

PROPOSAL SIMULATION SPECIFICATIONS

DYNAMIC STABILITY SIMULATION

The efficiency of the directional and/or rollover stability of motor vehicles, trailers and semi-trailers of categories M, N and O equipped with Electronic Vehicle Stability Control systems, shall be determined by a set of simulations. In the case of any trailer, a representative towing vehicle shall be defined for the simulation test runs – in agreement with the Technical Service.

1. GENERAL CONDITIONS

1.1. Modelling and simulation tool

The simulations shall be carried out with a validated modelling and simulation tool which is either used by or has been agreed with the type approval authority or Technical Service (see paragraph 4 below) on basis of data which verifies the simulation model against a practical vehicle test.

1.1.1. The simulation method takes into account the main factors which influence the directional and roll motion of the vehicle. The model should have at least the following vehicle parameters:

Axle/wheel parameters

- axle/wheel geometry
- wheel loads;
- track width;
- centre of gravity positions of unsprung masses;
- inertia (mass, J_x , J_y & J_z) of unsprung masses;
- in the case of steered wheels:
 - principal of steering;
 - steering ratio or self steering characteristics.

Suspension parameters

- principal of suspension;
- height of roll centre;
- stiffnesses of suspension (vertical and roll; lateral and for/aft if significant);
- damping characteristics of suspension;
- kinematics of suspension (if significant);
- roll stabiliser characteristic.

Tyre parameters

- pure cornering characteristics;
- pure braking characteristics;
- combined cornering and braking characteristics;
- relaxation length (dynamic behaviour);
- radial/vertical stiffness;
- lateral stiffness;
- dynamic tyre/road friction coefficient ranging from low (ice) to high (dry asphalt) and depending of road position.

Chassis/vehicle body parameters

- centre of gravity position of sprung masses;
- inertia (mass, J_x , J_y & J_z) of sprung masses;
- chassis/vehicle body (torsional) stiffness if significant.

Power train/driveline parameters if applicable

- power source characteristics (engine traction/braking torque/torque converter);
- transmission characteristics (gear ratios);
- differential gearing (gear reduction, locking characteristics).

Brake system parameters

- dynamic characteristics of the brakes.

Pay load parameters

- centre of gravity positions;
- Inertia (mass, J_x , J_y & J_z).

Other parameters/properties

- driver model with path following properties for the subjective type of simulation tests;
- steering stiffness;
- load sharing distribution between the axles of a bogie;
- in the case of a fast height levelling system (see paragraph 1.2.2 below), the properties/characteristics of the height levelling system.

The vehicle parameter values represent the loaded condition and are expressed in SI-units. The values of relevant parameters (e.g. suspension, tyres, etc.) have to be non-linear to predict correctly the directional and rollover stability of the vehicle.

- 1.1.2. The Electronic Vehicle Stability System shall be added to the simulation model by means of
- a) a subsystem (model or source code) of the simulation tool;
 - or
 - b) the electronic control box in a hardware-in-the-loop configuration.

1.2. Operating components

- 1.2.1. In the case of differential gearings with a locking mechanism which can be disengaged, every test must be conducted with engaged and disengaged differential lock.
- 1.2.2. Height-levelling systems shall not be included in the simulation model unless the response time of the system is less than one second.

2. NON POWER-DRIVEN VEHICLES

In the case of a non-powered vehicle, it shall be simulated using the characteristics of a representative power-driven vehicle to be agreed by the type approval authority or Technical Service in consultation with the manufacturer of the non-powered vehicle.

3. VEHICLE LOADING CONDITION

- 3.1. The standard test condition shall be the maximum technical permissible mass of the vehicle distributed among the axles as declared by the manufacturer such that the load on each axle is proportional to the maximum permissible load for each axle. In the case of tractors for semi-trailers, the load may be re-positioned approximately half-way between the kingpin position resulting from the above loading conditions and the centreline of the rear axle(s).

In the case of motor vehicles, trailers and semi-trailers of categories M, N and O used for the carriage of goods, the standard type of load shall be considered to be a fixed load with properties (mass, mass distribution and maximum recommended height of the centre of gravity) specified by the manufacturer.

In the case of a tank type vehicle the normally intended load shall be considered as an equivalent fixed load.

- 3.2. Every test shall be carried out with engaged and disengaged stability system. Also, every test shall be carried out in the unladen condition.

4. VALIDATION SIMULATION MODEL

- 4.1. The validity of the applied modelling and simulation tool has to be proven by means of practical vehicle tests:

- stationary circular test;
- step steer input test;
- μ - split single lane change;
- double lane change;
- reversed steering test or “fish hook” test;
- ...

The following motion variables shall be recorded or calculated:

- yaw velocity body;
- lateral acceleration body;
- roll angle body;
- forward velocity;
- ...

- 4.2. The modelling and simulation tool can be regarded as valid when the simulation data is within 5%? for the static (stationary circular) test and within 10%? for the other dynamic tests of the practical test data.

5. TEST SIMULATION

The test simulations to establish the dynamic stability shall be:

- directional stability
 - μ - split single lane change;
 - double lane change;
 - asymmetrical one period sine steer or pulse steer input test;
 - ...
- rollover stability
 - stationary circular test;
 - step steer input test;
 - double lane change;
 - reversed steering or “fish hook” test;
 - ...

The characteristic values of the dynamic stabilities are:

- directional stability
 - maximum path deflection;
 - initial speed;
 - amplitude lateral acceleration;
 - amplitude yaw velocity;
 - ...
- rollover stability
 - initial speed;
 - maximum lateral acceleration;
 - maximum roll angle;
 - ...