Technical Information

Light – Pedestrian Protection

HELLA

Ideas today for
the cars of tomorrow

The European Commission has set itself the ambitious target of halving the number of fatalities in road traffic by the year 2010. To achieve this, it is absolutely necessary to check all the possibilities and introduce potentially helpful measures. To reach this target, the EU Directive 2003/102/EC was agreed upon on December 23, 2003. The first phase of this directive comes into in October 2005. There is quite a considerable discussion going on between vehicle manufacturers and legislative bodies about the introduction of the second phase, planned for September 2010.

In the past few years, there has been a heavy increase in traffic density in Europe in general and in Germany in particular. This of course means that the risk of being involved in an accident has also increased. In the early 1960s, conscious considerations began on the subject of additional requirements for safety measures, particularly for passengers.

From the 1980s onwards, the newly awakened interest in passive safety brought seat-belt systems to the passenger compartment first, then airbags and now the first active driver assistance systems. However, these safety systems do not yet take into account unprotected road users, especially pedestrians.

The high number of pedestrian fatalities can be seen in the following statistics.

	2000	2001	2002	2003
Total no. of accidents	504,074	495,775	483,225	468,670
No. of pedestrians in accidents	38,115	37,101	37.216	35,796
Total no. of fatalities	7,503	6,977	6,842	6,618
Pedestrian fatalities	993	900	873	814

Accident statistics from the Federal German Statistics Office

On the occasion of the 10th Conference on Experimental Safety Vehicles (ESV) in Oxford, all the measures necessary for pedestrian protection were illustrated on a research vehicle. In 1997, the independent consumer organization “European New Car Assessment Programme” (EuroNCAP) documented the fact that no initiative of this kind had yet been taken up.

A pilot study found that none of the seven vehicles tested met the values suggested for the forces developed during a crash. Only more recent changes in legislation and the publication of the results of the EuroNCAP investigation have made vehicle manufacturers take pedestrian safety more strongly into consideration.

The detailed analysis of vehicle-pedestrian collisions shows that almost 70 % of the spots where initial contact takes place are at the front area of the vehicle.

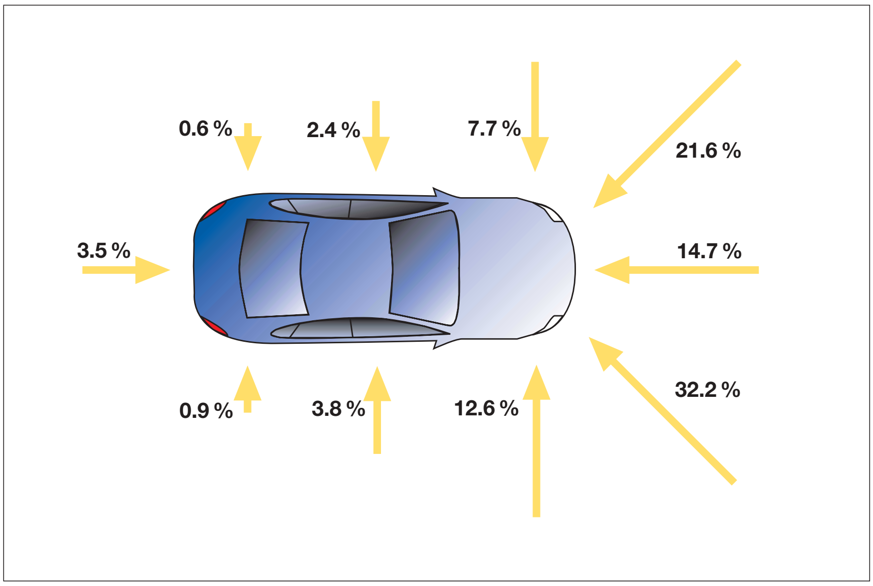

Fig. 1: Initial pedestrian-contact zone during vehicle-pedestrian collisions

For this reason too, Hella KGaA is working on optimizing headlamps in order to improve pedestrian safety.

The legal position

The European Community is working on a binding regulation for pedestrian safety. In 1987 the European Enhanced Vehicle-safety Committee (EECV) was founded upon recommendation by a series of European member states as a community of interests between vehicle manufacturers, test centers and research institutes. Workgroup 10 (later 17) developed detailed tests. In 1992, the ACEA (“Association des Constructeurs Européens d’Automobiles”) submitted a suggestion for a new European regulation. Today, the EEVC and ACEA tests form the basis for research on pedestrian protection on vehicles.

The European Parliament has been examining the legal position in the area of pedestrian protection since January 2002. Limiting values for vehicle fronts in terms of possible injuries to children and adults are being considered here.

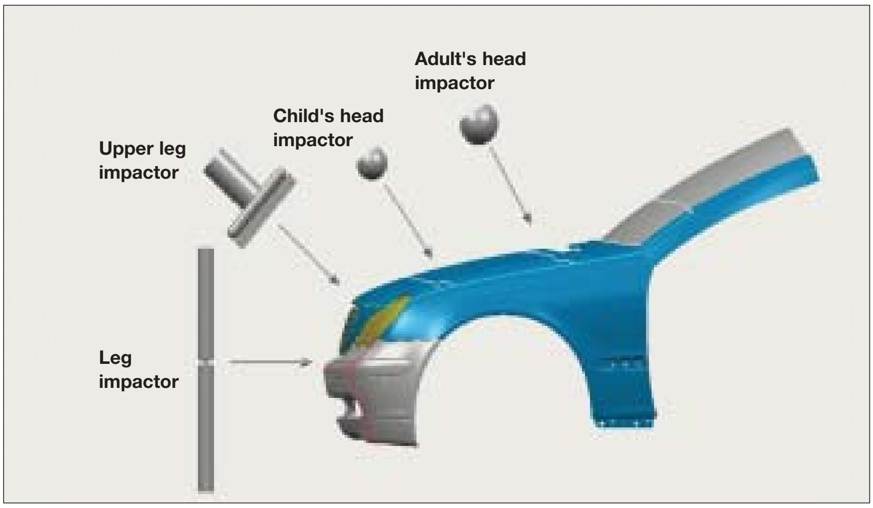

Fig. 2: Summary – EEVC WG17 tests

At the moment, Directive 2003/102/EC is binding for vehicle manufacturers. As mentioned above, this will come into force in two phases. The first phase begins in 2005 and includes leg and small adult-head impact. In the second phase (2010), the small adult-head is to be divided into a child's head and adult head. Upper leg impact is also to be added, and the limiting values to be met are to be tightened. This second phase is currently under much discussion, however.

EEVC test specifications

The collision between a pedestrian and a vehicle can be divided into a first impact on the vehicle and a second on the road. The first impact accelerates the body and influences the speed of the second impact. Both can be extremely severe.

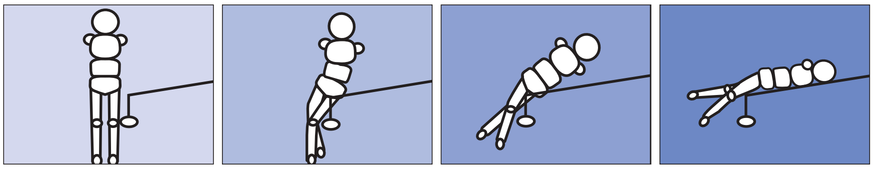

Fig. 3: First impact of a pedestrian on a vehicle

It must be pointed out that a vehicle with a long, stretched hood acts like a lever and accelerates the pedestrian further during initial impact. In contrast, vehicles which have a short and almost vertical front, e. g. vans, accelerate the pedestrian’s body to such an extent that it leads to an even more severe second impact. All in all, however, collisions between pedestrians and vehicles are always a complex series of events which depend, to a major extent, on the initial contact spot.

In order to develop reproducible tests for pedestrian protection, a series of assumptions were made:

- Four "impactors" are defined as test bodies; these represent an adult head and a child's head, as well as upper leg and lower leg.
- A "mold" is connected with each of the impactors, which records displacement/offset and acceleration. This means that in the case of the "leg mold" these would be the forces that act on the knee.

These test requirements are intended to simulate a collision with an average sized adult and a child.

Crash tests

The first vehicles to implement ideas developed by vehicle manufacturers on the subject of pedestrian protection entered the market in the fall of 2003. This influence relates to the complete frontend, including headlamps, in order to transfer the results directly onto future platforms.

The dynamic headlamp tests were carried out with the aid of a "drop tower". A detailed analysis of energy absorption and possible faults in the headlamp and its surrounding structures right through to the frontend module are possible. In order to simulate an impact at 40 km/h, the impactor is weighted at 7.13 kg and dropped from a height of 4.9 m.

The resulting impact energy from this action of

$$\mathbf{E_{pot} = m_{imp} \cdot g \cdot h = 350\ J}$$

is somewhat lower than the impact energy for the upper leg test according to the specification for the complete frontend in Directive 2003/102/EC.

The drop test is carried out with the aid of accelerometers at the impactor, laser distance measurement and a high-speed camera which provides 1000 images per second.

A typical test arrangement for the development of lighting systems is made up of a headlamp with certain areas reinforced or weakened.

For pedestrian protection it is important to avoid force peaks and to absorb the impact energy as evenly as possible. For this reason it is important to know how the forces develop during the complete impact in order to be able to optimize headlamps. The "upper leg test" according to Directive 2003/102/EC limits this force to a maximum of 5000 N.

Fig. 4: Headlamp during impact, taken from a high-speed video

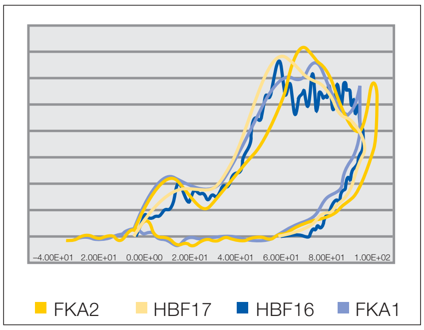

Fig. 5: Force-path diagram for the headlamp before optimization

Diagram 5 shows the typical curves of a headlamp before optimization. Four separate impactor paths are shown in the four curves. They show an initial increase in the forces measured after 15 mm, when the impactor hits the plastic cover lens.

At the point of the greatest deformation of the plastic cover lens, the force increases to around 2000 N. From this point, the force drops again until the impactor hits the interior components after about 30 mm. This force exceeds the 5000 N limit and reaches a maximum of approx. 7000 N. The headlamp housing becomes deformed at 65 mm. The forces fall again until the headlamp bracket finally absorbs the residual energy. After impact the interior of the headlamp is damaged. The plastic cover lens is not damaged.

Optimizing crash behavior

A whole series of changes to the headlamp shown above are necessary to protect pedestrians. In particular, the peak force produced must remain under the 5000 N limit. To achieve this target, some modifications have to be made to headlamp components. The headlamp housing is weakened and the projection module changed. A standard module can be seen in **Fig. 7**.

Fig. 6: Prototype of an optimized headlamp housing

Fig. 7: Current projector module

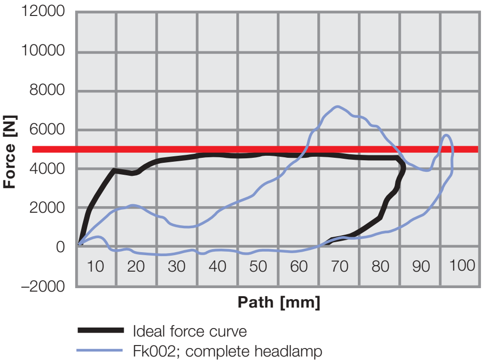

Fig. 8: Force-path diagram

These optimization stages reduce the maximum force which occurs to under 5000 N as required. The new simulation (**Fig. 6**), which includes the modifications of module and housing, remains clearly below this limiting value. Parts such as hood, fender or bumper cover have been taken into account for the simulation calculation, although they are not illustrated.

The structure of the headlamp attachment and the vehicle frontend are also very important. When the system is modified, geometry and material behavior change energy absorption and improve overall behavior during impact. **Fig. 8** shows the ideal curve (dark line) for pedestrian protection. The original maximum force which occurred at 60 mm has been displaced forwards. Which means the impact can be absorbed more evenly thanks to controlled deformation.

Effects on the headlamp design

Hella KGaA uses Finite Element Simulation software (FEM) in combination with standard CAD tools for the systematic evaluation of constructive alternatives.

Every headlamp demonstrates quite individual properties in impact situations. Headlamp attachment as well as the frontend structure make quite a major contribution to impact properties. The behavior of a headlamp can be compared with that of a tennis racket, i. e. it is soft in the center and hard at the edges. For this reason, space for controlled displacement to absorb impact energy is extremely important. The simulation shows the areas where the system either has to be weakened or reinforced depending on the vehicle's crash behavior, in order to make it possible to absorb the impact energy in as small a space as possible.

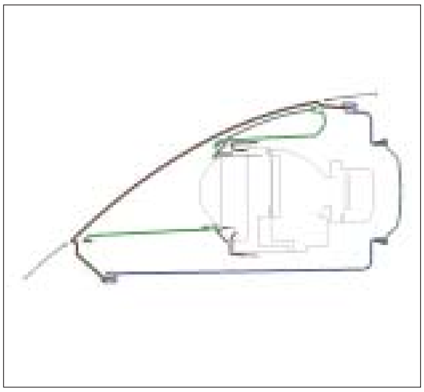

Fig. 9: Representation of a design concept before analysis

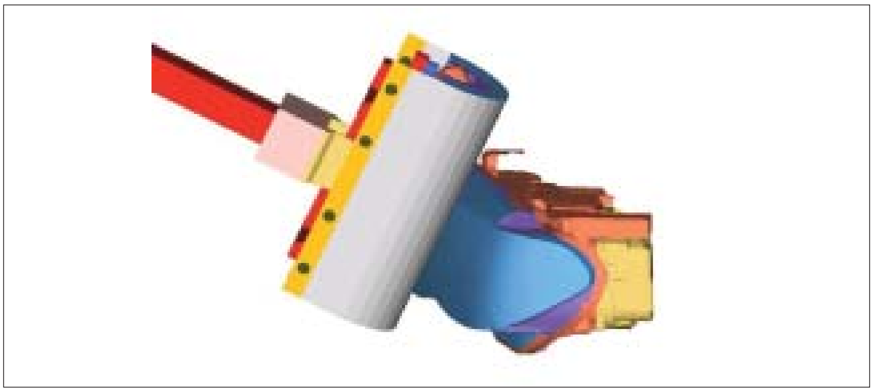

Fig. 10: FEM simulation of a design concept

Outlook

From this year onward, the implementation of the results gained on the subject of pedestrian protection for phase 1 will take place in series development. The general conditions of phase 2, which is planned to come into force in the year 2010, have not yet been defined in terms of content. The legal position is subject to continual observation, so that the concepts already developed can be requested or revised at any time.

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