

# Steady-state circular driving behaviour measurements according to ISO 4138

**What is the purpose?**

*The steady-state circular test is an open-loop test manoeuvre to determine the driving behaviour of passenger cars or light trucks. In particular, this test method aims to identify the vehicles road-holding ability, its self-steering properties and comfort such as oversteering or understeering behaviour.*

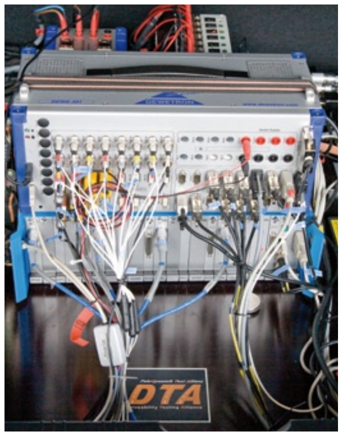
*We speak of understeering behaviour when the vehicle tends to follow a greater cornering radius than expected from the drivers input on the steering wheel. This effect makes the car more stable and controllable in many situations and is therefore common practice for many modern cars.*

*The opposite of understeering is oversteering which is often sought after by sportive drivers. Here, the rear of the vehicle tends to "break out" during cornering, which can result in a spin if the driver does not counteract with a steering input in the opposite direction (counter-steering). The oversteering behaviour is typical for (but not limited to) rear-wheel driven vehicles.*

# What is needed?

Due to the high dynamic nature of these kinds of measurements it is very important to measure all the parameters from the connected sensors synchronized. This is taken care of by the DEWETRON measurement unit in combination with the DEWESoft acquisition software. No matter whether you have analogue data, CAN data, video data, GPS data...

connected!



The following table should give you an overview on which measurement parameters are mandatory and which can be optionally acquired:

| Measurement parameter | Symbol | Unit | Required/Optional |
|---|---|---|---|
| Longitudinal velocity | υX | m/s | Required |
| Lateral acceleration | αY | m/s2 | Required |
| Steering-wheel angle | δH | ° | Required |
| Cornering radius | r | M | Required |
| Lateral velocity | υY | m/s | Optional |
| Longitudinal acceleration | αX | m/s2 | Optional |
| Steering-wheel torque | MH | Nm | Optional |
| Yaw velocity | dψ/dt | °/s | Optional |
| Sideslip angle | ß | ° | Optional |
| Roll angle | φV | ° | Optional |
| Front steer angle | δF | ° | Optional |
| Rear steer angle | δR | ° | Optional |
| Tire temperature | T | °C | Optional |

All of the required parameters, except the cornering radius, can usually be acquired from the vehicles CAN bus. However, tests have shown that the vehicles internal sensors do not have the quality, in terms of accuracy, latency and bandwidth, to produce good measurement results. Moreover, since the internal sensors or their calculation and filter methods can differ between vehicle types, the measurement results acquired from these sensors are not directly comparable.

The following sensors output all measurement parameters (and many more) required for the steady-state circular test and are fully compatible with DEWETRON measurement systems:

**GeneSys ADMA-G**

The GeneSys ADMA was engineered for all kinds of driving dynamics measurements and outputs all required motion parameters such position, velocity, acceleration, rotation angles, cornering radius etc. The ADMA outputs the measurement data via CAN which can be directly connected to the integrated CAN interface of DEWETRON measurement units.

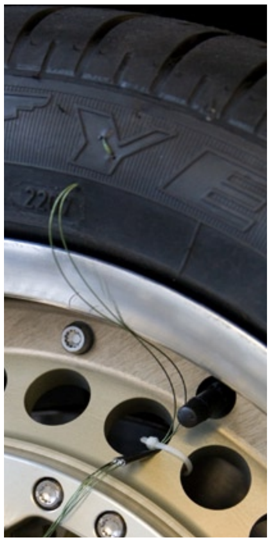
The unique DEWESoft measurement software features a plugin specifically designed for the GeneSys ADMA which allows the user to configure and control the ADMA right out of DEWESoft, without the need for additional software.

### *Corrsys-Datron Measurement steering wheel*

*The Corrsys-Datron MSW can be easily mounted instead of any vehicles steering-wheel, or, if the steering wheel can not be removed, the MSW can be mounted on top using the MSW-Adapter. Moreover, the MSW has a wide range of data-output possibilities (CAN, analog or digital) which are all supported by DEWETRON measurement systems.*

*Note: The driver airbag must be disabled when the MSW is mounted using the MSW-Adapter!*

*Furthermore, the tire temperature has a great influence on the cornering forces which is why the application of tire temperature sensors can be of great value for driving dynamics measurements. Therefore DEWETRON measurement systems support the T3M tire temperature sensors developed by TÜV Süd Automotive*



### *How is it done?*

*There are three methods to measure the steady-state circular driving behaviour: constant radius, constant steering-wheel angle and constant speed. Typically, the tests are performed in discrete increments of the varied parameters, where the increments of the lateral acceleration (which will naturally increase) should not be larger than 0.5 m/s2. To ensure good test results, the steady-state between the increments should last at least 3 seconds. Attention should also be paid to an even tire wear which is why the tests should be performed in alternating driving directions.*

### *Method 1 – Constant radius*

*The cornering radius is maintained constant while the vehicle speed is varied and the steering-wheel angle is being measured.*

### *Method 2 – Constant steering-wheel angle*

*The steering-wheel angle is maintained constant while the vehicle speed is varied and the cornering radius is being measured.*

### *Method 3 – Constant speed*

*The vehicle speed is maintained constant while the cornering radius is varied and the steering-wheel angle is being measured.*

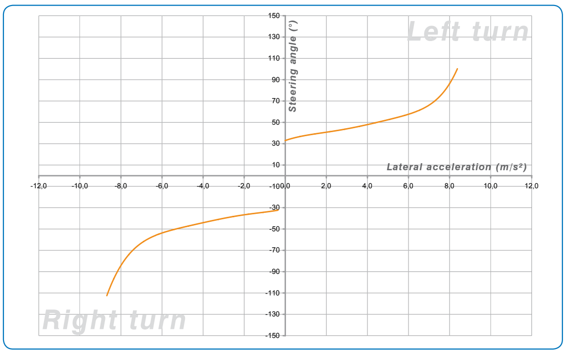
*Method 1 and 3 require a skilled driver while Method 2 is more demanding for the measurement instruments because the cornering radius has to be measured or calculated from the vehicles motion variables.*

### *What does the result look like?*

*The test results (speed, radius, steering-wheel angle) are plotted over the measured lateral acceleration. Example:*

*The diagram shows the steering wheel angle over lateral acceleration, which is one of the results of the steady-state circular test. You can see that the ratio between steering wheel angle and lateral acceleration is linear to about 6 m/s2 which gives the vehicle a direct and predictable steering behaviour. Above this threshold, the steering wheel angle is increasing non-linear which means that with higher cornering speeds (and therefore higher lateral accelerations) a greater steering wheel angle is needed to keep the vehicle on the desired radius. In this case we speak of under-steering.*

*In contrast, if the steering wheel angle would decrease with higher lateral acceleration, we speak of over-steering behaviour.*



# DEWETRON Ride and Handling Hardware Configuration

| | DEWE-211-RAH-16 | DEWE-501-RAH-64 | DEWE-501-PCI-64 | DEWE-2600-RAH-64 |
|---|---|---|---|---|
| Application | Smallest RAH system, 16 analog inputs | AC-DC-UPS power, 64 analog inputs | 64 channels expansion for DEWE-501-RAH | Fully battery powered, 64 analog inputs |
| Analog input channels | 16 MDAQ inputs | 64 MDAQ inputs | 64 MDAQ inputs | 64 MDAQ inputs |
| Digital channels | 8 x DIO + 2 CTR or 8 DI | 8 x DIO + 2 CTR or 8 DI | 8 x DIO + 2 CTR or 8 DI | 8 x DIO + 2 CTR or 8 DI |
| Channel expansion | No | Yes | No | Yes |
| CAN interfaces | 2 | 4 | Up to 4 (opt.) | 4 |
| Video | DEWE-CAM or USB DirectX | DEWE-CAM or USB DirectX | No | DEWE-CAM or USB DirectX |
| Display | External MOB-DISP-x | External MOB-DISP-x | No | 15" 1024 x 768 |
| Power supply | 8 - 30 $V_{DC}$, external AC adapter | Battery powered, 18 - 24 $V_{DC}$ or 11 - 33 $V_{DC}$ | Battery powered, 18 - 24 $V_{DC}$ or 11 - 33 $V_{DC}$ (UPS battery 1 min.) | Battery powered, 18 - 24 $V_{DC}$, external AC power supply |
| Dimensions (W x D x H) | 317 x 252 x 92 mm 12.48 x 9.92 x 3.62 in. | 439 x 209 x 181 mm 17.28 x 8.23 x 7.13 in. | 439 x 209 x 181 mm 17.28 x 8.23 x 7.13 in. | 417 x 246 x 303 mm 16.42 x 9.69 x 11.93 in. |
| Weight | Typ. 5 kg (11 lb.) | Typ. 9 kg (19.8 lb.) | Typ. 8 kg (17.6 lb.) | Typ. 14 kg (31 lb.) |
| MDAQ series modules are available for almost all kinds of sensors | | | | |

*Literature*

*ISO 4138:2004, Passenger cars – Steady-state circular driving behaviour – Open-loop test methods*
*ISO 3833:1977, Road vehicles – Types – Terms and definitions*
*ISO 7401:2003, Road vehicles – Lateral transient response test methods – Open-loop test methods*
*ISO 8855:1991 Road vehicles – Vehicle dynamics and road-holding ability – Vocabulary*
*ISO 15037-1:1998, Road vehicles – Vehicle dynamics test methods – Part 1: General conditions for passenger cars*