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Locomotive Crew Egress

SUMMARY

Locomotive operating crews and rescue workers need improved means of cab egress and access in the event of an accident. Although present regulations and practices address this need in a limited way, further measures could provide substantial improvements in the survivability of crews. The purpose of the first phase of this program was to conduct a multi-faceted assessment of egress options in current locomotives, assess some accident conditions that crews could face, and suggest the most productive improvements. The assessment involved review of existing regulations, site visits to commuter and freight railroads, and interviews with train crews. A review of National Transportation Safety Board (NTSB) accident investigation reports and the FRA accident/incident database identified accident scenarios where lack of adequate egress was an issue. Computer simulation of locomotive crash scenarios identified structural areas of the cab structure that could be improved for better egress, and also established the severity of the effects on crews. Based on the findings of the first phase of the program, subsequent work focused on development of an innovative crew egress system for rollover derailment accidents. Options for crew egress are most limited in this situation. Three design concepts were evaluated with train and engine crewmembers and emergency rescue personnel. A mockup of the most promising concept, a roof-mounted escape hatch, provided the means for a preliminary evaluation of the usability of the hatch system. Test subjects were able to actuate the hatch and escape the cab in 30 seconds or less. Future work will involve refining the hatch design so that it is easily manufactured and exploring secondary egress options.

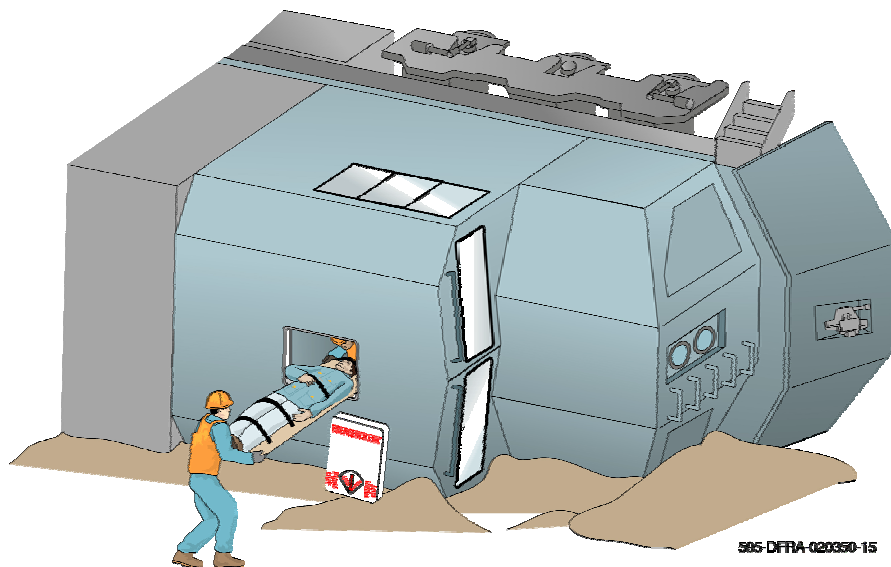


Figure 1. Concept for roof-mounted hatch egress system



BACKGROUND

Current federal regulations as well as industry standards and practices address various aspects of locomotive cab design with respect to crew egress. Elements of the FRA safety standards in the Code of Federal Regulations (49 CFR) deal with overall locomotive crashworthiness and glazing. The American Passenger Transit Association (APTA) has developed standards and recommended practices that pertain to emergency evacuation and crashworthiness of passenger equipment. While there is a substantial body of existing rail industry and equipment standards that relate to some cab egress issues, the FRA felt there was a need to specifically address the issues of crew egress, crew survivability and access to the crew in the event of an accident.

Assessment of Current Locomotive Cabs

The locomotive cabs evaluated included examples in three categories:

1. Wide nose heavy freight (SD-70MAC),
2. Narrow nose freight (SD-70), and
3. Passenger locomotives (FO-40).

Finite element analysis of crash scenarios with a representative locomotive from each of these categories provided an estimate of the cab damage and locomotive decelerations that the crew would experience.

Three accident scenarios were developed and are described in Table 1:

1. Slowly overturning onto wayside
 - A) Soft surface (earth)
 - B) Hard surface (pavement)

2. Locomotive in offset collision with stationary hopper car consist at 30 and 50 mph
3. Two locomotives in head-on collision at 60 mph closing speed

Table 1. Accident scenarios

| Type of Locomotive | Accident Scenario 1 | Accident Scenario 2 | Collision Scenario 3 |
|--------------------|---------------------|---------------------|----------------------|
| SD-70MAC | Yes | Yes | |
| SD-70 | Yes | Yes | SD-70 to SD-70 |
| FO-40 | Yes | Yes | |

Structural Improvements

The dynamic simulation analyses indicate that the primary benefit from strengthening of the cab structures will be improved integrity and not g-load reduction. In all of the accident scenarios analyzed, at least one emergency egress route remained accessible. A full study of possible injuries for these accident scenarios was beyond the scope of this study.

Locomotive Door and Emergency Window Operation

A survey of representative cab doors and windows revealed that cab windows, in particular, are of varying shapes and sizes depending upon the locomotive type and model. Table 2 summarizes this data.

Table 2. Window and door data for selected locomotives

| Locomotive | Windows | | | Doors | | | |
|---------------|-----------|--------|----------------------|--------------|--------|---------------|----------------|
| | Type | Number | Size (WxH) in | Type Opening | Number | Size (WxH) in | Location |
| GP40 | Double SL | 2 | 32 X 27 ¹ | Outward | 2 | 19 X 70 | Front and Rear |
| SD70MAC | Double SL | 2 | 33 X 22 | Outward | 2 | 23 X 69 | Nose |
| F59PHI | Single SL | 2 | 23 X 29 ² | Inward | 2 | 17 X 72 | Rear |
| P32 (Genesis) | Single SL | 2 | 22 X 18 | Inward | 2 | 21 X 60 | Side |

1. Double SL – double slider
2. Push out emergency window



Locomotive cabs can generally be accessed via two doors. A contemporary wide nose freight locomotive has an entry door at the right rear-facing corner, plus a front door in the nose. Doors in the cab open outward. However, the door opening widths may be narrow on the order of 16 inches in width, insufficient to accommodate emergency responders. Figure 2 shows a typical rear cab door for a wide nose freight locomotive. Both doors and windows may become deformed in crashes, thus hindering operation.



Figure 2. Rear cab door of SD-70 MAC freight locomotive

Windows are either single or double slider units, except some older models that have a double hung design. A few new locomotives, such as the F59PHI passenger model, have a push out emergency window (see Figure 3). Side-opening windows appear to have adequate dimensions to enable their use for emergency egress,

but since the window may be blocked in a rollover or be inaccessible following a crash, there is need for another option.



Figure 3. Interior view of F59 cab emergency exit window

Innovative Egress Concepts

Current egress equipment, as described above, is inadequate in the event that the locomotive is toppled in an accident. Three concepts that

offer improved egress under this scenario are the following:

- Hand/fooholds to aid climbing inside a toppled locomotive.
- Roof-mounted escape hatch.
- Externally removable windshield.

Review of Concepts

Focus groups with locomotive engineers and conductors provided a forum to gather information about train crew perceptions of the candidate designs. Overall, participants viewed the hatch concept as a significant improvement in cab egress. Participants unanimously agreed that the hatch would provide the quickest escape for the crew and that it would provide the quickest access for rescue workers. With regard to hand/fooholds, they favored their use as part of a hatch egress system. However, as a standalone concept, they considered the concept marginal. The removable windshield was considered to be of limited use since it would not provide the crew with an egress route unless the crew could release it from the interior of the cab.

Interviews with rescue personnel indicated that the major issues of concern to rescue personnel are *ease of access* and *personnel safety*. Compared to current procedures, the hatch would make it much easier to get into the locomotive cab and rescue an injured person.

Refinement and Evaluation of Hatch System Design

The user feedback led to several changes to the basic concepts. The hatch was redesigned to fall away from the roof when opened and the hand/fooholds became an accessory to the hatch, rather than a stand-alone system. To be a viable egress option, the removable windshield would have to be usable from the cab interior. For this reason it was not considered to be the preferred option.

Construction of a system mockup facilitated evaluation of the overall concept. A full-sized locomotive cab, with an integrated hatch and hand/foohold system was constructed. The mockup is a wood-framed, plywood-sheathed structure representing a "generic" freight locomotive cab (see Figure 4).



Figure 4. Top view of locomotive cab mockup with hatch system

Figure 5 shows an interior view of the hatch and Figure 6 shows the hand/foothold mockup in both its folded and actuated positions. The rungs are hinged so they can be folded flush to the ceiling when not in use, and folded down to allow access to the roof hatch. The hatch system design includes two hand/footholds below the hatch and two above the hatch in the rolled-over orientation.



Figure 5. Interior view of hatch



Figure 6. Hand/foothold mockup

To provide insight into the utility and effectiveness of the hatch and hand/foothold concepts, a limited sequence of testing was performed. These preliminary tests showed that with minimal knowledge and training, the devices were easy to use. The subjects were not experienced railroad workers and had no prior knowledge of locomotive cabs. None of the subjects had complaints about the location of either the hatch or hand/footholds. These preliminary tests did support the need for exterior grab irons to facilitate egress.

Interior Survivability

Simulations of a moderate-speed collisions scenario involving an F-40 passenger locomotive indicated that the crewmembers might not survive the crash, primarily due to head impacts with the interior. This was also a risk in slow-speed overturning accidents also modeled. Improvements that are likely to significantly improve survivability include:

- Restraint of crewmembers.
- Protective seat configuration or orientation.
- Improved design of interior features (e.g., control stand) to reduce impact injuries.
- Improved means of securing cab-mounted safety equipment (e.g., fire extinguisher, first aid kit).
- Additional survival aid equipment.

Ongoing and Future Work

Current work includes the following:

- Construction of a working prototype that can be used for operational testing.
- Verification that installation of the hatch will not reduce the structural integrity of the cab roof.
- Usability testing to assure that the hatch system meets specific operational criteria.
- Assessment of enhanced emergency egress lighting.
- Consideration of secondary egress equipment--removable windshield glazing and removable door hinge pins.
- Development of a training video for rescue workers.



WANT MORE INFORMATION?

Kokkins, S. (2002). *Locomotive Crashworthiness Research: Locomotive Crew Egress Evaluation*. (Report No. DOT/FRA/ORD-02-03). Washington, DC: Federal Railroad Administration.

Carter, J., Gertler, J., Kokkins, S., & Acton, S. *Evaluation of Concepts for Locomotive Crew Egress*. (under review) Washington, DC: Federal Railroad Administration.

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