

STUDY OF CURRENT STATE OF CRASH TESTING

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Abstract: *This paper studies the types of crash test that are conducted in the present day by different assessment programs. The types of collision used in different situations and the types of crash dummies used to simulate the human occupant and/or pedestrian, and the barrier type used. All assessment programs basically use the main three types of collision tests, frontal impact, side and rear impact. Also the most widely used dummy in these kind of tests is the Hybrid III dummy, male and female.*

Key words: *crash, impact, collision, testing, occupant, crashworthiness.*

1. Introduction

Crash testing has been around since the early 1900 when the number of vehicles on the road has risen to a level that accidents started to occur too often and raised the question of public safety.

Crash tests are a way of ensuring safety by means of destruction, in the automotive industry, impact tests between cars are performed to analyse the damage caused by the impact forces at certain velocities.

A vehicle's crashworthiness is determined by the capability of its structure to protect its occupants in case of an impact.

In the European Union, traffic accidents cause about 37000 deaths, and leave more than 1.2 million people injured [1].

The number of injuries, fatalities and accidents is presented in Figure 1, in the European Union in a period of 10 years [2].

In recent years there is a tendency to reduce the number of accidents in Europe by releasing the EU Road Safety action programme 2011-2020. This programme is focused on improving vehicles, infrastructure

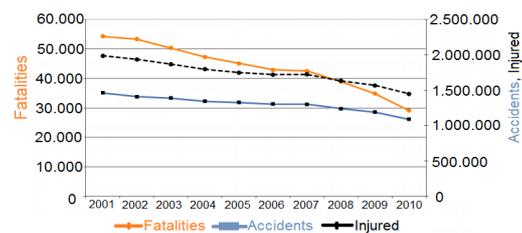


Fig. 1. Number of accidents, injuries and fatalities in a period of 2001-2010

and the behaviour of road users.

Vehicle impact tests are performed between 2 vehicles or between a vehicle and an obstacle. In the following are presented a few types of tests:

A. Frontal-impact test

It's the most common type of test, the vehicle is sent at a certain speed into a solid wall made of concrete.

B. Offset test

In this test only one area of the front of the vehicle is impacted into a wall, the forces remain just like in the frontal impact, but only an area of the vehicle has to absorb the shock.

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C. Small overlap test

In this test only a small area of the car hits an object, like a tree or a pole. This test is demanded because it focuses the forces on the vehicle internal structure at any given velocity.

D. Side impact test

This test is important because the side of the vehicle is usually not very rigid and an accident involving side impact can cause fatal injury to the occupants of the vehicle.

E. Roll-over test

This test is required to verify if the vehicle can support itself, mainly the pillars, in a crash involving roll-overs.

F. Computer simulation

This test is a computer simulation of an accident in a digital environment, similar to live tests. It is useful because if it's precise simulation and low cost.

2. Crash Test Programs

In different parts of the world there a number of vehicle safety assessment programs that conduct crash tests in order to increase vehicle safety and ensure that all vehicles manufactured have a good occupant and pedestrian safety rating.

These programs focus on improving the crashworthiness of motor passenger vehicles, and reduce the number of injuries.

In Europe there is the New Car Assessment Program (NCAP), based on the program introduced in 1979 by the NHTSA (National Highway Traffic Safety Administration) in USA [3].

EuroNCAP are responsible with rating new cars with safety awards, based on the vehicles performance in different types of crash test, like frontal barrier impact, side impact with a pole, and pedestrian impact.

Their release reports that contain information about car performance and rating. The maximum rating is 5 stars.

In other parts of the world there are

similar programs, in Australia and New Zealand there is ANCAP, in Latin America there is LATIN NCAP, in China there is C-NCAP and in Germany, ADAC (Allgemeiner Deutscher Automobil-Club).

All programs use the same crash test protocols, and are presented in the following paragraphs.

A. Frontal impact test

The frontal impact test uses a deformable barrier to imitate the mass of another vehicle and it is deducted at a speed of 64 km/h. In Figure 2 is presented the positioning of the vehicle with the barrier [4].



Fig. 2. Frontal impact test

B. Side impact test

This test is performed at a speed of 50 km/h. It uses a vehicle structure with an impact barrier mounted on the front, and sent into the side of the vehicle. The positioning of the vehicle is represented in Figure 3.

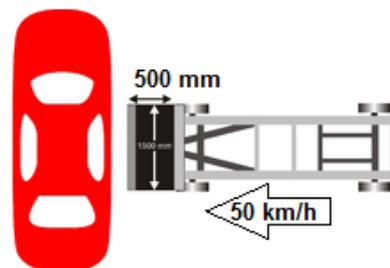


Fig. 3. Side impact test

C. Side pole impact test

In this test the vehicle is positioned sideways on a moving platform and sent into a stationary rigid pole at a speed of 29 km/h. In Figure 4 the positioning of the vehicle is shown.

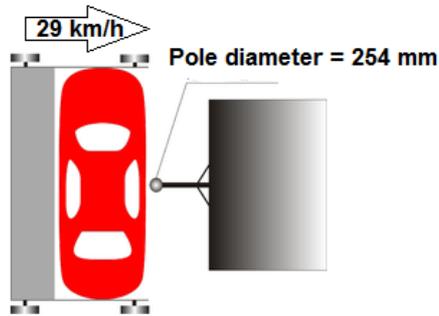


Fig. 4. Side impact with a pole

D. Pedestrian impact test

In this test a crash test dummy is positioned vertically to imitate a pedestrian and the vehicle is accelerated at a speed of 40 km/h, and sent into the dummy. In Figure 5 is presented the impact areas of the pedestrian with the vehicle.

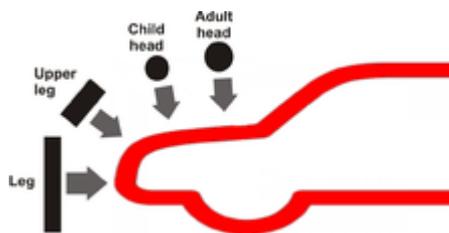


Fig. 5. Pedestrian impact

The EuroNCAP rating is conducted after a vehicle passed all types of tests. In Figure 6 are presented all types of tests and the rating system.



Fig. 6. Crash test types and rating system

For the occupant and pedestrian, the rating system uses a set of colors to indicate the areas of potential injury on the

body, the color range from green (very safe) to red (fatal injury). The system is presented in Figure 7.



Fig. 7. Occupant rating system

In addition to the color rating, the program also uses a percent rating, in modern cars, this gives the vehicle the overall star rating. This system is presented in Figure 8.



Fig. 8. Percentage rating system

In recent years new tests have been added to the program in order to keep up with the new safety technology implemented in modern motor vehicles, tests like AEB (Autonomous Braking System), active bonnet system, and rear impact test (whiplash).

In Figure 9 are presented the rating system of whiplash and the test involving AEB.



Fig. 9. Whiplash and AEB

Along the years, car manufacturers have always improved the safety of their models, increasing protection for the occupants and the pedestrians, by

conducting crash test, and nowadays, computer simulation models to determine new technologies to improve a vehicle crashworthiness. In Figure 10 is presented a evolution of the Volkswagen Golf model from 1993 to 2008.



Fig. 10. *Evolution of a vehicle model*

Since 1993, the vehicle structure has greatly been improved to protect occupants, in the lower leg part and, with the introduction of airbags, the survivability of the occupants has risen dramatically. As shown in Figure 10 the deformation of the vehicle in the frontal impact test has gone down due to modern rigid structure of the vehicle body.

3. Crash Test Protocol for Frontal Impact

A. Impact speed and overlap

Crash test programs use a similar protocol when conducting impact tests, in USA, the IIHS (Insurance Institute for Highway Safety) released a report regarding the protocol for frontal small overlap impact test.

This test is conducted at a speed of 64 km/h and 25% overlap. The vehicle is aligned with the barrier, offset to the left of the vehicle centerline by 25% of the vehicle width, as presented in Figure 11 [5].

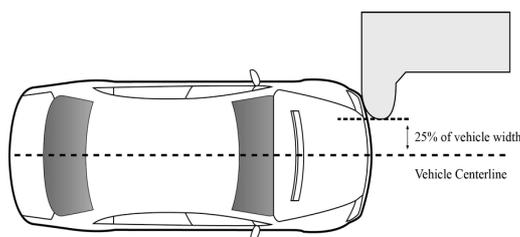


Fig. 11. *Positioning of the vehicle with the barrier*

For the test, the vehicle is accelerated at a rate of 0.3 g by a cable system, until it reaches the desired speed, and released 25 cm before it hits the barrier. The vehicle is also braked 1.5 seconds after the vehicle is released [5].

B. Barrier design

The barrier is made of a steel plate with a thickness of 38.1 mm, it's 1000 mm wide, and has a radius on the right edge. The radius has a 115 degrees arc, the height of the barrier is 1524 mm from the floor and the mass is 145,150 kg. In Figure 12 the barrier is presented with its primary dimensions [5].

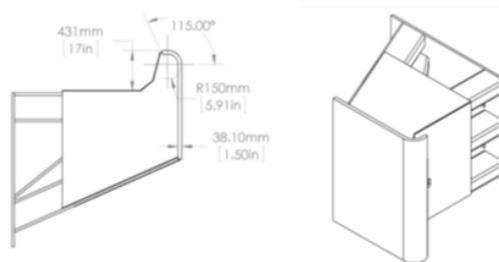


Fig. 12. *Dimensions of the barrier*

C. Test vehicle preparation

In the test facility all vehicles that are prior for tests are inspected for missing parts, damaged areas and repaired areas. All fluids in the vehicles are removed, battery acid, air conditioning agent, cooling agent and gasoline/diesel.

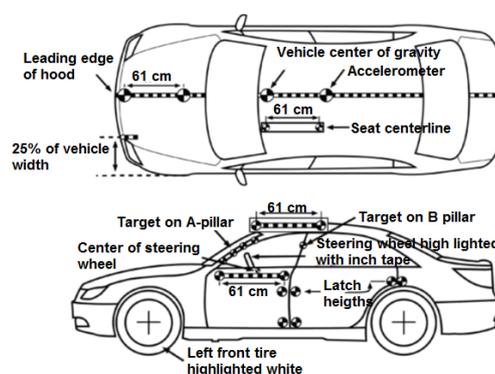


Fig. 13. *Crash markings on the vehicle*

The vehicle is attached to the propulsion system via chains fitted underneath the front of the vehicle. Sensors and cameras are added to the interior of the vehicle along with the crash test dummy occupants. The vehicle is also marked for video measurements. In Figure 13 is presented the markings on the vehicle [5].

4. Crash Test Dummies

In the automotive industry, when conducting impact test, the different safety programs use crash test dummies, or ATD's (Anthropomorphic Test Device).

These devices replicate the human body with its dimensions, weight, and body motion characteristics.

Test dummies have been in used since the early 1949, when the first dummy, Sierra Sam was created by Alderson Research Labs (ARL) and Sierra Engineering Co. to test aircraft ejection seats, but was also used in motor vehicles tests. In 1971, General Motors and Sierra Stan combined 2 dummies to create a better one, and so Hybrid I was born, a more accurate model of a human male, having the same proportions [6].

In the present day the most used all around dummy is the Hybrid III, 50th percentile male, having a height of 175 cm and a weight of 77 kg, its mainly used as a driver, occupant and pedestrian in many tests. In Figure 14 the Hybrid III dummy is presented.

There are different variations of the Hybrid III, mainly used in different types



Fig. 14. *Hybrid III 50th percentile male*

of test like the SID II, used in the side impact test and the BioRID II used in the rear impact tests. In Figure 15 these 2 variations of dummies are presented.

The BioRID differs by having a modified neck and spine that simulates a more realistic movement in an impact.



Fig. 15. *Hybrid III variations, a-SID IIs and b-BioRID II*

Crash test dummies before being used in impact tests, they are calibrated and equipped with different measuring devices, in the head in neck there are tri-axial accelerometers, in the chest there is a force cell and a device to measure chest deflection, and in the knees there are load cell to measure the force of the impact. Also the dummies have a human like silicone based skin to mimic the tearing of the skin when in comes in contact with different parts of the vehicle.



Fig. 16. *THOR test dummy*

A more modern version of the Hybrid III test dummy is THOR, it's the successor to the current test dummy, with a more human like spine and pelvis, and there are a number of sensors, located on the face to accurately measure the facial impact. In Figure 16 THOR is presented.

The *Transilvania* University of Braşov, Faculty of Mechanical Engineering has constructed in the last 2 year a custom type of crash test dummy, that has a very good bio fidelity, and can be used in different types of crashes, as an occupant but also as a pedestrian, having rigid components and able to survive multiple tests without the need of spare parts, unlike the market dummy Hybrid III. The custom dummy has been named DD (Dynamic Dummy). In the Figure 17 the dummy is presented.



Fig. 17. Custom built crash test dummy

5. Conclusions

In the modern world, motor vehicle crash tests have become essential, to the car manufacturers, to further increase the safety of both the occupants of the vehicle,

and to the pedestrians. A vehicle's crashworthiness is determined by the way it protects it's occupant in case of a collision with another vehicle or obstacle, and this is rated in the results of impact tests. Almost all tests rely on crash test dummies to determine the injuries that can happen to both the occupants of the vehicle or the pedestrians.

References

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