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**Federal Railroad
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Research Results

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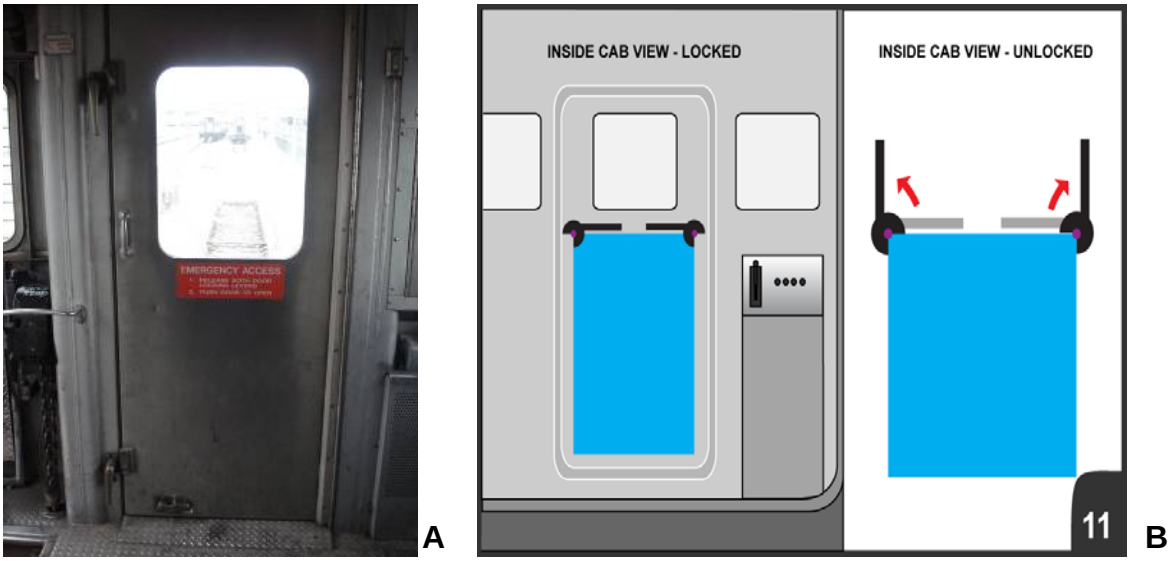
Quick-Release Emergency Egress Panels for Cab Car End Door

SUMMARY

It is feasible to equip passenger train cab car end doors with an emergency egress panel that can be quickly released and utilized during emergencies. The National Transportation Safety Board (NTSB) recommended that the Federal Railroad Administration (FRA) require passenger rail cars have a quick-release removable window or kick panel as a means of exiting the rail car in the event that the other exits are blocked or inoperable. This recommendation was issued following the February 1996 collision of a Maryland Transportation Authority (MTA) MARC commuter train and a National Railroad Passenger Corporation (Amtrak) train outside of Kensington, MD. Several passengers and crewmembers died as a result of the derailment and subsequent fire that broke out. The passengers were unable to locate or operate the emergency exit windows and side doors on the train. To fulfill the NTSB recommendation, FRA's Office of Research and Development, through the U.S. Department of Transportation (DOT) Small Business Innovative Research (SBIR) program, contracted with TIAX LLC to investigate the feasibility of such kick panels. TIAX enumerated the design requirements for emergency egress panels in the cab car end doors. They also developed, evaluated, and ranked design concepts based upon the design requirements. Twenty-three concepts were developed during a concept generation session. These concepts were later evaluated and ranked based on criteria such as strength, safety and security, ease of operation, cost, weight, maintainability, and resistance to aging and damage. The results of the Phase I SBIR project indicate it is feasible to equip cab car end doors with quick-release emergency egress panels, such as the one illustrated in Figure 1B.



A B

Figure 1: (A) Cab Car End Door of a Passenger Rail Car; (B) Rotating Locks Design Concept for Quick-release Emergency Egress Panel

BACKGROUND

FRA funds safety-related research for passenger trains. Emergency egress of passengers involved in accidents is extremely important, especially when the normal modes of egress are not available. Providing additional emergency egress panels at the end doors of cab and coach cars can help speed the egress of passengers in such situations. For example, on February 16, 1996, a MTA MARC commuter rail passenger train collided with an Amtrak train. Several of the railcars came to rest on their sides or at an angle following the collision; in addition, there was a fire. The final orientation of the railcars hindered the evacuation of the passengers. Several passengers and crewmembers on the MTA MARC train died as a result of the derailment and subsequent fire. Following this collision, NTSB made several safety recommendations to MARC, Amtrak, CSX Railroad, and FRA. NTSB recommended that FRA require passenger cars to have either removable windows, kick panels, or other suitable means for emergency exiting through the interior and exterior passageway doors. Because of this safety recommendation, FRA decided to fund research into the feasibility of equipping cab car end doors with an emergency egress panel.

OBJECTIVE

There were two major objectives of this SBIR research effort. The first was to define requirements for a quick-release emergency egress panel for cab car end doors and develop concepts for the panel that meet those requirements. The second was to evaluate and rank the concepts, and then identify those most suitable design for further development.

METHOD

There are no current mandates for cab car end door emergency egress panels, therefore there are no requirements governing their design, operation, or performance in a collision. Initially, it was thought that the emergency egress could be designed similar to the 'zip-strip' style side emergency exit window, in which you pull the gasket on the window and remove the window pane. However, to use this style of emergency egress for the cab car end doors, it would have to be designed to meet FRA Type I loading requirements. The egress panel would need to resist a 24-lb cinder block impacting at 30 mph. The panel would also need to inhibit the intrusion of fluids and debris into the cab car during extreme weather and grade-crossing accidents. The panel must be accessible from both inside and outside of the car. Most emergency egress systems require inspection of a representative sample twice each year. This emergency egress would also be subjected to such requirements. Commuter rail operating authorities' representatives expressed concerns over unintentional activation of the panels by small children. Because of this concern it was decided that the egress system must also be resistant to accidental removal.

To develop the preliminary design requirements, TIAX visited the Massachusetts Bay Transportation Authority Maintenance Facility to inspect the various designs of the cab cars on site. Drawings and sketches were made of the cab car end doors. These were used to develop finite element models of the end door to evaluate some of the concept's structural features. TIAX then chaired a concept generation session to develop concepts for the quick-release emergency egress panel. Participants in the brainstorming session included representatives from TIAX, FRA, and the passenger railcar industry. Twenty-two concepts were generated. (A representative from Kawasaki Railcar Corporation submitted a 23rd concept at a later date.)

The concepts generated were categorized as pertaining to either a "panel" type, where the panel is connected to the door and it is removed during egress, or as a "panel retention and release" mechanism, in which the panel is retained in the door and released during egress. The types of panel were later broken down further into subgroups that described the panel as hinged, detachable, sliding, rotating, rotating/sliding, compression/tension locking member, etc.

The 23 concepts were then ranked according to predefined criteria, with each criterion weighted according to its perceived importance.

Criteria	Weight
Effectiveness	5
Satisfaction of Requirements	*2*
Ease of Operation	*3*
Reliability	3
Simplicity of Design	*2*
Resistance to Damage/Aging	*1*
Safety and Security	3
Prevention of Accidental Use	*2*
Deterrent of Improper Use/ Vandalism	*1*
Ease of Integration into Multiple Cab Car Designs	3
Maintainability	3
Ease of Inspection	*2*
Ease of Repair	*1*
Cost of Material	1
Weight of Panel	1

Table 1: Ranking Criterion and their corresponding weights

The concepts were ranked according to the weighted criteria from Table 1 above and the top five were selected for further analyses and consideration. Finite element models were developed and analyzed to help evaluate structural features of the top concepts. Figure 2 shows a simplified three-dimensional model of a panel in which the load is transferred from the panel to the door support frame through compression of a rubber gasket that runs along its periphery.

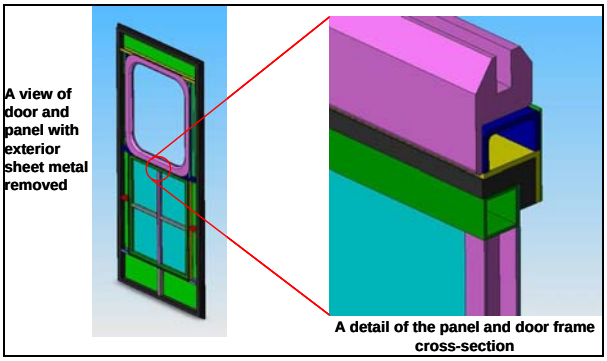


Figure 2: A three-dimensional model of a panel that supports impact loads through bearing

RESULTS

Preliminary design requirements for the quick-release panel for cab car end door were enumerated. The main design requirements identified were geometry, strength, maintenance, operation, safety, and security. The proposed minimum dimensions for the quick-release emergency egress panel are a height of 28 inches, a width of 21 inches. The bottom of the panel must also be less than 18 inches from the floor. The panel must be strong enough to resist the ballistic impact of a .22 caliber/40 grain rifle bullet impacting at 960 ft/sec and a 24-lb cinder block impacting it at 44 ft/sec (30 mph). The panel must be able to be opened from both inside and outside of the car. The panel must withstand binding due to racking of the door. The panel also must be easy to operate and must not be too bulky or cumbersome to activate or remove during emergency evacuation of the passengers. Also of importance, is the ability for passenger rail operating authorities to inspect a representative sample of the panel twice a year, at a minimum, during the maintenance cycle of the car.

Simple analysis shows that the emergency egress panels must be able to absorb, without failing, 8,000 ft-lbf of energy that would be transferred during the impact of the 24-lb cinder block at 30 mph. Of the top five highest-ranked concepts, there was one key difference between the highest-ranked concept, the double-glazed panel, and the other four concepts to which the manner the impact load is transferred to the supporting frame. The double-glazed panel has the advantage that it can be removed both from inside and outside. However, the panel carries the impact load primarily through shearing of its support gasket. The panel deforms considerably under the prescribed loading, as shown below in Figure 3.

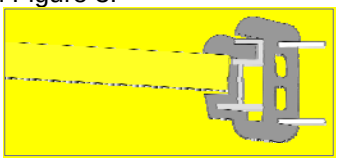


Figure 3: Finite Element Model of the Double-Glazed with Removable Gasket Panel under Impact Loading of 24-lb Cinder Block.

For the other concepts, it is assumed that the impact load is transferred to a metal bearing plate that is part of the locking device or to a support frame that is designed around its periphery. A simplified three-dimensional finite element model of such a panel was developed. Finite element analysis of the panel subjected to an impact loading, as shown in Figure 2, indicates that significant deformation of the rubber gasket and the door support frame occurs. The rubber gasket is under compression so it is not likely that the panel will fail. The support frame would likely need to be stiffened, adding weight to the design.

CONCLUSION

Phase I of this SBIR research project focused on the development of concepts for incorporating emergency egress in cab car end doors. Design requirements that were likely to be adopted to govern the design of these emergency egress panels were identified and enumerated. Twenty-three concepts based on the design requirements were identified. Of those 23 concepts, the top five were chosen for further evaluation. The 'Double-Glazed Window with Removable Gasket' concept was ranked at the top of the list. However, analyses of the panel under direct loading indicated it may be difficult to design such an egress system that can withstand the severe impact loads. An emergency egress panel that transmits the loads through compression of a gasket to a support frame in the door will more likely to be able to meet the impact load requirement. However, analyses showed that such a panel would need significant support structure to carry the impact forces, and as such would weigh at a minimum of 35 to 40 lbs. The most suitable emergency egress panel was found to be the one ranked second. It is the 'Rotating Locks' panel, as shown previously in Figure 1B. This panel is operated by rotating locks located at the top left and right of the panel. The panel would then be removable to the outside of the car. It would be designed to have its weight carried by a support at the bottom of the panel so that it does not need to be lifted.

FUTURE ACTION

Further research and development of such emergency egresses will focus on the reaction of the panel under various loadings, to test the strength and resilience of the panel. The proposed panels will be refined and sized for possible fit to the most common types of cab car end doors that are equipped on passenger rail cars. Risk assessment and extensive hazard analyses will be conducted. These analyses will be done to ensure that incorporating such emergency egress in the cab car end door does not reduce the strength of the end door as a whole. Also of concern, is that these panels will be able to exclude fluids and debris from entering the cab during grade crossing accidents and extreme weather.

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KEYWORDS

cab car, end door, emergency, egress, kick-panel