Structural Crashworthiness of Rail Vehicles – from the Requirements to the Technical Solutions

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Summary:
Rail transit provides a very safe means of public transport, which is due to the railroad specific principle of track guidance in combination with high active safety measures during operation. However, train accidents cannot totally be excluded and in the last two decades the subject of passive safety has become an issue of growing importance also in the railway industry. Administrations, operators, railway research institutes, and manufacturers have been active in investigating train collisions and defining relevant recommendations and standards for the realisation of a crashworthy rail vehicle design, providing the last means of protection when all possibilities of preventing an accident have failed.

An analysis of structurally significant accidents shows that most fatalities and serious injuries of occupants occur as a result of end-on collisions, often accompanied by overriding of the coach bodies. Consequently, the most effective means of reducing passenger and crew casualties in railway accidents is to concentrate on the design of crashworthy vehicle ends and to avoid overriding, which is also reflected in customer specifications and mandatories, e.g. the British Group Standard GM/RT 2100, the new crashworthiness standard EN15227, the TSI requirements for high speed trains, or the US APTA and FRA regulations.

In this paper an overview of current requirements for a structural crashworthiness design of rail vehicles is given. Herein, a focus is put on the new EN15227, which will be the relevant passive safety standard for the next generation of rail vehicles in Europe, covering all kind of passenger carrying rolling stock, from light rail, metro and commuter up to long-distance and high speed main line trains.

With regard to design and verification usually a combination of different steps of simulation and prototype testing is applied to consider the individual crash zone design, but also the dynamic behaviour and the crash energy management over the whole train rake. An outline of the methods and tools usually applied for the design and verification process is given.

Different examples from Siemens for the development of modern crashworthy trains are shown for both steel and aluminium railway vehicle structures, with an emphasis put on metro and commuter trains. The principles and main challenges of a crashworthiness design are stated and different design variants like car body structures with fully integrated crash zone areas or deformation zones with replaceable attached crash elements are shown. For the latter, particular consideration has to be put on the behaviour under non-perfect loading conditions, e.g. caused by colliding vehicles, which are vertically offset, because such a configuration may be particularly prone to overriding.

Keywords:
Railways, train crashworthiness, passive safety, metro trains, commuter trains, crash zone design