TecDay:
testing of the new C-Class

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Over 24 million test kilometres and extremely tough test-rig programmes to optimise long-term quality

Sindelfingen – When the new Mercedes-Benz C-Class is launched in spring 2007, the Saloon will have completed the most comprehensive test programme in the Stuttgart manufacturer's history. Over a period of three and a half years, the prototypes and pre-production models have clocked up a total of more than 24 million test kilometres all over the world. The tests performed on the test rigs at the Mercedes-Benz Technology Centre in Sindelfingen were equally extensive and intensive. Here the body and chassis were subjected to one exceptionally tough test after another to simulate the loads and stresses of an entire car lifetime within a matter of weeks. Each kilometre of these endurance tests, which Mercedes-Benz also carries out on highly demanding test tracks, is around 150 times tougher than everyday driving. These extreme tests form the basis for the high long-term quality of the Mercedes passenger cars.

Testing of the new C-Class began in summer 2003. A total of 280 prototypes completed systematic non-stop tests under various climatic and topographic conditions. These included the "Heide" endurance test, one of the world's toughest test programmes for newly developed cars. This torture-track test, carried out over a period of four to six weeks, goes back more than 50 years to a time when Mercedes performed much of its test driving on Lüneburg Heath ("Heide" is the German word for "Heath"). It is equivalent to 300,000 kilometres of everyday driving by a Mercedes customer.

Mercedes-Benz recreated these pothole and cobblestone-covered routes at its facilities in Stuttgart and Sindelfingen and now uses the data gathered during these in-house tests to control test rigs. This means the highly sophisticated rigs can relentlessly shake and bend car bodies around the clock to reproduce the driving conditions experienced during the "Heide" torture-track endurance test.

The forces acting on the connecting points between the chassis and body are immense – up to 20,000 Newtons – and they occur in quick succession. This is equivalent to a weight of up to two tonnes.

Durability testing: one of the world's toughest test programmes

The computer data compiled during the "Heide" torture-track endurance test are also used for chassis durability testing. Complete front and rear axles go through this unique series of tests around the clock on six servo-hydraulic test rigs. Mercedes engineers use four further installations to test the wheels, wheel bearings and wheel hubs for 60 hours non-stop on a simulated Hockenheimring Grand Prix circuit, during which time the chassis components are subjected to colossal lateral forces that stretch them to breaking point.

Similarly, the axle joints and bearings have to withstand extreme loads before they get the go-ahead for series production and installation in the new C-Class or other Mercedes models. In addition to permanent pressure and movement tests with forces of up to 35,000 Newtons, axle components must also resist extremely high temperatures of 90 degrees Celsius – verified in axle-joint field tests in city traffic in Tokyo.

Mercedes passenger cars also have to endure other simulated everyday conditions during testing, such as a high-pressure water jet (80 bar) and the systematic spraying of the joints with ice-cold dirty water and fine, hot sand dust over a period of three weeks. The most extensive test cycle in this environmental simulation lasts three weeks and includes over one million axle-joint load cycles – far more than any Mercedes-Benz usually experiences during its long lifetime.

The Mercedes-Benz Technology Centre has a total of around 160 innovative test rigs for chassis component durability testing alone.

"World Test" on three continents

Following a series of systematic long-distance tests in everyday traffic and at proving grounds, during which the cars were subjected to such high loads and stresses that they aged at a vastly accelerated rate, the 18-week "World Test" was one of the highlights of the systematic test marathon for the new C-Class. Four fully equipped pre-production vehicles successfully came through the tests in Germany, Finland, Dubai and Namibia. Here, under widely fluctuating climatic and topographic conditions, all of the vehicle components and systems – from the diesel particulate filter to the seats, from the door hinges to the shock absorbers – were tested once again.

Furthermore, 15 new C-Class pre-production models took part in a stiff final examination before production launch, involving tests in six countries within a period of seven months. Never before has a newly developed Mercedes model undergone such an extensive additional test programme – and passed with such flying colours.

For the final field test before production launch, Mercedes-Benz will be sending out around 450 new, factory-produced C-Class Saloons for "near-launch road trials" in which DaimlerChrysler employees will test the new model in normal everyday situations, covering a total of around 16 million kilometres in the process. This exhaustive series of tests is designed to ensure top quality right from the start.

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An entire car lifetime in just four weeks

- **One of the world's toughest tests for car bodies and chassis units**
- **Stresses and loads equivalent to 300,000 km of everyday driving**
- **Endurance testing based on torture-track tests on Lüneburg Heath**
- **C-Class completes extreme series of tests on test rigs and test tracks**

The body shakes and shudders to an almost unbelievable extent. Tremendous forces are applied to strike and pull the axles, causing the car to shift abruptly by varying degrees without any respite whatsoever.

There is method behind all that happens on this test rig at the Mercedes-Benz Technology Centre. This is one of the world's toughest tests for cars – a standard programme for every newly developed Mercedes-Benz, designed to ensure the long-term reliability for which the brand is renowned. Cars which pass this test and successfully withstand all the shocks and vibrations have experienced an entire car lifetime – and an extremely strenuous one at that – in just a matter of weeks.

This is because every kilometre completed on one of the state-of-the-art installations is 150 times more intensive than normal driving on the road. The test runs for a total of 2000 kilometres. In terms of the stresses and loads exerted on the car, this is equivalent to a Mercedes customer driving for 300,000 kilometres. Vehicle components which come through this test of endurance unscathed are therefore more than capable of withstanding the rigours of everyday driving.

The new C-Class, due for launch in spring 2007, passed this stern examination three times: once as a hand-built prototype in order to pinpoint any problem areas at an early stage, once as a pre-production vehicle manufactured using the series-production tools and, finally, once more as a factory-produced car.

History is a great teacher: testing based on the Lüneburg Heath roads

The relentless rig test has a (surprisingly harmless) name: it is called the "Heide" endurance test (from the German word meaning "Heath") and, although it sounds like an exercise in country pursuits, actually refers to the history of the test programme which began on Lüneburg Heath.

Here country outings in the car were a unique experience in the fifties. Not least because anyone venturing off the beaten track between Uelzen, Soltau and Lüneburg to get a close-up view of the idyllic surroundings subjected both themselves and their cars to the sternest of tests. Tarmac roads were something of a rarity. Instead vehicles had to labour over dirt tracks beset with potholes and bumps or struggle over large cobblestones which had an equally unsettling effect on both the body and the chassis.

Reports about the state of these heath roads circulated quickly. Inevitably the Mercedes-Benz engineers in Stuttgart – always on the look-out for suitable routes to test new models – got wind of this. During a reconnaissance mission in northern Germany, they found precisely what they were looking for: the Lüneburg Heath roads provided tough and, therefore, ideal conditions for car tests.

This is how the "Heide" test became an integral part of the Mercedes test programme. Engineers and test drivers regularly met up in the small town of Bispingen to embark upon the test drives on the heath's unsurfaced roads and dirt tracks. It was not long before they realised that this test was so punishing on the car body and chassis that, within a matter of weeks, the cars had experienced the stresses and loads of an entire vehicle lifetime.

Heath roads and dirt tracks simulated in southern Germany and on computer

The roads of Lüneburg Heath are now in a much better state and have had the benefit of tarmac for many years. But Mercedes-Benz still performs the "Heide" test, albeit in simulated guise on test rigs and at proving grounds. Before the

tarmac arrived, the test specialists managed to copy the bumpy surfaces of the original heath roads using plaster casts. They were therefore able to reproduce the roads on in-house torture-test tracks which were set up on the periphery of the proving ground in Stuttgart-Untertürkheim and in Sindelfingen.

**"Heide" endurance test to the power of two:
original route in the sixties (left) and rig testing at the Mercedes Development Centre (top)**

Later the development team succeeded in digitising the "load spectrum" and feeding the sophisticated test rig computers with data describing the high forces and torques which occur when negotiating the torture-track route. The test rigs' servo-hydraulic cylinders strike, pull, shake and bend the car bodies just as relentlessly as a drive on Lüneburg Heath did around 50 years ago.

Pure stress: forces of up to 20,000 Newtons

The 2000-kilometre stretch on the test rig lasts four to five weeks and simulates driving on various route profiles at speeds of just 25 and 60 km/h. This is all that is required to reproduce the extreme stresses and loads exerted on the car body by the bumpy roads. A total of 26 vertically and horizontally arranged servo cylinders pound the car body mercilessly. A hydraulic system pumps up to 2000 litres of oil per minute into the cylinders, generating a staggering 210 bar of pressure. This is how the immense forces of up to 20,000 Newtons, which are applied in quick succession by computer control and shake the car to its core, are achieved.

Test programme: checks after every 100 kilometres of the "Heide" test

The cars which take part in the torture-track endurance test are always full-specification models with the heaviest engine and the largest wheel/tyre combination possible. also, additional weights are applied at the front and rear axles.

To detect any damage at an early stage, the Mercedes engineers stop the test rig every 100 kilometres or so or if one of the approximately 150 sensors which permanently monitor the vehicle gives the signal to automatically shut down the test rig. The car body is then meticulously checked for damage. On account of their vast experience, the Sindelfingen specialists know exactly where the critical points are located and what to look out for. Whether it be the weld points, the bonded connections or the panels on the force-application paths between the body and the chassis, every aspect is subjected to the closest scrutiny, since these are the areas which have to withstand extremely high forces in torture-track endurance tests such as the "Heide" test. Other car body components that have to endure high loads include the integral support frame to which the front axle, steering and engine are fastened.

In addition, the Mercedes engineers scrupulously test and improve these and other problem zones in a separate components laboratory. Here, individual components – such as shock absorber towers, torsion bar bearings and pedal recesses – and body sections for new models have to pass durability tests. Many of these non-stop test programmes are also based on field data gathered over a period of around 50 years, stretching back to the time when tests were still conducted on Lüneburg Heath.

Body engineering: conflict of aims between durability and lightweight design

The vehicle only passes the endurance test if the body shows no signs of damage whatsoever. Even hairline cracks which can only be seen using special fluorescent fluids or under ultraviolet light are unacceptable.

Theoretically speaking, it would be easy to meet these high Mercedes standards: simply by using a vast amount of material. The car bodies would then be so robust that even the "Heide" test would seem like a stroll in the park. But automotive development is all about solving conflicts of aims. And this certainly applies in the case of body engineering. Here it is not just about ensuring excellent durability and longevity. A host of other, sometimes contradictory requirements also have to be fulfilled. By way of example, the body has to act as a sturdy backbone for the chassis as well as ensuring precise handling qualities and preventing annoying vibrations. Furthermore, the body has to be lightweight and aerodynamic in order to boost fuel economy. Plus it has to meet the most stringent of safety standards and be easy to repair.

The torture-track endurance test is one of the best ways of meeting all of these requirements. The test results, always achieved under the same conditions, show the engineers at a very early stage whether the concept will work, at what point damage occurs and which parts of the body are made using excessive or insufficient material.

Formula 1 on the test rig

- **Gruelling endurance tests for all chassis components**
- **Test rig computer programmed with race-track and test-route data**
- **Underwater pressure test and temperature tests at 90 degrees Celsius**

60 hours on the Hockenheimring: full throttle followed by braking followed by steering, over and over again. The wheels, wheel bearings and wheel hubs for newly developed Mercedes passenger cars must withstand this continuous pounding in order to get the go-ahead for series production.

This gruelling test of endurance – the chassis is subjected to lateral forces of up to 10,000 Newtons due to high acceleration when cornering and the components are heated up extremely quickly on account of the almost constant braking – is just one of many long-duration tests Mercedes performs on the chassis components. The new C-Class, due for launch in spring 2007, came through these tests several times during the course of its development.

For such extreme tests, the Mercedes engineers bring reality into the laboratory. The test rig computers are programmed with road characteristics and typical driving manoeuvres, enabling them to simulate the loads that occur when driving on a Formula 1 racing circuit such as the Hockenheimring or Nürburgring, for example. However, like body durability testing, chassis durability testing focuses primarily on the long-standing "Heide" torture-track endurance test which was developed by Mercedes engineers on the Lüneburg Heath roads during the fifties (see page 6).

This test – the world's toughest torture-track test – allows newly developed cars to be aged at a vastly accelerated rate: after just 2000 hours, the body and chassis have experienced the stresses and loads of an entire car lifetime.

For the torture-track endurance test on complete front and rear axle assemblies, the Mercedes-Benz Technology Centre in Sindelfingen has six servo-hydraulic test rigs which run day and night. Four installations are used to test the wheels, wheel bearings and wheel hubs under conditions akin to those experienced when driving around the Hockenheimring, while a further 150 test rigs are employed to rigorously check the chassis components – from the bearings to the rubber bellows, from the axle joints to the torsion-bar stabilisers.

Axle joints: thermal stress based on driving in heavy Tokyo traffic

Each test reflects the vast experience and know-how of the Mercedes engineers. They know exactly which factors cause the most stress to the chassis in real life. And they have adapted the test conditions precisely to mirror the everyday situations experienced by motorists all over the world.

As an example, they check the durability of the front and rear axle joints by performing a 100-hour pressure and movement test, during which the components are exposed to forces of up to 35,000 N and stretched to breaking point. As well as withstanding these high mechanical loads for long periods, the joints also have to resist high temperatures of up to 90 degrees Celsius – the level of thermal stress measured on the axle components whilst driving in city traffic in Tokyo, Japan. If the joints display any signs of play at the end of this wear test, the components are rejected.

Mercedes specialists are just as meticulous in their approach to testing the sealing bellows which protect the axle joints against dust, dirt and other environmental effects. To do this, they immerse the joint and sealing bellows in a glycol/water solution and move the components with varying angles of tilt up to 40,000 times in succession – 10,000 times at temperatures of minus 15 degrees Celsius alone.

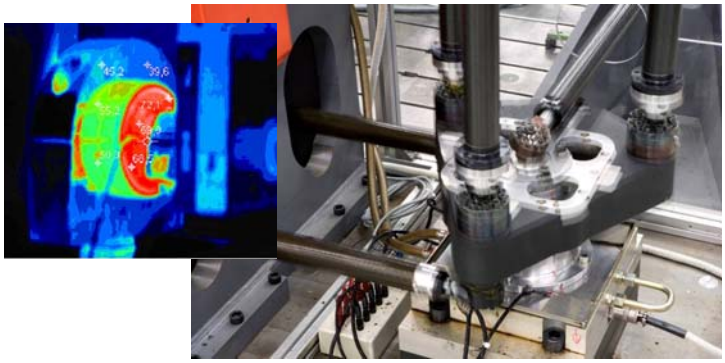
Environmental simulation: three weeks of dirt and ice-cold water

Mercedes passenger cars also have to cope with other simulated everyday conditions during testing, such as a high-pressure water jet (80 bar) and the systematic spraying of the joints with ice-cold, dirty water and fine, hot sand dust over a period of three weeks. The most extensive test cycle in this environmental simulation lasts the full three weeks and includes over one million axle-joint load cycles in simulated driving on motorways, country roads, urban roads and torture tracks – far more than any Mercedes-Benz has to contend with during its long lifetime.

Hydro-bushings: 17,000 Newtons of load from all directions

The tests which Mercedes-Benz employs for the hydro-bushings on the front and rear axle are no less strenuous. Inside these rubber components is a viscous fluid which prevents the engine and wheel vibrations from being transferred to the body. In these tests, the high-tech components have to withstand temperature and environmental effects as well as forces of up to 17,000 Newtons, which act on the bushings from all directions.

Mercedes-Benz simulates these real-life conditions on axial test rigs – the only machines of their kind in the world. Here the hydraulically damped bushings are subjected to tests that simulate the wear and tear of an entire car lifetime.



Hydro-bushings under continuous stress: thermal testing at 70 degrees Celsius (above) and load test on the triaxial test rig (right)

In addition to this mechanical endurance test, the bushings and their elastomer fillings undergo a four-week temperature test at up to 70 degrees Celsius. Using

thermographic cameras, the Mercedes engineers gain an insight into the inner workings of the bushings and can witness how the vibration-damping fluid reacts to this extreme heat.

Around the world 600 times

- **Most extensive series of tests in Mercedes-Benz history**
- **24 million test kilometres all over the world**
- **Non-stop testing involving over 900 prototypes and pre-production models**
- **Systematic "accelerated" endurance test**

Learning by testing is one of the maxims the Mercedes engineers live by. Hence they focus on three aspects when developing new models: testing, testing and testing.

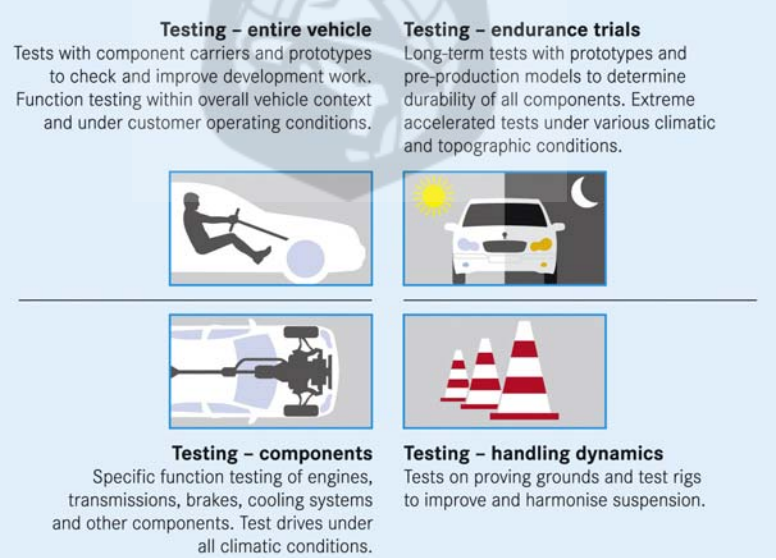
In the case of the new C-Class, this principle was applied especially rigorously as the team clocked up over 24 million test kilometres – an astounding feat never before achieved by any other Mercedes model. This distance is akin to circumnavigating the equator 600 times or making 62 trips between the Earth and the moon. A vast amount of time and gruelling test work has gone into achieving a key objective: hallmark Mercedes reliability and long-term quality.

The extensive programme of testing for the new C-Class got underway in summer 2003. At that point, component carriers still concealed parts and components of the new Saloon under the body of the outgoing model. These new components had to prove their worth in special tests under a range of climatic and topographic conditions. Months later the first of a total of 280 prototypes were ready to roll so that, alongside testing of the components for the engines, transmissions, axles, cooling systems and other subassemblies, systematic non-stop testing of the entire vehicle could begin in earnest.

Mercedes test engineers always go to the extreme – the coldest and hottest regions on Earth, the poorest and most dusty roads, the fastest test tracks and the slowest city traffic. These and other exceptional conditions are necessary in order to simulate the stresses and loads a Mercedes-Benz has to withstand over a period

of many years within just a few months. During the tests, the end of a car lifetime is reached at a vastly accelerated rate. By way of example, "Heide" torture-track endurance testing, one of the world's toughest series of tests for newly developed cars (also see page 6), involves an acceleration factor of 1 : 150. In other words, 2000 test kilometres are equivalent to 300,000 kilometres of everyday driving by a Mercedes customer.

And there is method behind every test drive. Each kilometre is logged, each test report meticulously evaluated and each potential problem area rigorously analysed and remedied. Hundreds of sensors on board the test cars monitor the technology closely and record temperatures, pressures, voltages and speeds, thus providing a myriad of measured data.



Test programme: phases of field testing for new Mercedes models

On-road endurance test: 150,000 kilometres in a single year

Durability testing of new Mercedes models includes a series of long-distance tests in everyday traffic and on proving grounds, during which the focus is on specific parts, components or functions. Such endurance tests include the "mixed-road test", a standard test for all new Mercedes passenger cars. Based on a precisely defined driving and route profile, each C-Class test driver clocked up 150,000 kilometres on a mixture of country roads, motorways and inner-city roads during

a one-year period, both during the day and at night. After the hand-built prototypes had completed their stint, the small group of pre-production vehicles completed the lion's share of this world-wide field test from early 2005 onwards. This test included:

- Several **full-throttle endurance tests**, each covering 50,000 km, at a proving ground in southern Italy;
- Various **proving-ground endurance tests,** each covering 63,000 km, on all of the heavy-load-inducing track sections at the test centre in Papenburg;
- Several **trailer endurance tests,** each covering 25,000 km, during which the C-Class pulled a 1.9-tonne trailer around the roads of the Swabian mountains in southern Germany;
- Various **"accelerated-rate" endurance tests,** each covering 81,000 km during a six-month period, including 12,000 km with the maximum trailed load as well as 6000 test kilometres on the Nürburgring racing circuit;
- **Electrical endurance tests,** each covering 15,000 km, during which test drivers piloted five vehicles and repeatedly tested the electronic systems in the C-Class under real-life conditions.
- A rigorous **corrosion endurance test**, in which a variety of climate conditions are combined with a typical customer operating profile. This full-vehicle corrosion test simulates approximately 15,000 kilometres of driving under the most gruelling dynamic and climatic conditions.

"World Test": dress rehearsal on three continents

Mercedes test engineers and test drivers are regularly on the road in almost all parts of the world. For instance, engine testing takes place in South Africa, the air conditioning systems are tested in the US state of Arizona and in northern Scandinavia, the car bodies and interiors are put through their paces in Texas,

chassis units undergo testing at a proving ground in northern Germany and part of the electrics/electronics testing is carried out in Japan.

But that is not all. The findings and results of all tests are then verified once more in a "World Test". For the new C-Class this was the first part of the final examination before production launch – a dress rehearsal with two fully equipped pre-production models, each of which covered a total of 52,000 km. Once again, this test simulates the stresses and loads experienced during an entire car lifetime.

It all began at the proving ground in northern Germany, with general function testing and 5000 kilometres of driving on merciless gravel tracks. From here, the testing team and the test cars travelled to Finland, to one of the coldest places in Europe, around 150 kilometres north of the Arctic Circle. At temperatures down to minus 40 degrees Celsius and after driving on the heavily snow-covered country roads, the Mercedes engineers paid particular attention to analysing the chassis and body components. In addition, the sub-zero Arctic temperatures provided the perfect opportunity to test the heating and electrical systems in the C-Class. Finally, the Saloons completed a special stop-and-go programme simulating city traffic in Paris, France in order to check the durability of the standard-fit diesel particulate filter in the CDI models.

After three weeks in Finland, the test specialists swapped their fleeced jackets and gloves for T-shirts and sun hats as the Middle East was the next stop-over on the C-Class "World Test" itinerary. Here two extremely hot challenges awaited the cars and drivers: a 12,000-kilometre long-distance test on the tarmac roads and sand tracks of the Arabian Desert and, in between, 5000 kilometres of city testing in heart of a big city where the mercury level rarely falls below 40 degrees Celsius and the traffic is so heavy that walking pace is usually as fast as it gets – an average speed of between seven and eleven km/h. A relentless thermal and wear test involving constant switching between the clutch, accelerator and brake pedals. And yet another extremely tough test for the chassis, air conditioning, engine cooling system and electrics.

But driving was not the expert testers' only task. They also had to stop at regular intervals to complete the checklists that the engineers need in order to be able to assess the quality of the air conditioning, the legibility of the cockpit instruments and the comfort of the seats.

Then came the next extreme test for the new C-Class: 24,000 kilometres in the uplands of Africa and in the Namib Desert. Here, on a daily basis, the test cars negotiated climbs of up to 23 percent and hundreds of bends and hairpin turns in order to reach an altitude of almost 2300 metres. And on the way there they encountered nothing but rocks, stones and dust – road conditions that are rarely experienced by any vehicle. A glance at the test log highlights just what this entails: dozens of tyres and wheels had to be changed during this ultimate test of endurance. And several windscreens, not to mention an exhaust silencer, were broken by flying stones. Apart from this, the test engineers had only good things to report back to Sindelfingen: the major components, chassis, bodies and interiors came through this final torture-track test without any major problems whatsoever.

The final report for this most unique of test marathons runs into several hundred pages. But when all the data sheets, logs and test reports are evaluated, the result is resoundingly clear: the new C-Class passed the "World Test" with flying colours.

Final examination: intensive testing and everyday-driving tests before "Job No. 1"

But this was only the first part of the final examination in the run-up to production launch. Whilst the "World Test" was continuing unabated, the Mercedes engineers sent out another 15 C-Class "Pro" models ("Pro" stands for "Production Test") to undergo a special examination that would take them to six countries within a period of seven months: in Finland, Spain and southern Italy, the main aims were to analyse the body, interior, heating system, climate control and electrics under the influence of icy temperatures and sweltering heat, while

in northern Germany, the Middle East and southern Africa, the focus switched to intensive testing of the chassis and its components.

Never before has a new Mercedes model undergone such an extensive additional test programme – and passed it with such top marks.

The same goes for the array of tests which the Mercedes specialists devised specifically for the first factory-produced versions of the new C-Class Saloon. The combination of on-road endurance trials and everyday testing is designed to ensure that the cars have reached their full level of maturity by the time "Job No. 1" – the first C-Class produced for customers – commences on the assembly line.

This final field test also includes the "near-launch road trials" covering a total of around 16 million kilometres, in which DaimlerChrysler employees from Sindelfingen and Bremen test around 450 C-Class pre-production models in normal everyday situations and report back to the development engineers with their findings.