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# Crash test of a tow hitch for car trailers

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**Abstract.** Each new type of the tow hitch must be tested for its homologation. The standard test simulates only its loading by a classic car trailer but some manufacturers do other additional tests [1]. Simulating the crash of a tow bar to a fixed barrier (such as a garage wall) when reversing is one of them. The test device for these tests was built in the University's laboratory in collaboration with the tow bar manufacturer. The testing methodology is described in this paper.

## Introduction

The tow hitch crash test simulates a situation where the driver crashes to a wall when reversing (see Fig. 1).

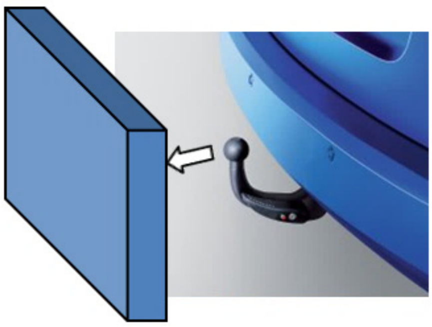

Fig. 1: The tow hitch crash test principle

The test is not carried out with a real car, the tow hitch is mounted on a special trolley that has the weight of the car. The trolley is accelerated to the prescribed speed and then in inertia movement it crashes to the barrier. It is clear that the reversing speed is not very high, the test parameters are based on this. Prescribed crash test parameters are shown in Table 1.

Table 1: Prescribed tow hitch crash test parameters

| Parameter | Prescribed value | Tolerance |
| --- | --- | --- |
| crash speed | 4 km/h | + 0.2 km/h |
| test trolley weight | identical to the car | ±5 % |
| recorded quantities | real crash speed | - |
| | tow hitch beam deformation | - |
| | high-speed video in the horizontal direction | - |
| | high-speed video in the vertical direction | - |

The new special testing device for this crash test was built in collaboration between the university and the towing device manufacturer. The device is located in the university lab and all crash tests are done there.

**The test device design**

The principle of the test device is shown in the Fig. 2.

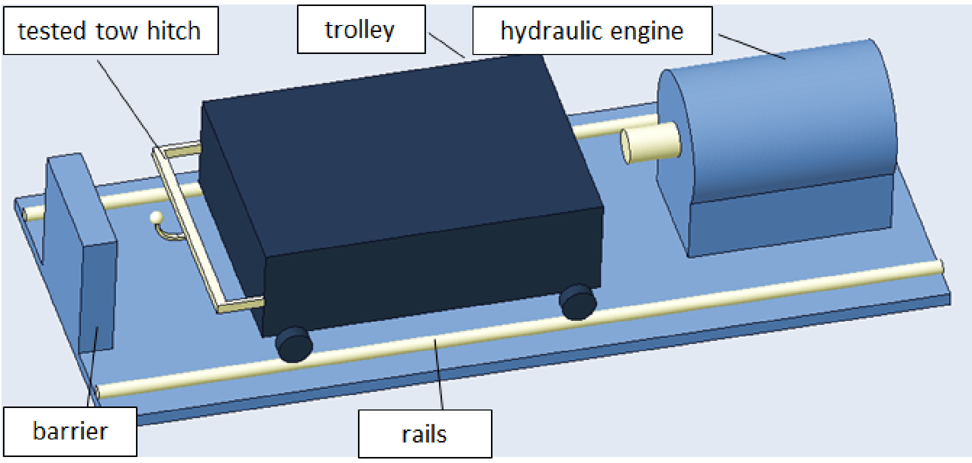


Fig. 2: The testing device principle

There are two rails on the base plate and the trolley with the attached tow hitch moves on them. The trolley is accelerated by a linear hydraulic motor. The barrier is attached to the base plate at the end of the rails. Two basic assumptions had to be fulfilled when designing the test device. Firstly, the weight of the trolley must be easily adjustable, as testing of the towing devices for vehicles of different weights is assumed. Secondly, the trolley must be able to accelerate to the prescribed speed with a hydraulic engine available in the laboratory. The required trolley weight is up to 2000 kg, the hydraulic motor has a piston rod stroke of 400 mm and its maximum force is 35 kN. The feasibility of the design was verified using the following simple equations for uniformly accelerated motion. The necessary acceleration to reach 4 km/h (i.e., 1.11 $ms^{-1}$) on the 400 mm track is:

$$a = \frac{1}{2} * \frac{v^2}{d} = \frac{1.11^2}{2*0.4} = 1.54\ [ms^{-2}] \tag{1}$$

The 35 kN hydraulic engine is capable of accelerating the weight 2000 kg to acceleration:

$$a = \frac{F}{m} = \frac{35000}{2000} = 17.5\ [ms^{-2}] \tag{2}$$

This simple calculation has shown that the required parameters are met with a large margin. So, it will not be a problem to keep them in a real test, where the conditions will be worse (trolley friction, engine start delay, etc.).

**The real test device instrumentation**

Two cylindrical rails are mounted on the base plate. A trolley moves on the tracks. Movement along a defined path and minimization of friction during movement is determined by the use of rails. The tested tow hitch is attached to the trolley in the same way as in the vehicle. The weight of the trolley is set using a steel sheet weight set. The crash barrier is attached to the base plate in front of the trolley, the hydraulic engine to the trolley acceleration is anchored to the base plate behind it (see Fig. 3). The hydraulic engine is controlled by a computer system so that the piston rod movement can be defined very precisely.

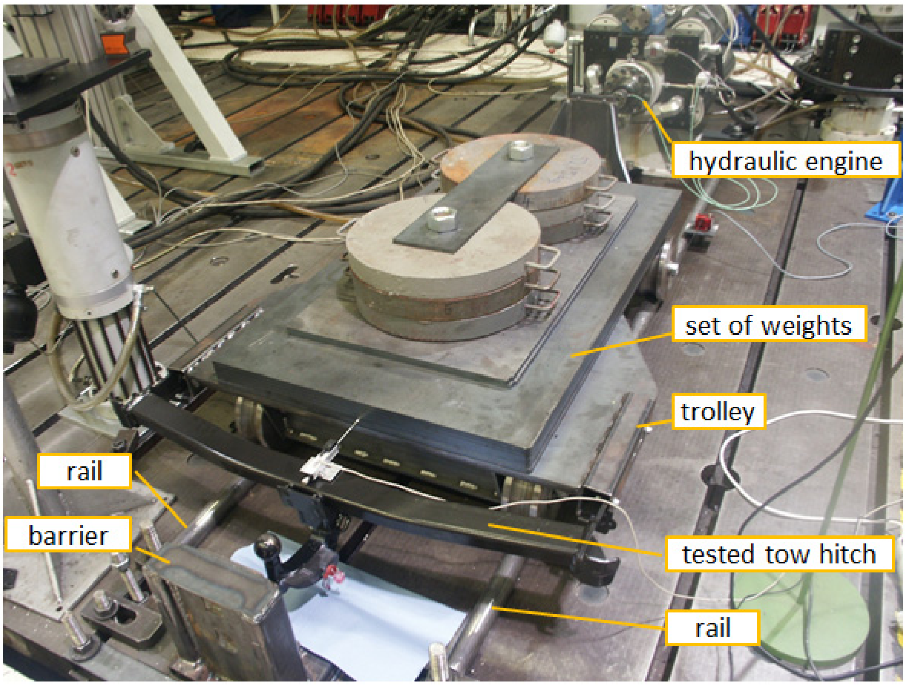


Fig. 3: The real testing device

The movement and speed of the truck should be monitored during the test. Both quantities are measured by the special cable-extension incremental transducer MT2E. This type allows measurements at very high accelerations and it is specifically designed for crash tests. The tow hitch deflection during crash is measured by the linear position sensor with restoring spring TR050. This sensor is designed for high acceleration and speed too (see Fig.4). Dewetron components [2] are used for measuring and recording signals and video. The measurement device DEWE5000 is the basis for the measuring system. Both sensors and the hydraulic engine piston rod position signal from the engine control system are connected to this measurement system. The sampling frequency is set to 2 kHz. Two DS CAM GiGE cameras capture the crash site at speed of 500 frames per second. The first is placed horizontally and the second one is vertical. The Dewe 5000 allows synchronous recording of camera images with measured signals. Unfortunately, it is too old and its hardware is not able to process the data streams from both cameras simultaneously. Therefore, only a horizontal camera is attached to it. The vertical camera is recorded to the separate measuring unit Dewesoft Sirius which is synchronized with the DEWE5000 and both records are linked together to one file after the test. The test device measurement and control system block scheme are shown in the Fig. 5.

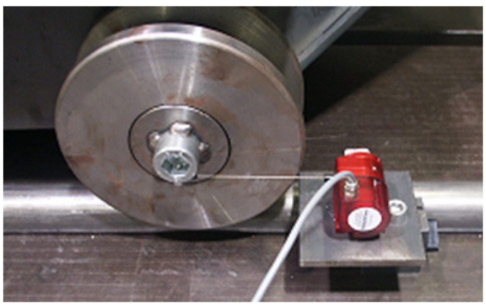

Fig. 4: The trolley position and speed sensor (left) and the beam deflection sensor (right)

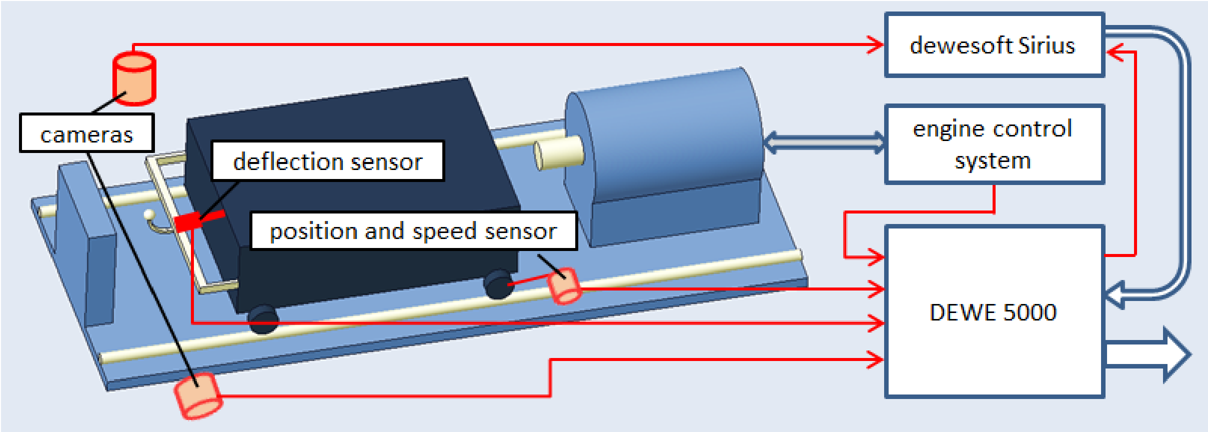


Fig. 5: The measurement and control system block scheme

**The tow hitch crash test**

The crash test is performed according to the following scheme. The trolley is accelerated by the hydraulic engine at the start of the movement. The cosine ramp movement of the piston is used to prevent the starting shock. When the prescribed speed is reached, the engine piston rod starts to brake and the trolley continues by its inertia to the obstacle. Of course, the starting speed must be slightly higher than the desired impact speed, because the trolley slows down due to the friction during inertia movement. The necessary speed increasing was determined by several attempts. Than the trolley crashes to the obstacle and bounces back. Meanwhile, the engine piston rod changes the direction of its movement and then it gradually brakes the returning trolley to prevent its further bouncing from the engine piston and its further impact to the obstacle. The engine control scheme is shown in the Fig. 6.

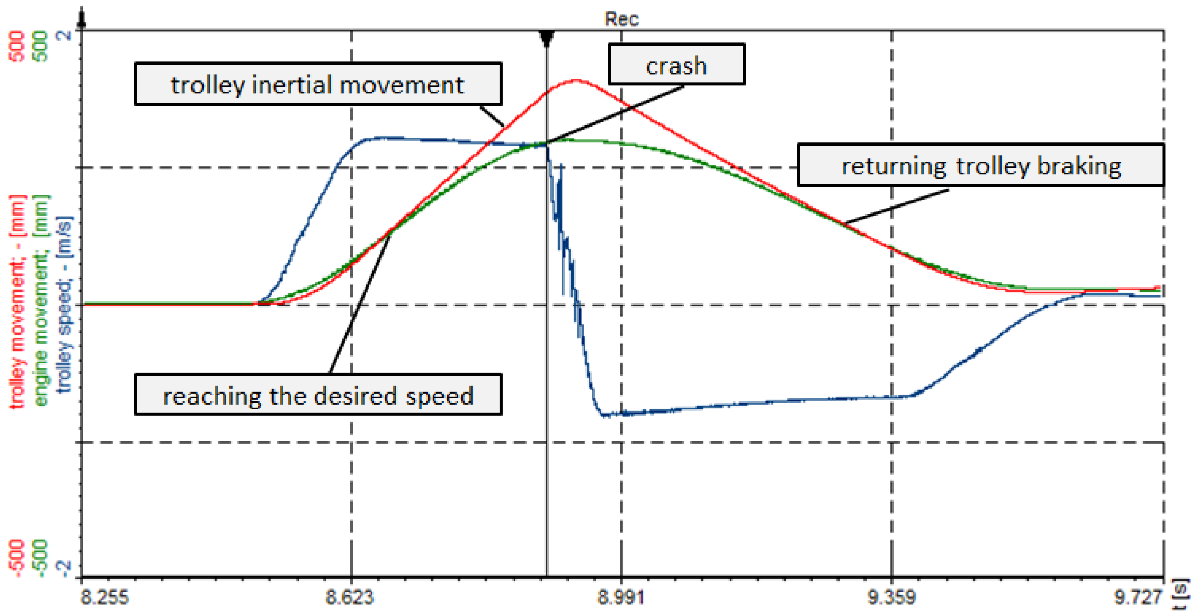


Fig. 6: The hydraulic engine control scheme

**Crash test result example**

All crash tests are done with prototypes of new tow hitches. It is therefore clear that the test results are the property of their manufacturer and cannot be published here. Therefore only the test result of tow hitch used to tune the motion of the hydraulic engine is used as an example of the test result in this article (see Fig.7). The graph shows that the prescribed crash speed of

4 km/h has been achieved very accurately. The maximum deflection of the tow hitch beam was nearly 20 mm and its permanent deformation after impact remained greater than 10 mm.

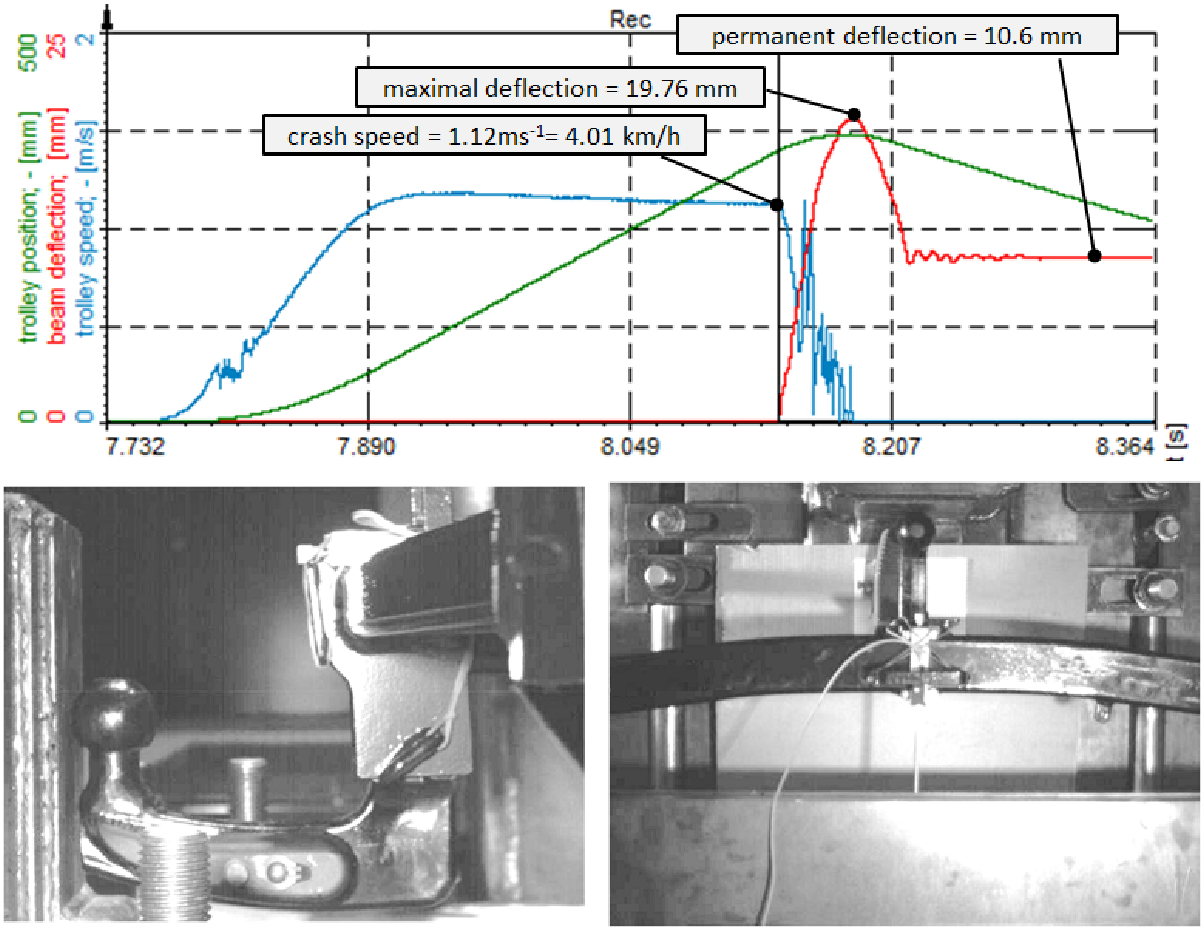


Fig. 7: The crash test result example

## Conclusions

The test device built at the Technical University of Liberec, in collaboration with the tow hitch manufacturer, allows the testing of tow hitch prototypes. The results of crash tests are used to develop new types of tow hitches and the manufacturer can effectively compare their proposed parameters with the real properties. Plus the tow hitches safety during their use has been increased.


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