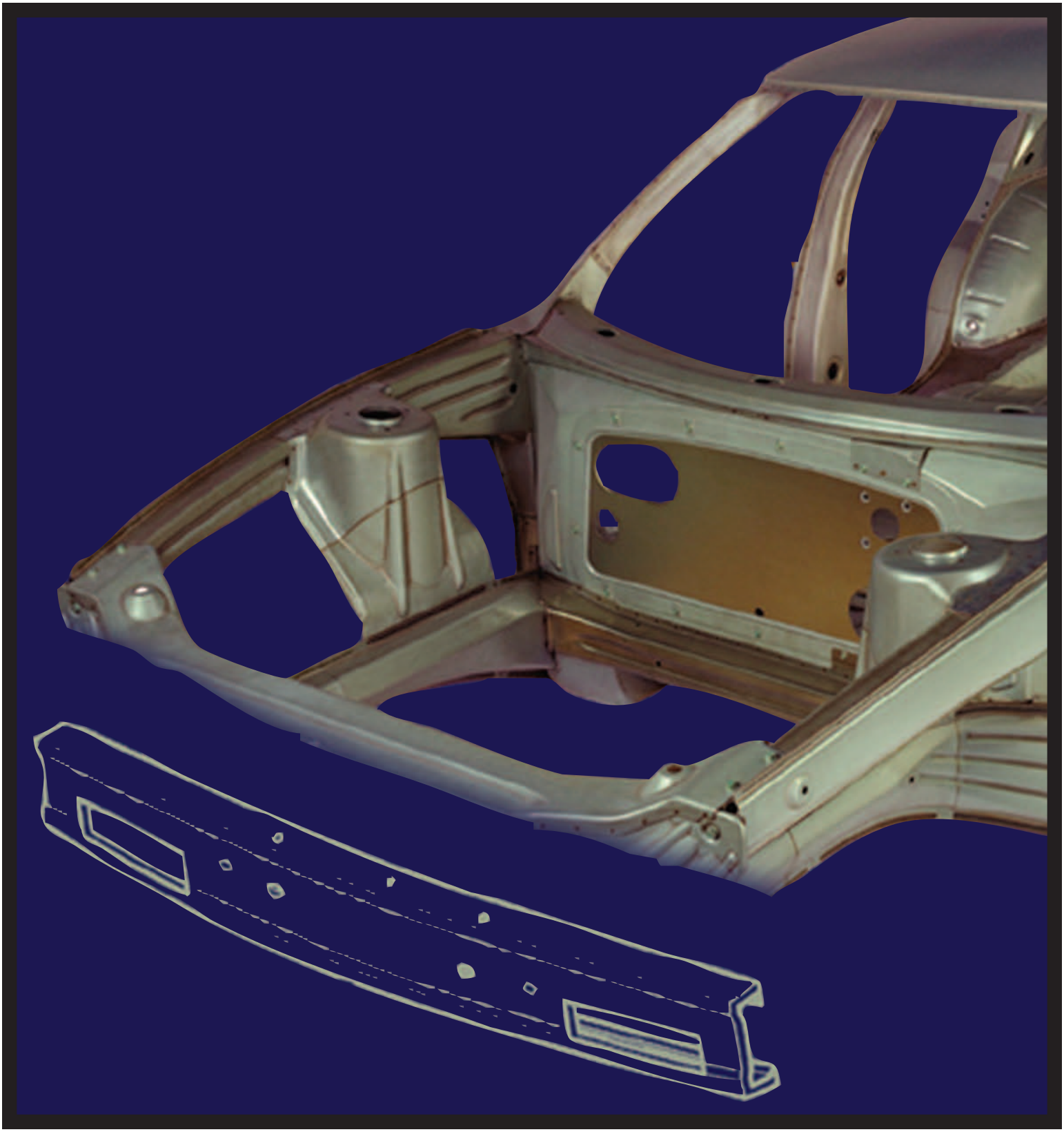

Pedestrian Bumper Design Survey

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Current Trends in Bumper Design for Pedestrian Impact

A Review of Design Concepts from Literature and Patents

December 31, 2004

A study funded by:

The American Iron and Steel Institute
Bumper Project

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Current Trends in Bumper Design for Pedestrian Impact:
A Review of Design Concepts from Literature and Patents

Summary

A survey of worldwide technical literature and patents has been performed. Documents related to the design of bumper systems for pedestrian lower limb impact were identified and categorized. Excluding bumper sensors and airbags, a total of 130 technical articles and 147 patented ideas (287 separate filings) were collected. Two general approaches to reducing the severity of pedestrian lower limb impacts were identified: (a) Providing cushioning and support of the lower limb in the bumper and a new lower stiffener, and (b) Using the bumper as a platform for impact sensors and exterior airbags. This study focused on the first approach.

The typical method proposed for *cushioning* the lower limb in an impact is with an energy absorber in front of a semi-rigid beam. The most common proposed energy absorbers are plastic foams (single or multi-density) and molded plastic 'egg-crates.' However, there are several designs utilizing 'spring-steel', composite steel-foam, or crush-can energy absorbers. The most common beams are rolled steel or extruded aluminum. However, there are also proposed designs using molded plastic beams or plastic-steel composite structures. In addition, there is a subset of designs that involve a deploying bumper that either moves or changes stiffness in response to the impact. Finally, some designs propose eliminating the beam and absorbing the impact with a cover or foam/cover unit only.

The typical method proposed for *supporting* the lower limb in an impact is with a secondary lower beam, also called a 'stiffener' or 'spoiler'. The most common types of lower stiffeners are plastic plates or metal beams. Typically, the engine undertray, the radiator support, or the front-end module provide support for these structures. In addition to these fixed concepts, there is a subset of designs that involve a deploying stiffener that moves based on either speed or impact.

There are only two proposed 'pedestrian-friendly' bumper designs with exposed metal surfaces (like current North American trucks). Without significant design development, exposed steel bumpers do not initially appear to be adaptable to meet the pedestrian test requirements. However, there are many design concepts in the literature that involve frontal airbags. While these may be costly and require advanced sensors, they would allow for the continued use of exposed steel bumpers.

Most of the proposed designs with foam or egg-crate absorbers represent similar concepts to that used in North American car bumpers today. In addition, nearly all designs recommend the addition of lower stiffness and several of these concepts add additional supporting metallic structures. So, for most passenger vehicles, the possibilities for continued steel use in the bumper will not be affected by the addition of pedestrian safety requirements.

Deliverables and Limitations

This report, and the referenced databases, comprises the results of the patent and literature survey and analysis performed by Dr. Peter Schuster of the California Polytechnic State University, San Luis Obispo (Cal Poly SLO). This work was funded by the American Iron and Steel Institute – Bumper Project. The goal of the project was to identify trends in how bumper design is affected by pedestrian impact considerations by studying published bumper designs in the European and Asian markets.

Technical articles and patents were limited to those giving bumper system design details. Specifically, the following types of articles and patents were excluded:

- Other areas of pedestrian impact analysis:
    - Head, torso, and thigh impacts
    - Accident data analysis
    - Impact kinematics and biomechanics
    - Test procedures
    - Computer simulation
- Design of other vehicle components:
    - Bumper-mounted impact sensors
    - External airbags
    - Hood, fender, shotgun, headlamps, wipers, windshield, etc.

Databases (Microsoft Access and Microsoft Excel) of the articles and patents—including bibliographic data and abstracts, as well as comments and categories—are included with this package. PDF files of the patents are included as well.

Background

Pedestrian safety is a globally recognized safety concern. Efforts toward modifying vehicle designs to offer some protection for pedestrians began in earnest in the 1970s. At the same time, test procedures to evaluate the performance of the new designs began to be developed. In industrialized countries pedestrian safety has improved significantly since then. However, as the number of motor vehicles increases rapidly in less developed nations, global pedestrian traffic fatalities are increasing.

Beyond the real-world concerns, the main drivers for automakers to introduce design features to enhance pedestrian safety are public domain tests and government regulations.

Public-Domain Tests

Pedestrian-vehicle impact tests have only recently become part of the mainstream. Since 1996, the European Union has been subjecting select vehicles to a battery of tests (frontal, side, pedestrian) as part of its European New Car Assessment (EuroNCAP, http://www.euroncap.com) program. The pedestrian tests consist of bumper impacts with a 'leg-form' impactor, hood edge impacts with an 'upper leg-form' impactor, and hood/fender impacts with two different 'head-form' impactors (see Figure 1). A vehicle is typically subjected to 3 bumper impacts, 3 hood edge impacts, and up to 18 head impacts. Vehicle results are reported with a 4-star rating system, similar to that used in the US NCAP program. The Australian NCAP (ANCAP, http://www.aaa.asn.au/ancap.htm) program is identical to

EuroNCAP. Vehicle performance in both test series have been improving, so it appears European and Japanese manufacturers are addressing these tests in their designs.

The Japanese NCAP (JNCAP, http://www.nasva.go.jp/assess/indexe.html) now performs tests simulating pedestrian head impacts onto the hood and fenders. The test procedure does not include bumper or hood edge impacts, however.

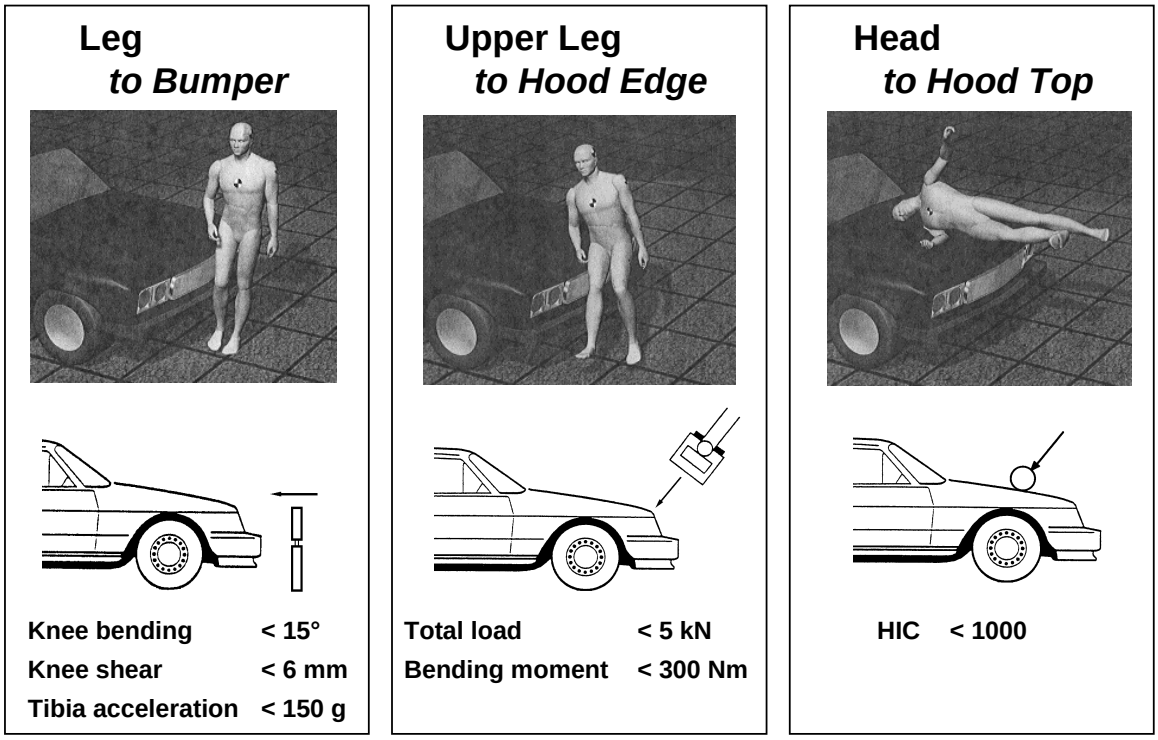

Figure 1: Pedestrian Impact Test Procedures

Government Regulations

The only existing government regulation for pedestrian safety in passenger cars is an external radii requirement in Europe. However, regulatory activity in Europe and Japan has increased significantly in the last decade. In particular, in Europe a 'Negotiated Agreement' has recently been reached between major manufacturer associations and the European Commission. This agreement states that vehicles will achieve a limited level of pedestrian impact performance starting in 2005, with an increased performance starting in 2010. (These dates apply only for new vehicle introductions, so overall fleet performance will lag.) The agreement effectively carries the force of law without the regulatory oversight. The limits shown in Figure 1 represent the initial targets for 2010. For 2005, the targets are less stringent. For 2005, the leg impact requirements are (bending < 20º, shear < 6 mm, acceleration < 200 g). More information on the Negotiated Agreement can be found at http://www.acea.be/ACEA/11072001.pdf.

The Japanese government is also considering implementing pedestrian head impact regulations, with leg impact potentially to follow at a future date. Pedestrian impact requirements are one of the subjects of the International Harmonized Research Activity

(IHRA), an international research group focused on developing common test standards for vehicle safety. In addition, an ISO (International Organization for Standardization) standard – ISO 11096:2002 – has been developed for pedestrian leg impact.

Pedestrian Leg Impact Test

A brief discussion of the pedestrian leg impact requirements will be helpful before proceeding into the design alternatives found in the literature.

The purpose of the pedestrian leg impact test procedure is to reduce the occurrence of severe lower limb injuries in pedestrian accidents. The most common severe pedestrian lower limb injuries are intra-articular bone fractures, ligament ruptures, and comminuted fractures. The pedestrian leg impact test is designed to evaluate a vehicle's potential to cause these types of injuries should an impact occur. In this test, a 'leg-form' impactor is propelled toward a stationary vehicle at a velocity of 40 km/h parallel to the vehicle's longitudinal axis. The test can be performed at any location across the face of the vehicle, between the 30º bumper corners.

The proposed performance criteria are illustrated in Figure 2, while the proposed 'leg-form' impactor is shown in Figure 3. The maximum tibia acceleration criterion is intended to prevent comminuted fractures of the tibia due to bumper contact. Maximum knee bend angle and shear deformation are intended to prevent severe knee joint injuries such as ligament rupture and intra-articular bone fractures.

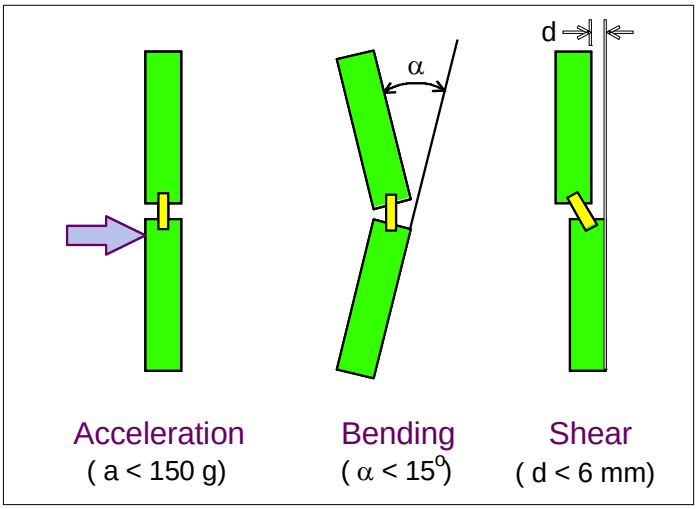

Figure 2: Proposed pedestrian 'leg-form' impact criteria

The proposed 'leg-form' impactor consists of two semi-rigid 70 mm diameter core cylinders (the 'tibia' and 'femur') connected by a deformable 'knee joint'. This core structure is wrapped in 25 mm of CF-45 Confor™ foam 'flesh,' covered by 6 mm of neoprene 'skin.' The inertial properties match those of a 50th percentile male human lower extremity, including the foot. The knee joint stiffness is intended to represent the resistance of the knee to lateral motion, rather than the anatomical flexion/extension. This corresponds to a pedestrian being hit from the side, for instance while walking across the street.

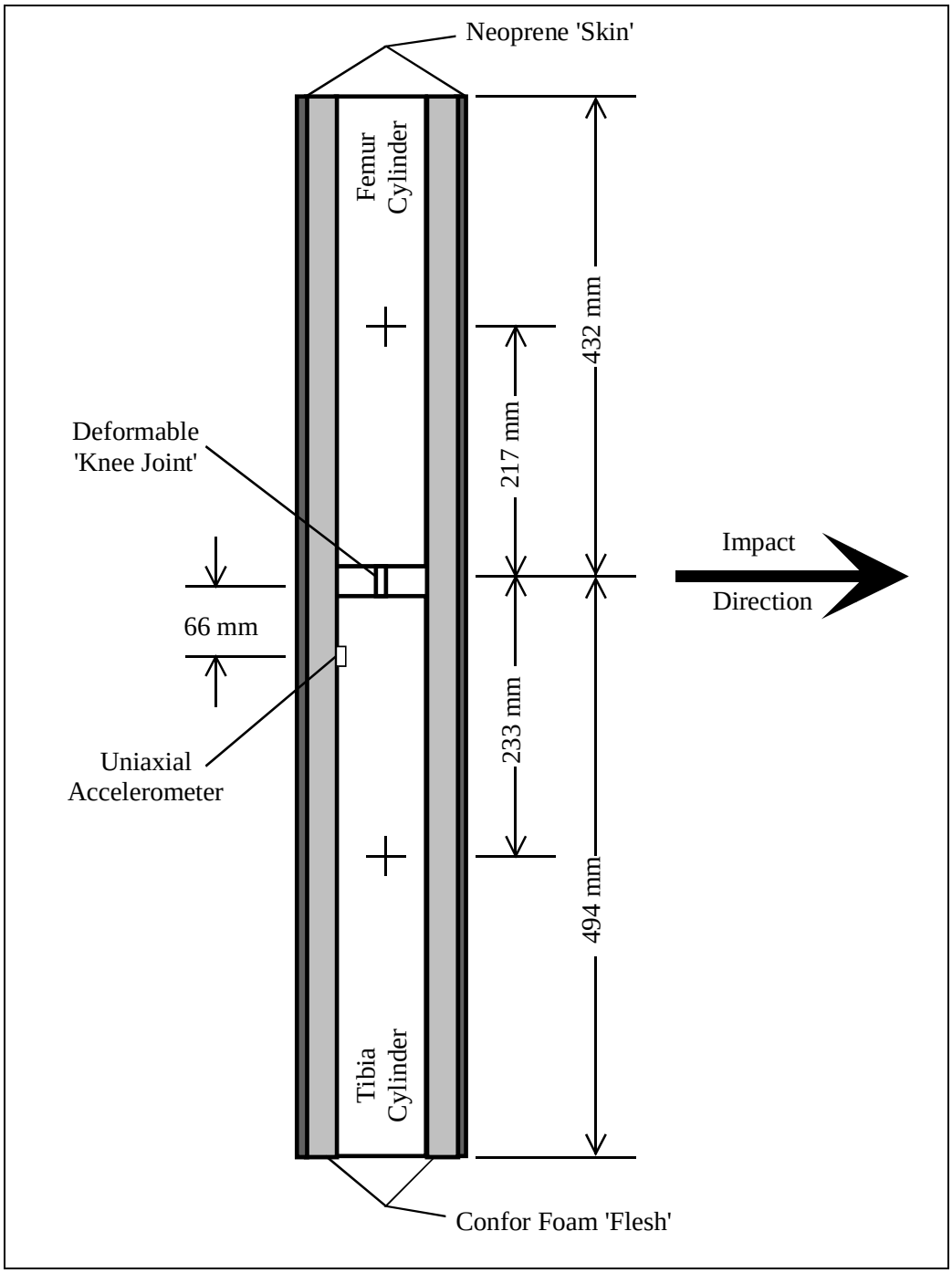

Figure 3: Proposed pedestrian 'leg-form' impactor

Methodology

Standard literature and patent search techniques were used for this study. For both cases, keyword searching was used, with the Boolean expression, "pedestrian AND bumper." The results were then manually searched to limit the field to those documents of interest to this study. The outcome of these searches is believed to be comprehensive in scope. While a few

global patents or technical publications may have been missed, the majority of relevant ones have been identified. Conclusions reached regarding design trends should not be affected by further searching.

Literature Search

In addition to using the available database search engines provided by the Cal Poly library (Applied Science and Technology Abstracts, ArticleFirst, Compendex, ContentsFirst, PapersFirst, ProceedingsFirst, SAE, Science Direct, and WorldCat), directed searches were pursued at the following web sites:

- http://www-nrd.nhtsa.dot.gov/departments/nrd-01/esv/esv.html - Proceedings of recent 'Enhanced Safety of Vehicles' conferences.
- http://www.imeche.org.uk/ils/catalogues.asp - The UK Institute of Mechanical Engineers library.
- http://www.umtri.umich.edu/library/simple.html - The University of Michigan's Transportation Research Institute library.

Patent Search

The patent search relied on several government search engines:

- http://www.uspto.gov - US Patent Office (US patents and applications)
- http://ep.espacenet.com - European Patent Office (worldwide patents)
- http://www.wipo.int - World Intellectual Property Organization (worldwide patents)
- http://www.surfip.gov.sg - Singapore Patent Office (worldwide patents)
- http://www.ipdl.ncipi.go.jp/homepg_e.ipdl - Japanese Intellectual Property Digital Library (Japanese patents and applications)
- http://depatisnet.dpma.de - German Patent Office (worldwide patents)

Bumpers in Production

EuroNCAP has been performing pedestrian tests on vehicles since 1996. There has been a wide variation in the response of vehicles to these tests. To evaluate production bumpers that perform well in the pedestrian leg impact test, the EuroNCAP and ANCAP ratings were reviewed.

Results

Literature Search

A total of 130 relevant (i.e., covering bumper design for pedestrian impact) articles were identified. Of the 58 recent (published since 1990) articles, 25% were authored by OEM's, 25% by suppliers, and 50% by other groups. Table 1, Table 2, and Table 3 identify the number of relevant articles authored by company or group.

Patent Search

A total of 147 relevant patents (covered by 287 separate filings) were identified. This number specifically excludes those patents related to pedestrian bumper-mounted sensors and pedestrian bumper airbags. These are both areas of significant patenting activity over the past decade, but were not deemed directly relevant to this study. Table 1, Table 2, and Table 3 identify the owners and types of design solutions identified in these patents. Where a

patent proposed designs falling into more than one category, it is split (hence, ½ appears in the tables). The database includes both issued patents and patent applications (when available). PDF files are provided of US patents (full text), US applications (first page) and issued foreign patents (first page).

Table 1: Non-Corporate Pedestrian-Bumper Design Articles & Patents (excl. sensors & airbags)

	Articles[1]	Patents
Individuals	8	18
Government Labs	4	2
Universities	8	-
Consultants	4	-
Consortia	4	-
TOTAL:	28	20

Table 2: OEM Pedestrian-Bumper Design Articles & Patents (excluding sensors and airbags)

		PATENTS								
Company	Articles[1]	Total	Foam	Stiffener	Beam	Egg-crate	Active Bumper	Active Stiffener	Crush-Cans	Other
BMW	-	1					½	½		
DaimlerChrysler	1	6	2½	1½			1	½	½	
Fiat	1	1	1							
Ford / Jaguar	3	17	2	4	2	1	½	2½	1	4
GM / Opel	-	3	1½	½			½	½		
Honda	3	4			½		1	1	1	½
Hyundai	2	1		1						
Kia	1	-								
Mazda	2	8	½	4½			1		1	1
Mitsubishi	-	4								4
Nissan	-	4	1	2½	½					
Peugeot	-	1			1					
Rover	-	1		1						
Subaru (Fuji)	1	10	2	3	1				½	3½
Toyota	-	6	1	2		2		1		
Volkswagen	-	3	2		1					
TOTAL:	14	70	13½	20	6	3	4½	6	4	13

[1] Only includes articles published since 1990.

Table 3: Supplier Pedestrian-Bumper Design Articles & Patents (excluding sensors and airbags)

		PATENTS								
Company	Articles[1]	Total	Foam	Stiffener	Beam	Egg-crate	Active Bumper	Active Stiffener	Crush-Cans	Other
Adlev S.r.l.	-	1	½		½					
Aisin Seiki	-	1	½		½					
Alcan	1	-								
Atlas Auto	-	1								1
Bayer	-	1						½		½
Benteler	-	1			½					½
Calsonic Kansei	-	2	1		1					
Cellbond	-	2								2
Decoma	-	3	1	2						
Denso	-	1		1						
Dow	3	2	2							
Dynamit Nobel	-	3		1						2
Faurecia	1	-								
FMB Fahrzeug	-	1								1
FPK	-	1								1
G P Daikyo	-	2		1						1
GE Plastics	5	6			1	5				
Inoac	-	1				1				
JSP Corp	3	5	4		1					
Kobe Steel	-	1							1	
Linpac	-	2	1					1		
Man Nutzfahrze.	-	1						1		
Mitsuboshi Belt.	-	1	1							
Netshape	1	3			1	2				
Peguform	-	2		1	1					
Plastic Omnium	-	6	2	2	½	1½				
Raufoss Auto.	-	1			1					
Siemens	1	-								
Solvay	1	-								
SSAB Hardtech	-	1			1					
Tatsuno	-	1					1			
Valeo	-	1				1				
ZF Boge	-	3					2		1	
TOTAL:	16	57	13	8	9	10½	3	2½	2	9

Bumpers in Production

Vehicles with bumpers performing well in the EuroNCAP or ANCAP tests are listed below.

Citroen C4	Mazda Premacy	VW Golf
Honda Civic	Mazda 323	VW Touran
Honda CRV	MG TF	
Honda Jazz	Seat Altea	

More information about the European design of these bumpers has been requested but not received. However, several are known to be open shell* designs. Obtaining the details of these designs is beyond the scope of this study, but with the vehicle names identified, the AISI Bumper Team should be able to obtain more information, either from vehicle benchmarking exercises already conducted by European divisions, or through replacement parts catalogs.

Analysis

Overview

The review of the patent and literature data revealed two general approaches to design a front bumper system for pedestrian lower limb impact:

- Design all of the vehicle front-end components to provide the appropriate stiffness to *cushion* the impact while at the same time providing *support* of all parts of the limb to limit knee joint lateral bending. Since this approach results in a preferred physical and mechanical arrangement of the front-end, especially the bumper system, it is the focus of this report.
- Design an active pedestrian safety system, utilizing *sensors* and external *airbags* to cushion and support thepedestrian. Since the bumper system then primarily serves as a mounting platform for sensors or airbags (and, indeed, is often excluded from the impact by the presence of an airbag), this scenario is not discussed further within this report.

Function: Cushioning (impact energy absorption)

The *cushion* function of the bumper in a pedestrian impact is directly related to the acceleration impact criterion shown in Figure 2. It is intended to reduce the severity of bone fractures in a pedestrian impact. This function is not entirely dissimilar from the traditional function of a bumper system (absorbing energy of a vehicle impact). But, there are two key differences: the impact energy and the acceptance criteria.

Impact energy. Based on a simple energy analysis, the vehicle impact requires a local energy-absorption 'density' at least double that of the pedestrian impact:

> The pedestrian leg-form test device has an active width of 70-mm. Assuming that a typical bumper energy absorber is approximately 150-mm tall, the contact area is (70)x(150) = 10500-mm^2. The total impact energy is $\frac{1}{2}mv^2$ = ½(13.4 kg)x(11.1 m/sec)^2 = 825 Joules. As a result, the energy-absorption 'density' of the bumper absorber would be approximately (825/10500) = 0.08 J/mm^2 (or less since other vehicle components will absorb some energy).

* Open shell bumpers have an air gap between the bumper cover and beam. Energy absorption is managed through deformation of the bumper cover.

> A 5-mph pendulum impact engaging only the top or bottom 2 inches of the energy absorber would have a contact area of approximately (50)x(500) = 25000-mm^2. The total impact energy for a 1500-kg vehicle is $\frac{1}{2}mv^2$ = ½(1500 kg)x(2.22 m/sec)2 = 3696 Joules. The energy-absorption 'density' needs to be approximately (3696/25000) = 0.15 J/mm^2.

Acceptance criteria. For the leg-form impact, the acceleration of the lower limb must be below 150-g. For the vehicle impact, the criteria are force at the frame rail (to prevent damage to the structure) and intrusion (to prevent damage to other components). This difference is often more important than the energy input, since the acceleration criterion limits the allowable stiffness of the bumper energy absorber to lower than that usually deemed acceptable for the vehicle impact.

To summarize, the goal in the design of bumper components to *cushion* a pedestrian impact is to limit the 'leg-form' acceleration without either (a) sacrificing vehicle damageability—a far more common impact—or (b) significantly increasing the depth of the bumper system—which has many follow-on effects for vehicle performance and styling.

The literature and patent review identified several common methods for achieving this goal. These are summarized below in order of decreasing popularity, as measured by the number of patents describing each solution. An example patent is listed for each design alternative, with the database reference number of that patent in italics:

1. Foam Energy Absorbers (35)
    a. Shape/profile to control absorption and leg rotation (13) – EP 1422110 (*282*)
    b. Multi-density to control absorption and leg rotation (7) – EP 1046546 (*334*)
    c. Fluid-filled foam for higher efficiency absorption (7) – WO 9725551 (*147*)
    d. Depression in beam to prevent bottoming-out (5) – US 6764117 (*245*)
    e. Foam coring to prevent bottoming-out (3) – JP 2004224106 (*346*)
2. Molded Plastic Energy Absorbers (21)
    a. 'Egg-crate' molded shapes (13) – US 6726262 (*249*)
    b. 'See-saw' to increase stiffness with contact width (4) – US 6554332 (*265*)
    c. Open shell & other shapes (4) – US 2004124667 (*279*)
3. Air-filled Energy Absorbers (11)
    a. Variable stiffness (6) – JP 09020192 (*94*)
    b. Fixed stiffness (5) – DE 4308021 (*61*)
4. Flexible or Plastic Beam (8) – US 6494510 (*268*)
5. Deploying Bumper* (7) – GB 2368565 (*329*)
6. Crush-Cans (7)
    a. Fixed stiffness (4) – DE 3434844 (*32*)
    b. Variable stiffness (3) – JP 2000025540 (*178*)
7. Bull-bar add-ons (6) – EP 0797517 (*82*)
8. Foam-encapsulated metal (3) – US 6793256 (*308*)
9. Steel energy absorbers (2) – US 6398275 (*275*)

* These designs provide for the additional energy absorber depth needed for pedestrian impact without increasing vehicle length by retracting the bumper under normal conditions, and only pushing it out when an impact is predicted.

Function: Support (load distribution)

The *support* function of the bumper system is directly related to the knee bend angle criterion illustrated in Figure 2. It is intended to reduce the risk of severe knee joint injuries such as ligament ruptures and intra-articular fractures. The idea is to provide enough support below and/or above the main bumper to limit the bending moment at the knee joint during an impact. This situation is complicated by a two vehicle design requirements:

(a) The vehicle impact standard for bumpers requires the front bumper to be located at approximately the same height as the pedestrian 'leg-form' knee, so without other components, the greatest bending moment would occur there. Also, this standard mandates no damage to other vehicle components, limiting how far forward they could be placed.

(b) The front-end approach angle requirement (to prevent front-end damage when driving up slopes) limits how low to the ground any components can be located.

So, the goal in the design of bumper components to *support* the lower limb during a pedestrian impact is to limit the 'leg-form' bending without either (a) sacrificing vehicle damageability—a far more common impact—or (b) violating vehicle approach angles—which has many follow-on effects for vehicle performance and styling.

The literature and patent review identified several common methods for achieving this goal. As above, these are summarized in order of decreasing popularity, as measured by the number of patents describing each solution. An example patent is listed for each design alternative, with the database reference number of that patent in italics:

1. Fixed Lower Stiffeners[*] (41)
    a. Metal beam (11) – GB 2069940 (*39*)
    b. Plastic tray (11) – US 20040238256 (*280*)
    c. Foam supported by radiator support or FEM (8) – US 6676179 (*253*)
    d. Reinforced cover (5) – JP 2002144988 (*366*)
    e. Integrated with engine undertray (3) – US 6540275 (*266*)
    f. Damper to absorb energy (3) – EP 557733 (*59*)
2. Deploying Lower Stiffeners (10)
    a. Mechanical (7) – JP 2004074972 (*353*)
    b. Pneumatic (3) – JP 2004074971 (*354*)
3. Mechanical Linkages[†] (3) – GB 2321624 (*242*)
4. Deploying Upper Structures (2) – US 6447049 (*272*)
5. Broad Face Bumpers[‡] (2) – GB 2336812 (*336*)

[*] Lower Stiffener – A new component, or a new function of an existing component, located below the bumper system, to prevent the lower part of the 'leg-form' from moving further toward the vehicle than the knee. The number of ideas in this area is understated, as many patents describe multiple design solutions.

[†] Mechanical Linkage – A mechanical connection between the bumper face and some solid lower support. This link forces the lower support forward when the bumper is pushed rearward.

[‡] Broad Face Bumpers – Bumpers with a tall front-view height to provide support without additional structures.

Notes:

- In addition to these specific design features, the patent and literature search also indicated that foam shape/profile, multi-density foam, and pedestrian 'bull-bars' could help reduce knee bend angle during the pedestrian impact.
- Several proposed lower stiffener designs included features that allow the device to deflect when an upward force is applied (i.e., if the approach angle were violated).

Discussion

Design Trends

Several common design trends can be identified based on the results of this survey. These represent alternative approaches to meeting the requirements of pedestrian leg impact. As bumper systems meeting these requirements are only beginning to hit the marketplace in Europe, Australia, and Japan, it is too early to state definitively which approaches will eventually be the most common. For the published data, the most commonly mentioned design trends are summarized below:

Bumper-mounted sensors and/or bumper airbags. These were not catalogued as part of this study, but they certainly represent one design trend. A benefit of this trend for AISI members is that any bumper system could be used with an airbag cover – the energy-absorption of the bumper becomes irrelevant. The key disadvantages to this design approach are cost and sensor capability.

Lower stiffeners (deploying or static). There are many ways of delivering the function of this part, as reflected by the breadth of design proposals in this area. This is a potential area of growth for steel components, so AISI may want to consider directing some effort to developing both deploying and static steel designs for this part.

Alternative energy absorbers. Between multi-density or 'tuned' shape foams and a plethora of molded plastic energy absorbers, this is definitely a growth area. The prevailing data suggests that some type of energy-absorber will be necessary between the bumper beam and the pedestrian. As an alternative approach, however, there are several design proposals that utilize steel as an energy absorber or add a crush-can behind the beam to perform that function. In general, since exposed steel bumper systems are not commonly used in Europe or Asia, there has been little activity devoted toward adapting them to meet pedestrian impact requirement. This is another area that AISI may want to address.

Beam design. The design of the bumper beam in a beam-absorber system (traditional passenger car) has also received some attention. In particular, there are several proposals to change the shape of the face of the beam to eliminate foam 'bottoming-out' and reduce leg-form knee bending. In addition, many molded plastic absorbers will likely need additional attachment points on the face of the beam. Neither of these changes will significantly affect AISI members.

Flexible beams. There are some indications that a flexible (usually plastic) beam can be used to improve pedestrian impact performance. At present, this does not represent a significant trend, so is not a direct threat to steel bumper beams.

'Bull-bars.' Add-on structures on the front of the bumper may be used to provide energy-absorption and support of the lower limb during a pedestrian impact. The design proposals in this area are predominantly plastic, so this is a potential market loss for AISI companies. However, since such a device could be added as standard equipment over an exposed steel bumper beam, this represents a potential feature to protect that market segment.

Pedestrian Safety in the US?

NHTSA, and to a lesser extent, the US media, has been primarily focused on pedestrian behaviors and roadway design as a means to reducing pedestrian accidents. While there are a few indications that this trend is changing in the media, it is unlikely that pedestrian requirements will migrate into the US market in the near term (~10 years).

However, there are several trends that will likely bring pedestrian impact requirements to the US eventually. First, the US has a high number of pedestrian accidents and fatalities that has not decreased significantly in the last decade. In addition, globally there are significant pressures toward harmonization of standards. Finally, vehicles designed to meet pedestrian standards in other markets are now being sold in the US, so demonstrating the feasibility of such designs.

Given these facts, it is worth considering the financial ramifications of the design trends discussed above. Vehicles are highly cost-sensitive, and new requirements are often at odds with market pressures. Marketable features are the primary source of price increases in the current market. Given the public perception of pedestrian safety as primarily a pedestrian's responsibility, it is doubtful pedestrian bumpers could represent a marketable feature in the US. As a result, the lowest cost options are likely those that will be most prevalent as pedestrian impact performance moves into the US. External airbags, pedestrian sensors, and deployable bumpers and stiffeners are not likely to become mainstream features in the US for the foreseeable future.

Notable Patents

Based on the above design trends and the AISI Bumper Team objectives, there are several patents that deserve more in-depth attention. These are listed below, and the PDF files are included with this report:

- US 20030168869 (Honda) – a steel pedestrian energy-absorbing structure.
- US 6398275 (Benteler) – a steel pedestrian elastic energy-absorbing structure.
- US 6659518 (Peguform) – a leaf spring design for the bumper beam.
- GB 2336812 (Rover Group) – describes a mechanism for energy-absorption
- JP 2002178862 (Subaru) – a semi-rigid bumper attached by deformable brackets.
- US 6428065 (Subaru) – Deformable structure behind bumper

Patent Trends

With the notable exceptions of Ford, GE Plastics, and Netshape, foreign individuals and corporations have submitted most of the newer US patent applications relating to the design of bumpers for pedestrian impact. If AISI Bumper Project members do not wish to pay royalties to foreign corporations for future pedestrian-related design features, I recommend an accelerated effort at developing designs and submitting patent applications in this area. In particular, members may wish to focus attention on (a) lower stiffeners and (b) steel energy absorbers.

It is illuminating to look at the growth of patented ideas in this area over time (Figure 4). A modest increase in patents in this area started in 1995, when EuroNCAP began performing and publicizing pedestrian impact tests. But the more striking part of the figure is the extraordinary increase starting in 2001, when the European 'negotiated agreement' on pedestrian protection was being publicly discussed. It appears that the increased publicity and apparent progress toward mandated standards has significantly increased the number of new ideas generated in this area.

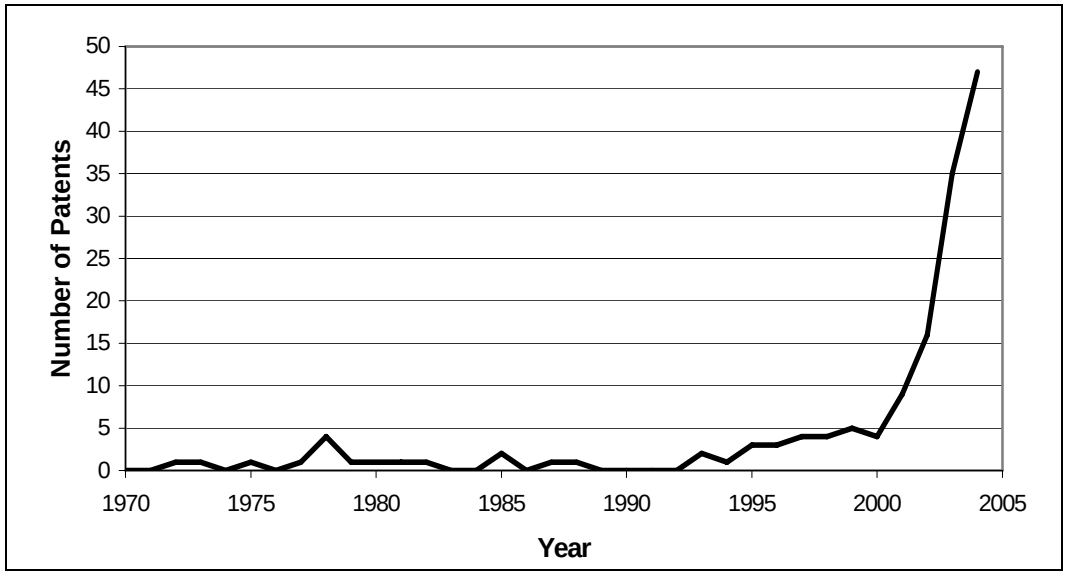

Figure 4: Worldwide Pedestrian Bumper Patented Ideas (excluding sensors & airbags)

Comments

For the current study of trends in bumper design for pedestrian impact, the results from the patent search were more useful than the literature results. The articles from the literature search primarily identified a preferred physical arrangement and relative stiffness of front-end components for improved pedestrian impact performance, without presenting any specific designs. The patent results, in contrast, give design details for different methods of achieving the preferred physical arrangement and relative stiffness. This situation is likely a result of the fact that technical papers written by automotive engineers strive to avoid giving detailed design information to maintain their company's competitive advantage. However, this information is required for patent declarations.

Although the literature search was not as useful to the results of this study, it is worth noting that the literature available on pedestrian impact is much broader than that covered here. The board scope of pedestrian impact literature provides the best means to understand the problem and to work from fundamental principles.

Conclusion

130 technical articles and 147 patented ideas were found describing bumper designs to reduce pedestrian injuries. While the technical articles provide information on the preferred shape and stiffness of the bumper system, the patents provided details on designs providing those features. An analysis of the data found that some common design trends for pedestrian impact are (a) bumper mounted-sensors and pedestrian airbags, (b) new lower stiffeners, (c) alternative energy absorbers, (d) beam face features, (e) flexible beams, and (f) bull-bars.

These trends identify market risks and opportunities for AISI. Since energy absorbers are preferred in front of bumper beams for pedestrian impact, exposed steel bumper beams may be at risk. Flexible bumper beams, while a minor trend, also represent a risk to the AISI bumper beam market. Lower stiffeners will be a new component for pedestrian impact, and the possibility of designing these in steel represents an opportunity for AISI members.

Based on these observations, it is recommended that AISI pursue further investigations in steel energy-absorbing structures and lower stiffeners. In addition, efforts to encourage the development of pedestrian frontal airbags or bull-bars would provide further protection of the exposed steel bumper market.

Appendix A: Articles Included in the Database

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Appendix B: Patents Included in the Database

Database ID	Title	CC	Patent Number	Date
321	A Bumper Assembly for a Motor Vehicle	GB	2384218	7/23/2003
323	A Bumper Assembly for a Motor Vehicle	GB	2384213	7/23/2003
332	A Vehicle Bumper Arrangement	WO	0128818	4/26/2001
		DE	6000684	
		EP	1222094	
		GB	2355435	
329	A Vehicle Front Impact Arrangement	GB	2368565	5/8/2002
79	Air Cell Bumper Device	US	5431463	7/11/1995
39	An Impact Protection Device for Vehicles	FR	2474982	8/7/1981
		GB	2069940	2/29/1984
		IT	1170639	6/3/1987
		DE	3003568	12/20/1990
372	Automobile Bumper	JP	60042138	3/6/1985
330	Automobile Bumper Exhibits Defined Pivot Movement upon Frontal Impact for Protecting Pedestrian or Cyclist	DE	10031526	1/10/2002
288	Automobile Bumper Structure	US	20040124643	7/1/2004
		JP	2004203157	7/22/2004
		JP	2004203158	7/22/2004
		EP	1433664	
94	Automobile Having Safety Device	JP	09020192	1/21/1997
283	Blow Molded Energy Absorber for a Vehicle Front End	US	20040174025	9/9/2004
		WO	2004080765	
278	Bumper Absorber for Pedestrian Protection	WO	2004028863	4/8/2004
		JP	2004175338	6/24/2004
258	Bumper Apparatus for Vehicle	US	6808215	10/26/2004
		DE	10350451	
		JP	2004148915	
336	Bumper Arrangement	GB	2336812	11/3/1999
275	Bumper Arrangement	US	6398275	6/4/2002
		EP	1199224	
337	Bumper Assemblies for Motor Vehicles	GB	2322602	9/2/1998
		DE	19806541	
		FR	2759655	
311	Bumper Assembly	US	20030067178	4/10/2003
		EP	1300294	
		GB	2380714	
259	Bumper Assembly	US	6659520	12/9/2003
		EP	1300296	
		GB	2380715	
293	Bumper Assembly Including an Energy Absorber	US	20040066048	4/8/2004
249	Bumper Assembly Including an Energy Absorber	US	6726262	4/27/2004
		EP	1441928	
		WO	03037688	
242	Bumper Assembly with Forwardly Displaceable Lower Portion	GB	2321624	5/8/1998
		DE	19802841	
		FR	2758779	

Database ID	Title	CC	Patent Number	Date
260	Bumper Bar for a Motor Vehicle with an Intermediate Web	US	6659518	12/9/2003
294	Bumper Core	JP	2004082957	3/18/2004
		US	20040056491	3/25/2004
279	Bumper Device	US	2004124667	7/1/2004
		EP	1365945	
		NL	1017483	
		WO	02070305	
340	Bumper Device for a Vehicle, in Particular for a Motor Vehicle	WO	2004106118	4/10/2004
361	Bumper Device for Vehicle	JP	2003154908	5/27/2003
365	Bumper Face Fitting Structure	JP	2002178862	6/26/2002
245	Bumper for a Vehicle	US	6764117	7/20/2004
		WO	0224487	
189	Bumper for Automobile	JP	11208389	8/3/1999
67	Bumper for Motor Vehicle - has Impact-Near and Impact-Remote Layer of Foam Separated by Support Part which has Resilient Holders to Connect to Vehicle Chassis	FR	2606718	5/20/1988
		US	4826226	5/2/1989
		DE	3639195	4/19/1990
		GB	2197267	6/26/1991
		SE	466845	4/13/1992
		IT	1211895	
		JP	63130446	
		SE	8704382	
374	Bumper for Motor Vehicles has U-Shaped Deformation Element with Two Legs Engaging on Rear Support Surface via Intermediate Space	DE	10143532	3/27/2003
252	Bumper for Reducing Pedestrian Injury	US	6685243	2/3/2004
		WO	2004011306	
289	Bumper for Reducing Pedestrian Injury	US	20040119301	6/24/2004
334	Bumper for Vehicle Having Mechanical Characteristic Optimized to Improve Pedestrian Protective Performance	JP	2000318551	11/21/2000
		EP	1046546	
129	Bumper Holding Device for Vehicle	JP	11078734	3/23/1999
335	Bumper Including Lower Protection Beam	EP	1038732	9/27/2000
		FR	2791311	
358	Bumper Mounting Structure of Automobile	JP	2003252135	9/10/2003
347	Bumper Protector with Personal Safety Grille Guard	JP	2004203255	7/22/2004
287	Bumper Structure for a Motor Vehicle	US	20040130167	7/8/2004
		EP	1433665	
		JP	2004196156	
163	Bumper Structure for a Vehicle	JP	11078732	3/23/1999
		US	6106039	8/22/2000
		GB	2328654	
274	Bumper Structure for Automobile	EP	1138556	10/4/2001
		US	6428065	8/6/2002
		JP	2001277963	
362	Bumper Structure for Automobile	JP	2003011750	1/15/2003
366	Bumper Structure for Automobile	JP	2002144988	5/22/2002
277	Bumper Structure for Vehicle	EP	1384629	1/28/2004
		US	2004160071	8/19/2004
		JP	2004058726	
363	Bumper Structure for Vehicle	JP	2002274298	9/25/2002

Database ID	Title	CC	Patent Number	Date
270	Bumper Support for Improved Pedestrian Protection in Motor Vehicles	US	6467822	10/22/2002
		DE	19934141	
		EP	1072476	
326	Bumper Support for Improved Pedestrian Protection on Motor Vehicles	EP	1273483	1/8/2003
		DE	10137911	
328	Bumper System	WO	02057119	7/25/2002
256	Bumper System for Motor Vehicles	US	6663151	12/16/2003
271	Bumper System for Motor Vehicles	US	6460909	10/8/2002
257	Bumper with Integrated Energy Absorber and Beam	US	6663150	12/16/2003
353	Collision Object Protecting Device for Vehicle	JP	2004074972	3/11/2004
354	Collision Object Protecting Device for Vehicle	JP	2004074971	3/11/2004
339	Collision Protection Appts. for Vehicle	DE	19572600	10/10/1996
		US	5785368	
273	Combination Bumper Skin and Under-Engine Fairing for a Vehicle	US	6435577	8/20/2002
		EP	1082247	
		FR	2791628	
298	Composite Foam Structure Having an Isotropic Strength Region and Anisotropic Strength Region	US	20040001945	1/1/2004
		WO	2004003064	
342	Composite Foamed Polypropylene Resin Molding and Method of Producing Same	WO	03078127	3/19/2003
147	Device Incorporating Elastic Fluids and Viscous Damping	WO	9725551	7/17/1997
341	Dual Bumper for Protecting Walker	WO	2004103777	12/2/2004
246	Energy Absorber for Interposing Between a Rigid Beam and a Bumper Skin, and an Energy-Absorbing Assembly	US	6758506	7/6/2004
		EP	1350680	
		FR	2836878	
285	Energy Absorber with Crash Cans	US	20040145195	7/29/2004
		EP	1427609	
		WO	03022639	
297	Energy Absorbing Bumper Structure	US	20040003974	1/8/2004
		EP	1330378	
		WO	0234578	
360	Energy Absorbing Bumper Structure	JP	2003160009	6/3/2003
		DE	10149121	
		EP	1300295	
		US	20030141728	
61	Energy Absorbing Collision Body for Front of Goods Vehicle - Uses Series of Air Cells Supplied with Air Via Valves Giving Active or Passive Air Release	DE	4308021	9/15/1994
351	Energy Absorbing Member for Personal Protection and Bumper Reinforcement	JP	2004090910	3/25/2004
248	Energy Absorption Unit	US	6755452	6/29/2004
		EP	1417115	
		WO	03013910	
319	Energy-Absorbing Bumper Assembly and Front Face Comprising Said Assembly	WO	03072399	9/4/2003
		FR	2836434	
305	Energy-Absorbing Elements for Automobile Bumpers and Methods of Making the Same	US	20030164618	9/4/2003
		CA	2392672	
		WO	0138140	
318	Extendible Safety Device Above a Vehicle Bumper	GB	2394920	5/12/2004

Database ID	Title	CC	Patent Number	Date
250	Extending Bumper with Combined Stiffener and Method	US	6726260	4/27/2004
251	Extruded Aluminum Bumper	US	6712410	3/30/2004
16	Flexible Bumper for Car - has Integral Heating Ducts Coupled to Coolants Circuit to Keep Flexible to Prevent Injury to Pedestrians in Minor Collisions	DE	2641887	3/23/1978
344	Fluid Filled Impact Absorber	WO	0221013	3/14/2002
		EP	1409888	
303	Formable Energy Absorber Utilizing a Foam Stabilized Corrugated Ribbon	US	20030183466	10/2/2003
		EP	1348884	
348	Front Body Structure of Vehicle	JP	2004203183	7/22/2004
368	Front Body Structure of Vehicle	JP	2001088634	4/3/2001
369	Front Body Structure of Vehicle	JP	2001010424	1/16/2001
370	Front Body Structure of Vehicle	JP	2001010423	1/16/2001
352	Front Bumper Core	JP	2004168077	6/17/2004
357	Front Bumper Device for Vehicle	JP	2003260994	9/16/2003
333	Front Bumper, has Support Structure with Deformable Cover for Reducing Impact Force in Event of Vehicle Hitting Pedestrian	DE	19944670	3/22/2001
254	Front End Structure of a Vehicle	US	6672652	1/6/2004
		EP	1266818	
		JP	2002370674	
135	Front Garnish	JP	10230798	9/2/1998
82	Front Protective Bar for Motor Vehicles, Esp. All-Terrain Types - has Joining Points of Parts and Points Where Bar is Joined to Vehicle Body Yielding and Absorbing Forces When Person is Struck by Vehicle	WO	9620852	7/11/1996
		DE	29500106	
		EP	0797517	
		RU	2126334	
178	Front Structure for Vehicle	JP	2000025540	1/25/2000
324	Front Structure of a Motor Vehicle	WO	03039915	5/15/2003
		DE	10154113	
		EP	1451041	
253	Front Structure of Vehicle Body	US	6676179	1/13/2004
		DE	60103687	
		EP	1138557	
		JP	2001277964	
264	Front-End Module for a Motor Vehicle	US	6634702	10/21/2003
		DE	10002499	
		EP	1194327	
		WO	0100478	
136	Grille Guard for Vehicle	JP	09315243	12/9/1997
134	Guard Bar	JP	10230802	9/2/1998
70	Impact Absorbing Cover for Bumper - has Lubricated Plastics Deformable Layer on Underside	DE	2711372	10/5/1978
268	Impact Absorbing Mechanism and Bumper Reinforcement Having the Mechanism	US	6494510	12/17/2002
		JP	2001225707	
32	Impact Absorbing Vehicle Bumper has Array of Springs Embedded in Plastics for Impact Absorption	DE	3434844	5/23/1985
261	Impact Damper	US	6655509	12/2/2003
		DE	10136300	

Database ID	Title	CC	Patent Number	Date
314	Impact Damper	US	20030020219	1/30/2003
		DE	10136299	
60	Impact Energy Absorber for Motor Vehicle - has Support Beam on Vehicle Engaging Swinging Arm with Roller	GB	2262719	6/30/1993
		US	5226685	7/13/1993
34	Impact Energy Absorbing Bumper for Motor Vehicle has Foam on Back-Up Beam and External Skin of Synthetic Resin or Rubber	JP	57040136	3/5/1982
281	Impact Energy Transmitting Arrangement	US	20040222667	11/11/2004
		EP	1386794	
327	Impact Protection for Vehicles has Rubber-Elastic Impact Strip with Inflatable Tube on Bumper Connected to Pressure Reservoir	DE	10136297	1/2/2003
		US	2003020289	
345	Improved Elastomeric Impact Absorber with Viscous Damping	WO	9949236	9/30/1999
		DE	69808147	
		EP	1068460	
290	Integrated Solitary Bumper Beam	US	20040094977	5/20/2004
		WO	2004045910	
315	Integrator Front Element	EP	1433663	6/30/2004
		WO	03008238	
349	Lip Spoiler Formed in a Single Piece with Pedestrian Protecting Bracket	JP	2004196004	7/15/2004
59	Lorry Bumper System with Lower Upwards-Hinging Override Protection - has Four-Link Non-Parallelogram Mechanism Moving	DE	4206022	9/2/1993
		EP	557733	1/31/1996
317	Lower Protection Beam for the Collision of a Pedestrian with a Vehicle and Vehicle Bumper Comprising Such a Lower Protection	EP	1419936	5/19/2004
		FR	2847214	
56	Motor Actuated Shiftable Supplemental Bumper	DE	2352179	10/17/1973
		US	3992047	11/16/1976
		GB	1470894	
255	Motor Vehicle Bumper Beam, and a Bumper Fitted with Such a Beam	US	6669252	12/30/2003
		EP	1277622	
		FR	2827235	
286	Motor Vehicle Front End Comprising a Bumper Unit	US	20040144522	7/29/2004
		DE	10112424	
		EP	1368208	
		WO	02074570	
325	Motor Vehicle with Bumper Assembly for Pedestrian Protection	EP	1300293	4/9/2003
282	Passive Safety Device	US	20040217605	11/4/2004
		EP	1422110	
118	Pedestrian Catching Device	DE	422259	12/7/1925
47	Pedestrian Contact Guard	US	4076295	2/28/1978
371	Pedestrian Crash Protection Device for Vehicle	JP	2001001848	1/9/2001
295	Pedestrian Energy Absorber for Automotive Vehicles	US	20040036302	2/26/2004
		WO	2004018261	3/4/2004
265	Pedestrian Impact Energy Management Device with Seesaw Elements	US	6554332	4/29/2003
		DE	10352629	
108	Pedestrian Injury Protection Device for Vehicle - has Extending Padding Released by Impact Sensor and Positioned at Likely Injury	DE	19654447	7/31/1997
		US	5794975	
355	Pedestrian Protecting Device for Vehicle	JP	2004025976	1/29/2004
50	Pedestrian Protecting Fender	JP	4721834	2/28/1972
		US	3784244	1/8/1974

Database ID	Title	CC	Patent Number	Date
247	Pedestrian Protection Assembly	WO	0187672	11/22/2001
		US	6755459	6/29/2004
		CA	2409134	
		EP	1286863	
267	Pedestrian Protection Leg Spoiler	US	6513843	2/4/2003
		DE	10304784	
		GB	2385566	
280	Pedestrian Safety System Having Lower Leg Impact	US	20040238256	12/2/2004
		CA	2454727	
		EP	1409295	
		WO	03010029	
62	Plastics Bumper for Motor Car - Comprises Flexible Carrier, Deformable Polyethylene Wires of Circular Cross-Section, Pvc-Coated Polyester Envelope and Polyurethane Corners; Polyvinyl Chloride	DE	2824613	12/6/1979
85	Pneumatic Buffer for Vehicle or Boat - is in Form of Closed Square Tube of Elastomeric Material and is Partially Sealed by Two Air Release Valves	GB	2295800	6/12/1996
15	Pneumatic Bumper Strip for Car - has Pressure Relief Valve for Each Chamber which is Inflated to Set Pressure	DE	2645823	4/13/1978
262	Protective Structure for Vehicles, Designed to be Used, in Particular, in the Event of Impact with Pedestrians	US	6648383	11/18/2003
		EP	1262382	
263	Safety Bumper Comprising an Energy-Absorbing Element Controlled by an Impact Sensor	US	6637788	10/28/2003
		CA	2371173	
		DE	19918202	
		EP	1171326	
		WO	0064707	
52	Safety Device for Vehicles [Guard for a School Bus]	US	4688824	8/25/1987
338	Shock Absorbing Apparatus	GB	1478849	7/6/1977
		DE	2438828	
		FR	2241023	
		NL	7410824	
		SE	7410326	
		US	3913963	
3	Shock Absorbing Assembly for Front of Car - has Three Deformable Parts at Varying Heights Intended to Protect Pedestrian If Hit	FR	2445783	8/1/1980
350	Shock Absorbing Member	JP	2004155313	6/3/2004
359	Shock Absorbing Structure of Vehicle	JP	2003191806	7/9/2003
235	Stiffener Assembly for Bumper System of Motor Vehicles	EP	0983909	3/8/2000
		US	6089628	7/18/2000
272	Structure for Front Body of Vehicle	US	6447049	9/10/2002
		EP	1118530	
		JP	2001138963	
320	Structure of Auxiliary Bumper for Protecting Pedestrian	KR	2002085134	11/16/2004
301	Structure of Front Portion of Vehicle Body	US	20030192727	10/16/2003
		EP	1433665	
		JP	2004196156	

Database ID	Title	CC	Patent Number	Date
266	Structure of the Front of a Vehicle Body	US	6540275	4/1/2003
		EP	1065108	
364	Structure of Vehicle Bumper	JP	2002205613	7/23/2002
346	Vehicle Bumper	JP	2004224106	8/12/2004
322	Vehicle Bumper Assembly with Movable Auxiliary Bumper	GB	2384215	7/23/2003
308	Vehicle Bumper Energy Absorber System and Method	US	6793256	6/19/2003
		WO	03051678	
284	Vehicle Bumper Structure	US	20040174024	9/9/2004
		EP	1454799	
276	Vehicle Bumper System	US	6394512	5/28/2002
		EP	1215093	
57	Vehicle Fenders of Resilient Material	US	3917332	11/4/1975
		DE	2429625	
		FR	2234159	
		GB	1476257	
		JP	50035830	
66	Vehicle Front Bumper to Minimise Damage or Injury on Impact - Comprises Thick Foam Rubber or Plastic Pad with Density Increasing From Front to Back, Replacing Conventional Bumper and Incorporating Headlights and Air Inlet Aperture	GB	2265117	7/26/1995
86	Vehicle Impact Absorbing Bumper - has Longitudinal Region Absorbing Collision Force by Controlled Yielding with Ends Providing Counter Hold	DE	19519110	12/21/1995
304	Vehicle Pedestrian Safety Bumper System	US	20030168869	9/11/2003
		JP	2003285704	10/7/2003
		EP	1340653	
356	Vehicular Body Mounting Structure for Bumper	JP	2004017814	1/22/2004

Appendix C: Using the Databases

Two databases are included on the CD accompanying this report, one for the pedestrian-related bumper patents and the other for the pedestrian-related bumper design articles. Each database is provided in two formats: Microsoft Access (*.mdb) and Microsoft Excel (*.xls). Both databases are more useable in the MS-Access format, as this allows a 'form' to view all of the information about an article or patent on a single page. However, most of the information is contained in each format.

To navigate the MS-Access databases, the user will:

1. Open the database by double-clicking on it. If this is your first time using Access, you may receive some warnings or help messages before the database is opened.
2. Single-click on Forms from the 'Objects' list on the left of the database window.
3. Double-click on Patent Form or Article Form in the database window. *Do not select the Patent Number Subform, as this is included inside the "Patent Form" already.*
4. You can navigate through the patents or articles by clicking on the arrow buttons at the bottom of the page.
5. You can sort the databases on most (but not all) of the fields. To do so, place the cursor in the field of interest, then click on the sort button  in the menu at the top of the screen.
6. Searches can also be performed – see the MS-Access help menu for details.

Pedestrian Bumper Articles

The Pedestrian Bumper Articles database files contain the following fields:

- # – Reference number of the article in the database.
- Author(s) – List of article's authors.
- Article Title – English title of article.
- Source – Journal name/number/volume, or conference, or publisher.
- SAE # – SAE paper number, if applicable.
- Date – Publication date (or conference date).
- Company – Primary author's employer.
- Abstract – Text of the abstract, if available in electronic form.
- Component – Part of the bumper system this article most directly relates to.
- Comments – My comments about the articles contents (rarely used).

Pedestrian Bumper Patents

The patent database is a little more complex than the article database. Because a single patentable idea can have multiple patent filings associated with it (and therefore multiple patent numbers), the MS-Access database has two separate tables which are linked. When using the Patent Form this should be transparent … there is actually a 'sub-form' on the same page that references the patent filing information. However, with the Excel file, the two tables are contained in unlinked spreadsheets, so the user has to switch back and forth between them to find the patent numbers associated with a particular idea.

The Pedestrian Bumper Patents database files contain the following fields:

- PatentID – Reference number of the patent description in the database.
- Patent Title – English title of the patent (note – this is the most common title. Unfortunately, multiple filings of the same idea sometimes have different titles!).
- Inventor(s) – Inventor names.
- Company – Inventor(s) employer (patent owner).
- Abstract – English abstract of the patent (again, the most common).
- Comments – My brief description of the patented design.
- Active? – check-box – Is there an active or deploying component to the design?
- Airbag? – check-box – Is there an airbag in the design?
- Beam – Type of beam (look-up box)
- Stiffener – Type of lower stiffener (look-up box)
- Absorber – Type of energy absorber (look-up box)
- Picture – Picture of the design (Access only)

The Patent Numbers sub-form in Access (or the Patent Numbers worksheet in Excel) contains the following additional fields:

- PatentID – Reference number of the patent description in the database.
- #ID – Reference number of the specific issued patent number in the database.
- CC – Country Code specifying the organization issuing the patent:

CA – Canada	*GB – Great Britain*	*RU – Russia*
DE – Germany	*IT – Italy*	*SE – Sweden*
EP – European Patent Organization	*JP – Japan*	*US – United States*
	KR – Korea	*WO – World Patent Organization*
FR – France	*NL – Netherlands*	

- Number – Patent (or application) number.
- Date – Date patent was issued (or application received).

These two tables are linked in Access by the PatentID field. In Excel, once you have found a patent idea of interest in the Patent Form worksheet, you will need to look for the corresponding PatentID number in the Patent Numbers worksheet to identify the specific filed patent numbers.

Patent Files

In addition to the databases, the CD includes PDF files of the relevant patents. The US patent files (7-digit numbers) contain the full text, while the US application files (11-digit numbers) and all other global patents contain the first page. Each patented idea has only one patent file included on the CD (regardless of number of separate filings). In case of multiple filings, the patent file included on the CD uses the first available of these numbers:

- US
- EP
- WO
- GB

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