U.S. Department
Of Transportation

**Federal Railroad
Administration**

Research Results

**RR07-03
February 2007**

A Crash Energy Management Specification for Passenger Rail Equipment

SUMMARY

At the request of Metrolink, the Federal Railroad Administration (FRA), with the Federal Transit Administration (FTA) and American Public Transportation Association (APTA), decided to form the ad hoc Crash Energy Management (CEM) Working Group in May 2005. This group developed recommendations for including crush zones in rail passenger cars for Metrolink to include in its procurement specification. The Volpe Center provided the Working Group with technical information from the research on passenger equipment crashworthiness it is conducting for FRA. Metrolink released its specification, including the recommendations from the Working Group, on September 16, 2005, as part of an invitation for bid.

The specification is written so that the requirements prescribe levels of performance for the train, the car, and the mechanisms. Each requirement includes quantitative criteria for evaluation of compliance. The Working Group extensively discussed various evaluation methodologies, including non-linear large deformation finite element analysis and dynamic component tests, and worked to assure that practical evaluation methodologies are available for each requirement. For the components critical to the functioning of the crush zone, some of which may be difficult to analyze, component tests are required.

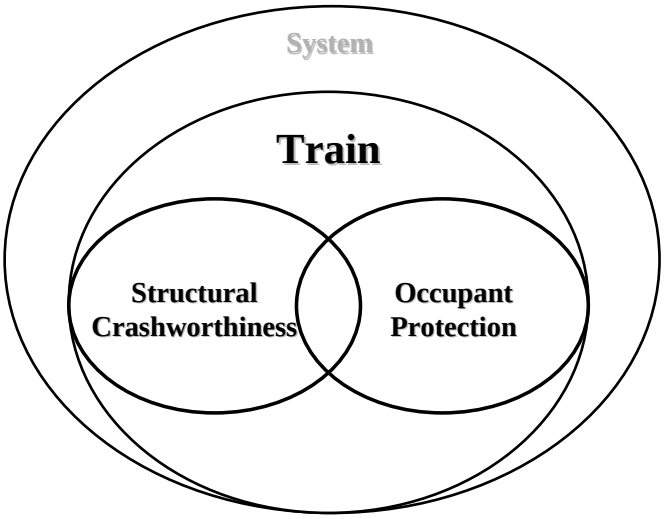

Figure 1. Crashworthiness Specification Components

BACKGROUND

At the time of the Glendale incident, in which 11 commuter train occupants were fatally injured, Metrolink was preparing to purchase new equipment. As part of its response to the incident, Metrolink decided to apply results of FRA's research into passenger train crashworthiness in this procurement. In coordination with APTA, Metrolink approached FRA and FTA. FRA, FTA, and APTA decided to form the ad hoc Crash Energy Management Working Group in May 2005. This Working Group included participants from the rail industry, including the passenger railroads, the suppliers, and industry consultants. Using the results of FRA's research, as well their collective experience in operating, maintaining, and constructing passenger rail equipment, this group developed recommendations for including CEM features in rail passenger equipment for Metrolink to use in its procurement specification. A symposium and four meetings were held to accomplish this goal.

The Crash Energy Management Technology Transfer Symposium was held June 29 through July 1, 2005, in San Francisco. The Volpe Center presented an overview of the research, details of the effectiveness of CEM, and, with support from Tiax, LLC, details on the design, fabrication, and testing of FRA's prototype crush zone designs. Bombardier, Kawasaki, and ARA/Indian Railways presented their capabilities as suppliers of CEM equipment. Amtrak and New Jersey Transit presented their experiences using CEM equipment in service.

The first meeting of the Working Group was held July 27–28, 2005, in Los Angeles. As planned, consensus was reached on the energy absorbing capacity of the cab end and non-cab end crush zones. The second meeting was held August 8–9, 2005, in Cambridge. Consensus was reached on the details of the crush zone requirements, and evaluation procedures were discussed in detail, including options for testing and analysis. The third meeting was held September 8–9, 2005, in Chicago. Consensus was reached on the appropriate tests and analyses needed to show compliance with the requirements. Consensus was also reached on most of the criteria to be used in evaluating compliance. The fourth and final meeting was held in Washington, DC, on October 5, 2005. Consensus was reached on the remaining details on the evaluation criteria.

OVERVIEW OF SPECIFICATION

Figure 2 shows a flow diagram of the specification and its relation to the design of the equipment. The specification consists of the individual requirements that prescribe the performance of the train, car, and mechanisms. Each requirement is associated with an evaluation case. Each evaluation case is associated with criteria. Testing or analysis may be required to show that the train, car, or mechanism meets the prescribed requirement. If the criteria are not met, then redesign is necessary.

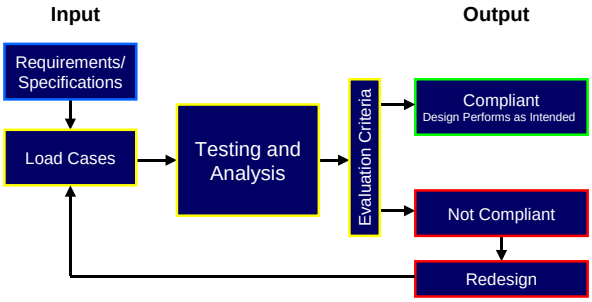

Figure 2. Flow Diagram of Specification

Table 1 lists all of the individual requirements in the specification. As noted, three groups of requirements exist: train level, car level, and mechanism level. Three mechanisms are required: the Coupling Mechanism (CM), the Load Transfer Mechanism (LTM), and the Principal Energy Absorption Mechanism (PEAM). The train level requirements specify a collision scenario for which there must be no intrusion into the occupied areas and limits on the relative velocities at which the operator and passenger may impact interior surfaces. The car and mechanism level requirements follow from the train level requirements. The car level requirements include specifications for a crush zone at the cab end of the cab car capable of absorbing 3.0 million ft-lbs of energy and crush zones at the non-cab end of the cab car and each end of trailer cars capable of absorbing 2.0 million ft-lbs. Specifications are also provided for the crush zone kinematics and the target force/crush characteristics of the crush zones. Mechanism level requirements include specifications for the CM, LTM, and PEAM.

The specification is written so that the requirements prescribe levels of performance for the train, the car, and the mechanisms. Each requirement includes quantitative criteria for evaluation of compliance. Practical evaluation methodologies are available for each requirement, including non-linear large deformation finite element analysis and dynamic component tests. For the components critical to the functioning of the crush zone, some of which may be difficult to analyze, component tests are required.

Table 1. Individual Requirements

Load Case	Analysis				Test	
	Train	Cab End	Non-cab End	Mechanism/ Component	Quasi-Static Test	Dynamic Test
Collision Scenario	X					
PEAM Bump	X					
CM Service	X					
Ideal Impact		X	X			
LTM-only Impact		X				
Offset Impact		X				
PEAM Support Structure		X	X			
CM Support Structure		X	X			
Retention		X	X			
Cab End LD Geometry		X				
PEAM Energy Absorption				X		X
PEAM Initiation Load				X	O	O
CM Energy Absorbed				X		X
CM Initiation Load				X	O	O
Coupled LD Deformation				X		
Cab End LD Deformation				X	O	O

Key: X – required test or analysis
O – optional quasi-static or dynamic test; one option must be selected

CONCLUSIONS

Metrolink released its specification, incorporating the recommendations from the Working Group, on September 16, 2005, as part of an invitation for bid (IFB). The initial IFB specified conventional trailer cars with pushback couplers. After some consideration, Metrolink revised the IFB to require non-cab end crush zones at each end of the trailer cars. The final revision to the IFB was released on November 18, 2005.

During the final meeting of the Working Group, APTA stated its intention to use the Metrolink specification as a starting point for an industry standard. APTA plans to wait until Metrolink is close to accepting delivery of its new equipment to be sure that any issues with the specification have been resolved. The Standing Committee on Rail Transportation has also expressed interest in adapting the Metrolink specification to its needs.

ACKNOWLEDGMENTS

David Solow, President, and Bill Lydon, Chief Mechanical Officer, Metrolink, requested the support in applying FRA's crashworthiness research to Metrolink's procurement. Bill Lydon coordinated the Working Group's recommendations with the procurement. Dr. Cliff Woddbury and Jeff Stastny, LTK Engineering Associates, wrote the specification language in the IFB from the ad hoc CEM Working Group's recommendations. Jo Strang, Acting Director, Office of Research and Development, FRA, led the ad hoc CEM Working Group. Ron Hynes, Associate Director, Office of Research Demonstration, and Implementation, FTA, coordinated FTA's support and helped to lead the Working Group. Tom Peacock, Director, Technical Services, APTA, helped organize and manage the Working Group.

REFERENCES

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KEYWORDS: *crash energy management, CEM, crashworthiness, occupant protection, cab car*