CASE STUDY

Volvo Cars Safety Centre
Accelerometers Help Improve Car Safety

Sweden

Automotive

Transducers

The name of Volvo is synonymous with car safety. The new Volvo Cars Safety Centre at Gothenburg, Sweden, incorporates unique facilities and is the only one of its type in the world. The investment is a part of Volvo's continual investigations into this vitally important area. Together with the existing facility, Volvo uses hundreds of ENDEVCO accelerometers to measure the effects of impacts on vehicles and their occupants – allowing it to design even safer cars.

Test Laboratories

The opening of Volvo's new car safety centre a year ago has significantly increased the capacity to perform crash safety tests. Together with its original crash test centre, Volvo now has the ability to perform about 450 full-scale tests per year. Additionally, the new centre, with its state-of-the-art facilities, enables Volvo to make a number of new, unique, advanced tests which provide great quantities of data.

The original safety centre can test cars at impact speeds of up to 50 mph (80 km/h) – in the new centre the speed can be up to 75 mph (120 km/h) and two cars can be collided together in a variety of positions and angles. In the new safety centre there are two tracks – one is fixed but the second can be moved to any required position in order to reduce different types of real-life car traffic accidents for car side impacts at different angles and impact speeds. As the picture above shows, it is a huge structure, but the entire track moves easily using air cushions, rather like a hovercraft.

Patrik Settergren is a test engineer at Volvo's safety centre. Patrik explains, "Each car model made by Volvo is built to only one specification and is sold throughout the world. The car has to meet different regulations but also must conform to Volvo's safety standards and therefore we must make tests, not only as a part of our development work with car safety, but also in accordance with these international standards."

Some of the huge variety of tests that can be performed include:

- Free Motion Head (FMH) test – used to ensure that the interior of the car meets stipulated safety standards
- Dynamic Inspector Test System – this test rig uses different models of parts of the body (torso, legs, knees, etc.) which are directed at, for example, the bonnet, to measure the effects of a collision with an unprotected pedestrian
- Drop Test Rigs – three different heights are used where an artificial body part is hoisted up and dropped onto a test object, such as a door panel or dashboard
- High-tech Crash Barrier – the forces exerted on a car with an offset impact are measured more effectively than ever before
- Computer Simulation – a supercomputer crashes non-existent cars for even faster development of new Volvo car models with even greater protection
- Parking – determining damage at low speed, the effect of impacts at 3 mph (4.8 km/h) and 5 mph (8 km/h)
- Sled test – a vehicle chassis is mounted on a sledge which is propelled by compressed air. The effect of impacts on crash-test dummies on such components as air bags, dashboard, steering column, seats, seat belts can be determined at various levels of impact

Preparation

Fig. 1
It takes about 10 days to prepare each car for a full test

Patrik Settergren explains, “Each test car is a full production model, exactly as it would be seen by a customer”.

He continues, “We have a special preparation area where around 25 people are employed and it takes us about 10 days to prepare each car.” Volvo paints it’s test cars matt orange. We have found that this is the best colour for filming the tests as it gives clear pictures from the high speed cameras”.

High-tech

Up to ten digital cameras can be mounted on the test vehicle to document the impact – in the car itself, on the rear, the side, under the chassis, in fact anywhere, and fibre optics technology is used to record special or visually inaccessible areas. Patrik says, “The digital cameras record the crash at 1000 frames a second. We also position cameras on the ground and under glass floors to document the underside of the car during a crash. We use special high-power lamps which simulate daylight and we have found that the orange paint reduces reflections from the lamps and gives the best results.”

During the test, the speed and acceleration of the vehicles have to be very accurately controlled to ensure a perfect collision which is repeatable. This is done using laser sensors and two cars can be collided into each other with an incredible accuracy.

Fig. 2
Left – Each crash-test dummy, as with all measurement instruments, must be carefully prepared – and they are not cheap! Right – before a test, a child-sized dummy is positioned in a child's safety seat

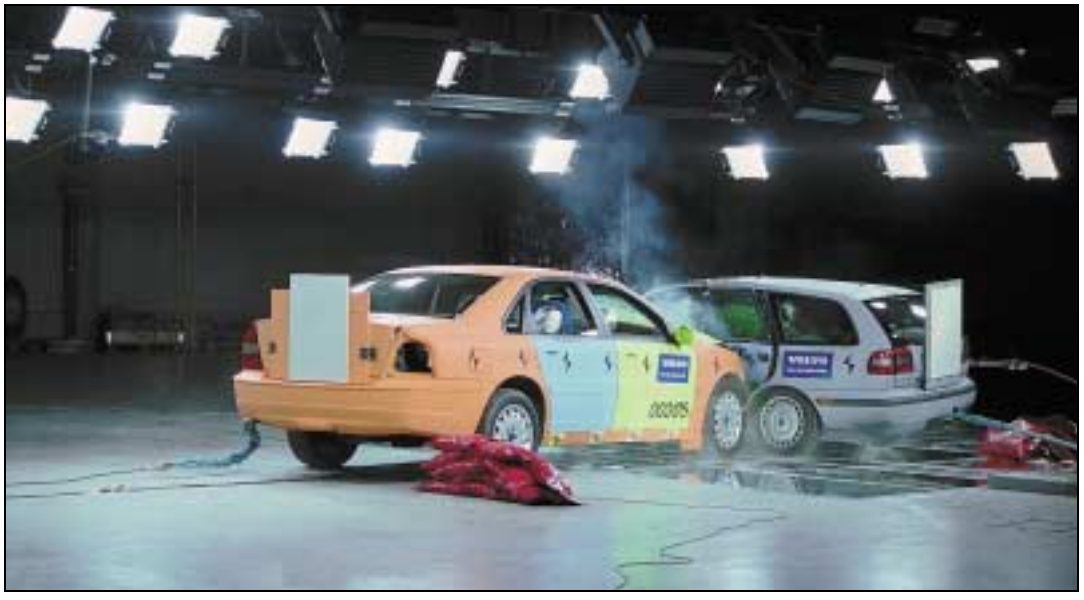
Accelerometers

An average of 80 accelerometers are used during each test, although up to 200 can be used in special circumstances. Patrik says, "We currently use two types of ENDEVCO accelerometers supplied by Brüel & Kjær. The accelerometers attached to the crash-test dummies are rated at 500 g while those used on the car itself record impacts at up to 2000 g."

Patrik continues, "We buy hundreds of accelerometers each year from Brüel & Kjær. Their product range is very wide, so we can get the specifications we need. We get good service and technical support, and deliveries are always on time".

After a test, all the accelerometers go to Volvo's calibrations department where they are tested to ensure that they remain within their specifications. Work is now under way to incorporate ID chips into the LEMO socket of each accelerometer. This will allow for automatic detection of the parameters of each individual accelerometer when it is connected to the data recording computer. Patrik explains, "This is a kind of TEDS (Transducer Electronic Data Sheet), and it will save a lot of setting up time". ENDEVCO is producing a first batch of 50 of these new "smart" accelerometers for evaluation.

Fig. 3
At the moment of impact, digital cameras record the crash at up to 1000 frames a second. Accelerometers measure the g forces on the cars and the dummies



Valuable Data

The data collected during a test is extremely valuable. After all, normal production and extremely expensive prototype cars are used and each takes many days to prepare. Volvo has a large number of crash test dummies available, representing adults and children of all sizes, shapes and weights, special whiplash dummies, etc., and each dummy can cost about SEK 1 million – they are so accurately built, calibrated and certificated.

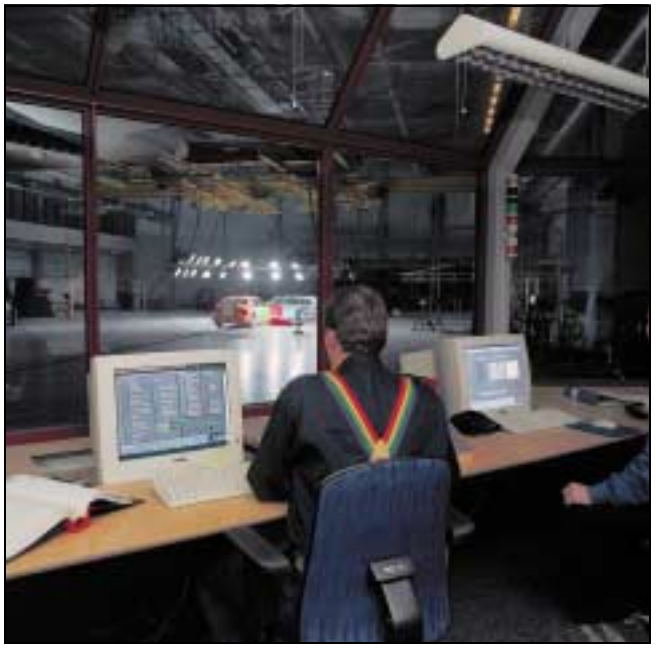


Fig. 4
The crash-test process is initiated in the control room. Here, all the data is recorded for future analysis

Patrik Settergren explains, "The test engineer specifies the test required, and the objective. The test specification covers everything from speed, acceleration, point of impact, the positioning of camera and accelerometers, all down to minute detail so that each test is repeatable. We also place marks which my colleagues call "Patrick marks" on each vehicle so that, by viewing the films, we very accurately measure the speed and distance travelled at the time of the impact".

The accelerometers are connected to a data collection computer which is placed in the test vehicle. This is connected to the control room by a cable which trails behind the car during the test. A cable also carries the data from the digital cameras.

If the safety test specifies the vehicle to be impacted against a solid barrier, sensors can be placed on the surface of the barrier and up to 128 data channels can be used. The impact data from the barrier, as well as from the vehicle itself, is then available. And the test engineers can even simulate a 50% frontal impact – like a vehicle hitting the corner of a building.

Fig. 5
The crash-test barrier weighs 800 tonnes but is easily moved to the required position on air cushions

Control Room

The control room, which looks rather like an airport control tower, is where the complete test is controlled and supervised.

The data, once collected, is very carefully evaluated and enables decisions to be made during the development of new models. Additionally, Volvo also takes sample cars from the production line for test. Patrik explains, "During the life-time of a model, we are constantly

making changes of various kinds, and therefore we have to check that these changes have not affected the safety of our cars negatively".

Example

As an example of how the data is used, by simulating impacts using various speeds and crash-test dummies of different sizes, shapes and weights, the optimal specification for driver and passenger airbags can be determined. And the data has helped to develop a new generation of two-stage airbags. In these, 70% of the available air is used to initially inflate the bag and then the remaining 30% a split second later. "This gives a softer and safer impact into the bag when it inflates", explains Patrik.

Traffic Accident Research

Fig. 6
A hydraulic "cannon" is used to impact samples with the size and texture of parts of the human body on to different areas of a stationary vehicle

Storage

Once fully evaluated, the data is permanently and securely archived. But so too are the cars, and Volvo has a large building where the vehicles which have been used in safety tests are stored.

Research

Volvo has a special traffic accident research department. Here, Volvo's experts can compare the damage from real-life traffic accidents on the car and its occupants with data which has been stored following Volvo's own safety tests. "We get requests from all over the world for help in investigating the causes and effects of real-life accidents involving Volvo cars," says Patrik.

Also, to check the accuracy of their own data, engineers from Volvo frequently visit the scene of real-life accidents where Volvo cars are involved.

Not Just Cars – and not just Volvos

Although AB Volvo, which manufactures trucks and buses among other products, is now a separate corporation, the two safety centres also perform safety tests for Volvo trucks and buses. The transportation of large numbers of passengers and goods can be accurately simulated.

And, as a part of the Ford Motor Companies Premier Automotive Group, the advanced facilities are used by other group companies.

Computer Simulation

As mentioned before, full safety tests, including the preparation, take a long time and are very expensive. Therefore, to reduce the number of real tests, Volvo is continually developing advanced computer simulation techniques to predict the effects of crash tests. Patrik explains, "This allows us to run simulated safety tests in the early devel-

opment stages of new models and we can greatly reduce the number of real tests required with prototypes and pre-production vehicles."

Improved Safety

The Volvo Car Corporation has always placed great emphasis on the safety of its vehicles and the company continues to invest heavily in this important area. As a result of the tests made by the Car Safety Centre, the safety of Volvo cars is constantly improving and the knowledge gained means safer driving, not only for the driver and passengers of Volvo cars but also for pedestrians, cyclists, other drivers, in fact for all road users.

As Stefan Nilsson, Director, Volvo Cars Safety Centre says, "This knowledge makes it easier for us to provide the occupants with the best possible protection".

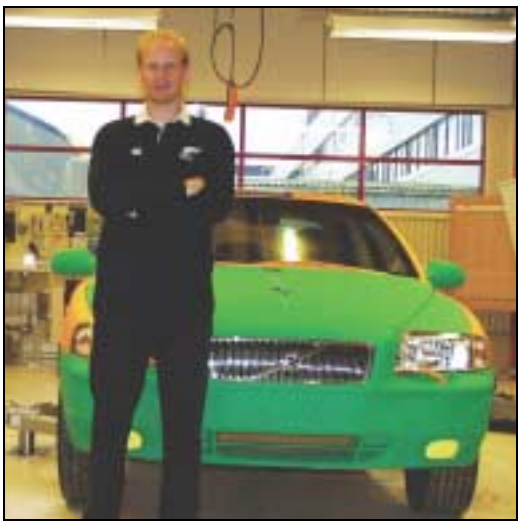


Fig. 7
Left – Crash-tests are expensive. Computer simulation techniques are increasingly used during the development of new models
Right – Patrik Settergren is a test engineer in Volvo Cars Safety Centre

Key Facts

- The Volvo Car Corporation is 100% owned by the Ford Motor Company and is one of the companies in Ford's Premier Automotive Group, together with Jaguar, Aston Martin, Lincoln and Land Rover
- Volvo has been a Brüel & Kjær customer for many years – the first PULSE system was ordered in 1997 – it is testimony to this relationship that a Volvo S60 is one of the central features in Brüel & Kjær's exhibition area
- Volvo is Scandinavia's largest automotive manufacturer producing about 400 000 cars a year
- The Volvo Car Safety Centre has unique and highly advanced crash-test facilities
- Accelerometers are used to measure the forces of impacts in car safety tests – up to 2000 g
- Volvo buys several hundred ENDEVCO accelerometers from Brüel & Kjær each year
- Volvo has the capacity to perform up to 450 full-scale collision safety tests per year

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HEADQUARTERS: DK-2850 Nærum · Denmark · Telephone: +4545800500 · Fax: +4545801405 · http://www.bksv.com · e-mail: info@bksv.com
Australia (02)9450-2066 · Austria 0043-1-8657400 · Brazil (011)5182-8166 · Canada (514)695-8225 · China (86) 1068029906
Czech Republic 02-67021100 · Finland (0)9-755 950 · France (01)69907100 · Germany 06103/733 5-0 · Hong Kong 25487486 · Hungary (1)2158305
Ireland (01)803 7600 · Italy 02 57 68061 · Japan 03-3779-8671 · Republic of Korea (02)3473-0605 · Netherlands (31)318 559290 · Norway 66771155
Poland (22)858 9392 · Portugal (1)4711453 · Singapore (65) 377- 4512 · Slovak Republic 421 2 5443 0701 · Spain (91)6590820 · Sweden (08)4498600
Switzerland (0)1 880 70 35 · Taiwan (02)7139303 · United Kingdom (0) 1438 739 000 · USA 800 332 2040
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