



Railway Accident Investigation Unit

Ireland



INVESTIGATION REPORT DART Wrongside Door Failure, Salthill & Monkstown Station, 10th August 2013

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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 Dublin Area Rapid Transit (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.

RAIU investigations are conducted for the purpose of accident and incident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the determination of causes and, when appropriate, the making of safety recommendations 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

At approximately 08:50 hours (hrs) on Saturday 10th August 2013 the driver of the DART service from Howth to Greystones was stopped at Salthill & Monkstown Station, when he noticed that the blue Door Interlock Light, a light used by drivers for confirmation that the passenger doors are closed, was illuminated while the rear passenger doors of the train were open. After a number of checks, the driver found that the *coupler* was damaged and the rear units of the train were incorrectly *coupled*. He contacted the Chief Mechanical Engineer's Department (CME) and the train was taken out of service and sent to Fairview Depot for inspection.

A CME inspection of the train found that the door of the coupler electrical head had been damaged, which resulted in the train not being correctly coupled electrically; resulting in the display in the driving cab showing that the doors were closed; as the 'doors closed' *signal* did not pass through the incorrectly coupled carriages due to a design weakness in the coupler.

This design weakness was first recorded on the 26th August 2010; in February 2012 after reports of two similar incident, an investigation was carried out by the CME which resulted in a number of recommendations, including a recommendation in relation to a design modification to rectify the design weakness and an interim mitigation measure of a 'Coupler Electrical Head Integrity Test' to be carried out by drivers after coupling to ensure correct coupling. These recommendations were not fully implemented at the time of the incident.

The *immediate cause* of the blue Door Interlock Light illuminating while the passenger doors were open, causing a wrongside failure, was as a result of the autocouplers on carriages 8102 and 8314 being incorrectly coupled, which resulted in the Door Closed *Circuit* not passing through the incorrectly coupled carriages, resulting in the driver's display indicating that all doors were closed.

Contributory Factors (CFs) associated with the incident are as follows:

- One of the electrical head doors of carriage 8102 was damaged at some time previous to the coupling on the day of the incident, which stopped the electrical coupler head from moving in either direction, preventing correct coupling;
- A design weakness in the autocoupler, known to the CME prior to the incident, allowed the blue Door Interlock Light to illuminate when passenger doors remained open;
- A train driver did not carry out the full train preparations and therefore did not notice the damage to the electrical coupler head.

Underlying causes (UCs) associated with the incident are as follows:

- The CME did not correspond with DART Operations to consider the introduction of a Coupler Electrical Head Integrity Test for EMU trains after coupling, to mitigate the risk associated with the known design weakness;
- The Drivers' Manual put an unrealistic reliance on drivers to identify coupling faults, given that minor flaws can result in the autocouplers being incorrectly coupled;
- The design modification process, being undertaken by the CME at the time of the incident, did not require for sufficient risk mitigation measures to be introduced (such as the Electrical Coupler Head Integrity Test) to mitigate the identified risk of re-occurrence until the design modification was complete.

Root causes (RCs) associated with the incident are as follows:

- The CME did not fully adhere to their relevant SMS documents (CME-SMS-001 & RU-SMS-007) as they did not adequately address the recommendations from their own internal investigation report in relation to the design weakness of the autocoupler.

As a result of this investigation, the RAIU have made four safety recommendations:

- The CME (IÉ RU) should review and modify their design for the EMU autocouplers to ensure a more robust coupler circuit that will provide assurance that both coupler electrical heads have connected correctly and that coupler circuits are continuous throughout the train consist. Any modification made should be documented in Rolling Stock Design Standards.
- The CME (IÉ RU) should introduce a visual indicator on the driving console to indicate to the driver that coupling has been completed successfully (or a visual or audible indication that coupling has failed).
- DART Operations (IÉ RU) should update the Drivers' Manual to include specific guidance on the requirement for the examination of couplers. The update should also include guidance on associated testing of coupler integrity and guidance on any indications in the driving cab that would assist the driver in detecting any coupler failure.
- The CME (IÉ RU) should review and modify the processes set out in their SMS for closing recommendations to ensure recommendations from investigations are recorded, monitored and closed. When these processes have been established, they should be audited (by a party external to the CME) at predefined intervals to ensure compliance.

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The incident

Summary of the incident

- 1 At approximately 08:50 hrs on Saturday 10th August 2013 the DART service from Howth to Greystones was stopped at Salthill & Monkstown Station, see Figure 1.



Figure 1 – Location of accident

- 2 When the driver had observed that all passengers had disembarked and boarded the train, the driver pressed the button to close the passenger doors. The driver noticed that the blue Door Interlock Light was illuminated in the driving cab; which confirms to the driver that the doors are closed and he can take power.
- 3 However, as the driver was about to take power, he looked back along the train, and saw that the exterior amber lights were illuminated on the rear carriages, indicating that the passenger doors were open; and there were two doors open at the rear of the train.
- 4 The driver opened and reclosed the passenger doors and the same sequences of lights occurred, where the blue Door Interlock Light illuminated while the passenger doors were open. He then disembarked the DART and walked the length of the DART and saw that one of the electrical coupler heads was not attached correctly on the rear portion of the train.

- 5 The driver returned to the cab and contacted the *Suburban Signaller* to inform him of the issue with the coupler. The driver was then put in contact with the CME representative from Fairview and the decision was made to cancel the service, detrain the passengers and return the train to Fairview DART Maintenance Depot.

- 6 Since this incident occurred on the 10th August 2013, there were two similar incidents on the 18th September in Tara Street Station and Salthill & Monkstown Station where the blue Door Interlock Light was illuminated while the passenger doors were open. After these incidents were reported to the RAIU, the RAIU issued an Urgent Safety Advice Notice. This notice requested for permanent mitigation measures to prevent a reoccurrence; and interim measures to manage the risks associated with the fail safe mechanism of failure.

General description of the railway

Infrastructure

- 7 The route from Howth to Greystones, including Salthill DART Station is a double line section of flat bottom *continuously welded rail* (CWR) track mounted on concrete sleepers in ballast, with some areas of slab track. The line is fitted with Overhead Line Equipment (OHLE) to supply electricity to the EMU trains between Howth and Greystones. No factors in relation to the condition of the track or the OHLE were found to have contributed to the incident.

- 8 Salthill & Monkstown Station is the nineteenth stop after departing Howth. It has two platforms, one serving southbound trains and one serving northbound trains, see Figure 2. The train was stopped on the southbound track.



Figure 2 – Salthill & Monkstown Station (southbound track on right)

Rolling stock

- 9 The train involved was the 08:02 hrs DART service (train identification number E104) from Howth to Greystones. The service was operated by an eight carriage 8100 class EMU, manufactured by Linke-Hofman-Busch. The 8100 class EMU comprises of two-carriage sets which can be operated in multiples up to a maximum of eight carriages in passenger service.
- 10 On the day of the incident, four two-carriage sets (eight carriages in total) were in operation, consisting of carriages 8133, 8333, 8114, 8314, 8102, 8302, 8121 and 8321; carriage 8321 was the leading carriage at the time of the incident.
- 11 This train consist is 164 metres (m) in length with a combined weight of 277 tonnes and can travel at maximum speeds of 62 miles per hour (mph) (100 kilometres per hour (km/h)).
- 12 The train was fitted with an event recorder that records the status of predefined equipment on the train (i.e. displays on the driving console).

Signalling and communications

- 13 The double track route from Howth to Greystones is signalled using three and four aspect *colour light signals*. This section of track (except Greystones Station) is controlled by the Suburban Signalman based in Centralised Traffic Control (CTC), Connolly. *Track Circuit Block* regulations apply to this route.
- 14 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 incident.

Operations

- 15 The route is fitted with a Continuous Automatic Warning System (CAWS) & Automatic Train Protection (ATP).
- 16 All train drivers directly or indirectly involved in the incident were all competent to perform driving duties.

Fatalities, injuries and material damage

Fatalities and injuries

17 There were no fatalities or injuries as a result of this incident.

Material damage

18 Figure 3 shows the damage to the electrical coupler head cover, preventing the door opening. No other coupler mechanisms on the train were found to be damaged.



Figure 3 – Damage to coupler electrical head cover

Parties and roles involved in the incident

Parties involved in the incident

19 Iarnród Éireann (IÉ) RU operates mainline and suburban railway services in Ireland. The RU departments associated with this incident are the:

- DART Operations – Responsible for the supervision and operation of trains on the DART network;
- CME – The department within the RU responsible for the specification, purchasing, commissioning and maintenance of rolling stock, including management of the maintenance depots, associated personnel and procedures. Support on technical matters is provided through the CME's Fleet Technical Services (FTS) staff.

Roles involved in the incident

20 There are a number of driving roles involved in the incident, who were all employees of IÉ RU; and who were trained and competent to drive EMU trains. The train drivers are as follows:

- Train Driver A – The train driver who coupled and prepared the train, in Bray, prior to the first service of the day of the incident;
- Train Driver B – The train driver who drove the first service on the morning of incident;
- Train Driver C – The train driver who relieved Train Driver B, and who noticed the door interlocking light illuminated while the two passenger doors were open and notified the incident to the relevant parties.

External circumstances

21 The weather at the time of the incident was recorded by Met Éireann as cloudy with a temperature of 11 °C. Sunrise was at 05:58 hrs on the day of the incident.

RAIU Investigation

RAIU decision to investigate

22 In accordance with the Railway Safety Act 2005 the RAIU investigate all serious accidents. Given that under slightly different conditions, this incident may have led to a serious accident where there would have been potential for fatalities and serious injuries due to the passenger doors being open while the train was able to take power, which is a wrongside failure (i.e. is not a *failsafe* system), a decision was made to investigate under Article 19 (2) of the Railway Safety Directive 2004/49/EC.

Scope of investigation

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

- Establish the sequence of events;
- Establish, where applicable, the immediate cause, CFs, UFs, RCs;
- Examine the design and operation of the coupling mechanism;
- Examine the standards and procedures associated with the coupling mechanism;
- Examine the relevant elements of the safety management system (SMS);
- Examine the actions taken by the relevant parties on the day of the incident;
- Examine any other significant safety deficiencies identified as a result of this investigation which may result in *additional observations* (AO).

Investigation and evidence

24 During the on-site and off-site investigation the RAIU collated the following evidence:

- Photographic record of damage to coupler;
- Witness evidence from parties involved in the incident;
- Other evidence from members of the RU with information pertaining to the incident;
- RU standards, procedures and other documentation;
- SMS documentation from the RU associated with recommendations from investigations;
- Maintenance regime for the couplers;
- Design specifications for the couplers;
- Download from the event recorder.

Evidence

The coupler

General description

25 A coupler on a train connects two rail vehicles together. An automatic coupler (*autocoupler*), the type of coupler associated with the incident, simultaneously couples the two vehicles pneumatically, mechanically and electrically.

Autocoupler design

26 The autocoupler associated with the incident is the Scharfenberg autocoupler. To couple mechanically, the mechanical heads are moved towards each other, with mechanical coupling achieved when the mechanical heads engage. Simultaneously, pneumatic cylinders operate the electrical heads, allowing the electrical pins make contact with the opposing electrical coupler head pins to complete electrical coupling.

27 See Figure 4 for an example of the autocoupler involved in the incident, with the mechanical and electrical mating parts.

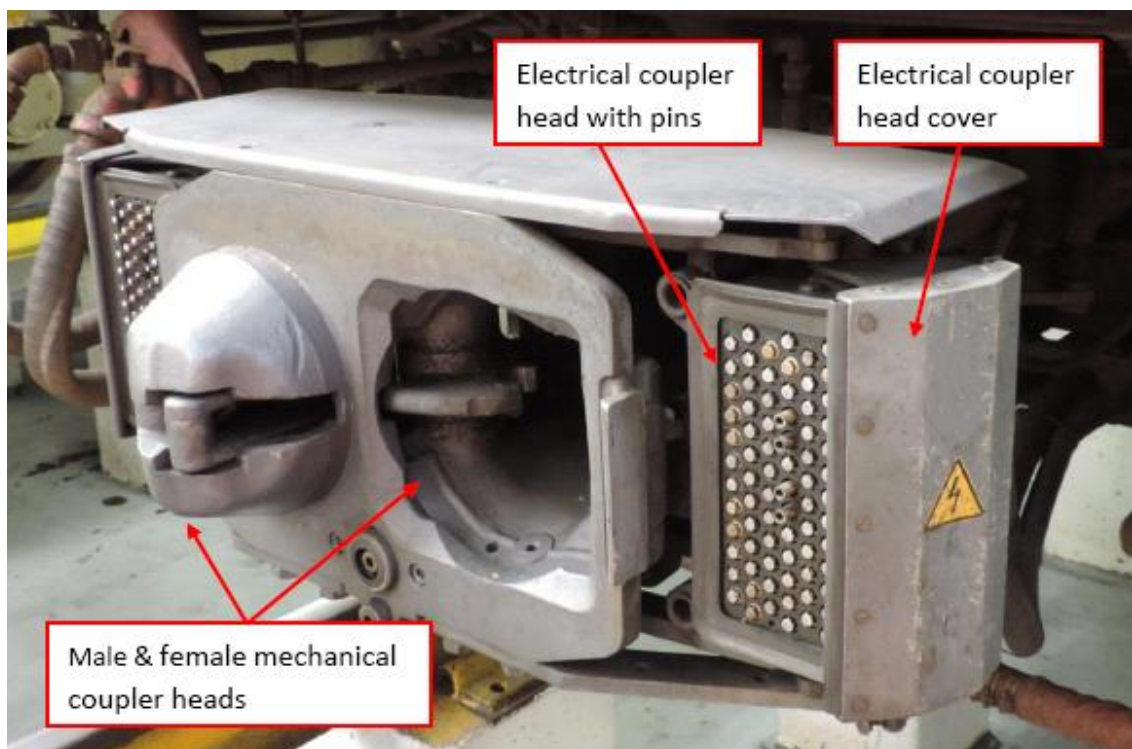


Figure 4 – Scharfenberg autocoupler

28 The electrical head pins contact is required, as it allows the transmission of signals throughout all the coupled carriages which feeds information back to the driving cab. The joining of the electrical autocoupler heads, when coupled correctly, allows opposing pins to connect, which in turn opens the spring-loaded normally-closed contacts; allowing the signals flow through to the next carriage, see Figure 5; and throughout all the coupled carriages.

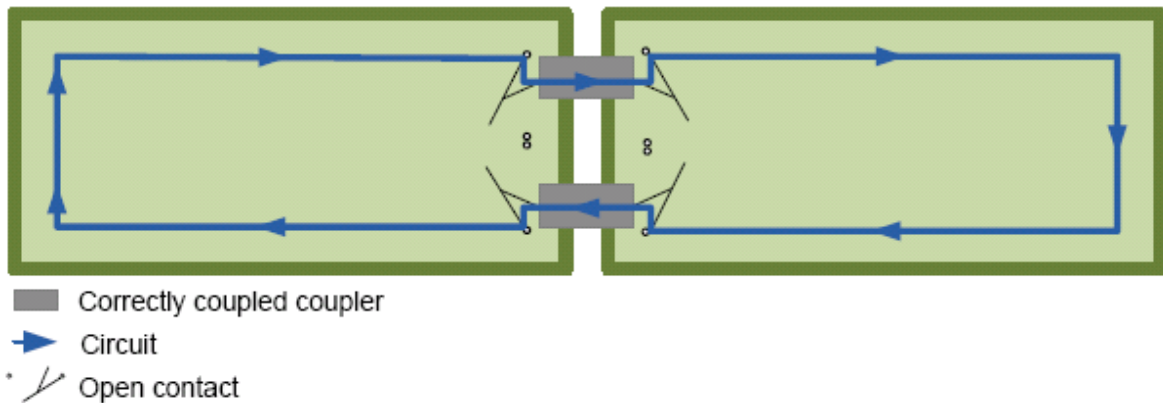


Figure 5 – Coupled units, with open contacts, and Door Closed Indication Circuit

29 The 'Door Closed Indication Circuit' is one of the signals that flows through the contacts. When the passenger doors are closed on all the vehicles the Door Closed Indication Circuit flows throughout the carriages, completing the circuit and illuminates the blue Door Interlock Light in the driving cab (Figure 6). This verification of the doors being closed energises the traction interlock relay, allowing the train driver to take power.



Figure 6 – Driver's display with 'Door Interlock' light illuminated

Autocoupler design weakness

- 30 In February 2012 there were two incidents where the blue Door Interlock Light was reported by the drivers to have remained illuminated while the passenger doors were open (these individual incidents are discussed in paragraph 91). One investigation into the two occurrences was conducted by the CME FTS after a CME FTS inspection found that a broken “electrical male pin” had lodged in an “electrical female pin” which prevented the electrical heads from connecting properly and was responsible for both incidents of the blue Door Interlock Light illuminating.
- 31 The CME FTS report into these incidents was called the ‘Door Failure on EMU 8114-8314, at Blackrock, on the 10th February 2012’, document number CME-T12-005; and was issued on the 28th August 2012. This report will be referred to as the ‘CME FTS August 2012 Report’ for the remainder of this report. (It should be noted that although these two carriages were involved in the August 2013 incident, the failure modes were different, which will be discussed in the report).
- 32 Quoting from the CME FTS August 2012 Report, it states that the “Door Closed Indication Circuit operates through spring loaded normally closed contacts in the coupler electrical heads which open when the electrical heads are properly coupled sending the circuit down through the train consist. When the passenger doors are closed on all vehicles within the set the door closed indication signal is returned to the leading/driving cab via spring loaded normally closed contacts in the electrical heads of the last uncoupled coupler. This signal will indicate a blue light and energise the traction interlock relay allowing the train to take power”.
- 33 The CME FTS August 2012 Report includes the two diagrams below. Figure 7 shows that when the coupler heads are correctly coupled, the pins press together to open the normally closed contacts, which sends the circuit through to the next car. Figure 8 shows that when the coupler heads are uncoupled or incorrectly coupled, the pins do not press together, leaving the normally closed contacts closed; which returns the circuit signal to the leading/driving cab, omitting any connected carriages.

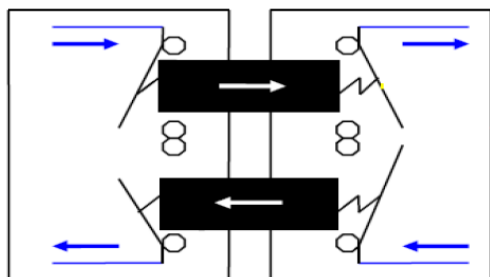


Figure 7 - Correctly coupled autocoupler

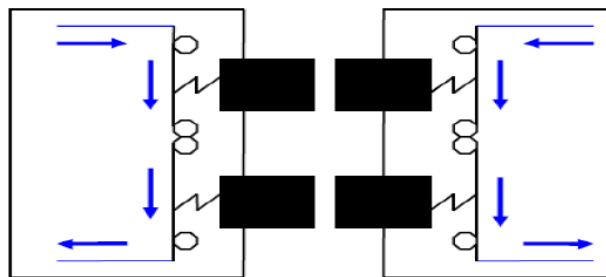


Figure 8 - Uncoupled or incorrectly coupled autocoupler

- 34 The CME FTS August 2012 Report concluded that the “reliance of normally closed spring loaded contacts to send the signal on to the remaining vehicles in the consist is seen as a weakness that could lead to similar occurrences if the autocoupler electrical heads are damaged or not coupled correctly”. This design weakness was identified by IÉ on the autocouplers for the entire EMU fleet.
- 35 Another finding in the CME FTS August 2012 Report highlights the fact that the incident on the 10th February 2012 was not fully investigated, and it was only after the incident on the 14th February 2012 that the fault was detected and an investigation initiated into both occurrences. In relation to this, the CME FTS August 2012 Report noted that the “closer examination of the autocoupler electrical heads after the initial failure may have identified the root cause and prevented the second occurrence”.
- 36 Two recommendations made in the CME FTS August 2012 Report are as follows:
- A review of the door closed indication circuit with a view to a modification to remove the dependence upon the autocoupler pin spring loaded normally closed switches should be undertaken;
 - Testing the integrity of Door Closed Indication Circuit should be considered for EMU trains after vehicles have been coupled.
- 37 In relation to the first of these recommendations, relating to the review of the Door Closed Indication Circuit. The CME Drawing and Design technicians commenced the review in November 2012, which requires the CME to request an Engineering Change Instruction (ECI). Due to the requirements involved in the coupler design, seven iterations of ECI were required with the finalised design being agreed and validated on the 26th March 2014 (after the incidents in August and September 2013). Between November 2012 to September 2013 (the date of the introduction of the ‘Coupler Head Integrity Test’ no other mitigations (design or operational) were introduced to prevent the re-occurrence of incidents similar to those in February, despite the risk of re-occurrence being identified in August 2012 (in the CME FTS August 2012 Report).
- 38 In relation to the second recommendation, the consideration for testing of the integrity of Door Closed Indication Circuit by drivers, this can be done through conducting the ‘Coupler Electrical Head Integrity Test’. This test requires drivers to perform a number of checks with the rear most door open, such as checking the blue Door Interlock Light extinguishes and ensuring the train cannot take traction. This was not a formalised test at the time of the incident in August 2013.
- 39 Every period (once every four weeks) the Mechanical Engineering Safety Steering Group (MESSG) meet to review occupational safety, bogie and wheelset safety and rolling stock safety as set out in the CME SMS, CME-SMS-001 (Version 4.0, published on the 30/01/2011 was the version at the time of the incident).

- 40 The MESSG is chaired by the Safety Manager CME and is attended by the CME, the Technical Manager CME, Manager FTS, Manager Bogie & Wheelset Technical Support, Fleet/Depot Managers, Head of Fleet Management, CME Production Plan Manager, members of the CME Safety Team and Quality Team.
- 41 Section 8.5 of CME-SMS-001 requires that the recommendations from accident, incident and other investigations are approved (8.5.6); and safety audit findings are reviewed, corrective action plans are reviewed and the implementation of recommendations are tracked (8.5.7). Section 8.5 requires that “this review is recorded in minutes.”
- 42 The CME informed the RAIU that recommendations from the CME FTS August 2012 Report was discussed at the MESSG meeting on the 23rd October 2012. Under the ‘Audit, Technical & Safety Remits’ item of the minutes the actions are minuted as “Review of remits completed and appropriate actions discussed” with the owner of this action minuted as “All Managers”. There is no direct reference to the CME FTS August 2012 Report or the associated recommendations. No further evidence was provided from other MESSG meetings in relation to the approval of recommendations, review of audit findings and corrective action plans and the implementation and tracking of recommendations.
- 43 As another department, DART Operations, were affected by the ‘Coupler Electrical Head Integrity Test’ recommendation, the ‘Coupler Electrical Head Integrity Test’ recommendation could have been included in the agenda for the RU Safety Review Group (SRG) to ensure that the recommendation was discussed, accepted, divided into discreet actions, responsible managers for delivering them assigned and target completion dates set, as per 4.6.1.1, ‘Managing Recommendations’ of the RU SMS, ‘Policy and Principles for Reporting and Investigation of Accident and Incidents’, RU-SMS-007 (Issue 1, published in 25/03/2013). The CME did not bring this recommendation to the attention of DART Operations through the SRG.
- 44 The CME have not provided the RAIU with any other evidence to illustrate that DART Operations were made aware of this recommendation. In addition, the Passenger Services Manager, North & East, at the time of the incident, cannot recall any correspondence with the CME in relation to this recommendation and confirmed that that first time he was made aware of the design weakness associated with the coupler was after the incidents in August and September 2013.
- 45 In addition to these incidents in February 2012 and the incident initiated the RAIU investigation on the 10th August 2013; the CME have recorded two other incidents associated with the design weakness where the blue Door Interlock Light was illuminated with the passenger doors open since 26th August 2010. These are further discussed in paragraphs 92 and 94.

Autocoupler maintenance

- 46 Vehicle Maintenance Instructions (VMIs) are the procedures set out for the inspection and maintenance of rolling stock. The VMIs requires a visual inspection of the DART train to be conducted every thirty days, an A Exam Mechanical, (which includes a visual inspection of the electrical coupler); with a more intensive inspection carried out every sixty days (which includes a more thorough inspection of the coupler).
- 47 The inspection and maintenance of the DART trains is in accordance with the VMIs, with the last recorded inspection, an A Examination, occurring on the 6th August 2013 (four days before the incident). No faults associated with the coupler were found as part of this examination.
- 48 As with other rolling stock, when defects are identified on the DART 8100 fleet through the inspection regime, IÉ upload these defects onto its *SAP Software* computer system (a tool used by the CME to co-ordinate resources and activities in order to manage work). SAP then generated a 'Fault List' and 'Work Order List'. On review of this list, there were four other incidents where the blue Door Interlock Light remained illuminated while the passenger doors on EMUs, as a result of faults with coupling since 26th August 2010 until the date of the incident on the 10th August 2013.

Post incident examination of the autocoupler

49 The autocoupler was examined when returned to Fairview depot on the 10th August 2013. One of the electrical coupler head covers was damaged (Figure 9) which prevented the electrical coupler head from moving in either direction (Figure 10); this resulted in the opposing electrical pins not connecting, resulting in the autocoupler being incorrectly coupled.



Figure 9 – Damage to electrical head cover



Figure 10 – Closed electrical head cover

50 A door interlock integrity test was carried out; and it was found that it was possible for the blue Door Interlock Light to illuminate in the leading cab when a door was open in the trailing carriage.

51 The testing by CME also identified that a gap of three millimetres (mm) between the autocouplers can cause unwanted isolation of certain safety critical circuits. Therefore, when the electrical coupler head is not coupled, or incorrectly coupled, the circuit is returned via the normally closed contacts behind the moveable pins, see Figure 11.

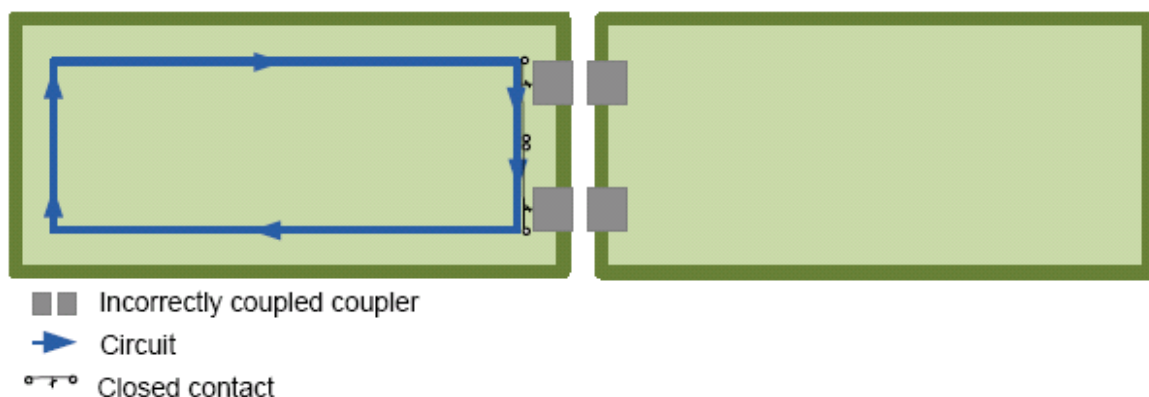


Figure 11 – Electrical coupler incorrectly coupled, with circuit not flowing through the uncoupled carriages

52 The size, shape and position of the indentation on the electrical head cover (Figure 12) is consistent with the cover coming into contact with the mechanical coupling cone section (see Figure 13) of another autocoupler.



Figure 12 – Indentation on electrical head cover

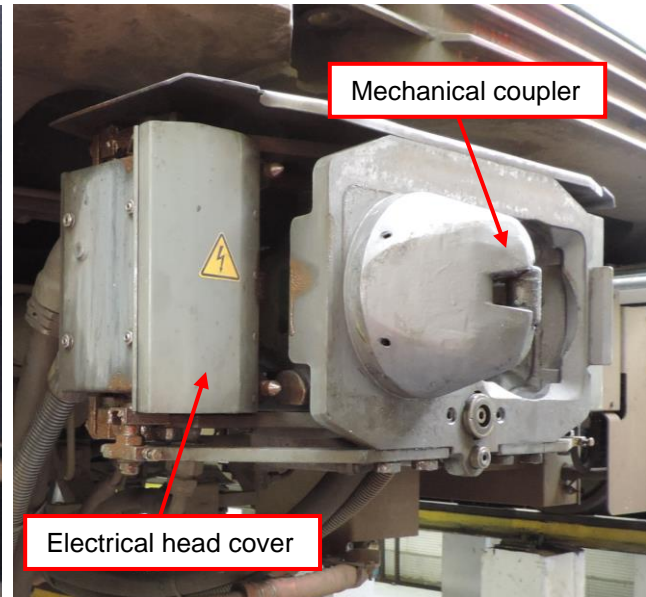


Figure 13 – Electrical head cover and mechanical mating cone

53 The event recorder download recorded the status of the doors as displayed in the driver's cab, i.e. recorded that the doors were closed when the driver's display showed that the doors were closed, prior to and during the incident.

The passenger doors

Passenger door operation

- 54 Each individual 8100 Class EMU vehicle is fitted with four electro-pneumatically operated double leaf outside doors.
- 55 During passenger service, passenger doors may be released when a train has come to a complete stop at a station platform and the driver is satisfied that all passenger doors are on the platform.
- 56 The passenger doors operate on the 'Driver Enable, Passenger Open' principle; where the driver controls the release of the passenger doors from the door control panels in the driving cab by pressing the two red doors enable 'Doors Release' push buttons simultaneously for the appropriate side of the train (red buttons in Figure 14); and when the door locking mechanism has been released, passengers may then open individual sets of passenger doors, either from inside or outside the train, by pressing the illuminated push buttons located at each door. The 'Doors Release' buttons are not operative at speeds above 3 km/h as this will release the door locking mechanism.



Figure 14 – Driver's control panel for right hand side door operation controls

- 57 According to Section 12 of the Class 8100 EMU Drivers' Handbook (which will be referred to as the Drivers' Handbook for the remainder of the report), issued 1st July 2010, the passenger doors can only be enabled when the train is stopped. When the passenger doors are released, the illuminated blue Door Interlock Light on the driver's desk (Figure 14) will extinguish. At the same time the amber 'Doors Enabled' external indicator, positioned over the passenger doors, will illuminate when the passenger doors are open.

58 The passenger doors are closed by the driver pressing the appropriate 'Door Close' button (green button in Figure 14). This will illuminate the blue Door Interlock Light when the Door Interlock Circuit is complete when the signal recognises that the passenger doors have all physically closed (see Figure 15). It should be noted, that passenger doors may be slower to close than normal in some instances, this may be due to a busy passenger service.

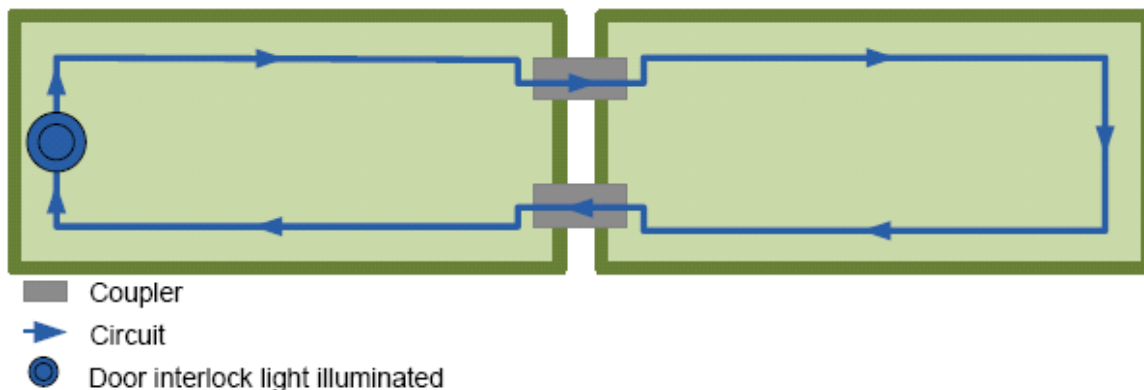


Figure 15 – Doors Closed Circuit returned with illuminated blue Door Interlock Light

59 Section 12.2, 'Method of Operation' of the Drivers' Handbook notes that, the illumination of the blue Door Interlock Light is required to enable traction power to be taken by the driver and that the passenger door and traction control system are so interlocked that "power cannot be provided for traction purposes if doors are released or if any passenger door on the train is open".

60 Therefore, if a door remains open, the Door Interlock Circuit does not form a complete circuit, and the blue Door Interlock Light remains extinguished on the driver's console, see Figure 16.

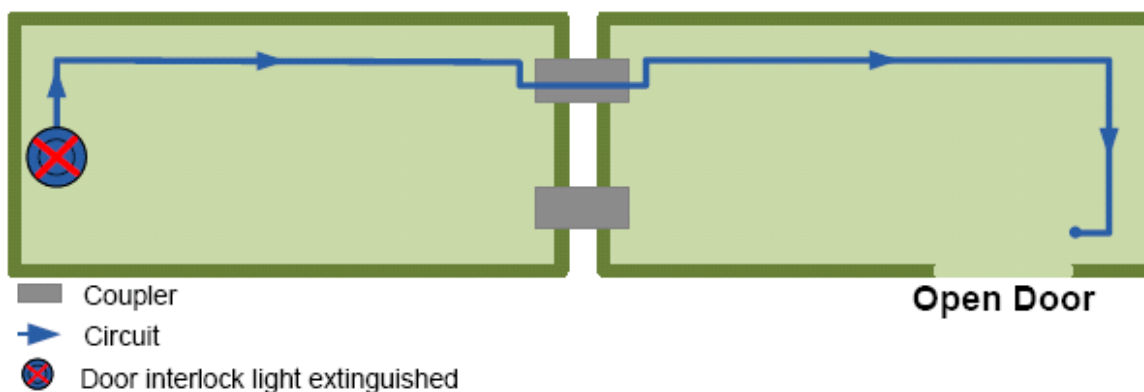


Figure 16 – Doors Closed Circuit not returned with Door Interlock Light extinguished

61 Section 12 continues that the door and traction control systems are interlocked, so that:

- Power cannot be provided for traction purposes if passenger doors are released or if any passenger door is open;
- If in the unlikely event of a passenger door opening while a train is in motion, then power would be cut off and the driver alerted by the extinguishing of the 'Door Interlock' light.

62 Section 12.3 'Door test' outlines procedure for a door test, however, it does not state when these procedures should be adopted; the procedures are as follows:

- With the cab energised, place the master switch in the neutral position;
- Enable passenger doors on both sides of unit;
- Close controller and remove key;
- Enter saloon and open each set of passenger doors in turn, checking for the illumination of the exterior door obstruction lights;
- Return to cab and re-energise;
- Attempt to take power with passenger doors in open position and ensure that unit was unable to motor in this state;
- Press door close buttons on both sides;
- Check for illumination of the blue Door Interlock Light.

63 Section 12.4, 'Door problems possible cause' identifies some issues with passenger doors, these include (as illustrated in Figure 17):

- No blue Door Interlock Light (12.4.1);
- Passenger doors will not open (12.4.2);
- Passenger doors will not close (12.4.3);
- Identification of faulty passenger door (12.4.4).

12.4.1 No blue interlock light.

- Controller closed?
- Lamp on dim or bulb blown?
- MCB tripped?
- Door closed button pressed?
- Emergency button pressed?
- Door obstructed?
- Faulty proximity switch?
- Defective coil cable?
- Exterior crew access open?

12.4.3 Doors will not close

- Controller closed?
- Offside doors pressed?
- MCB tripped?
- Door obstructed?
- Emergency button pressed?
- Defective door relay?

12.4.2 Doors will not open

- Controller closed?
- MCB tripped?
- Door isolated?
- Defective door relay?
- Faulty low speed relay?

12.4.4 Identification of faulty door

- Check for car with exterior amber light.
- Electrically isolate / de-isolate each door in turn until blue light returns. (Only necessary if no door is obviously open).

Figure 17 – Section 12.4 of Drivers' Manual, Door problems possible cause

64 There is no guidance in any section, in relation to issues associated with the blue Door Interlock Light being illuminated while the passenger doors are still open.

Maintenance of the passenger doors

65 The inspection of the passenger doors also falls under the procedures set out in the VMIs which were adhered to by IÉ. The passenger doors were last inspected, as set out in the A Exam Electrical procedures on the 6th August 2013 (the same day as the last A Exam Mechanical). No faults were found with the passenger doors.

Post incident examination of the passenger doors

66 The passenger doors were examined on the trains return to Fairview Depot, no damage or faults were identified with the passenger doors.

Train driver procedures

Drivers' Manual

67 The Drivers' Manual sets out the procedures into tasks, where tasks are laid out with diagrammatic illustrations to indicate whether the task is activity based, observational or a visual or physical check, see Figure 18:

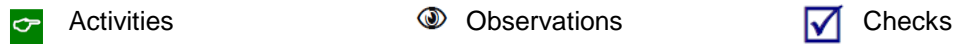


Figure 18 – Illustrations of task requirement in Drivers' Handbook

Full train preparation instructions

68 Drivers are required to follow the procedures set out in Section 8.3 of the 'Full train preparation instructions' from the Drivers' Handbook when leaving a maintenance depot after a CME examination, or a stabling point where a train has been stabled overnight (which was the case in this incident).

69 The full train preparation instructions includes sixteen separate sets of tasks to be undertaken, the order of which is illustrated in the 'Class 8100 EMU Walkaround Plan', see Figure 19. The sixteen sets of inspections and checks are as follows:

- Initial inspection on approaching unit;
- Leading drive cab inspection;
- Outside front inspection;
- Battery box side inspection;
- Rearmost driving cab (Trailer Car (TC)) inspection;
- Inside saloon inspection;
- Intermediate cabs (Motor Car (MC) inspection;
- Return to rearmost driving cab checks;
- Rear driving cab inspection;
- Leaving rear driving cab checks;
- Line breaker side inspection;
- Enter leading driver cab (MC) checks;
- Inside saloon inspection;
- Intermediate cab;
- Return to leading driving cab checks;
- Leading driving cab inspection.

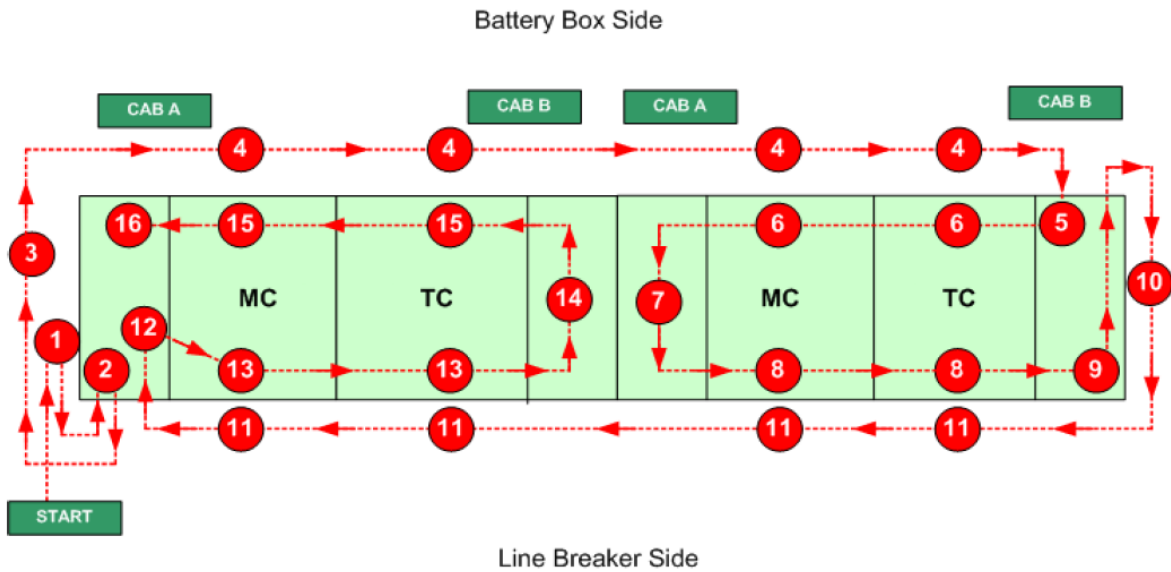


Figure 19 – Class 8100 EMU Walkaround Plan

70 The instructions require the drivers to do a number of ‘checks’ in relation to the coupler, including, during Step 4 (16) of the ‘battery box side inspection’ the driver should visually check that the “Units are correctly coupled”; this is repeated for the ‘line breaker side inspection’ in Step 11 (15), see Figure 20.

4 Battery box side inspection.

- Proceed down the Battery Box side of the train carrying out a visual inspection and check
- 1. There are no scotches or obstructions on the rails
- 2. Check for air leaks
- 3. Coupling hoses are secure and cocks closed
- 4. No damage to cables
- 5. Air suspension & levelling valve on all cars
- 6. Local air spring cut off valve all cars
- 7. Bogie isolation cut off valve all cars (sealed in Bray direction)
- 8. Servotrol decoder cable all cars
- 9. Fuse box closed MC only
- 10. All equipment boxes closed and secure all cars
- 11. Doors secured on the Emergency egress cocks
- 12. Semi-permanent coupling in good condition
- 13. All pantographs are raised
- 14. No sign of damage to the train
- 15. No shore supply is connected
- 16. Units are correctly coupled
- 17. All air pipes, air cocks and sanders are in proper condition
- 18. Handrails and steps are in order.
- 19. No marker, headlights or taillights are illuminated on intermediate cabs

Repeat Step 4 for Next Unit

11 Line breaker side inspection

- Proceed down the line breaker side of the train carrying out a visual inspection and check
- 1. There are no scotches or obstructions on the rails
- 2. Coupling hoses are secure and cocks in correct position
- 3. Speedo cables for damage
- 4. Condition of compressor
- 5. Condition of air tanks
- 6. No obvious air leaks
- 7. Air suspension & levelling valve on all cars
- 8. Doors secured on the emergency egress cocks
- 9. Semi-permanent coupling in good condition
- 10. Hand rails and steps are in good order
- 11. All equipment boxes closed and secure all cars
- 12. General condition of MA, Aux compressor,
- 13. No shore supply is connected and all equipment boxes are closed and secured
- 14. Check pantograph isolation handles are in correct position (10 to 3 Normal) (5 past 6 Isolated)
- 15. Units are correctly coupled
- 16. All air pipes, air cocks and sanders/sand level are in proper condition at coupled position
- 17. No marker, headlights or taillights are illuminated on intermediate cabs
- 18. No sign of damage to the train
- 19. REPEAT STEP 11 FOR NEXT UNIT UNTIL DRIVING CAB IS REACHED

Figure 20 – Full Train Preparation sections associated with checking coupling (highlighted)

71 The Drivers’ Manual notes that only after all these inspections and checks have been carried out is the train ready for departure.

Attaching and detaching procedures

72 Section 8.4 of the Drivers' Handbook outlines the procedures for attaching and detaching train carriages. Section 8.4.1 of the attaching procedures for the driver when positioned in the leading driving cab. It sets out that the driver must check the coupler alignment and follows by setting out the driver tasks (activities) for the coupling of carriages. No other checks are required once the carriages are coupled. Figure 21, sets out the procedures for the drivers, where there is an observation check for the coupler alignment.













-  Stop the unit 1 metre from the stationary unit
- Check the coupler alignment
- 
-  Ensure all illumination is extinguished on the stationary unit.
-  Place the couple / uncouple switch to the couple position on the stationary unit.
-  Ensure that the couple / uncouple switch is in the uncoupled position on the unit being driven.
-  Select forward.
-  Sound the Horn
-  Select power position one.
-  Couple to the other unit
-  Place the couple /uncouple switch to the couple position.
-  Extinguish all intermediate illumination
-  Remove key and secure cab

Figure 21 – Attaching procedures for drivers

73 Section 8.4.3, 'Unit will not couple correctly' gives procedures for the driver, in relation to both driving cabs, where the units will not couple correctly, where it states that drivers should visually check the condition of the coupler heads of obstructions or damage, see Figure 22.


- Ensure that the coupler switch in both cabs is in the couple position. This is located in the non drivers' side E-cabinet.
- 
- Visually check the condition of the mating coupler heads for obstructions or damage
- Check the position of the pneumatic isolation cock (PET) that is it in the normal position. This is located behind the electrical head of the coupler

Figure 22 – 'Unit will not couple correctly' procedures

(note: spelling mistake matting instead of mating)

Events before the incident

- 74 There had been four recorded occurrences of the blue Door Interlock Light being illuminated while the passenger doors were open, similar to this incident since 26th August 2010 until the time of the incident on the 10th August 2013.
- 75 Of the four recorded occurrences, two were investigated by the CME FTS under one investigation, and the CME FTS August 2012 Report created. The CME FTS August 2012 Report resulted in recommendations associated with the design modification of the autocoupler (which was being undertaken at the time of the incident); and the consideration for the introduction of a blue Door Interlock Light integrity test (which had not been introduced at the time of the incident).
- 76 At some after the last maintenance inspection on the 6th August the electrical coupler head cover was damaged. This damage is likely to have been caused by impacting with the cone of another coupler during a previous coupling activity.
- 77 The train was returned to Bray after service on the 9th August 2013. There were no reported defects with the train.

Events during the incident

- 78 In the early morning of the 10th August 2013, Train Driver A was responsible for the coupling of the train carriages of the train for service, including carriages 8102 and 8314, as per Section 8.4 of the Drivers' Manual. Although, there was low ambient light at the time of coupling, the forward facing CCTV from 8314 shows damage to the coupler head door, which prevented the electrical coupler head from moving in either direction, see Figure 23. Train Driver A did not notice this at the time of coupling (as he was not required to check the couplers before or after coupling).



Figure 23 – CCTV still showing damaged and closed autocoupler electrical head door

- 79 The CCTV footage also shows the coupling of the carriages appears as a normal coupling event with Train Driver A mechanically coupling successfully coupling on the first attempt (he would have assumed that electrical coupling was also successful).
- 80 Train Driver B was required to carry out the Full Train Preparation Instructions, which included to check that “units are correctly coupled” (Section 8.3 of the Drivers’ Manual), paragraph 68. However, Train Driver B did not carry out the Full Train Preparation Instructions assuming that this was carried out by Train Driver A. As a result, Train Driver B did not check if the units were correctly coupled.
- 81 Train Driver B then operated the empty train to Greystones, to operate the 06:30 hrs from Greystones to Howth (train identification E901); before finally operating the 08:02 hrs from Howth to Greystones (train identification E102), prior to a scheduled roster break when he returned to Fairview Depot.
- 82 Train Driver B, although not noticing anything wrong with the train during service, thought that the blue Door Interlock Light was coming on quicker than normal, but assumed this was as a result of low passengers numbers on Saturday morning, which meant that only a few passenger doors were being opened, which he assumed, resulted in the passenger doors closing quicker.
- 83 Train Driver B handed over the train to Train Driver C at Fairview Depot and told Train Driver C that there were no problems with the train, but that he thought the blue Door Interlock Light was coming on quicker than normal.
- 84 Train Driver C took control of the train and proceeded driving the Howth to Greystones service. Train Driver C had not noticed anything unusual about the train when he arrived at Salthill & Monkstown Station at 08:49 hrs. Then, when Train Driver C observed that all passengers had alighted and boarded the train, the driver pressed the green ‘Door Close’ button, and saw the blue Door Interlock Light illuminated (which normally confirms to drivers that the passenger doors have closed and can proceed to take power).
- 85 However, as Train Driver C was about to take power, he looked back along the train, and saw that two exterior amber lights were illuminated at the rear of the train, and two passenger doors were still in the process of closing.
- 86 Train Driver C opened and reclosed the passenger doors and the same occurred. He disembarked the train and walked the length of the train and saw that one of the electrical coupler heads was not attached correctly at the rear of the train, between carriages 8102 and 8314.

87 Train Driver C returned to the driving cab and contacted the Suburban Line Signaller to inform him of the issue with the blue Door Interlock Light. Train Driver C was connected to the CME representative for assistance; and the decision was made to take the train out of service and send the train to Fairview DART Maintenance Depot.

Events after the incident

88 Train Driver C followed all post incident procedures correctly and followed the advice from the CME's representative and returned the train to Fairview Depot for post incident inspection.

89 Following this incident, there were two other reported incidents where the passenger doors were open while the blue Door Interlock Light was illuminated on the 18th September 2013. After these incidents were reported to the RAIU, the RAIU issued an Urgent Safety Advice Notice. This notice requested for permanent mitigation measures to prevent a reoccurrence; and interim measures to manage the risks associated with the failsafe mechanism of failure.

90 IÉ introduced the 'Coupler Electrical Head Integrity Test' in September 2013, to be completed by drivers during full train preparation and after the coupling of two or more trains together.

Similar occurrences

- 91 Excluding the incident on which this report is based, the CME have recorded four other similar occurrences on 8100 Class EMUs, of the blue Door Interlock Light being illuminated while the passenger doors have been open; and in service, from 26th August 2010 until the date of this incident (10th August 2013), with two occurrences recorded after the incident.
- 92 The first similar occurrence recorded was on the 26th August 2010, where the blue Door Interlock Light was illuminated while the passenger doors were open and in service of a 8100 Class EMU. This was as a result of mechanical damage to the electrical head door which prevented electrical coupling. No other information is available as to the cause of this occurrence.
- 93 The next two similar occurrences are related to the incidents in February 2012, previously mentioned in this report are also associated with the 8100 Class EMUs. On Friday 10th February 2012 the driver of the 08:37 hrs Dun Laoghaire to Connolly DART train service reported that the blue Door Interlock Light was illuminated before the passenger doors were closed. On Tuesday 14th February 2012 the driver of the 20:25 hrs Bray to Howth DART train service reported that the blue Door Interlock Light remained illuminated while passengers prevented the passenger doors from closing at the rear of the train. An inspection by FTS found that a broken “electrical male pin” had lodged in an “electrical female pin” which prevented the electrical heads from connecting properly and was responsible for both incidents; a number of conclusions and recommendations resulted from this investigation which were included in the CME FTS August 2012 Report, as discussed in paragraphs 30 to 36.
- 94 The next recorded similar occurrence, also recorded on a 8100 Class EMU, was on the 5th May 2012, where the blue Door Interlock Light was illuminated while the passenger doors were open and in service. This occurrence was as a result of damage to the electrical head door. No other information is available as to the cause of this occurrence.
- 95 In relation to incidents after the occurrence, in the month following the incident on the 18th September 2013, in Tara Street Station and Salthill & Monkstown Station, drivers reported that the blue Door Interlock Light was illuminated while the passenger doors were still open and in service. Both incidents were as a result of the electrical coupler heads not fully engaging.
- 96 It should be noted that the occurrences discussed in this report relate to the blue Door Interlock Light being illuminated with the passenger doors open where there has been an issue with the autocouplers. There have been a number of other occurrences reported when the blue Door Interlock Light was illuminated and the passenger doors open, which were not associated with the performance of the couplers.

Analysis

Autocoupler design & operation of passenger doors

97 As discussed previously, the correct mating of the electrical head pins is required in order to couple carriages correctly, as it allows the normally-closed spring-loaded contacts to open and allow the transmission of signals throughout all the coupled carriages. One of the signals to flow through the carriages is the Door Closed Circuit; when all the passenger doors are closed, the signal's circuit is complete and this information is displayed in the driving cab through the illumination of the blue Door Interlock Light, see Figure 24.

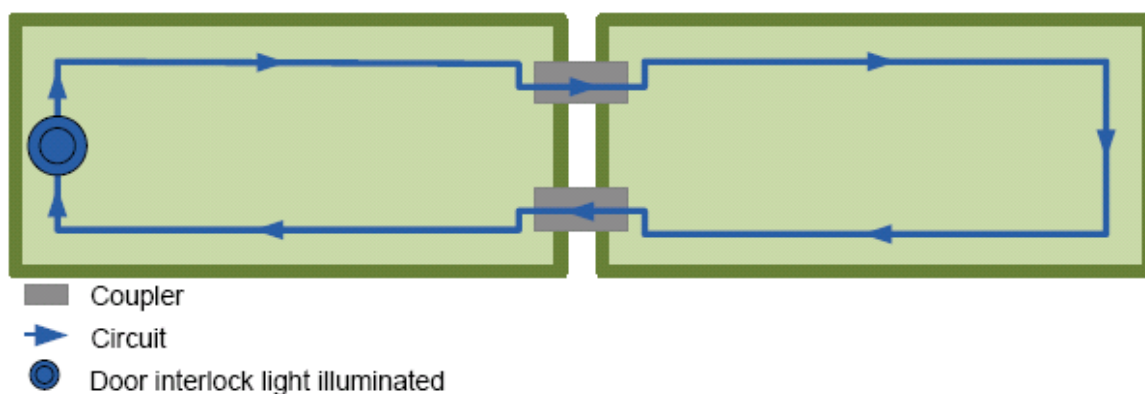


Figure 24 – Passenger doors closed with blue Door Interlock Light illuminated

98 When passenger doors are open, the Doors Closed Circuit is interrupted (incomplete) and the Door Interlock Light is extinguished, see Figure 25.

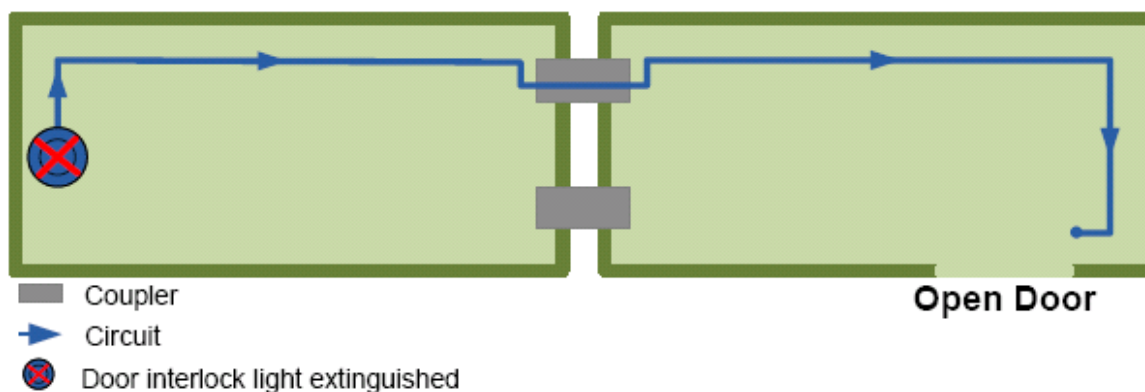


Figure 25 – Open passenger door with extinguished blue Door Interlock Light

99 However, on the day of the incident, the electrical coupler heads were not coupled correctly, which resulted in the Door Interlock Circuit not being sent through to all the carriages and the circuit looped through the coupled carriages, resulting in a complete circuit for those carriages, omitting the incorrectly coupled carriages, see Figure 26.

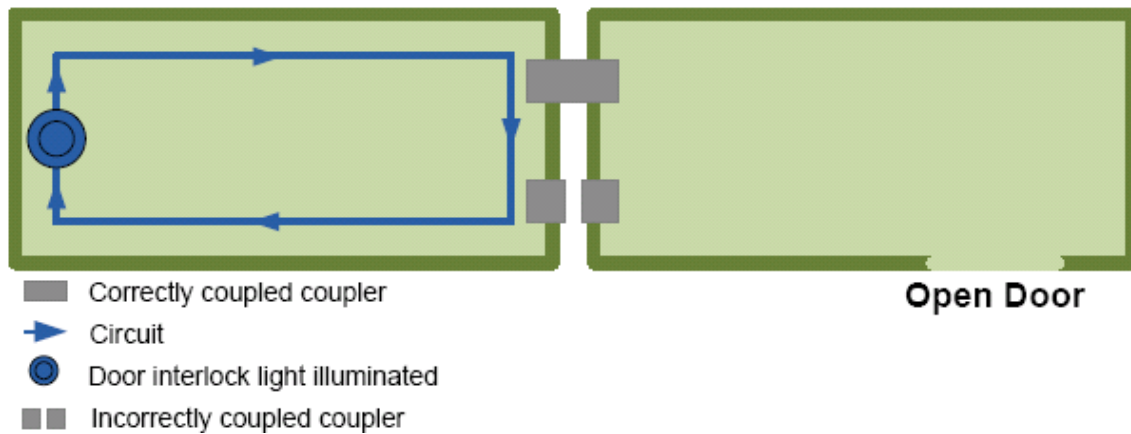


Figure 26 – Incorrectly coupled units, with door open and blue Door Interlock Light illuminated

100 This omission of the circuit not passing through the incorrectly coupled units, is similar to the units not being coupled, see Figure 27.

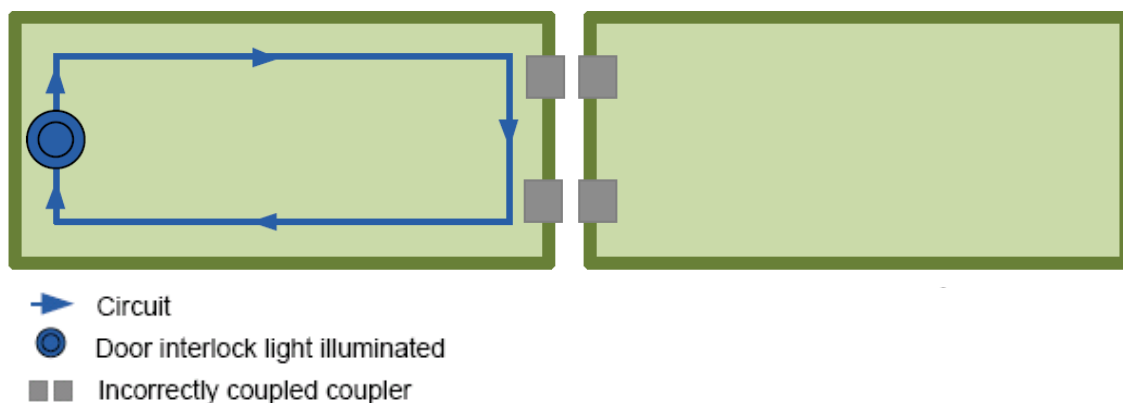


Figure 27 – Uncoupled units, with blue Door Interlock Light illuminated

101 This ability of the blue Door Interlock Light to illuminate while the passenger doors are still open due the autocouplers being incorrectly coupled has been identified by the CME on four occasions since 2010, with the first incident recorded on the 26th August 2010 (paragraph 48).

102 The next similar incidents were recorded in February 2012, which resulted in an investigation and the CME FTS August 2012 Report which identified that there was a weakness in the design; as the design relied on the normally-closed spring-loaded contacts to send the signal onto other carriages; which would not occur if the autocoupler electrical heads are damaged or not coupled correctly.

103 The CME FTS August 2012 Report recommended that the design of the autocoupler be modified to remove the dependence on the spring-loaded normally-closed pins. This design process commenced in November 2012, however, the design was not finalised until March 2014 (seven

months after the incident). Given the iterative design process involved in the design modification to the autocoupler, it may not have been expected to have been completed prior to the incidents in August and September 2013, however, the process should have required the introduction of mitigations (design or operational) to prevent the re-occurrence of incidents similar to those in February, especially given that the risk of re-occurrence was identified in August 2012 (in the CME FTS August 2012 Report), paragraph 37.

104 The CME FTS August 2012 Report also recommended that consideration should be given to the introduction of a door closed integrity test. CME-SMS-001 requires that the recommendations from accident, incident and other investigations are approved; and safety audit findings are reviewed, corrective action plans are reviewed and the implementation of recommendations are tracked have been discussed (paragraph 41) however, the MESSG meeting held on the 23rd October 2012 only minuted that “Review of remits completed and appropriate actions discussed” with no corrective plans identified or adequate evidence that the recommendations were discussed (paragraph 42) and no further evidence was provided in relation to tracking the recommendations past this date (paragraph 42).

105 In addition, the CME did not contact DART Operations, who were affected by the ‘Coupler Electrical Head Integrity Test’ through the RU SRG, as required by RU-SMS-007 (as DART Operations is a different department to the CME), to ensure that the recommendation was discussed, accepted, divided into discreet actions, responsible managers for delivering them assigned and target completion dates set (paragraph 43).

106 In addition, the CME did not contact DART Operations through any other means in relation to the ‘Coupler Electrical Head Integrity Test’ as confirmed by both the CME and DART Operations (paragraph 44), with DART Operations only becoming aware of the design weakness after the incidents in August and September 2013 (paragraph 44).

Train driver procedures

107 The 'Door test' section of the Drivers' Handbook outlines procedures for a door test. The test includes checking the illumination of the exterior amber lights, attempt to take power with the passenger doors open and check for the illumination of the blue Door Interlock Lights. The 'Door Problems possible cause' section identifies some issues with passenger doors, however, there is no guidance in relation to the illumination of the blue Door Interlock light when the passenger doors are open.

108 The 'Full train preparation instructions' section of the Drivers' Manual, sets out a number of checks in relation to the train, prior to taking the train into service, which includes an instruction that drivers should visually check that units are correctly coupled (paragraph 68). The actions of the Train Driver B will be discussed below in relation to his checks before service. However, it should be noted, that it was identified by the CME FTS that a gap of just 3 mm between the autocouplers can cause unwanted isolation of certain safety critical circuits (paragraph 51), therefore there is some doubt as to the efficacy of a visual check by drivers in relation to correct coupling of autocouplers.

109 Also in relation to the requirements of drivers, in relation to coupling, the Drivers' Handbook outlines a number of procedures that should be followed (paragraph 72). However, the Drivers' Manual does not require that the drivers carry out an observation check of the condition of the coupler (paragraph 72), only an alignment check. Nor does it require an observation check after coupling to check if the units are coupled correctly.

110 The only case where a driver must check the condition of the coupler head for obstructions or damage is where the 'units will not couple correctly' (paragraph 73). There is also some doubt in relation to the efficacy of this check, given that on 10th February 2012, depot staff did not notice an electrical pin lodged in the opposing pin of the electrical head, with the CME FTS August 2012 Report noting that "closer examination of the autocoupler electrical heads after the initial failure may have identified the root cause and prevented the second occurrence" (paragraph 35).

111 The CME FTS August 2012 Report recommended that "Testing the integrity of Door Closed Indication Circuit should be considered for EMU trains after vehicles have been coupled". However, this was not implemented at the time of the incident. Had the 'Coupler Electrical Head Integrity Test' been introduced at this time, Train Driver A would have performed this test after coupling the units and failed the train, resulting in the incident on the 10th August 2013 not occurring. The performance of this test would also have avoided the incidents in September 2013.

Drivers actions on the day of the incident

112 Train Driver A, was responsible for the coupling of the units before the train entering service. He carried out the procedures as set out in Section 8.4.1 of the Drivers' Manual correctly (paragraph 72). There was no apparent problem with the coupling, as mechanical coupling was achieved on the first attempt, and therefore Train Driver A assumed electrical coupling was also achieved. There was no requirement for Train Driver A to carry out the Full Train Preparation Instructions, which included a check to ensure that the couplers were correctly coupled.

113 Train Driver B did not carry out the Full Train Preparation Instructions, which requires drivers to check that the "units are correctly coupled", as he incorrectly assumed that this was carried out by Train Driver A. Given that the electrical head door was damaged, as seen in the CCTV (Figure 23 and paragraph 78), the trains were clearly not coupled correctly, however, as Train Driver B carry out the checks, the damage to the coupler head was not detected. However, it should be noted that he would see the blue Door Interlock Light illuminated on the driver's console and assumed the units were all coupled correctly.

114 Despite the fact that the incorrect coupling was clearly visible, there is some doubt as to the efficacy of this check given that a small gap between the pins can cause unwanted isolation and in effect mean that the couplers are incorrectly coupled, a fault that is unlikely to be noticed by the driver.

115 Train Driver C, on seeing the blue Door Interlock Light illuminating while the passenger doors were open, carried out some checks and saw that the electrical head cover of the autocoupler had not opened the electrical heads resulting in the carriages not being coupled. He then carried out all post incident actions correctly.

Conclusions

Autocoupler design & operation of the passenger doors

116 The autocoupler electrical head door had been damaged at some time previous to the coupling event on the day of the incident. Train Driver A coupled the units without any noticeable incident. Train Driver B did not carry out the Full Train Preparation Instructions and therefore did not notice the damage to the electrical head cover door and that the units were not correctly coupled. Train Driver C noticed that the blue Door Interlock Light was illuminated while the passenger doors were open and the train was failed and returned to Fairview Depot.

117 Prior to this incident, there were four occurrences of the blue Door Interlock Light being illuminated while the passenger doors were open (associated with the coupler), since 26th August 2010. Two of these incidents occurred in February 2012, which resulted in an internal CME FTS investigation which resulted in the CME FTS August 2012 Report, which included two recommendations of significance to this investigation.

118 The first of these recommendations was in relation to a design modification to the autocoupler to rectify the weakness in the autocoupler design which relied on the normally-closed spring-loaded contacts to send the signal onto other carriages. The design process for this modification commenced in November 2012, however, the design was not finalised until March 2014 (seven months after the incident). Between November 2012 to September 2013 (the date of the introduction of the 'Coupler Head Integrity Test' no other mitigations (design or operational) were introduced to prevent the re-occurrence of incidents similar to those in February, despite the risk of re-occurrence being identified in August 2012 (in the CME FTS August 2012 Report), paragraph 103.

119 Had an investigation been carried out after the first incident in 26th August 2010 or a failsafe design modification been applied in August 2013, the incidents in August and September 2013 would not have occurred.

120 However, given the iterative design process involved in the design modification to the autocoupler, it is unlikely that it would have been achievable to have been completed prior to the incidents in August and September 2013.

121 The second recommendation suggests that a door closed integrity test should be considered, to be conducted after carriages have been coupled. This should have been introduced as an interim measure during the design modification process to avoid reoccurrence, especially given that the CME FTS August 2012 Report identified the possibility of reoccurrence. However, it was not

introduced until after the incidents in August and September 2013. Had this recommendation been introduced in August 2012 (after the publication of the CME FTS August 2012 Report), the incidents in August and September 2013 would not have occurred.

122 The CME did not adequately address the recommendations in the CME FTS August 2012 Report, and failed to fully adhere to the requirements of CME-SMS-001 to review safety audit findings and approve their recommendations, develop corrective action plans and implement and track recommendations and only briefly address the report at the MESSG meeting on the 23rd October 2012, only minuting that “Review of remits completed and appropriate actions discussed” and not addressing the CME FTS August 2012 Report at any other MESSG meetings (paragraph 104).

123 In addition, the CME did not contact DART Operations (a difference department), who were affected by the ‘Coupler Electrical Head Integrity Test’ through the RU SRG, as required by RU-SMS-007 (paragraph 105) or through any other means (paragraph 106), which resulted in DART Operations only becoming aware of the design weakness after the incidents in August and September 2013 (paragraph 106).

Train driver procedures

Full train preparation instructions

124 The 'Full train preparation instructions' section of the Drivers' Manual states that the driver should visually check that the units are correctly coupled. However, given that a gap of just 3 mm between the autocouplers can cause unwanted isolation of certain safety critical circuits, there is some doubt as to the efficacy of a visual check by drivers in relation to correct coupling of autocouplers.

125 The Drivers' Handbook does not identify the blue Door Interlock Light illumination while the passenger doors are open as an issue that may occur on EMU trains.

126 As above, the recommendation in relation to the integrity of Door Closed Indication Circuit was introduced in September 2013, after the occurrences in September 2013.

Attaching and detaching procedures

127 During the coupling of trains, the Drivers' Handbook only requires that the driver check the alignment of a coupler (not the condition) where the 'units will not couple correctly' (paragraph 110). In addition, the Drivers' Manual does not require that the couplers are checked after coupling.

128 The CME FTS August 2012 Report recommended that "Testing the integrity of Door Closed Indication Circuit should be considered for EMU trains after vehicles have been coupled". However, the 'Coupler Electrical Head Integrity Test' was only introduced in September 2013.

Immediate cause, contributory factors, underlying causes, root causes and additional observations

129 The immediate cause of the blue Door Interlock Light illuminating while the passenger doors were open, causing a wrongside failure, was as a result of the autocouplers on carriages 8102 and 8314 being incorrectly coupled, which resulted in the Door Closed Circuit not passing through the incorrectly coupled carriages, resulting in the driver's display indicating that all doors were closed.

130 CFs associated with the incident are as follows:

- CF-01 – One of the electrical head doors of carriage 8102 was damaged at some time previous to the coupling on the day of the incident, which stopped the electrical coupler head from moving in either direction, preventing correct coupling;
- CF-02 – A design weakness in the autocoupler, known to the CME prior to the incident, allowed the blue Door Interlock Light to illuminate when passenger doors remained open;
- CF-03 – Train Driver B did not carry out the full train preparations and therefore did not notice the damage to the electrical coupler head.

131 UCs associated with the incident are as follows:

- UC-01 – The CME did not correspond with DART Operations to consider the introduction of a Coupler Electrical Head Integrity Test for EMU trains after coupling, to mitigate the risk associated with the known design weakness;
 - UC-02 – The Drivers' Manual put an unrealistic reliance on drivers to identify coupling faults, given that minor flaws can result in the autocouplers being incorrectly coupled;
 - UC-03 – The design modification process, being undertaken by the CME at the time of the incident, did not require for sufficient risk mitigation measures to be introduced (such as the Electrical Coupler Head Integrity Test) to mitigate the identified risk of re-occurrence until the design modification was complete.

132 RCs associated with the incident are as follows:

- RC-01 – The CME did not fully adhere to their relevant SMS documents (CME-SMS-001 & RU-SMS-007) as they did not adequately address the recommendations from their own internal investigation report in relation to the design weakness of the autocoupler.

133 The following AO, without relevance to conclusions on causes of the incident, was made during the investigation:

- AO-01 – The Drivers' Manual does not include any instructions to drivers on any actions to take in relation to the blue Door Interlock Light being illuminated when the passengers doors remain open.

Measures that have been taken or in progress

Measures that have been taken by IÉ

134 *Measures* that have been taken by IÉ include a design modification to the autocoupler and door interlock circuits being introduced to the entire EMU rolling stock. This modification will result in a more robust coupler circuit that will guarantee that both coupler electrical heads have connected correctly and that the coupler circuits are continuous throughout the train consist. It will include a visual indicator on the driving console that coupling has been completed successfully or a visual and audible indication that coupling has failed.

135 The design modification is based on the approach currently in place on all of the Diesel Multiple Units and InterCity Railcar fleets, which includes the following changes:

- The spring-loaded contacts will be removed from the electrical heads and will be replaced with fixed contacts;
- Coupling confirmation relays in the driving cab are being installed;
- Revisions to the coupler and door interlock circuits are being introduced;
- Coupling complete and coupling failed indicators are being installed in the driving cab;

136 If coupling has not been completed successfully, these modifications will result in the traction circuits and the brake safety loop being interrupted (not completing a full circuit); and it will not be possible for the driver to take traction.

137 The design of the door interlock circuit has also been revised and will ensure that it is not possible to bypass other units in the consist as the door interlock circuit will be interrupted unless coupling has been successfully achieved (which is a failsafe system).

Safety recommendations

General description

138 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.

139 This RAIU investigation has resulted in four new safety recommendations being made.

New safety recommendations related to the occurrence

140 In relation to the design weakness of the autocouplers, where the autocoupler do not fail safe (CF-02), the RAIU make the following safety recommendation for autocouplers the entire EMU fleet:

The CME (IÉ RU) should review and modify their design for the EMU autocouplers to ensure a more robust coupler circuit that will provide assurance that both coupler electrical heads have connected correctly and that coupler circuits are continuous throughout the train consist. Any modification made should be documented in Rolling Stock Design Standards.

141 In relation to the drivers inspection, the sole reliance on drivers to check the coupling (including damage) should be removed (CF-01, UC-02) as a result the RAIU make the following safety recommendations:

The CME (IÉ RU) should introduce a visual indicator on the driving console to indicate to the driver that coupling has been completed successfully (or a visual or audible indication that coupling has failed).

142 However, Train Driver B did not carry out the full train preparation instructions as set out in the Drivers' Manual (CF-03), assuming they had been carried out by Train Driver A. In addition, the Drivers' Manual does not include any instructions to drivers on any actions to take in relation to the blue Door Interlock Light being illuminated when the passengers doors remain open (AO-01). Therefore the RAIU make the following safety recommendation:

DART Operations (IÉ RU) should update the Drivers' Manual to include specific guidance on the requirement for the examination of couplers. The update should also include guidance on associated testing of coupler integrity and guidance on any indications in the driving cab that would assist the driver in detecting any coupler failure.

143 In relation to the closing of CME FTS August 2012 Report recommendations (UC-01, UC-03 & RC-01) in line with their internal SMS and the introduction of interim risk mitigation measures where design changes are required, the RAIU make the following safety recommendation:

The CME (IÉ RU) should review and modify the processes set out in their SMS for closing recommendations to ensure recommendations from investigations are recorded, monitored and closed. When these processes have been established, they should be audited (by a party external to the CME) at predefined intervals to ensure compliance.

New safety recommendations related to additional observations

144 A recommendation associated with the AO, AO-01, has been addressed in paragraph 142.

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
UC	Underlying cause
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.
Additional observation	Deficiencies and shortcomings established during the investigation but without relevance to conclusions on causes.
Autocoupler	An automatic coupler that simultaneously couples two rail vehicles pneumatically, mechanically and electrically.
Causal factors	Any factor(s) necessary for an occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.
Circuit	A path in which electrons from a voltage or current source flow. Electric current flows in a closed path called an electric circuit.
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	Factors relating to actions taken by persons involved or the condition of rolling stock or technical installations.
Controlling signalman	The signalman designated to control a specific section of track.
Couple	Attaching of rail vehicles.
Coupler	Connects two rail vehicles together (an autocoupler is a type of coupler).
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.
Failsafe	A design principle that requires a failed system to preserve the safety of the railway line.
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.
Measure	Record of measures already taken or adopted as a consequence of the occurrence (European Railway Safety Directive 2004/49/EC).
National safety authority	The national body entrusted with the tasks regarding railway safety in accordance with European Railway Safety Directive 2004/49/EC.
Railway Undertaking	Organisation that operates trains.
Relay	An electrically operated switch. Relays are used where it is necessary to control a circuit by a signal or where several circuits must be controlled by one signal.
Rolling stock	Railway vehicles.
Root cause	Cause relating to framework conditions and application of the safety management system (European Railway Safety Directive 2004/49/EC).
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.

Signal	A voltage or current which conveys information, usually it means a voltage.
Track circuit block	A signalling system that uses track circuits to confirm the absence of trains in order to control the movement of trains.
Underlying cause	Cause relating to skills, procedures and maintenance (European Railway Safety Directive 2004/49/EC).
Wrongside failure	A failure condition in a piece of railway equipment that results in an unsafe state.

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.

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