior of the driving cab were damaged.

12 The leather bag, carried by the driver, was badly damaged as were the contents consisting of signal flags and rule books, see Figure 3.

Figure 2 – Damage to driving cab ceiling

Figure 3 – Damage to driver's bag

Parties and roles involved in the occurrence

Parties involved in the occurrence

13 Iarnród Éireann (IÉ) is the *railway undertaking* (RU) that owns and operates mainline and suburban railway services in Ireland. IÉ is also the railway *infrastructure manager* (IM), managing the design, installation, testing, inspection, maintenance, renewal and operation of the railway's physical assets. The IÉ departments associated with this occurrence are the:

- Procurement Department – Responsible for the ordering of materials;
- Central Stores – responsible for the storage and issuing of plant and equipment.

14 Alsetex are a manufacturer of fog signals approved to French railway Standard CT444.

15 Etienne Lacroix (who will be referred to as Lacroix for the remainder of this report) is a pyrotechnics manufacturer (who bought Alsetex in 2006) who had been supplying IÉ with the fog signals since 1997. Prior to 1997, Ruggeri (who were bought by Lacroix in 1997) had been supplying the fog signals to IÉ.

Roles involved in the occurrence

16 The roles involved in the accident are as follows:

- Train Driver – An employee of IÉ who was trained and competent to drive trains.

External circumstances

17 The weather at the time of the incident was recorded by Met Éireann as cloudy with a temperature of 5°C degrees Celsius and with a wind speed of 10 kilometres per hour (km/h).

RAIU Investigation

RAIU decision to investigate

18 In accordance with the Railway Safety Act 2005 the RAIU investigate all serious accidents. Given the unusual nature of this occurrence and given that under slightly different conditions, this occurrence may have led to a serious accident where there would have been potential for fatalities, serious injuries and extensive damage a decision was made to investigate under article 19 (2) of the Railway Safety Directive (EC, 2004).

Scope of investigation

19 The RAIU must establish the scope of the investigation to ensure that only pertinent information is recovered and reviewed. Therefore, for this occurrence, the RAIU have defined the following scope:

- Establish the sequence of events;
- Establish, where applicable, the *immediate cause, casual factors* (CF), *contributory factors* (CoF) and *underlying factors* (UF);
- Examine the relevant elements of the safety management system;
- Examine any other significant safety deficiencies identified as a result of this investigation.

Investigation and evidence

20 The RAIU were notified of the incident at 08:25 hrs on the 6th March 2012 and attended at Bray Station at 09:00 hrs. At the time of arrival of the RAIU, the occurrence site was being treated by the Garda as a potential crime scene; therefore the Irish Defence Forces Explosives Ordnance Department were in attendance to deal with any unexploded fog signals. The RAIU were unable to access the scene until it declared safe at 13:30 hrs.

21 Subsequent enquiry by the Garda established that it was not a criminal act and at this stage in agreement with the Garda, and the Health and Safety Executive that the RAIU would take the lead to investigate the cause of the accident. During the on-site and off-site investigation the RAIU collated and logged the following evidence:

- Photographic record of accident site;
- Witness testimonies from parties involved in the occurrence;
- Other testimonies from members of the RU with information pertaining to the accident;
- IM and RU standards, procedures and other documentation;

- Standards, procedures and documentation from other relevant bodies;
- Design specifications for the fog signals;
- Testing of the fog signals.

Evidence

The Fog Signals

General description

22 A railway fog signal is a small metal device containing a limited quantity of explosive. In use, the device is placed on the running surface of a rail such that any rail-mounted vehicle passing over it would cause it to explode, and in so doing alert the driver of the vehicle to a hazard on the line ahead.

23 IÉ use clip type fog signals, which clip directly onto the rail.

24 Fog signals manufactured by two different suppliers were involved in this occurrence. Fog signals from Lacroix and Alsetex, see Figure 4 and Figure 5.

Figure 4 – Lacroix branded fog signal

Figure 5 – Alsetex branded fog signal

Fog signal design

25 These fog signals are designed to meet the criteria set out in CT444, a French Standard that refers to fog signals. The standard requires that the signals must not detonate (activate) when 1 kg is dropped from 1 m; and detonate when 5 kg is dropped from 2 m, see Figure 6.

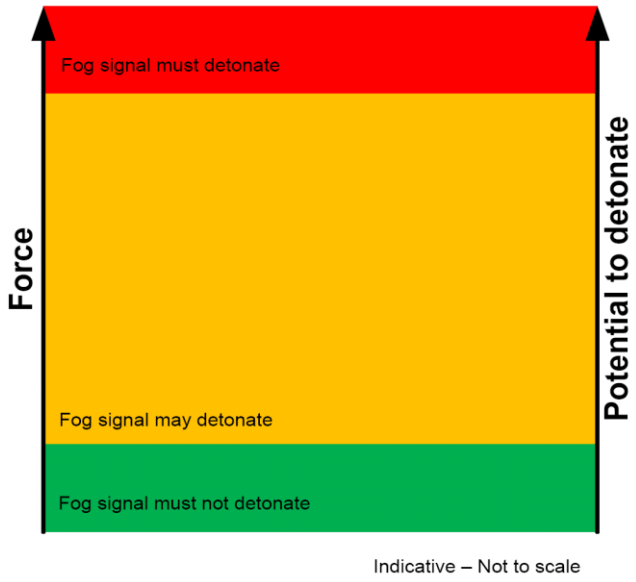

Figure 6 – CT444 criteria for activation of fog signals

26 The Lacroix fog signal has a metal surround and contains a glass marble which is enclosed with flash powder. Additionally the Lacroix design has a rubber membrane between the metal base and the explosive mixture. See Figure 7 for the design of the Lacroix fog signal.

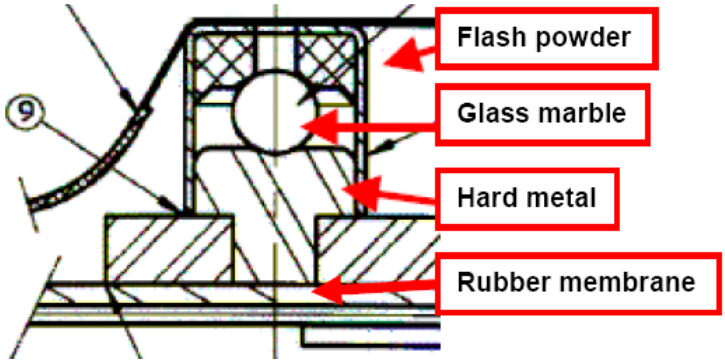

Figure 7 – Design of the Lacroix fog signal

27 When pressure is applied to the outer metal casing by the wheels of a train the glass ball deforms and breaks on the hard metal. This ignites and generates a flame which in turn ignites the surrounding flash powder, see Figure 8. The ignition of the flash powder produces a loud bang.

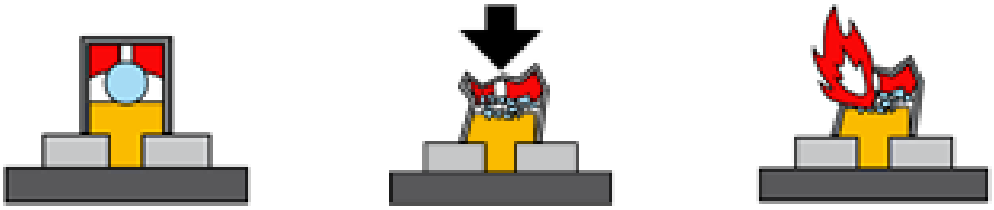

Figure 8 – Activation process for Lacroix fog signal

28 The Alsetex fog signal has a metal exterior and contains two small plastic cylinders capped at both ends in the centre of the device. The top cap has a small scraper attached and the bottom cylinder contains pyrotechnic materials. These plastic cylinders are surrounded with flash powder, see Figure 9. The Alsetex has a rubber O-Ring around the edge of the device between the cap and the base of the fog signal.

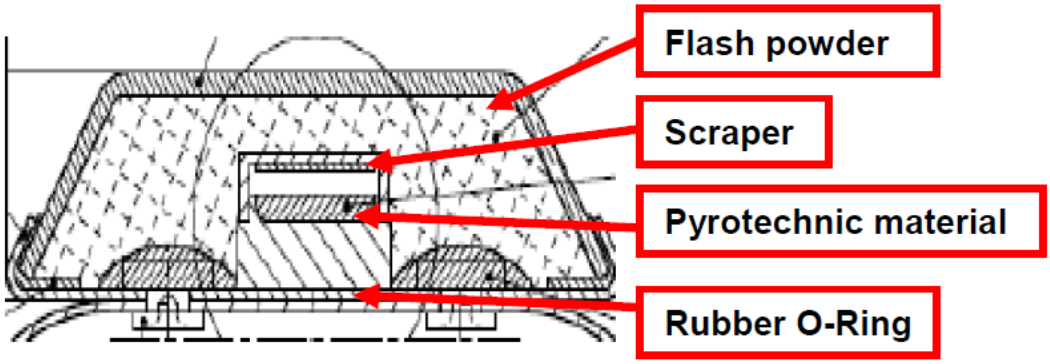

Figure 9 – Design of the Alsetex fog signal

29 When pressure is applied to the outer metal case the case deforms, the two plastic cylinders deform and the scraper comes into contact with the pyrotechnic material. This generates a flash with ignites the flash powder, which in turn produces a loud bang, see Figure 10.

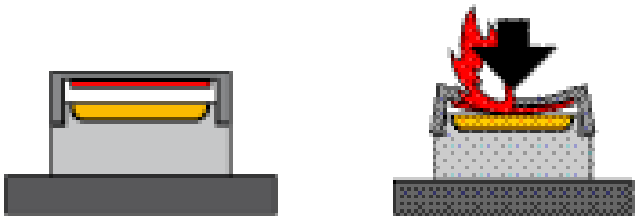

Figure 10 – Activation process for Alsetex fog signal

Fog signal procurement

30 In the 1960s IÉ purchased fog signals from Ruggeri, France. Ruggeri was purchased by Lacroix in 1997, and IÉ continued purchasing the fog signals. IÉ ordered the fog signals, from Lacroix, using *SAP software* which required that the Lacroix factory part number, IAA1007, be entered. In general, the fog signals are ordered when stocks are running low and normally this is in batches of 5,000.

31 The factory part number identification has never changed, since 1997, and IÉ routinely ordered a supply of fog signals in 2010, using factory part number IAA1007. The order was processed in the normal way by Lacroix; however, Lacroix had now purchased Alsetex and supplied IÉ with the Alsetex fog signals instead of Lacroix fog signals. Both fog signals look very similar externally, see Figure 4 and Figure 5, but have different internal design features.

32 IÉ received the Pyrotechnic Safety Data Sheet (PSDS) with the consignment which carried the same factory part number, IAA1007, as the Lacroix PSDS, see Figure 11 and Figure 12. The PSDS have a similar layout, and both identify the manufacturer.

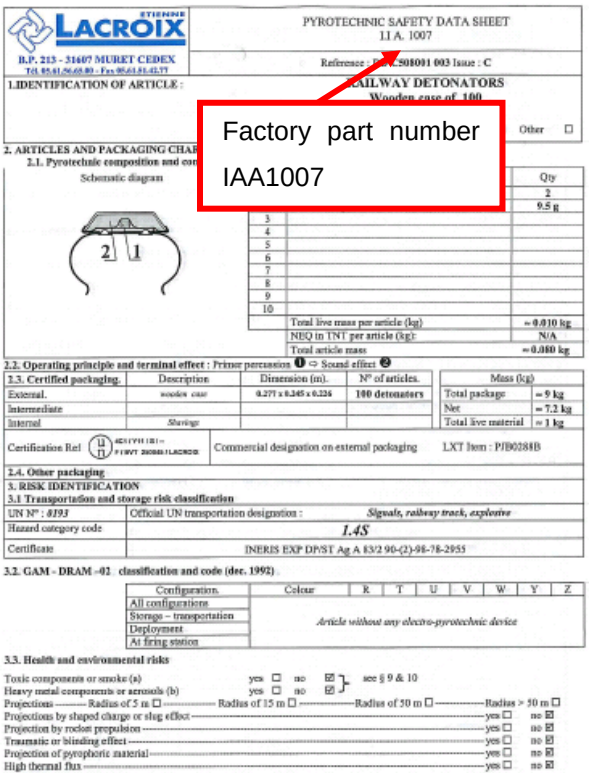

Figure 11 – Lacroix PSDS

Figure 12 – Alsetex PSDS

Transport and storage of fog signals

33 The fog signals are transported to Irish Rail Central Stores in Inchicore within a United Nations (UN) approved container designed and approved for this type of pyrotechnic which is categorised as a Class 1.4 explosive, see Figure 13. These boxes are made of wood construction and contain one hundred fog signals with sawdust chippings between the fog signals. The boxes are labelled 'Lacroix'. Central Stores is licensed by the Local Authority Fire Officer for the storage of the fog signals and all transportation from this location is done in compliance with the European Regulations for the transportation of dangerous goods by road.

Figure 13 – Fog signal storage boxes

Issuing of fog signals to drivers and their storage

34 The fog signals are issued to drivers directly from these boxes. When inspections identify out of date signals, they are exchanged on a one for one basis. There is no formalised procedure for the issuing of the fog signals.

35 The fog signals are issued to drivers in a batch of twelve. They are stored by stacking them (Figure 14) inside a purpose made stainless steel tube with removable plastic covers at either end, see Figure 15. The stainless steel tube weighs 1,478g; the twelve fog signals clipped together weigh 793g.

Figure 14 – Twelve stacked fog signals

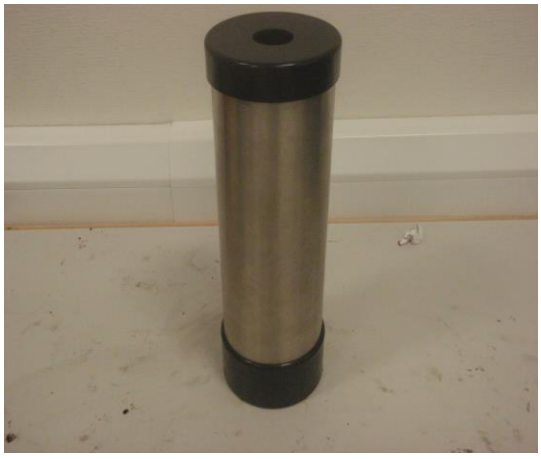

Figure 15 – Stainless steel tube with cap

36 When the fog signals are placed into the carrying tube there is a gap between the end of the clip and the end cap of 25 millimetres (mm) allowing the fog signals to move up and down within the container, see Figure 16.

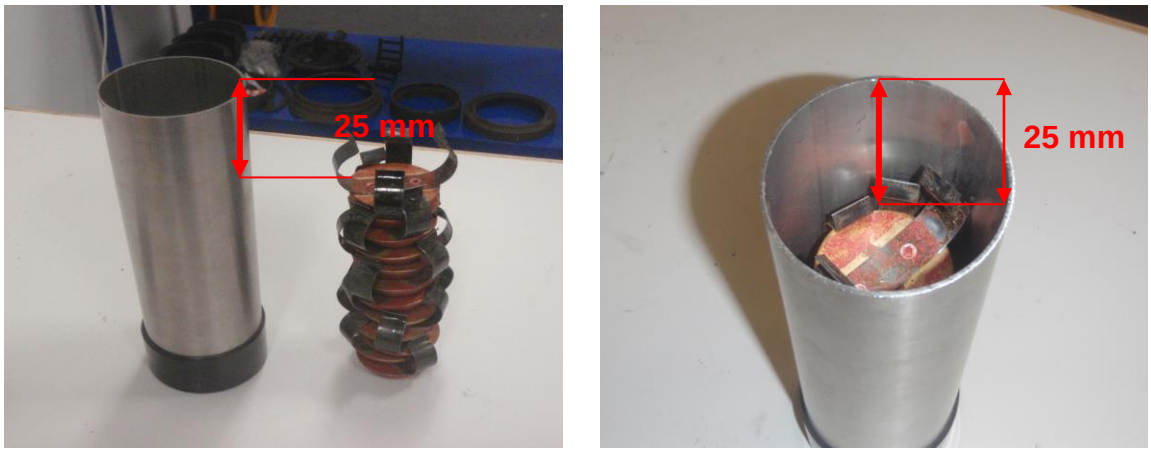

Figure 16 – Photographs illustrating the gap in the tube when the fog signals are stacked

37 The stainless steel tube was designed by IÉ specifically for the purpose of carrying the fog signals. There were no containers or instructions supplied by Lacroix in relation to carrying them other than in the UN approved cases. District Track Executives check the signals once per year and drivers are required to check them bi-annually in March and September to ensure that they are undamaged and in date any damaged or out of date signals are replaced.

38 The stainless steel tube is carried inside the driver's leather bag. The driver's bags are issued to all drivers and are robustly constructed in 3mm leather with riveted seams and a double buckle fastening, a shoulder strap is attached to the bag. Drivers use the bags to carry signal flags and a signalling lamp, rule books and twelve railway fog signals for use in emergency, see Figure 17 for photographs of a driver's bag similar to the bag used on the day of the occurrence.

Figure 17 – Photographs of the driver's bag

39 The driver's bag has a section designed to allow it to remain upright and separated from any other contents of the bag, see Figure 18. A protective flap covers the top of the container before the bag is fastened, see Figure 19.

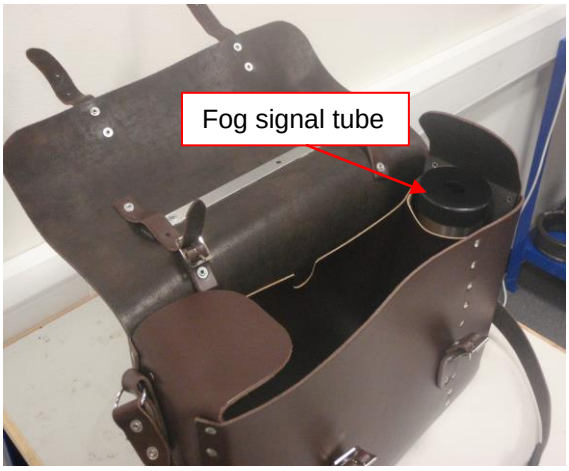

Figure 18 – Tube in driver's bag

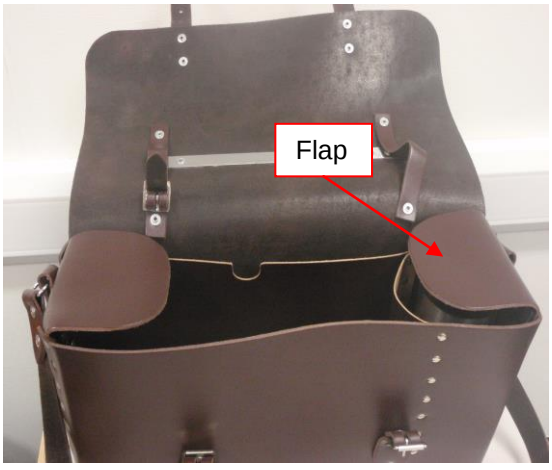

Figure 19 – Tube protected by flap

Post occurrence examination of the fog signals and associated storage equipment

40 Eleven of the twelve fog signals exploded. The eleven exploded fog signals were marked as 'Irish Rail Alsetex' while the remaining unexploded fog signal was marked 'Irish Rail Lacroix'. The Lacroix fog signal was out of date at the time of the explosion; the date on the case was 01-06 (indicating this was the first batch of 2006), meaning that it should have been replaced five years later, in January 2011.

41 An examination of the carrying tube revealed that the majority of its down facing edge had been burnt in the explosion; also the fog signals at the bottom of the tube had rubber burnt onto its surface, see Figure 20; and the rim of the tube was burnt, Figure 21.

Figure 20 – Fog signal that was found at the bottom of the tube

Figure 21 – Rim of the tube

42 The leather bag which had been fastened was ripped apart indicating that explosion occurred within the bag.

Post occurrence examination of the scene of the explosion

43 The source of the explosion was within the drivers cab to the right of the driver's seat, indicating that the initiation occurred where the bag had first been put by the driver.

44 When the linoleum covering was removed from the floor, the stainless steel underneath had a large dent at the point of the explosion, see Figure 22. The shape of the dent matched the shape of the fog signal container. Fragments of the fog signals were also embedded into the sides and roof of the driving cab.

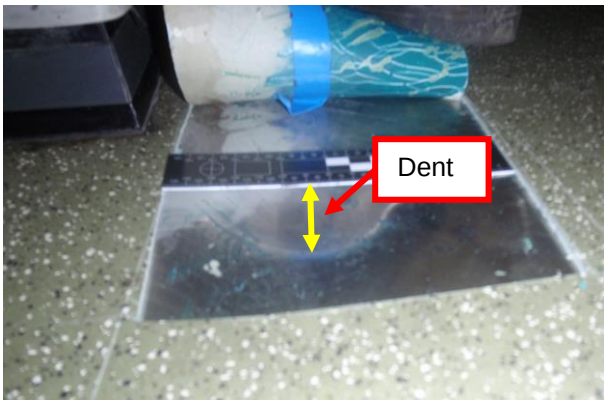

Figure 22 – Dent in the floor

Post occurrence testing of the fog signals

45 During the investigation a sample batch of eighty Alsetex fog signals held by IÉ were tested by Lacroix, this included some from the same batch as were involved in the occurrence. Additionally, forty Lacroix fog signals which were out of date (same as the Lacroix fog signal in the occurrence) were subjected to the same tests. The tests were observed by the RAIU and included:

- A visual inspection of the casings for defects;
- X ray of the fog signals to check integrity;
- Dimension check;
- Water tightness / resistance to bursting;
- Resistance to extremes of heat (75 ˚C) and cold (- 40 ˚C);
- Resistance to impact.

Events before the occurrence

46 In 2010 IÉ ordered a supply of fog signals using the Lacroix factory part number. The fog signals were manufactured by Lacroix issued from a 2008 batch and delivered in May 2010, a further order of 5100 were supplied by Lacroix in January 2011, Then in July 2011 IÉ were supplied with the Alsetex fog signals which had the same factory part number, IAA1007, in a wooden UN specification storage box marked 'Lacroix'.

47 This batch of the Alsetex fog signals were used to restock the driver's allocation after the routine removal of out of date fog signals. Eleven Alsetex fog signals were placed in the driver's storage tube. However, one Lacroix fog signal remained in the tube and was not identified in any subsequent checks of the fog signals.

48 On the 6th March 2012, at 08.10 hrs the 08:00 hrs DART service from Greystones to Malahide arrived onto Platform 2 in Bray Railway Station, a driver change was scheduled at Bray. The

Driver who had been in the staff rest area for approximately ten minutes made his way to Platform 2 where he had a brief exchange with the driver coming off shift, and the driver made his way on board the train entering via the side door of the driving cab.

49 On entering the driving cab, the driver put his leather driver's bag on the floor just to the right of his chair which is a routine he did every time he took over driving duties, the bag contained twelve railway fog signals in a metal case, a signalling lamp signalling flags and the drivers rule books.

Events during the occurrence

50 When the bag was dropped onto the floor of the driving cab there was an explosion from fog signals within the bag.

51 The driver was dazed but was able to immediately exit the driving cab back on to the platform, see Figure 23 for a view inside the driving cab.

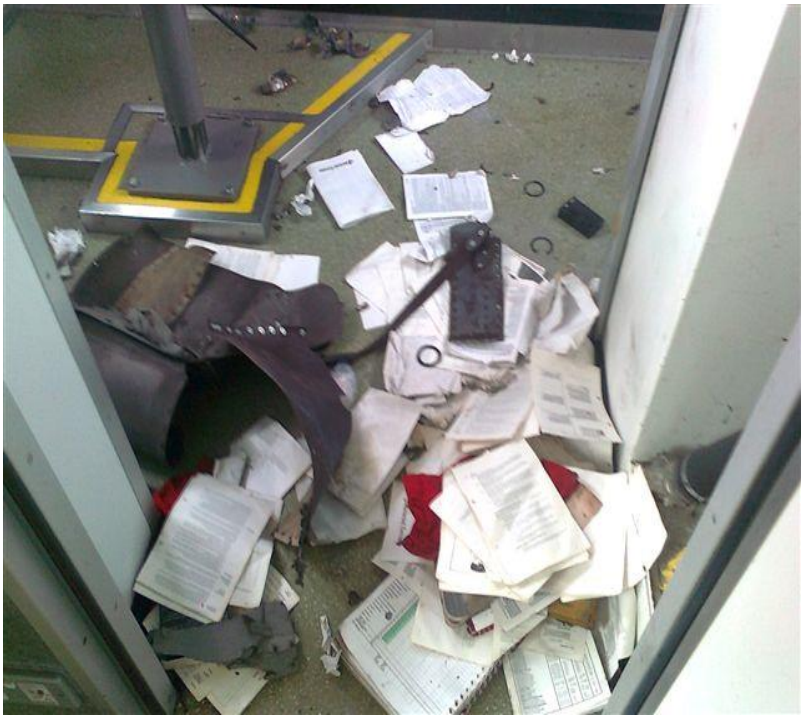

Figure 23 – Inside the driving cab

52 The driver suffered minor injuries to his left hand and hearing loss he was assisted by platform staff and the emergency services were called. The train was evacuated; no other person was injured in the occurrence.

Events after the occurrence

53 The DART train was moved from the platform where the incident took place to another platform to allow trains to use the station; subsequently the scene of the explosion was significantly disturbed by IÉ staff before being declared a crime scene by the Garda.

Similar occurrences

54 There have been no similar occurrences recorded in Ireland, however during the investigation it was found that there had been an accidental activation of fog signals in France when Alsetex fog signals were being used by a railway work gang. This involved fog signals that were not stored in qualified packaging and had been subjected to a degree of mishandling, examination of some of these were found to have a damaged initiator, no further information was available.

Analysis

Fog signal design

55 The Lacroix and Alsetex fog signal designs are very different in terms of the initial ignition. The Lacroix design requires that the glass marble break when a force is applied (paragraph 26) as opposed to the Alsetex design which requires that there is friction between the scraper and the pyrotechnic material when the force is applied (paragraph 28).

56 The Lacroix fog signal has two stages of ignition. The first stage is breaking the glass marble (Figure 24); the second stages is that the broken glass enables the primer to be initiated (Figure 25); the ignition then occurs.

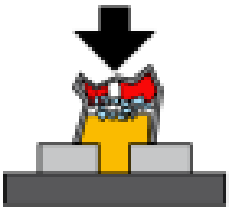

Figure 24 – Stage 1 Lacroix

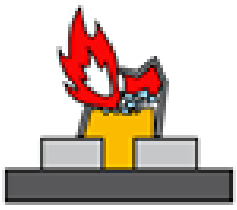

Figure 25 – Stage 2 Lacroix

57 The Alsetex fog signal has only one stage of activation, as the scraper is in direct proximity to the ignition primer; which means that when the plastic deforms, the scraper initiates the ignition, see Figure 26.

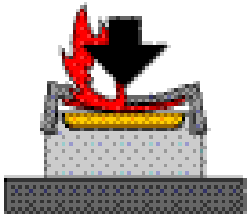

Figure 26 – Stage 1 Alsetex

58 The Lacroix two stage process versus the Alsetex one stage process, coupled with the light plastic on the Alsetex fog signal means that the Lacroix fog signal is more robust and that more force is required to initiate the Lacroix fog signal (which may explain why the Lacroix device did not activate despite being out of date and still functioning).

59 In addition, the rubber membrane completely covers the base of the Lacroix fog signal which may have reduced the chance of accidental activation as it did not allow any flash powder to leak into the rest of the fog signal (paragraph 26); whereas the rubber O-Ring in the Alsetex fog signal only

covered the base of the plastic cylinders (paragraph 28), potentially allowing for the flash powder to leak. However, this could not be confirmed to have contributed to the explosion.

60 Of the eighty fog signals sent for testing, all of the fog signals tested passed the specifications set out in CT444 and the PSDS Sheets (from Lacroix and Alsetex) in relation to the dropping of 1kg from 1m. None were found to be damaged internally or leaking any explosive compound. All of the fog signals were activated and again they performed within the manufacturer's specification.

61 Reviewing the CT444 specifications (paragraph 25) for fog signals there is a large spectrum between when a fog signal must detonate and must not detonate (orange area in Figure 27). For example, a fog signal could detonate when a weight of 1 kg is dropped from a height of 4 m or when a weight of 4kg is dropped from a height of 1 m.

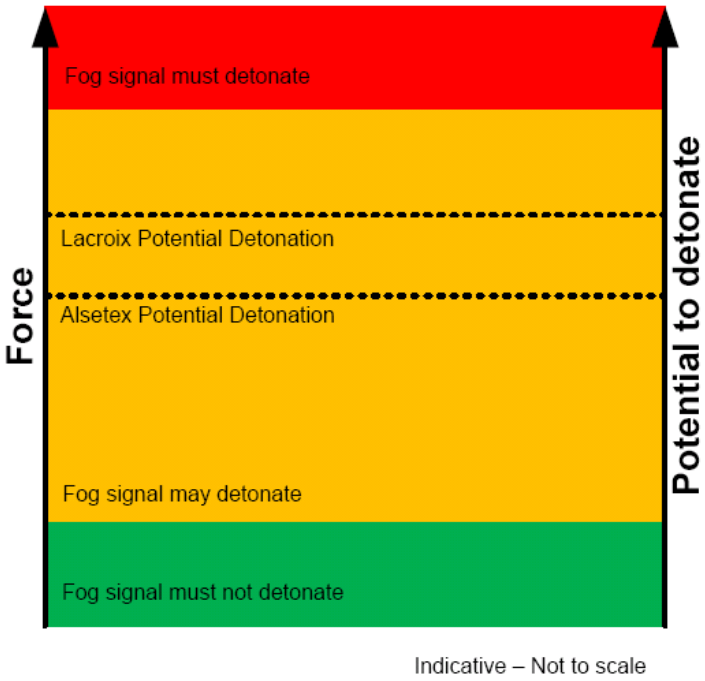

Figure 27– Alsetex and Lacroix potential to detonate

Fog signal activation

62 Although the RAIU cannot confirm, on the day of the occurrence, it appears that the bag was dropped from a height of no greater than 1m which should not have generated enough force to ignite the fog signals. However, one or more fog signals initially ignited, resulting in all but one of the other fog signals igniting within the tube and discharging out from the tube in a high trajectory, this was evidenced by the damage in the cab.

63 Examination of the site of explosion by technical experts indicated that the explosion occurred within the tube as and the damage to the bag confirmed that the tube was in the bag at the time of the event (paragraph 42).

64 The 25 mm free space in the stainless steel tube allowed for movement (as discussed in paragraph 36) this unrestricted movement may have led to a certain amount of degradation of the units over a period of ten months and on the 6th March 2012.

Fog signal issuing to drivers

65 IÉ have adopted a stringent approach to the transport (to and from Central Stores) and storage at Central Stores (paragraph 33), in that:

- They have approved containers for the transport and storage of explosives;
- They have been granted a license by the Local Authority Fire Officer for the storage of the fog signals at Central Stores;
- They comply with the European Regulations for the transportation of dangerous goods by road for all transportation from Central Stores.

66 IÉ specifically designed a system allowing the drivers to conveniently carry fog signals on duty within a purpose made bag, this was used without incident with the original Lacroix design. Drivers during their normal duties are lifting and dropping the bag numerous times daily, DART drivers because of the shorter journeys are moving cabs and locations more often than other drivers. However, no risk assessment or procedures have been developed for the safe issue of fog signals to drivers (paragraph 34); and although the stainless steel tube and leather bag has been provided to the drivers for the transport of the fog signals, no apparent safety checks have been applied to see if these were fit for use.

67 In relation to the stainless steel tubes, the fog signals are free to move within the tube as there was 25 mm free space in the tube (paragraph 64) when the fog signals were stacked may have contributed to the activation of the fog signals. This action appeared of no consequence with the Lacroix fog signal but with the less rugged initiation system in the Alsetex device it is within the balance of probability that the movement within the carrying tube was sufficient to degrade one or more of the fog signals over time resulting in the explosion within the DART cab in Bray when the driver dropped his bag onto the floor as he commenced driving duties.

Staff Training

68 Fog signals are routinely carried by drivers on duty and are subject to cursory checks twice yearly (paragraph 35) there are no instructions in handling fog signals only instructions in how to deploy them if required. Additionally the manufacturer has no instructions for carrying the fog signals outside of the initial shipment packaging.

Procurement and Quality Control

69 IÉ have been using clip type fog signals of French manufacture since the 1960s. Firstly from Ruggeri, then Lacroix (who bought Ruggeri in 1997) and then Alsetex (who were bought by Lacroix in 2006). The fog signals were ordered using the factory part number, IAA1007, which had been supplied by Lacroix.

70 When IÉ ordered a consignment of fog signals from Lacroix in 2010, they used the factory part number, IAA1007 (paragraph 31). When the consignment arrived it arrived in a box marked 'Lacroix' despite containing Alsetex fog signals. When staff checked the Data Sheet for the factory part number, it was as expected, IAA1007. The fog signals themselves were not checked, these were marked 'Alsetex Irish Rail'. There was no apparent system in place for any quality control checks by Central Stores in relation to checking the actual parts that arrive at Central Stores.

Conclusions

Fog signal design

71 The broad spectrum allowed under CT444 where fog signals may detonate resulted in two different fog signals meeting the criteria, but one being more robust that the other. In this case, both the Lacroix and the Alsetex fog signals met the CT444 standards, but the Lacroix fog signal was more robust (paragraph 56) and therefore more ideally suited to be carried by drivers in their equipment bags on a daily basis.

Staff Training

72 Although stringent systems are in place for the storage and transport of fog signals at Central Stores no risk assessments, or procedures for the safe handling and transport of fog signals have been carried out in relation to the drivers (paragraph 68).

Procurement and Quality Control

73 Lacroix informed IÉ on the 27th June 2011 that the fog signals would be manufactured by Alsetex and on the 5th of July informed IÉ that the marking on the signal would be Alsetex the signals were delivered to central stores with an Alsetex safety data sheet but were in a Lacroix box.

74 However, there was no system in place at Central Stores for the checking the actual detail of consignments upon their arrival (paragraph 70) and the difference in design was not sufficient to be noticed, whilst the Safety data sheets were different the same identification number remained.

Immediate cause, contributory factors and underlying factors

75 The immediate cause of the explosion could not be established but with the evidence available it is probable that the movement of the fog signals within the carrying tube when the bag was dropped on the floor of the cab caused the an initial activation within the tube resulting in all of the Alsetex designed fog signals exploding.

76 Causal to the explosion were the following causal factors:

- CF-01 – The Alsetex fog signals supplied to IÉ, by Lacroix, were not as robust as the Lacroix fog signals requested by IÉ;

- CF-02 – IÉ did not notice that the Alsetex fog signals provided to them were not the Lacroix fog signals that were ordered.

77 The contributory factors identified were:

- CoF-01 – The fog signals storage tube, designed by IÉ, allowed the fog signals to impact on one another which may have caused them to degrade over time;

78 The underlying factors identified were:

- UF-01 – IÉ had no process for carrying out any risk assessment or guidance on the storage and transportation of fog signals outside of Central Stores;
- UF-02 – IÉ had not introduced any training to staff in the handling of fog signals;
- UF-03 – IÉ Stores did not have a process in place for the checking of parts when they arrive at Central Stores.

Relevant actions taken or in progress

Actions taken by IÉ

79 At the time of publication of the this report IÉ:

- Have withdrawn all Alsetex for signals from IÉ service;
- Have sourced fog signals from a supplier in the United Kingdom, which conform to British Standards;
- Have Developed a new procurement process, where all orders for replacement fog signals will request the manufacturer to notify IÉ of any change to the specification, these orders will be accompanied by a safety data sheet and all new stock arriving to IÉ will be quarantined until a check is performed;
- Have purchased a new storage container to meet guidance from the British Railways Safety Standards Board, see Figure 28;
- Have produced a risk assessment on all aspects of fog signal use, storage, transportation procurement and disposal;
- Have begun developing a procedure for use and storage of fog signals;
- Are introducing a system where the drivers are no longer required to carry fog signals in their driver's bag.

Figure 28 – New fog signal storage container

Actions taken by Lacroix

80 As Alsetex joined the Etienne it has been decided to rationalise the different designs manufactured by both entities. The group have decided to manufacture only the Lacroix design; this will be effective from September 2013.

Safety recommendations

General description

81 In accordance with the Railway Safety Act 2005 (Government of Ireland, 2005a) and the European Railway Safety Directive (European Union, 2004), recommendations are addressed to the national safety authority, the RSC. The recommendation is directed to the party identified in each recommendation.

82 As a result of the RAIU investigation three new safety recommendations are made, three relating to the occurrence and one relating to an additional observation.

83 The RAIU have made no safety recommendation in relation to the supply of fog signals or containers as IÉ have changed fog signal and container suppliers (CF-01).

New safety recommendations related to the occurrence

84 There was no quality control process within IÉ did not ensure that the fog signals ordered were of the same specification as those received (CF-02, UF-03), therefore the RAIU make the following safety recommendation:

IÉ should ensure that their procurement and quality control processes verify that goods received are of the correct specification as those ordered.

85 There were no risk assessments or guidance for the storage or handling of fog signals (UF-01, UF-02). Therefore the RAIU make for following safety recommendation:

IÉ should introduce appropriate procedures and standards for the safe issue, storage and transportation of fog signals.

86 Drivers had no training in the handling of fog signals (UF-02), therefore the RAIU make the following safety recommendation:

IÉ drivers should receive adequate training in the safe handling of fog signals.

Additional information

List of abbreviations

°C	Degrees Celsius
CF	Causal factor
CoF	Contributory factor
EMU	Electrical Multiple Unit
IM	Infrastructure Manager
Kg	Kilogram
km/h	Kilometres per hour
M	Metre
No.	Number
RAIU	Railway Accident Investigation Unit
RSC	Railway Safety Commission
RU	Railway Undertaking
SI Units	International System of Units
UF	Underlying factor
UN	United Nations

Glossary of terms

Accident	An unwanted or unintended sudden event or a specific chain of such events which have harmful consequences including collisions, derailments, level-crossing accidents, accidents to persons caused by rolling stock in motion, fires and others.
Causal factors	Any factor(s) necessary for an occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.
Colour light signals	Signals that convey movement authority to train drivers by means of coloured lights.
Continuous welded rail	Sections of rail that are welded together.
Contributory factor	Any factor(s) that affects, sustains or exacerbates the outcome of an occurrence. Eliminating one or more of these factor(s) would not have prevented the occurrence but their presence made it more likely, or changed the outcome.
Contributory factors	Any factor(s) that affects, sustains or exacerbates the outcome of an occurrence. Eliminating one or more of these factor(s) would not have prevented the occurrence but their presence made it more likely, or changed

	the outcome.
Controlling signalman	The signalman designated to control a specific section of track.
Electrical Multiple Unit	A multiple unit train whose source of power is an electrical powered engine.
Extensive damage	Damage that can be immediately assessed by the RAIU to cost at least €2,000,000 in total.
Immediate cause	The situation, event or behaviour that directly results in the occurrence.
Incident	Any occurrence, other than an accident or serious accident, associated with the operation of trains and affecting the safety of operation.
Infrastructure Manager	Organisation that is responsible for the establishment and maintenance of railway infrastructure, including the management of infrastructure control and safety systems.
National safety authority	The national body entrusted with the tasks regarding railway safety in accordance with European directive 2004/49/EC.
Railway Undertaking	Organisation that operates trains.
Rolling stock	Railway vehicles.
SAP Software	Computer programme that co-ordinates all resources, information and activity needed to complete an enterprise wide information system, it includes an accounting and finance function.
Serious accident	Any train collision or derailment of trains, resulting in the death of at least one person or serious injuries to 5 or more persons or extensive damage to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety, where extensive damage means damage that can be immediately assessed by the RAIU to cost at least €2,000,000 in total.
Serious injury	Any injury requiring hospitalisation for over 24 hours.
Track circuit block	A signalling system that uses track circuits to confirm the absence of trains in order to control the movement of trains.

References

European Union (2004), Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification (Railway Safety Directive), 2004/49/EC, 29th April 2004.