CAR LOAD SECURITY TEST (“CITY CRASH”) INSTALLATION

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Abstract

Among the tests that are carried out to the lifting bars system of an automobile, there is one of load security denominated City Crash that consists of an impact at 30 km/h with a controlled deceleration of maximum 12g. The test is made with a load on the bars of the 120% of the nominal, assembled on a body fixed to a sleigh that hits against a deformable barrier.

In CT SEAT exists a low speed impact installation which is unapt for this test. The project has consisted of incorporating a compatible system with the existing one for this application.

The main problem to solve has been the limitation of mass of the existing pneumatic impelling system. This has forced to replace the usual sleigh in these tests by the own body to which the following is added: a crash device and carts on rails directly coupled to the fixations of the assembly line of the vehicle. Thus it is possible not to exceed the maximum mass that the impeller is able to carry to the required speed and we obtain a guidance system that does not interfere with the existing tests.

The assembly is made hit against a deformable barrier in such a controlled way that provides the deceleration prescribed in the test.

The installation is complemented with a configuration of speed calibration in which the deformable barrier is replaced by a braking system.

Keywords: *City-Crash; Security tests; Automotive.*

1. Introduction

For the authorization of a roof rack system by an automobile producer, several tests are needed, ranging from material and coating tests, to mechanical fatigue and passive security tests.

This group of tests includes one called “City Crash”, which simulates an impact in a city environment of a vehicle with bearing bars loaded with the maximum weight permitted.

The test is described at the ISO 11154-5 standard used by accessory part producers. The VW Consortium uses an own, more demanding standard than that of ISO, using for this a complete body in order to validate the response of the bars and body.

The test is carried out launching the assembled body with the rack bars loaded with 120% of the nominal weight at 30 km/h against a deformable barrier to produce in the body a deceleration of 12g with specified ramps of raise, maintenance and descent of acceleration. Permanent deformations are admitted, in the body, as well as in the bars, but the detachment of the load, or the hurling of parts or component pieces heavier than 10 grams (standard E DIN 75302:2006-05) are not allowed.

The test is performed assembling the set on a sleigh onto which the necessary velocity is transmitted and which hits on the deformable barrier. There are other types of non-deformable barriers which absorb the impact energy through elastic elements, but they do not provide such an efficient control on deceleration as the deformable barrier, and require a more complex installation.

Current tendency is using the reverse catapult system through which a controlled acceleration in reverse is applied directly on the set instead of an impact against a barrier.

2. Objective

The objective of this project is to set up an installation to perform this test at the SEAT Technical Center, based on a previously existing installation for low speed impact, currently used for impact test to validate car bumpers, as well as for RCAR tests to assess safety and reparation costs in case of low speed impacts.

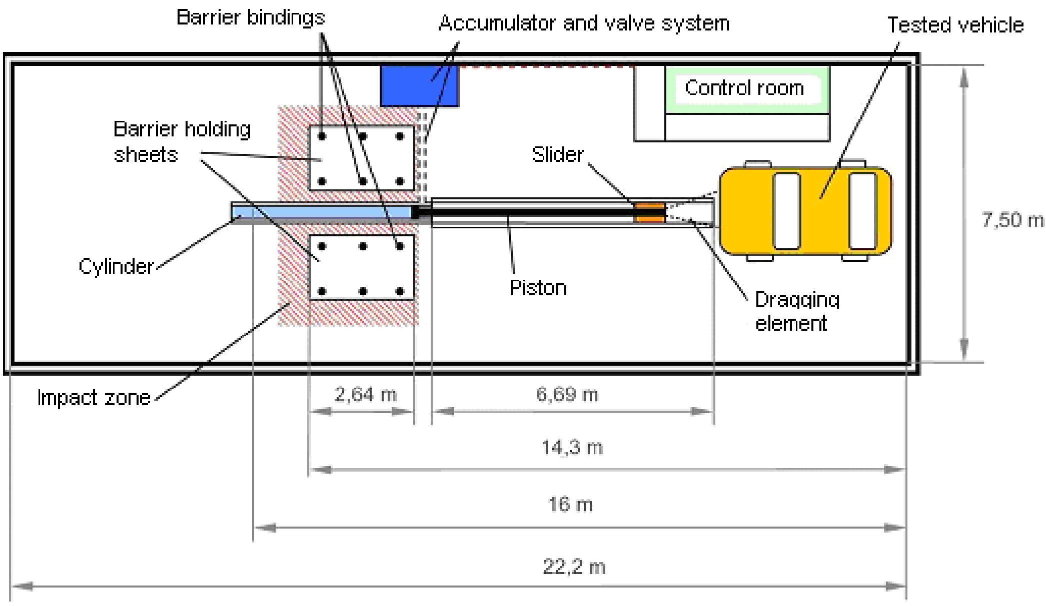
City Crash tests are currently performed in external facilities, not at the SEAT TC, with the consequent lack of time flexibility this situation creates and higher costs in logistics and personnel traveling.

3. Project

3.1. Current Installation

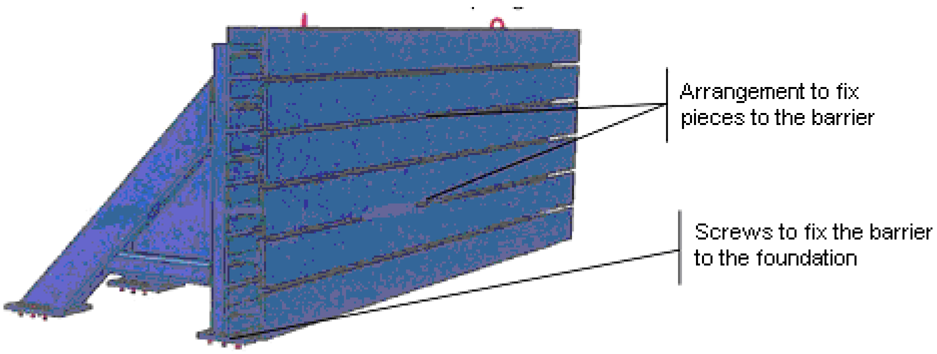
The installation for low speed impact is formed by an impeller consisting of pneumatic cylinder fed by a compressed nitrogen-charged accumulator, with a roughly 5-meter trajectory which moves a sliding element guided over metal profiles and rolling bearings. The vehicle or ballast car (depending on the test), is taken to the required speed by dragging it using this element. The entire set is below ground level or levelled in a way that the entire system leaves a plain surface in the installation.

Figure 1: Low Speed Impact Installation Chart



The impact takes place on fixed barrier screwed over metal sheets inserted in the ground with the adequate foundation.

Figure 2: Fixed Barrier



This installation suits the use for which it was designed, but shows great inconvenience and restrictions to bring the project to completion.

3.2. Restrictions

The greatest restriction to the project lies in the use of the existing pneumatic impeller.

Previous calculations to this project (Chapus, P, 2008) had shown that the current configuration of the system does not allow the mass of a body, with its load assembled to a sleigh in a conventional way, to reach the speed required.

This limitation materializes in a maximum mass of 700 kg to accelerate. The same research anticipated that it was not possible to improve a pneumatic installation for the requirements of this trial and that, in any case, it would have to be replaced.

Other restriction to the use of a pneumatic impeller stems from the fact that before each test, a calibration of parameters for the entry of gas to the cylinder is needed, since the final speed of it depends on atmospheric pressure and temperature at the moment of the test, among other factors.

Present tests use a complete vehicle rolling on its own tires or a ballast car also on tires, given the low speed these tests need and that no high precision on the impact spot is required, there is no need for a special guidance system, being able to do without elements to perform that function.

It is not the case of the City Crash test, where the impact has to be done against a deformable barrier in its mid-point and that due to safety reasons it is not possible to have a mass relatively heavy taken to a speed of something more than eight meters per second, without the certainty it will continue a defined trajectory.

The fact of having to combine the new use with the existing one carries the necessity of incorporating a guidance system for the body which does not interfere with the trajectory of current tests, and also, for various security and functioning reasons, none of the elements should stand out the ground level.

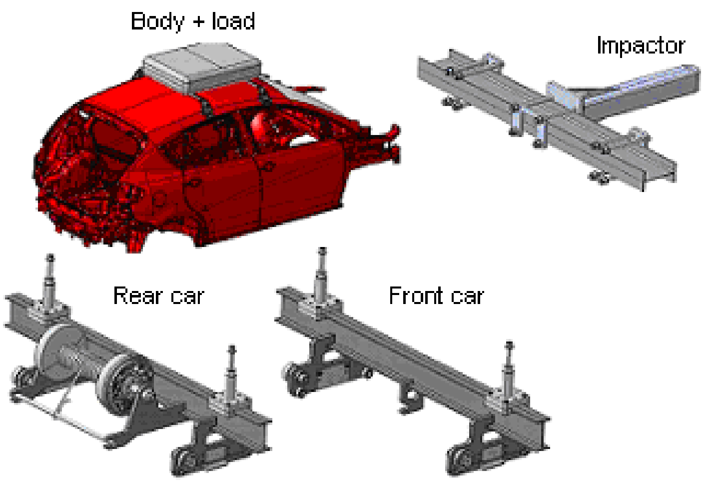
3.3. Maximum Mass

In order to solve the limitation problem of the mass to accelerate, it was needed to disregard the conventional solution of setting up the body for the test on a sleigh. The mass of the sleigh should not exceed 200 kg and none of the solutions studied was capable of showing the rigidity needed to endure the impact efforts without easily exceeding this limit.

The final solution came by eliminating the sleigh and making the body itself to perform this function. To accomplish it, it was only needed to equip it with cars resting on rails fixed in the front and rear to the bindings used in the car assembly line. The element of impact against the barrier is put on the body beams. This also has the advantage of elevating the impact point to a point near the body plus load system's inertia center, which decreases the turning moments during the impact and the efforts applied on the guidance in that moment.

The general arrangement of the system can be seen in figure 3.

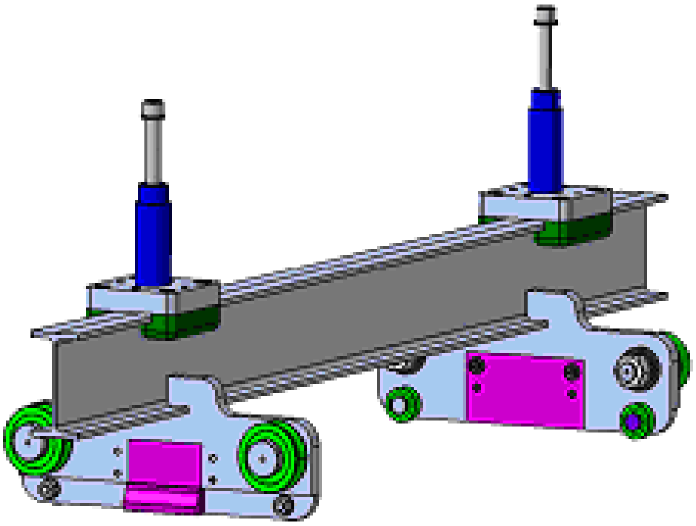
Figure 3: Car System and Impactor



3.4. Guidance System

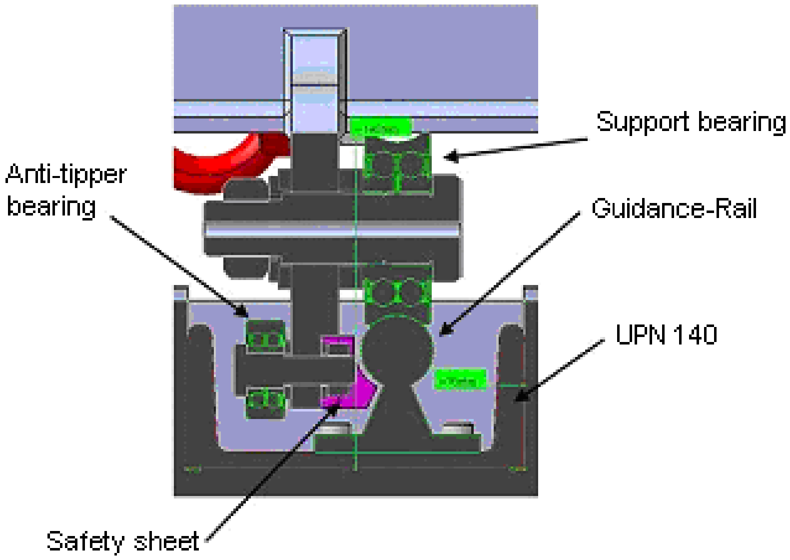
The cars consist of IPN (HIECAL) profiles with welded sheets, which incorporate rolling elements on the rails. Some supports, aimed to be introduced in the drill holes to fix the body in line and to screw it later to the body, are added to the higher part of the profile. These supports slide along the profile in order to be adapted to different body widths.

Figure 4: Front Car Detail



Due to the arrangement of current elements in the installation, it is not possible to exceed the width of 150 mm for the guidance, that is why the system represented in figure 5 was used, based on a UPN (HIECAL) profile of 140 mm width with a SCHAEFFLER (INA_SCHAEFFLER KG) linear guidance system, along with roller bearings and accessories by this brand.

Figure 5: Guidance detail

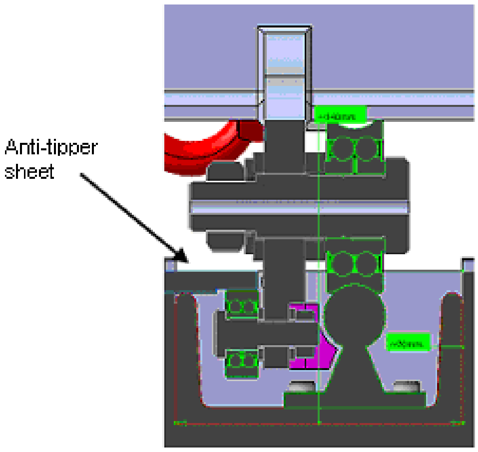


The right rail includes rolling bearings adapted to the guidance, while the right side rests on plain bearings. This arrangement eliminates the little imperfections of guidance parallelism.

Additionally, there is a safety sheet in both rails placed in a short distance from the lower part of the guidance, aimed to avoiding the guidance system's cars to slip out in case of accident.

It also adds a rolling bearing called "anti-tipper", aimed to work only in a sheet welded on the profile at the impact zone, to absorb the system's turning moments at the moment of impact.

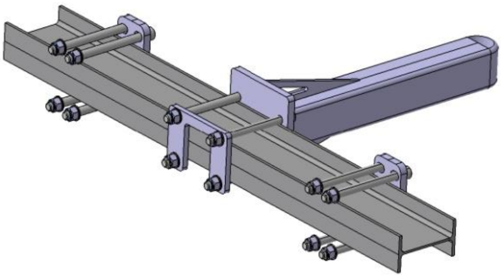
Figure 6: Impact zone guidance detail



3.5. Impactor

The impactor consists of an IPN profile assembled to the body beams, which has another profile connected perpendicularly with a semi-cylinder to its end. Due to its setting way, this set adapts to the widths of different bodies, also being the beams an ideal place for this element, since it is the zone where body's frontal efforts are best transmitted. Its structure can be seen in figure 7.

Figure 7: Impactor

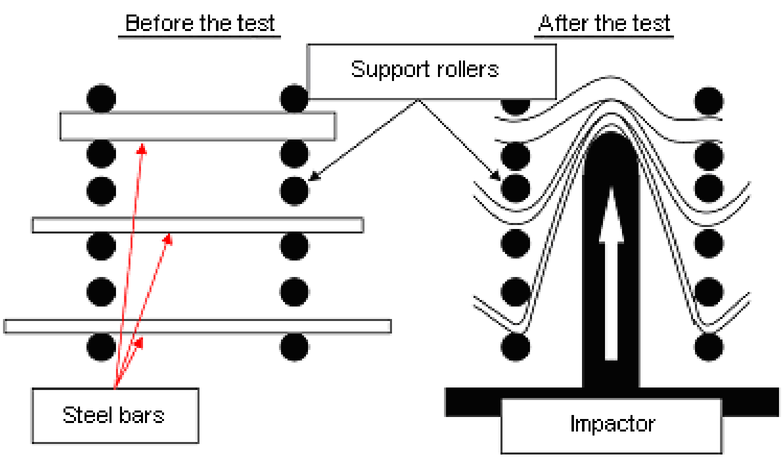


3.6. Deformable Barrier

The barrier is a deformable one, due to its easy construction and assembly on the existing fix barrier. Besides, as it has been previously said, it grants better control of deceleration, compared to other more expensive systems to set up, despite the inconvenience that the bars, once deformed, are not reusable.

The barrier is formed by a series of mild steel bars lying on dead rollers which, through the deformation received by the impact, absorb the energy of the set. The operating chart can be seen in figure 8.

Figure 8: Deformable barrier operating chart



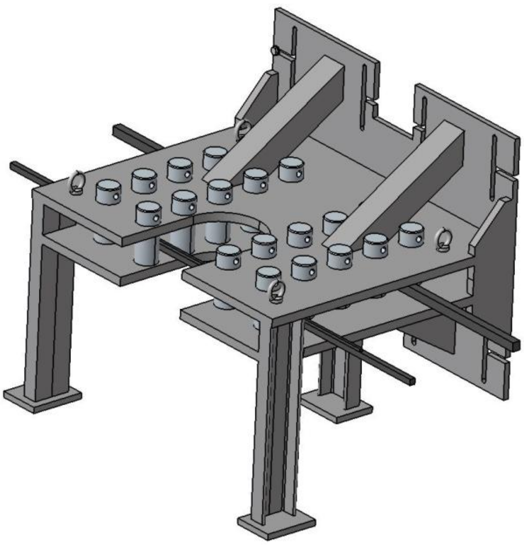
A research has been conducted on the number, caliber and length needed for the bars that form the barrier, and this research has been complemented with real deformation tests at the test bench, to measure the energy absorbed by the deformation of different bar calibers with the purpose of checking the results.

Figure 9: Deformation energy test

With it, a starting point/base has been attained, to use later on the final evaluation of the barrier and while choosing the exact bars and length needed to get the deceleration curve required. In order to avoid doing this work for the different bodies to test, it was decided to always use for the test a mass close to the maximum one the pneumatic system is capable to accelerate to, weighing down the body with the mass needed up to reaching this value.

The result of the project for the barrier can be seen in figure 10.

Figure 10: Deformable Barrier



3.6. Speed Calibration

The last problem lies in having to calibrate the pneumatic system before testing. In this system, the final speed depends, among other factors, on the atmospheric pressure and temperature at the moment of the test.

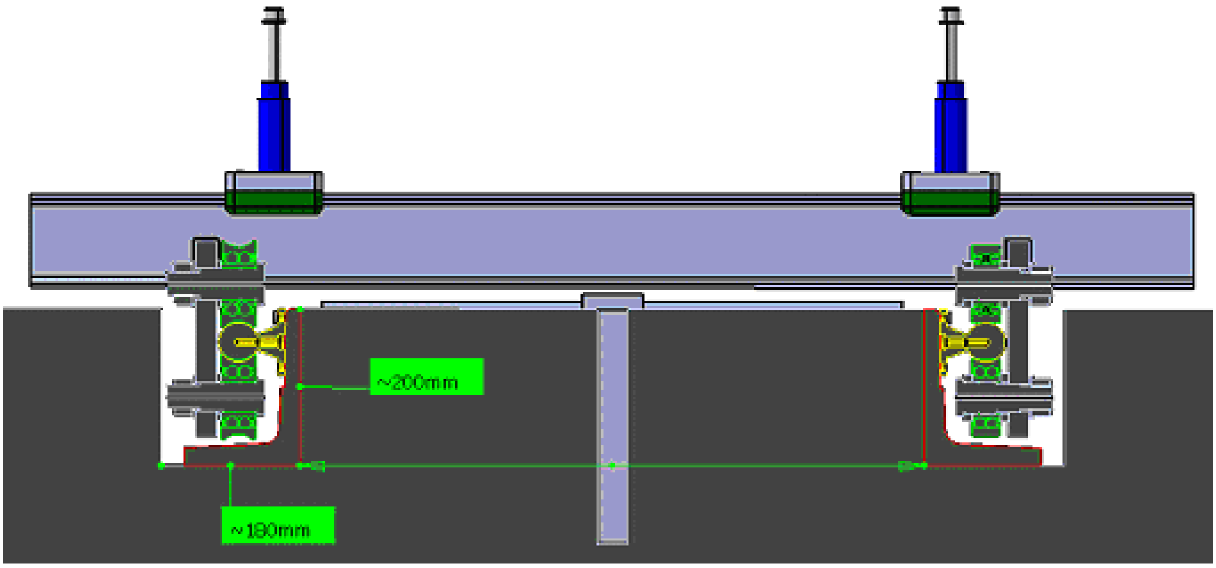
In the test currently performed, calibration is carried out without placing the fix barrier on its place, and a ballast car is used instead of a vehicle, so as to get the same mass, or directly the car with the corresponding mass for the test. This car has an electric brake activated once the point where the barrier should be is passed.

For the City Crash test's speed calibration, it is not possible to use this system, since inertia and drag resistance of the car with automobile wheels is not the same than that of the body put on rolling bearings and mild steel guidance.

This implies using the body prepared for test and lengthening the guidance trajectory as far as the room available allows in the current installation to brake after passing the point where the barrier will be at the moment of testing.

The installation of the brake system is not trivial. As the first restriction to face, lengthening the guidance route implies having them pass the zone of the barrier's anchor plate. Fortunately, the anchoring system consists of four sheets, with a 150 mm separation among each of them, which allows lengthening the guidance lines, but with the limitation of not exceeding this measure. This is the reason why a guidance system adding a UPN profile of 140 mm was a must, instead of a better sized system, which allowed using guidance as that shown on figure 11, with no problem for absorption in the moments created at the instant of impact. Another reason to use the profile with this guidance is the possible depth for the system, since it is limited by the foundation for the barrier's anchor plates, not advisable to be cut to make the guidance go through.

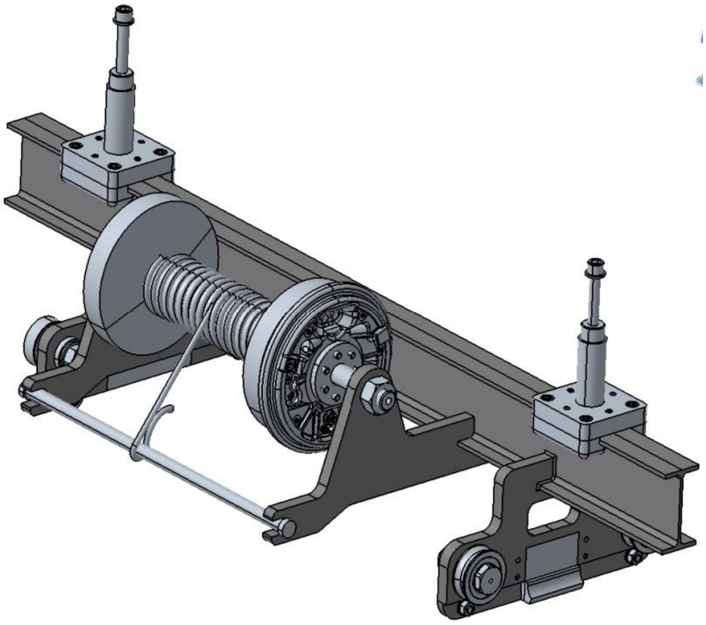
Figure 11: Initial guidance system, not possible due to incompatibility with the installation



Another added restriction is having the pneumatic cylinder lodged in the braking zone, making impossible to anchor anything in the center of the guidance lines.

The solution compatible to every restriction has been adding a drum brake like those used in automobiles, to the rear car, with a modified drum brake around which a wire joined to a bar is coiled. This bar ends up parallel to the ground, slightly higher than the position of the impeller's dragging hook, in order to not to interfere with it. The brake is activated before the calibration launch, by a small hydraulic circuit with a pressure multiplier.

Figure 12: Rear car



In the place of the barrier, two hooks are anchored in a way they impede the brake bar to pass, which uncoils the wire joined to it, exerting the braking force. It is needed to have the necessary control elements for the body not to be launched in speed calibration mode until the brake is triggered and arresting hooks are in place.

Once established the command parameters of the pneumatic system, arresting hooks in the barrier zone are dismounted and they are replaced by the fix barrier, with the deformable barrier over it.

3.7. Construction and installation

The project wouldn't be complete if the way to build the different parts or the assembly system in the current installation had not been planned.

The entire guidance set is made of steel profiles and standardized rails. It would only be needed to level the UPN profile's internal surface with a milling machine to put the rails on it. Since rails are 4000 millimeters long, it has been necessary to divide the total length of the guidance into various sections and there is a planned imbalance between profile and guidance, so as the guidance stands out at one end of the UPN profile. These arrangements guarantee one piece to be reference for the next while setting it up, which helps the guidance linearity. On the other hand, leveling elements have been planned for the profiles in a way that the guidance's horizontality could be kept. The guidance parallelism was attained by a gauge expressly made for this purpose, but it is not critical, since one side of the guidance uses bearings adapted to the rails and plain bearings to the other side, allowing some millimeters of tolerance in parallelism.

The rest of the elements are based on IPN profiles and milled-shaped sheets, joint by welding. All the rolling elements are standardized.

The braking system is built from a drum brake used in serial vehicles, for which a drum is shaped with the appropriate form to perform as a brake and coiling the braking wire.

4. Results

Finally, it has been achieved to install the City Crash test in the available low speed impact installation, in spite of the important restrictions its use implies, to the level of the size of the elements that have been adapted to the current arrangements and the foundations of the barrier anchor plates, as well as to the limitations of the mass to impel, which have caused the development of a system different to the usual ones using the body as a sleigh.

Like it happened in the current situation, it has been necessary to carry out the project with two arrangements, one for testing and other for speed calibration associated to the impelling system.

This does not differs at all from the current methods used and has been accepted by the department responsible of these tests.

The project has been developed in CATIA V5 in the SEAT Technical Center (Raffier, A; Edo, M. and González M.M., 2009) and offered to be built by possible suppliers.

Figure 13: Test Configuration

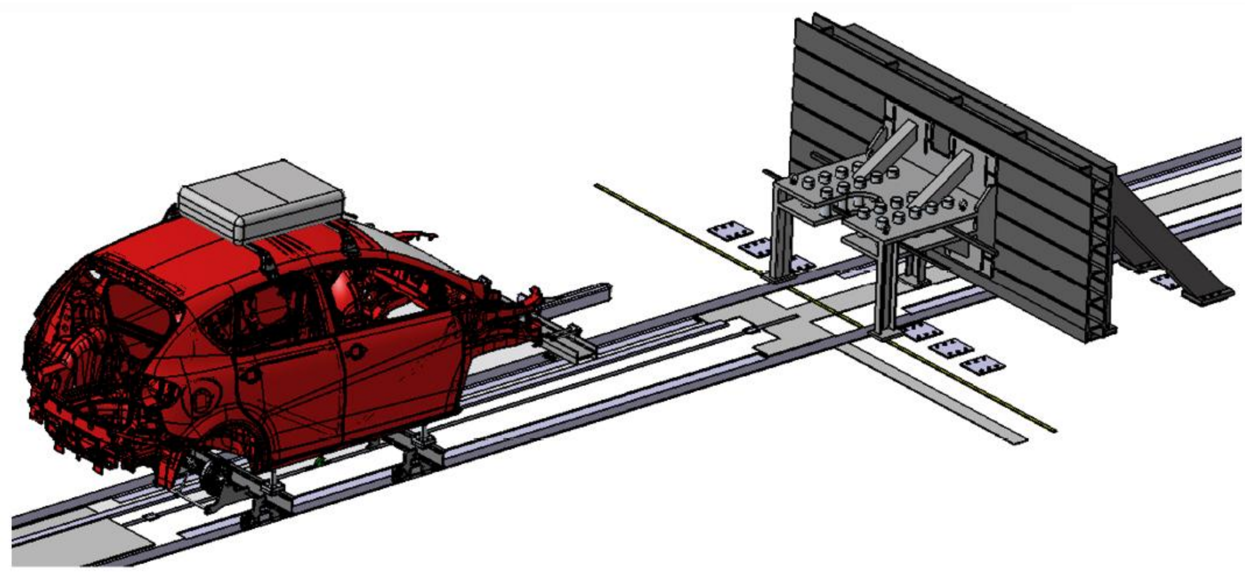
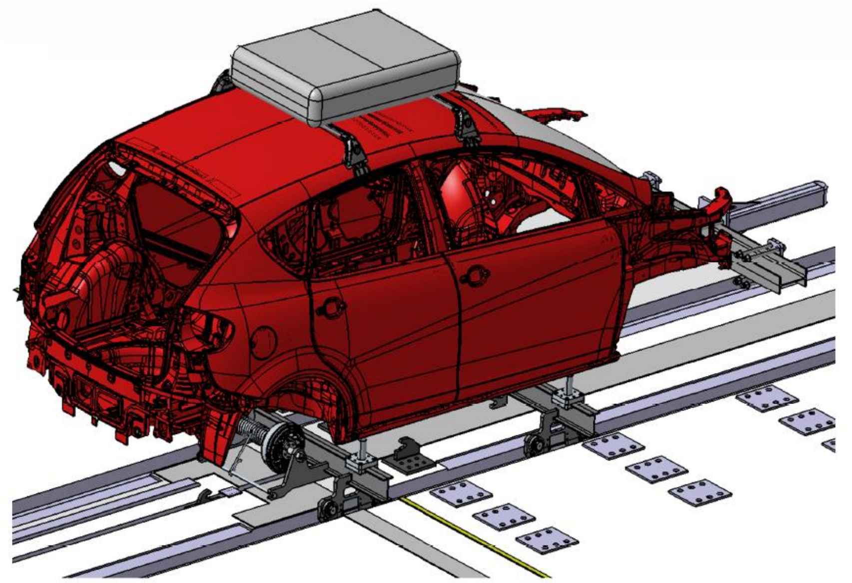


Figure 14: Configuration of calibration



5. Conclusion

It is possible to install the necessary elements to perform the City Crash test in the current low speed impact installation at SEAT Technical Center without interfering with the tests currently operating.

Offers from possible suppliers also grant economic feasibility to the project, since it is redeemable in a reasonable time.

6. References

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