



## Requirements for Train Windows on Passenger Carrying Rail Vehicles (T424)

### *Introduction*

Investigations into a number of recent accidents in the UK have emphasised the role windows play in passenger safety. On the one hand a number of fatalities have resulted from people being ejected from trains via windows that have broken. On the other hand large numbers of people have broken windows in order to escape.

During the course of these accident investigations it was found that passengers were ejected through train bodyside windows. These windows had failed for one or more of the following reasons:

1. Internally impacted by passengers, luggage or other object.
2. Externally impacted by ballast, crash debris, or other object.
3. Structural deformation of the vehicle.

During the course of these investigations it was also found that, in a number of cases, the rapid escape of passengers from vehicles was impeded by their inability to break the glass using the hammers provided.

Prior to the 1990s vehicles had been fitted with toughened glass in order to provide a means of escape in an accident when required. Toughened glass was also considered to be less likely to cause injury to escaping passengers because of the small cube like dice formed on breakage.



**Crazed Toughened Glass Window**

Subsequently laminated glass was introduced for bodyside windows on new

trains. The standard GM/TT0122 stated that all windows that were not designated for escape should be made of laminated glass, which is stronger than toughened glass. This standard was introduced in 1993, before being superseded by standard GM/RT2456 in 2000 (these requirements remaining unchanged). As yet all vehicles involved in significant accidents in the UK pre date this standard and were fitted with toughened glass.

When considering the containment of passengers within a rail vehicle it is also important to consider the escape and rescue requirements. Increasing the impact integrity of window systems to improve passenger containment will make it more difficult to use windows for escape. The role of the window as a means of containing passengers thus conflicts with its potential role in emergency egress or rescue.

### *Aims*

This project consists of six phases developed to investigate the role of windows on passenger carrying rail vehicles. The work will resolve the dichotomy of containment versus escape as well as developing and validating escape strategies and standards.

AEA Technology Rail is delivering the work in six phases:

- 1 Accident Data Review
- 2 Containment/Escape Requirements
- 3 Development of Glass Specification
- 4 Validation
- 5 Window Performance
- 6 Strategy for Containment/Escape

To date phase one has been completed and phases two and three are in progress. The work and results so far are summarised in this brief, which is being



issued to complement the findings of the work on two-point restraints (T201).

In delivering this research, the project utilises and builds on the findings from two earlier projects:

- T066a 'Train evacuation risk model - Stay or Go', which developed a model to calculate and compare the risks of two options: staying on a train following an accident, and evacuating promptly.
- T310 'Review of injury causation and human factors in recent vehicle accidents', which determined the causes of fatalities and injuries in recent major rail accidents, and identified features of train design that contributed to them.

### *Progress*

#### **Phase One**

Phase one was designed to understand past accident data with respect to rail vehicle body side window performance.

Data from 50 passenger vehicles involved in the seven major accidents covered in project T310 has been reviewed with the following findings:

- Toughened glass is not effective at providing containment.
- Approximately 50% (14) of passengers ejected from vehicles receive fatal injuries.
- A significant percentage (65%) of all fatalities are due to structural intrusion, 39 in total.
- Passenger containment may be possible by fitting restraint devices, however consideration must be given to the negative consequences of structural intrusion.
- Passengers escaped through windows where other, safer routes, were available.

This information has been analysed as a basis for developing a strategy for containment and escape.

#### **Phase Two**

A workshop was conducted to consider the impact of the findings of phase one. It involved industry specialists, stakeholders and technical and risk consultants as follows:

- AEAT Vehicle specialists
- RSSB
- Human Factors experts from Cranfield University
- Representation from Her Majesty's Railway Inspectorate
- Representation from the Association of Train Operating Companies
- Risk Solutions, the consultants who delivered T066a

Data from project T310 was then used to predict how the installation of laminated glass would affect the escape requirements. AEAT analysed witness statements from passengers who escaped through windows. This information was used to establish the effect on escape of fitting laminated glass to windows.

Discussions have also been held with an Emergency Planning Officer (East Midlands Ambulance Service) and Fire and Rescue experts in the Office of the Deputy Prime Minister to understand escape requirements.

Previous work conducted by RSSB into the risk of evacuation (project T066a) has also been applied to establish the preferred course of passenger action. The implications of fitting laminated glass are being reviewed and the findings will inform the project.

#### **Phase Three**

This phase is working towards establishing the performance requirements for the complete window system and will involve looking at:

- The window frame-to-bodyside fixing
- The glazing unit to window frame fixing
- The glazing itself



The specific window requirements will be based on the findings of phases one and two and may comprise:

- Laminated glass
- Toughened glass
- A combination of both

A second workshop will then be held consisting of those stakeholders involved in phase two as well as:

- Glass manufacturers
- Glass specialists
- Window frame manufacturers

The workshop will seek to confirm the window requirements as well as agree an escape strategy emerging from the findings of phases one and two.

Following validation of the requirements, window samples will be manufactured and tested to confirm compliance with the specification.



**Laminated Glass Impact Test**

### **Phase Four**

Following laboratory testing, windows made to the new specification will be fitted to a vehicle. The capability of the system in escape and rescue terms will be evaluated in horizontal and vertical orientations.

The optimal glass specification will be recommended.

### **Phase Five**

Following the testing and validation stages a standard for the performance criteria for windows on passenger rail vehicles will be developed.

### **Phase Six**

In parallel with the creation of a window standard, an evacuation strategy will be developed based upon the requirements for containment and escape established in phases two and three.

It may then be necessary to review and amend current UK standards to reflect findings of this research.

### ***Recent Developments***

As a result of the accident at Ufton Nervet on 6th November 2004, RSSB is conducting two further elements of work as part of this project:

- The performance of hammers in recent accidents is being reviewed and a new specification is being developed to eliminate the problems experienced. This specification will take account of the window specification emerging from this project, as well as windows in current operation, and stipulate requirements for hammer performance and testing.
- RSSB is also working with First Great Western to develop a laminated window that may be used as a direct replacement for the toughened windows currently fitted to High Speed Trains (and a significant amount of rolling stock built before 1993). The target is to have such a window available for early 2006.

### ***Contact***

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