Measure Name Front-end impact reduction system

Definition Equipment installed on the front-end of a train to reduce the severity of injuries from a collision.

Tags

Incident Type	Both trespass and suicide
Location	Both station and right-of-way
Intervention Strategy	Engineering: technological and physical deterrents
Measure Group	Infrastructure modification

Description

Trains are extremely heavy and cannot quickly avoid a person in the right-of-way (ROW). For example, trains travelling at 60 mph can take up to a mile to stop. Unlike most safety measures, which aim to reduce the number of train-person collisions, the goal of this measure is to reduce the severity of injuries when a collision is inevitable.

Front-end impact reduction systems refer to the installation of an impact attenuator (e.g., airbag or mechanism to capture an individual) on the front end of a train to reduce the severity of injuries to a person from a collision. The measure would work by absorbing or transferring the collision energy to the impact attenuator mounted on the train or by redirecting a pedestrian away from the train [1].

As of 2021, these systems have been proposed conceptually, but none have been deployed for use on a train experimentally or in revenue service [2]. Similar reduction systems have been deployed successfully for other modes of transportation, such as external airbags on automobiles [3]. Locomotives, however, present challenges that automobile collisions do not: for example, the train is likely to continue moving well past the collision until the braking system brings the train to a full stop [2]. It is unknown how elements of other designs may translate to the railroad environment, and this requires investigation.

This measure may be most effective on trains that travel through corridors or other areas with a high number of trespasser fatalities or suicide attempts. There are several concepts that have been proposed for this strategy: a controllable airbag that pushes a pedestrian to the side of the track, a system to "catch and hold" an individual, a crushable airbag to reduce impact, and a crushable bumper [1].

FRA studied the potential of a front-end airbag system to mitigate grade crossing collisions [2]. The findings conclude that such designs had been "conceptualized, but not engineered to the point where a feasible design has been developed" (p. 11). From a conceptual perspective, injury reduction models indicate that such a system could feasibly reduce injuries. However, more research is required to understand how these concepts might be turned into practice. FRA identified key technical issues that will be important to consider should research on this topic continue, including the versatility of the system, as well as the design of the system such that the pedestrian can be delivered to the side of the railway reliably while minimizing potential injury.

Additional search terms: *airbag, Cowcatcher, head-end*

Advantages

- Potential to reduce the number of trespass and suicide fatalities and the severity of injuries if a collision does occur.
- Potential to reduce the time needed to bring rail line back to service by reducing severity of injuries and likelihood of fatalities.

Drawbacks

- Front-end impact reduction systems have been proposed, but none have been installed and tested during revenue train operations [2].
- The cost of installation and maintenance is unknown.
- The system may increase the length of a train or reduce the number of revenue service railcars due to accommodating length or weight requirements.

Notable Practices

- Consider the system's effectiveness for a wide range of collision types, including various pedestrian scenarios (e.g., standing, sitting, and laying on the rails).
- Ensure that the struck pedestrian can be moved completely to the side of the railway, given that the locomotive is likely to progress well past the initial collision site [2].
- Consider how extra length added by the reduction system effects train operation, especially at stations located near crossings.
- Consider railroad operator and manufacturer liability for injury or death caused by reduction systems.
- Consider safety, economic, and operational impacts of airbags deploying due to collision with animals or objects on the tracks.
- Develop an operation and maintenance plan to address a range of situations, including impact with animals and other obstacles on the ROW, or failure of the front-end impact reduction system to properly deploy.
- Consider the installation of impact reduction systems on both ends of train, as the locomotive can operate in both a push and pull mode.

References

[1] Paden, B., Kelly, P., Hines, J., Bothman, D., and Simms, C. (2016). On the feasibility of life-saving locomotive bumpers. *Accident Analysis & Prevention*, 89, 103-110.

Abstract: Motivated by the thousands of pedestrians killed each year in train impacts, this paper investigates the life-saving capability of four high-level locomotive bumper concepts. The head motions produced by the four concepts are modeled as one or two square acceleration pulses and are analyzed using the Head Injury Criterion (HIC). Surprisingly, the analyses show that all four concepts can achieve HIC values of less than 200 for an impact with a locomotive traveling at 100 km/h. Two of the concepts eject the pedestrian trackside with at a velocity of roughly 40 km/h and the risk of ground-impact injury is discussed in the context of related automobile accident data. The computed bumper lengths are a fraction of the overall length of a locomotive and are thus feasible for practical implementation. One concept involves an oblique impact and the potential for rotational head injury is analyzed. This basic feasibility research motivates future investigations into the detailed design of bumper shapes, multi-body pedestrian simulations, and finite-element injury models.

[2] Merkle, A. & Harrigan, T. (2016*). The Use of Air Bags for Mitigating Grade Crossing and Trespass Accidents: Literature Review and Research Plan*. Technical Report No. DOT/FRA/ORD-16/22. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration.

Abstract: This literature review will confirm prior work in the use of locomotive airbag technologies for vehicle or pedestrian collision mitigation, and to focus planned activities and tasks for this research. The state of the art in relevant technologies has been summarized to assess the feasibility of this technology and identify critical model challenges for supporting impact simulations. The literature review did not reveal any currently deployed locomotive airbag solutions. In patent literature, external airbag technology has been described for mitigation of crashes between railcars and motor vehicles, but no meaningful analysis of feasibility has been discussed in detail in scientific or professional literature. Therefore, it appears that although crash mitigation technology using airbags in front of locomotives has been conceptualized, it has not yet been rigorously engineered or implemented.

[3] Jakobsson, L., Broberg, T., Karlsson, H., Fredriksson, A., Gråberg, N., Gullander, C., & Lindman, M. (2013). Pedestrian airbag technology–a production system. In *23rd International Technical Conference on the Enhanced Safety of Vehicles (ESV) National Highway Traffic Safety Administration* (No. 13-0447).

Abstract: Pedestrians in conflict with passenger cars represent an important portion of all road user fatalities. This paper presents the world-first pedestrian airbag technology offered in a production vehicle, being one way of addressing pedestrian protection, focusing on trying to help further cushion the impact for a pedestrian and also enable a sleek styling of the vehicle in question. A description of the technology is provided as well as examples of tests for evaluating technical performance, head impact characteristics and overall technology performance. Sensors in the bumper provide input to the pedestrian airbag control unit that determines if the system should be activated. The hood hinges are released and the pedestrian airbag deploys helping both to elevate the hood itself as well as helping to cushion a potential impact. The lift height is controlled and limited. Numerous tests of the components and the system are performed in various situations, including different weather conditions, verified the technical performance and validated the complete chain of events from detection of a pedestrian leg to the final state of deployment. Using head impactor tests, the head impact protection capabilities showed overall good performance. Impact towards the pedestrian airbag reduces the acceleration level as compared to without the airbag. Overall performance of the complete technology, including head impact timing, airbag coverage and overall occupant kinematics was verified using a pedestrian prototype crash test dummy and four different

pedestrian FE human models. The pedestrian airbag technology as being one possible solution to cushion an impact helps to protect pedestrians in certain situations when struck by the vehicles front end with a consequent impact to the hood and the area around the windscreen wiper recess and A-pillar.

Additional Resources

Related Measures

- Anti-suicide pits
- Identify funding opportunities
- Incident cost estimation