Requirements for emergency lighting on passenger rail vehicles

Introduction

Interviews with witnesses from recent accidents highlighted many issues about the lack of effective emergency lighting. Lack of light during an accident prevents passengers from being able to see their surroundings so that they can react to protect themselves or others if possible. Immediately following an accident, lack of light inhibits orientation and deployment of first aid, and can increase anxiety leading to a desire to exit the vehicle as soon as possible. Rapid exit from an accident may put people at further risk. Furthermore, given its presence in such places as cinemas and aircraft, many passengers now expect emergency lighting in trains.

It was therefore necessary to investigate the case for trains to be equipped with emergency lighting that is effective both during and after an accident; a system that is independent of normal vehicle systems and that supports passengers in taking more informed actions.

Aims

This project investigated the case for fitting emergency lighting on passenger carrying vehicles. It identified what levels are required for true emergency lighting and sought to confirm that such levels are achievable in a reliable way, using current technology.

Method

The work was carried out in four phases in a collaborative venture led by AEA Technology (now DeltaRail) and involving Interfleet Technology and Atkins Rail, each bringing to the project their own skills and knowledge in this area. The phases covered are:

• A literature review
• A workshop at the HSBC Rail Rollover Rig, looking at lighting levels and available equipment
• A second workshop to identify the design requirements for emergency lighting
• An evaluation of the costs and benefits
• Development and validation of a specification

Integrated into this work is the learning obtained from witness interviews and statements as part of other research commissioned by Rail Safety and Standard Board (RSSB).

Figure 1: The roll-over rig can rotate from 0-100

Findings

Literature review
This phase of the work reviewed documents applicable to rail, marine, and air mass-transit systems in the UK and internationally. It confirmed that the existing Railway Group Standard (GM/RT2176) was targeted at preserving the operational capability of the train after an incident, rather than ensuring survival of lighting suitable for passengers during and after an accident.

The following definitions for lighting on passenger vehicles have been used throughout the project:

• Normal Lighting: when the vehicle systems are working as designed.
• Reduced Lighting: when the vehicle is being supplied from the train battery, but there is a need to conserve battery power as there is no battery charging. (GM/RT2176 covered this requirement at the time of the research)
• Emergency Lighting: lighting required during and after an incident, which will operate even if the vehicle's normal lighting system has been damaged.

This project has not identified any other EU railway administration that mandates effective emergency lighting.
First workshop
The first workshop was undertaken at the HSBC Rollover Rig and involved rail industry stakeholders and representatives from other transport modes, and human factors specialists. The workshop considered the emergency lighting equipment installed in the Rollover Rig, with all natural light excluded. This enabled a technical review of some current technologies, measurement of lighting levels at different positions, and a subjective assessment of the effect on passengers of alternative levels of reduced lighting. It also identified scenarios when emergency lighting would be needed.

The results of an earlier research project (T066a), the 'Stay or Go' study, were presented, which concluded that in the overwhelming majority of cases it is safer for passengers to stay on the train following an accident, as opposed to evacuating promptly. The accident scenarios developed as part of the 'Stay or Go' study, informed the choice of scenarios in this project so that passenger requirements could be established. By way of example, scenarios include such events as:

• A derailment where the vehicle stays upright and does not foul other lines
• A derailment where the vehicle ends up on its side fouling another line
• Collision with infrastructure

Second workshop
The second workshop addressed these questions:

• In what circumstances is emergency lighting required?
• What lighting is required?
• When is lighting required, with respect to the situations and scenarios defined during the first workshop?

The conclusion reached was that an ideal emergency lighting system should:

1. Provide a level of illumination during and immediately following a reasonable foreseeable event (including the loss of battery power supply) sufficient to:

   • Enable passengers to see other passengers and train crew and inform actions during an accident.
   • Enable passengers or crew to identify the need for, and administer, urgent first aid in the immediate aftermath of an accident.
   • Enable passengers to read emergency notices at all times.
   • Enable passengers to move safely between vehicles if appropriate.
   • Encourage passengers to stay on board the vehicle in those circumstances in which it is safer to do so.
   • Provide necessary illumination to facilitate the safe use of exits during evacuation.
Enable passengers to locate and use exits and emergency equipment in escaping the vehicle where appropriate.

2. Maintain at least a minimum standard of illumination for a period of time sufficient for most foreseeable events.

3. Withstand defined shock and vibration levels associated with an accident scenario.

During the project there were a number of discussions on the different objectives of an emergency lighting system, which sometimes conflict. For example the desire to persuade the passengers to remain within the vehicle, needs to be balanced with the provision of the right level of lighting to show the passengers how to escape, should this be necessary.

The workshops identified that the following areas of a vehicle would ideally be illuminated by emergency lighting:

• Saloons (aisles and seating positions)
• Vestibules
• Inter-vehicle gangways
• Emergency equipment and its storage locations
• Egress points, especially door thresholds
• Alighting points on the track
• Emergency signage, especially safety instructions and local signs giving egress instructions (e.g. emergency door release instructions)

The duration and level of both reduced and emergency lighting have been specified for each of the areas identified. The work concludes that lighting should be available for a minimum of three hours after the initial incident. Specifically two situations need to be catered for, as depicted in the following graphs:
Figure 2: Normal lighting system continues to operate

Figure 3: Train immediately switches to emergency lighting

In addition, a selection of proprietary equipment has been checked to assess its performance, confirming that the required lighting levels are achievable with current technology.
Examples of such equipment have been tested against the crash pulse defined in AV/ST9001 'Vehicle Interior Crashworthiness', confirming that the technology used in emergency lighting components can survive the accelerations of a crash and will continue to function after an accident.

**Evaluation of benefits and costs**

Supported by feedback from witnesses, the work identified a number of safety benefits associated with the fitting of emergency lighting:

- Helping passengers to react to protect themselves and others during an accident
- Providing comfort and re-assurance immediately following an accident thus reducing trauma
- Facilitating deployment of first aid measures
- Assisting in train evacuation should the need arise

There is also operational benefit in routine service, when lengthy delays without an available power supply might otherwise leave passengers without light.

The cost of fitting emergency lighting to the existing passenger carrying vehicles is expected to be in the range £13m to £27m (or approximately half this if only saloon areas were fitted). The cost per vehicle for fitting new vehicles will be substantially lower.

The work has shown that it is not possible to quantify the size of the safety benefits because of a lack of related injury data or a sufficiently accurate means of modelling the various scenarios. A quantified cost benefit analysis that considers the level of safety benefit in comparison to the cost has not, therefore, been possible.

However, given the relatively low cost for fitting the lighting in new build vehicles and the potentially severe nature of the accidents requiring the use of
emergency lighting, the level of safety benefit need only be comparatively small to make the provision of emergency lighting reasonably practicable for new build vehicles.

In conclusion there are potentially significant safety and operational benefits that may make the fitting of emergency lighting to existing rolling stock reasonably practicable in certain circumstances. The case is likely to be stronger for new vehicles.

**Development and validation of a specification**

The two workshops and the testing carried out on the rollover rig confirmed requirements that can be defined in standards.

A procurement specification for emergency lighting in MkIII coaching stock has been produced for train operators and owners to use. It specifies the requirements for the design, manufacture, testing and delivery of the Emergency Lighting system to be installed on MkIII coaching stock undergoing refurbishment.

An industry code of practice has been produced to guide train operators, owners, and new train specifiers as to how the required lighting levels can be achieved. This has been validated with industry stakeholders, testing the assumptions made during the course of this work (in particular that the design reinforces the desired passenger behaviour). The code of practice identifies three sets of requirements. These are for new build, retrofit, and vehicles approaching the end of their lives.

**Next Steps**

This research has produced guidance that will enable train operating companies, owners, and builders to implement emergency lighting that will encourage appropriate passenger behaviour during and after incidents, and that addresses the many issues about the lack of effective emergency lighting.

The results of this work will be used to inform consideration of changes to Railway Group Standards, as well as input to the development of Technical Specifications for Interoperability and European Standards.

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