Council Directive 96/53/EC of 25 July 1996 laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic

ANNEX II

CONDITIONS RELATING TO EQUIVALENCE BETWEEN CERTAIN NON-AIR SUSPENSION SYSTEMS AND AIR SUSPENSION FOR VEHICLE DRIVING AXLE(S)

1. DEFINITION OF AIR SUSPENSION

A suspension system is considered to be air suspended if at least 75 % of the spring effect is caused by the air spring.

2. EQUIVALENCE TO AIR SUSPENSION

A suspension recognized as being equivalent to air suspension must conform to the following:

2.1. during free transient low frequency vertical oscillation of the sprung mass above a driving axle or bogie, the measured frequency and damping with the suspension carrying its maximum load must fall within the limits defined in points 2.2 to 2.5;

2.2. each axle must be fitted with hydraulic dampers. On tandem axle bogies, the dampers must be positioned to minimize the oscillation of the bogies;

2.3. the mean damping ratio D must be more than 20 % of critical damping for the suspension in its normal conditions with hydraulic dampers in place and operating;

2.4. the damping ratio D of the suspension with all hydraulic dampers removed or incapacitated must be not more than 50 % of D;

2.5. the frequency of the sprung mass above the driving axle or bogie in a free transient vertical oscillation must not be higher than 2,0 Hz;

2.6. the frequency and damping of the suspension are given in paragraph 3. The test procedures for measuring the frequency and damping are laid down in paragraph 4.

3. DEFINITION OF FREQUENCY AND DAMPING

In this definition a sprung mass M (kg) above a driving axle or bogie is considered. The axle or bogie has a total vertical stiffness between the road surface and the sprung mass of K Newtons/metre (N/m) and a total damping coefficient of C Newtons per metre per second (N.s/m). The vertical displacement of the sprung mass is Z. The equation of motion for free oscillation of the sprung mass is:

$$M\frac{d^2Z}{dt^2}+C\frac{dZ}{dt}+kZ=0$$

The frequency of oscillation of the sprung mass F (rad/sec) is:

$$F=\sqrt{\frac{K}{M}-\frac{C^2}{4M^2}}$$

The damping is critical when $C = C_o$,

where

$$C_o=2\sqrt{KM}$$

The damping ratio as a fraction of critical damping is

$$\frac{C}{C_o}$$

.

During free transient oscillation of the sprung mass the vertical motion of the mass will follow a damped sinusoidal path (Figure 2). The frequency can be estimated by measuring the time for as many cycles of oscillation as can be observed. The damping can be estimated by measuring theheights of successive peaks of the oscillation in the same direction. If the peak amplitudes of the first and second cycles of the oscillation are A_1 and A_2, then the damping ratio D is;

$$D = \frac{C}{C_{cr}} = \frac{1}{2\pi} \times \ln \frac{A_1}{A_2}$$

'ln' being the natural logarithm of the amplitude ratio.

4. TEST PROCEDURE

To establish by test the damping ratio D, the damping ratio with hydraulic dampers removed, and the frequency F of the suspension, the loaded vehicle should either:

(a) be driven at low speed (5 km/hr + 1 km/hr) over an 80 mm step with the profile shown in Figure 1. The transient oscillation to be analyzed for frequency and damping occurs after the wheels on the driving axle have left the step;

or

(b) be pulled down by its chassis so that the driving axle load is 1,5 times its maximum static value. The vehicle held down is suddenly released and the subsequent oscillation analyzed;

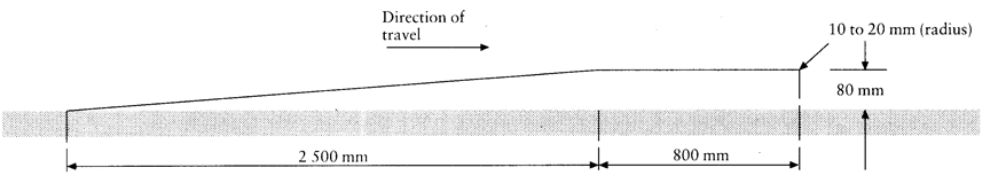
or

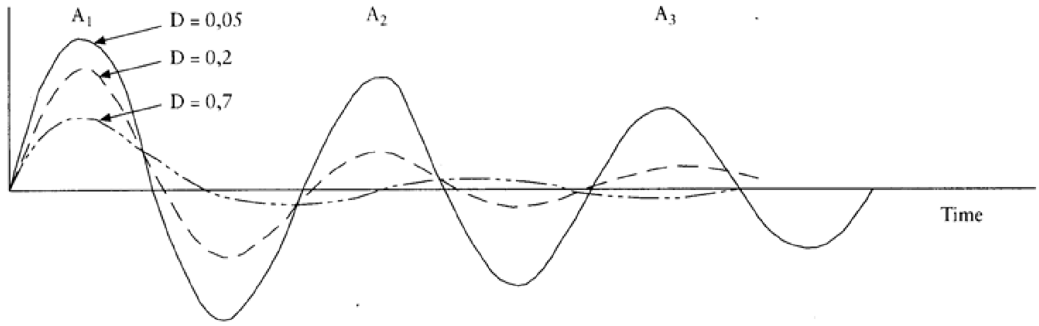
(c) be pulled up by its chassis so that the sprung mass is lifted by 80 mm above the driving axle. The vehicle held up is suddenly dropped and the subsequent oscillation analyzed;

or

(d) be subjected to other procedures insofar as it has been proved by the manufacturer, to the satisfaction of the technical department, that they are equivalent.

The vehicle should be instrumented with a vertical displacement transducer between driving axle and chassis, directly above the driving axle. From the trace, the time interval between the first and second compression peaks can be measured to obtain the frequency F and the amplitude ratio to obtain the damping. For twin-drive bogies, vertical displacement transducers should be fitted between each driving axle and the chassis directly above it.




A1
D = 0,05
D = 0,2
D = 0,7
A2
A3
Time