COMMISSION OF THE EUROPEAN COMMUNITIES

COM(90) 486 final
Brussels, 17 October 1990

Proposal for a
<u>COUNCIL DIRECTIVE</u>

amending Directive 85/3/EEC on the weights, dimensions and certain technical characteristics of certain road vehicles

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(presented by the Commission)

EXPLANATORY MEMORANDUM

A. General Comments

1. Background

1.1 On 24 July 1986 when directive 86/360/EEC concerning the drive axle weight of 5 and 6 axle vehicle combinations was adopted the Council "called upon the Commission, when fixing the value of the weight of the driving axle at 11.5 tonnes as from 1 January 1992, to look into the possibility of reducing wear and tear on the roads through "road friendly" design of the vehicles in question and to submit a report to it in due course accompanied, if appropriate, by a proposal for a Community regulation". The statement went on to say that "in this context account should be taken interalia of the following factors: tyres (double/single), tyre contact pressure, suspension, vibration damping".

1.2 At the Council of Ministers Meeting on 14 March 1989 the Commission was requested to examine, when setting the weight for the vehicle drive axle, for 2, 3 and 4 axle rigid vehicles and 4 axle vehicle combinations, at 11.5 tonnes, the possibility of reducing the damage to the transport infrastructure taking into consideration new vehicle construction techniques (e.g. twin tyres and air suspension or suspension recognized as being equivalent within the Community) and to submit to the Council a report on the matter and a proposal for a Community regulation.

1.3 Directive 89/338/EEC which resulted from agreements made at the March 1989 Council specifies that for vehicles identified in sections 2.2.4.2., 2.3.2. and 2.3.3. of Annex I to this amending directive (that is the 4 axle articulated vehicle and the 3 axle and 4 axle rigid vehicles) in order that they may realise their maximum gross vehicle weight allowed for in that directive, they should fit twin tyres and air suspension or suspension recognized as being equivalent within the Community to the drive axle.

1.4 The equivalence to air suspension is discussed in part B of this explanatory memorandum and results in the first part of the proposal. The concept of road friendly suspension is addressed in part C and results in the second part of the proposal. The scope of the first part of the proposal relates only to those vehicle types described in sections 2.2.4.2, 2.3.2 and 2.3.3 of Annex 1 to Directive 89/338/EEC that is the 4 axle articulated and 3 and 4 axle rigid vehicles. In this case the equivalence of suspension systems to air suspension is established in a set of objective parameters in an additional Annex III to Directive 85/3/EEC. However, taking account of the Council's statements at the adoption of Directives 86/360/EEC and 89/838/EEC concerning the reduction in road wear and tear through the provision of "road friendly" vehicle design, the scope of the proposal has been expanded to cover all vehicles subject to Directive 85/3/EEC. In this way, in order that a vehicle engaged in international transport may be used at its maximum gross vehicle weight with an 11.5 tonnes drive axle then the drive axle should in every case, be equipped with twin tyres and air suspension or suspension recognized as being equivalent within the Community. Where the drive axle is not so equipped then its maximum authorized weight is limited to 10.5 tonnes.

B. Technical equivalence to air suspension

2. Introduction

2.1 Road wear is, amongst other things influenced by the wheel loads. Wheel load consist of a static part and a dynamic part. The suspension type mainly affects the dynamic wheel loads, but in the case of bogies it can also influence the static load depending on the degree of static compensation of interaxle loads. The Proposal does not tackle the axle bogie and so neither static compensation nor the dynamics of axle bogies are catered for. The proposal only concerns the equivalence to air suspension (and tyre criteria) for the single 11.5 tonnes drive axle.

2.2 The two most important parameters of the suspension for its effect on dynamic wheel loads are the spring rate and the damping rate.

The damping rate has, for a given stiffness, an optimal value for which the dynamic wheel load has a minimum. If the damping is lower than the optimum the dynamic wheel load increases rapidly. It becomes larger also if the damping is much higher but then it increases at a slower rate. In practice the actual damping is usually lower than the optimal damping. The damping rate can be specified as the relative damping. In practice there must be a compromise between the vibration level in the vehicle and dynamic wheel loads. A damping ratio of at least 20 % has been chosen as being both realistic and as providing the limit of acceptability regarding road wear.

The spring rate of the suspension has no optimal value. The lower the spring rate is the lower the dynamic wheel loads are and hence the lower the road wear. For leaf spring suspensions there is often a very large difference between the static and dynamic spring rates due to the inherent friction. The dynamic spring rate is very much affected by the excitation level. The simplest way of specifying the spring rate is to relate it to the natural frequency of the spring. Modern air suspensions have natural frequencies as low as 1.2 Hz but some have relatively high frequencies of 2 Hz or slightly more. Steel springs can theoretically be made to provide low frequencies, but in practice the variation of static axle position with static load would be excessive.

3. Natural frequency

3.1 There are differences of opinion as to the value of natural frequency that would render the suspension as being equivalent to that of air suspension.

One view is that if the objective is to favour suspensions that give lower dynamic wheel loads for the 11.5 tonnes drive axle than current conventional steel suspensions, then the natural frequency should be set at a maximum value of 1.5 Hz which is a figure that most modern air suspensions should meet although in practice some can be as high as 2 Hz or more.

The opposing view is that a value of 1.5 Hz would rule out virtually all steel sprung suspensions. Consequently if an objective is to discourage the use of the very stiff multi leaf suspensions then this could be achieved by setting a natural frequency of 2.0 Hz. This would make it possible to use parabolic steel springs with a practical level of stiffness.

It is recognized that certain air suspension systems are primarily there to provide an axle lift mechanism rather than to provide a vehicle suspension medium and in these cases the natural frequency of the systems can be relatively high. On the other hand vehicle manufacturers' wish to maximise driver comfort has driven them towards reducing the natural frequency of the suspension even though this means the use of relatively long parabolic springs with anti roll bars or the use of air suspension. Where manufacturers have gone to these lengths it is possible to attain the 1.5 Hz natural frequency with the use of steel suspensions. However, the vast majority of heavy goods vehicles in service today that do not have air suspended drive axles would not be able to meet the 1.5 Hz suspension parameter.

3.2 In conclusion, the most difficult parameter for agreement with regard to the equivalence of air suspension is the natural frequency. If it is set as a maximum of 1.5 Hz then a true equivalence to the better air suspensions can be realised and in this way make a significant contribution to minimising road damage. On the other hand if the aim is to discourage the use of at least the worst types of steel suspension systems and allow the use of the better type of conventional parabolic springs then a maximum level of 2.0 Hz should be set. Member States technical experts together with industry generally favour a 2 Hz limit.

The graph at figure 1 shows the relationship between the dynamic load factor K and suspension natural frequency.

$$\text{Where } K = \frac{\text{Standard deviation of the dynamic pavement load plus the static load}}{\text{Static load}}$$

The relationship between road wear and K is expressed as:

Dynamic road wear factor = $1 + 6\,(K - 1)^2 + 3\,(K - 1)^4$

The graph shows the straight line relationship between increased suspension frequency and dynamic load factor and hence the suspension contribution to road wear.

Comparing the effects on road wear of the two frequencies in the proposal on a good and a poor road surface gives:

	Smooth surface	Medium surface	Poor surface
Dynamic load factor			
K at 1.5 Hz	1.045	1.08	1.10
K at 2.0 Hz	1.065	1.10	1.13
Dynamic road wear factor			
α at 1.5 Hz	1.012	1.04	1.06
α at 2.0 Hz	1.025	1.06	1.10

Consequently the increased road wear caused by using a suspension at 2.0 Hz natural frequency over and above that at 1.5 Hz is:

For a smooth road surface = 1 %
For a poor road surface = 4 %

It is considered that the 2 Hz limit is a reasonable compromise bearing in mind that some air suspensions cannot achieve a lower value and that 2 Hz would enable the use of the better parabolic spring type suspensions.

4. Damping

4.1 The vehicle parameter which is most important for minimising dynamic road stressing is generally regarded to be the vehicles spring damping characteristic. The springing system for a highway vehicle is always provided with some form of damping, viscous or frictional or a combination of the two. Purely viscous damping is only conceivable in theory. Frictional damping cannot be avoided in practice but the aim of the design of modern springing systems is to reduce frictional damping as much as possible.

With viscous and frictional damped systems there is an optimum damping quotent which produces a minimum dynamic contribution. The smallest dynamic load contribution is obtained with purely viscous damping.

The graph at figure 2 shows the relationship between dynamic road impact against damping quotent. It can be seen that a 20 % damping quotent is important as a value below this gives a significant rise in the contribution of the vehicle to road damage. However a damping quotent much higher than 20% could result in the system being too stiff for part laden or unladen vehicles.

The proposal sets a damping ratio which must be more than 20 % of critical damping for the suspension in its normal condition with hydraulic dampers in place and operating. Also the amount of damping of the suspension with all hydraulic dampers removed or incapacitated must not be more than 50 % of the total damping. This refers to the frictional damping of the system. An axles damping is taken to mean the ratio of the springing systems actual damping coeficient and the damping coefficient of the critical damping:

[$D = C/Cc$ where $Cc = 2\sqrt{k\,M}$ where k is the springs rigidity (N/M) and M is the mass of the oscillating system (kg)].

With air or parabolic spring suspension the axles damping will be provided by the use of hydraulic dampers. Whereas these systems can be set to give 20% critical damping when new, it will be important to maintain this level in service. Some form of physical inspection of the dampers should take place during roadworthyness testing.

5. Tyres

5.1 Wide single tyres are characterised by the width of the tyre section being appreciably greater than its height. The saving in weight which can be made by using wide single tyres is one of their undisputed advantages. However, an axle fitted with twin mounted tyres produces a lower spring rate than with the wide single tyre and this is a significant contributer to the reduction in the overall dynamic loading effect of the vehicles weight, much more important than the saving in unspring mass by the use of the wide single tyre. For a given axle load the wide single tyre reduces the fatigue life of an asphalt surface by increasing the stretching at the bottom of an 8 cm thick surface by 40 % over that of conventional twin tyres. Also wide single tyres produce over twice as much rutting as do twin tyres. Road stress increases by 20-25 % with the use of the wide single tyre. For these reasons the development of a wide single tyre that would be capable of supporting the 11.5 tonne drive axle is discouraged. Therefore the requirement for twin tyres on the drive axle is considered to be fully justified. It is recommended that consideration be given to setting a maximum weight limitation for the wide single tyre when fitted to any axle (not just the drive axle) that would fully take account of its "road unfriendlyness".

The lower the tyre contact pressure the more the road pavement, in particular the surface, is spared.

The proposals place constraints on tyres in two ways. Firstly, they confirm Directive 89/338/EEC is so far that the wide single tyre cannot be used on the drive axle up to its maximum weight of 11.5 tonnes. Secondly, they add to the requirements of Directive 89/338/EEC the restriction that the tyre contact pressure must be no more than 8 bar.

6. <u>Contents of the proposal as regards the definition of the equivalence to air suspension</u>

An Annex III which concerns the tyres and suspension fitted to the 11.5 tonne drive axle will be added to Directive 85/3/EEC, as amended by Directive 89/338/EEC which will:

i. define "air suspension"

ii. define the equivalence of air suspension refered to in Annex I sub-sections 2.2.4.2, 2.3.2, 2.3.3 and 3.5.3

iii. define a simple test method to establish the air suspension equivalence parameters

iv. prohibit the use of the wide single tyre on the 11.5 tonne drive axle

v. set a maximum limit for the tyres ground contact pressure

Annex I sub sections 2.2.4.2, 2.3.2, 2.3.3 and 3.5.3 with regard to the requirement that "air suspension or suspension recognized as being equivalent within the Community" shall be amended to

"Air suspension or suspension recognized as being equivalent within the Community as defined in Annex III".

C. "Road friendly" suspension and their beneficial effect on pavement loading

7. The relationship of axle load and pavement deterioration

7.1 There is a common opinion of researches working in this area that the constructive layout of the vehicle suspension has a great influence on the magnitude of the dynamic axle loads and thus on the deterioration of the road.

Structural stress in the road is caused by loads affecting the pavement courses including the subgrade soil. High stress is due to inadequate structural strength, adverse wheather conditions and the use of materials that are unsuitable for the prevailing traffic. The most typical modes of structural stress are fatigue cracking in bound courses and permanent deformation of bitumous courses, unbound base layers and subgrades.

7.2 The first significant real life pavement test undertaken is now refered to as the AASHO road test, this took place in the USA in the 1950's. A great many different pavement structures were subjected to traffic loads and the equivalence between loads, expressed by their magnitude and the number of applications, was established. An appropriate statement of this load equivalence is:

$$NI/NJ = (PJ/PI)^4$$

NI = the number of loads of magnitude PI to cause failure
NJ = the number of standard loads of magnitude PJ to cause failure

This result, known as the forth power law, founded great hopes of simplifying approaches towards national pavement design, i.e. the calculation of pavement thickness as a function of subgrade pavement materials, traffic, axle loads and climate. However, it is now recognized that there are a number of problems with this simplistic relationship. Types of material used in the road pavement, the applied loads, how the load is applied i.e. types of tyre, tyre pressure, suspension type etc. and the prevailing conditions i.e. temperature, water saturation, ice formation etc. all influence the degredation of the road pavement to a greater or lesser degree. Research has now shown that there is a different load equivalence law for each distress mechanism - cracking, pavement deformation, longitudinal unevenness - for each type of pavement and for each climatic zone.

7.3 Since the AASHO test, other tests have been undertaken with the aim of comparing, in quantitative terms the damage caused by real traffic loads and load configurations such as the single wheel, twin wheels, twin wheel tandems and triaxles, all for twin and wide single tyres and various axle configurations, spacings etc. for different types of vehicle and, more recently, with different types of suspension.

The relationship between load and pavement destructive power assumed in the AASHO test to be proportional to the forth power of the load has now been reassessed with the relationship depending upon the type of failure mechanism and the type of pavement used. For fatigue phenomina and permanent deformation of flexible pavements it is usual to set the relationship to the forth power (as per AASHO). For semi rigid and rigid pavements and in regard to fatigue of hydraulically bound materials the power valves are between 11 and 33, depending upon the materials concerned. It is important to note that such high values reflect the dominant relationships of heavy axle loads even if they are infrequent.

The magnitude of the dynamic pavement loads varies with the unevenness of the longitudinal profile of the road, the type of suspension and the speed of the vehicle. When account is taken of the dynamic pavement loads, the load equivalence law for pavement life takes the form:

$$NI/NJ = \alpha (PJ/PI)^n$$

where n is the value of the power that best relates static rolling load to cycles of failure for the particular road surface, and α is a coefficient relating the life of the surface under a dynamically varying load to that under a rolling static load. At a speed of 80 km/h on a smooth road α can vary from 1.01 for a good air suspension to 1.25 for a steel semi-trailer suspension. At the same speed on a medium roughness road the corresponding range of α could be 1.03 to 1.25, and on a rough road 1.08 to 1.54. At higher speed or with poorer suspensions values of α in access of 2 have been estimated (thus reducing the life of the road by up to a half as a result of the dynamic pavement loads).

7.4 For poor road surfaces the dynamic effect of heavy axles remains significant even with air suspension (or its equivalent) but at a lesser degree than for poor conventional steel suspensions. However, on good, flat roads air suspensions produce dynamic loads that are less than on rough roads, and are less than those from steel leaf suspensions on smooth roads. Steel suspensions, particularly leaf spring with high friction produce relatively high dynamic loads on smooth road surfaces. It is a fallacy to suggest that if there were good flat roads then dynamic loading would be eliminated. This can only be approached if the vehicle suspension is "road friendly".

8. <u>"Road friendly" suspensions</u>

8.1 All the factors that help obtain good suspension performance also help to minimise the dynamic loads at the wheel and hence on the road. To make a good vehicle springing system soft springs, a rigid chassis, long suspension travel, good damping and a large ratio of sprung to unsprung mass are required. Most trucks have very stiff springs, very flexible chassis, very short suspension travel, a very low ratio of sprung to unsprung mass when unladen or lightly laden and either no dampers at all or have dampers mounted so that they have little effect. A poor suspension system leads to poor retardation and stability under braking. It is not possible to stop or steer when all the wheels are in the air.

With a damping system the damping force should increase with velocity. This is so with fluid damping but the inverse is so with frictional damping systems typical of multi leaf suspensions.

The use of air suspension (or suspension giving a similar performance), can reduce dynamic axle loads and improve load equalisation between multiple axles, especially on the semi trailer of articulated vehicles.

Although more expensive than steel suspensions, the use of air suspension is becoming more widespread as operators find it cost effective over the life of the vehicle, taking into account savings such as reduced tyre and brake wear and reduced vehicle structure and load damage.

8.2 Much practical research has shown that the center pivoted beam type of tandem axle suspension, known as the walking beam, causes much higher dynamic loads than even steel leaf springs, which in turn cause much higher loads than air or torsion bar suspensions..

Research by the UK and Germany has shown that dynamic axle loads are higher for leaf steel spring semi trailer bogies (loaded to their maximum permitted weight) than for the steel sprung tractor drive axle (again loaded at its maximum permitted axle weight). This is shown in the graph at figure 3 where not only the importance of the bogie is emphasised by its higher dynamic loading values than the drive axle when the suspension is either steel or rubber but it also shows that with air suspension the dynamic loads are radically improved.

9. Legislation for "road friendly" suspensions

9.1 Directive 89/338/EEC which gives rise to the first part of this proposal gives an advantage to air suspension for the drive axle of certain vehicles but also enables other suspensions to be used provided their performance matches that of air suspension.

9.2 As current legislation only promotes the use of air suspension or equivalent for drive axles of 3 and 4 axled vehicles the first logical step to road friendly vehicles is the extension of this concept to the other vehicles subject to Directive 85/3/EEC as amended, in particular to the 5 and 6 axled combinations. For these latter vehicles the maximum total weights and drive axle weights are already fixed (since 1986) and the question now is how to introduce or encourage the use of well suspended drive axles on these combinations.

There are two possible methods:

a) follow the pilosophy as applied to 3 and 4 axle vehicles and allow more total weight if a well suspended drive axle is fitted;
b) follow the method as applied to other technical requirements such as are contained in Annex II to Directive 85/3/EEC by which it will be compulsory to have drive axles which accord to the Community specifications for vehicles which are put into service as from a certain date.

Given the political difficulties in the past with the agreement for the 40 tonnes truck the Commission has chosen option (b).

9.3 It is considered that air suspension, or its equivalent (and that must include the ability to equalise load between axles of a bogie both statically and dynamically) should also be a pre requesite for trailer and semi trailer axles and that the Council should endorse the inclusion of these axle combinations as well, in a future directive on "road friendly" suspension. Depending upon the parameters selected for the equivalence to air suspension directive, it may be desirable to make a future directive more stringent by adopting lower frequencies, higher damping and lower tyre pressures.

9.4 Work on the effect of tandem and triple axle bogies of semi trailers on the road pavement has shown that even though the individual static axle loads are less than that of a drive axle their adverse effect can be as marked if the individual axle loads cannot equalise adequately.

9.5 It would be feasible to set a standard now by requiring air suspension to be fitted to tandem and triple axle bogies: i.e. all axles of a bogie, be they on a motor vehicle or trailer/semi-trailer should be fitted with suspension systems that are recognised as being "road friendly". As things stand at the moment it is only air suspension through its ability to minimise dynamic loading and to equalise the loading between axles that can be considered as road friendly.

9.6 For the future, current research should produce a definition of "road friendlyness" for suspension design which could enable these proposals to be amended in such a way as to specify performance criteria (and for bogies acceptable levels of load equalisation) which can truly relate to known benefits to the road pavement.

10. On going research

10.1 The OECD scientific expert group IR2 study on "the dynamic loading of pavements" is a project to do with the pavement and vehicle as an interactive system. In particular the project is concerned with that part of the dynamic loading of road pavements that is due to or influenced by the vehicle suspension.

10.2 The study includes the key players in worldwide research and legislative programmes. The groups investigation will be programmed over a two year period.

10.3 A complementary programme to the OECD study is the USA's Strategic Highway Research Programme (SHARP) which has been launched at an estimated total cost of $ 150 M but over a 5 years period.

10.4 Recommendations from these research programmes need to be fed into future legislation on the design parameters of vehicle suspension so as to further mitigate the harmful effects of load on the road pavements. These current proposals which only relate to the 11.5 tonnes drive axle, should be seen as the first step in that direction.

11. **Extending the scope of the proposal to cover all vehicles subject to Directive 85/3/EEC**

To Article 4 of Directive 85/3/EEC third and fourth indents are added.

The third indent makes the use of twin tyres and air suspension or its equivalent compulsory for drive axles of all vehicles covered by Directive 85/3/EEC and put into circulation from January 1993 where the maximum authorized weight of the drive axle is 11.5 tonnes.

The fourth indent lays down an upper maximum authorized weight limit for the drive axle of 10.5 tonnes where that drive axle is not equipped with twin tyres and air suspension or its equivalent, again for the relevant vehicles that are first put into circulation from January 1993. This is necessary to limit the adverse effect of the drive axle weight on the road pavement and encourage the use of "road friendly" tyres and suspensions through permitting a 11.5 tonne drive axle weight.

FIGURE I

DYNAMIC LOAD FACTOR AGAINST NATURAL FREQUENCY

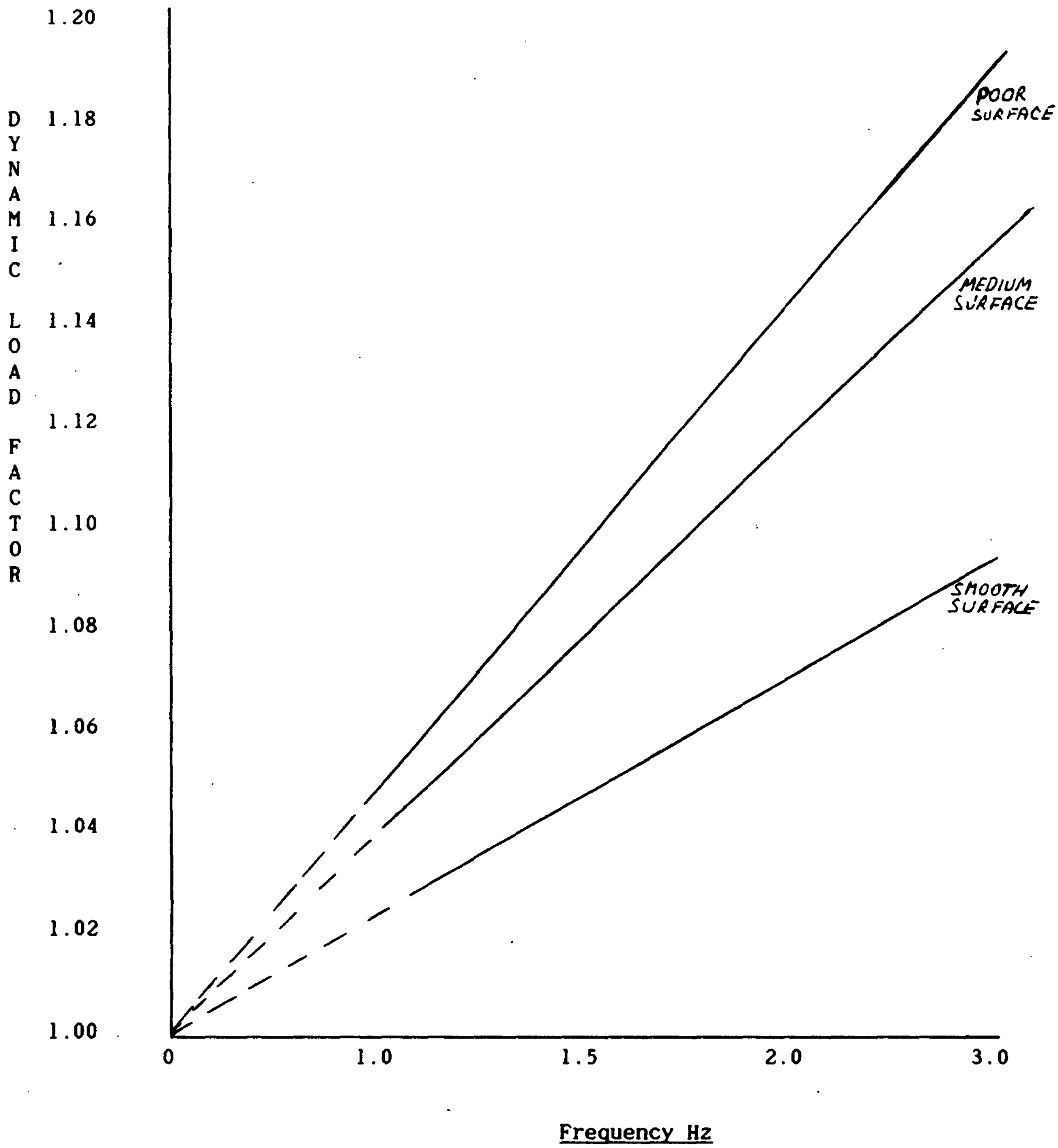


FIGURE 2

EFFECT OF VISCOUS DAMPING COEFFICIENT ON DYNAMIC WHEEL LOAD
FOR DIFFERENT NATURAL FREQUENCIES

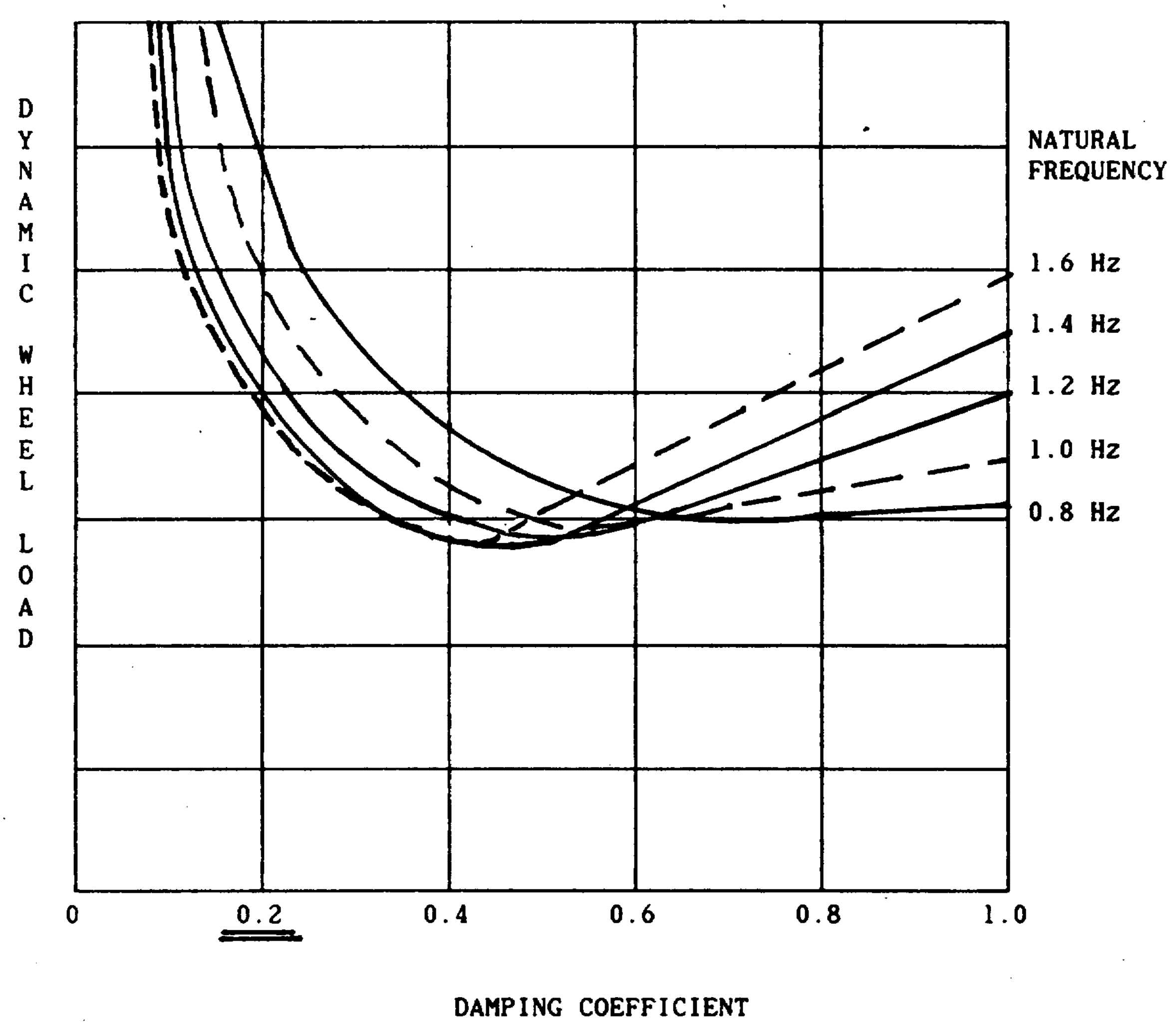
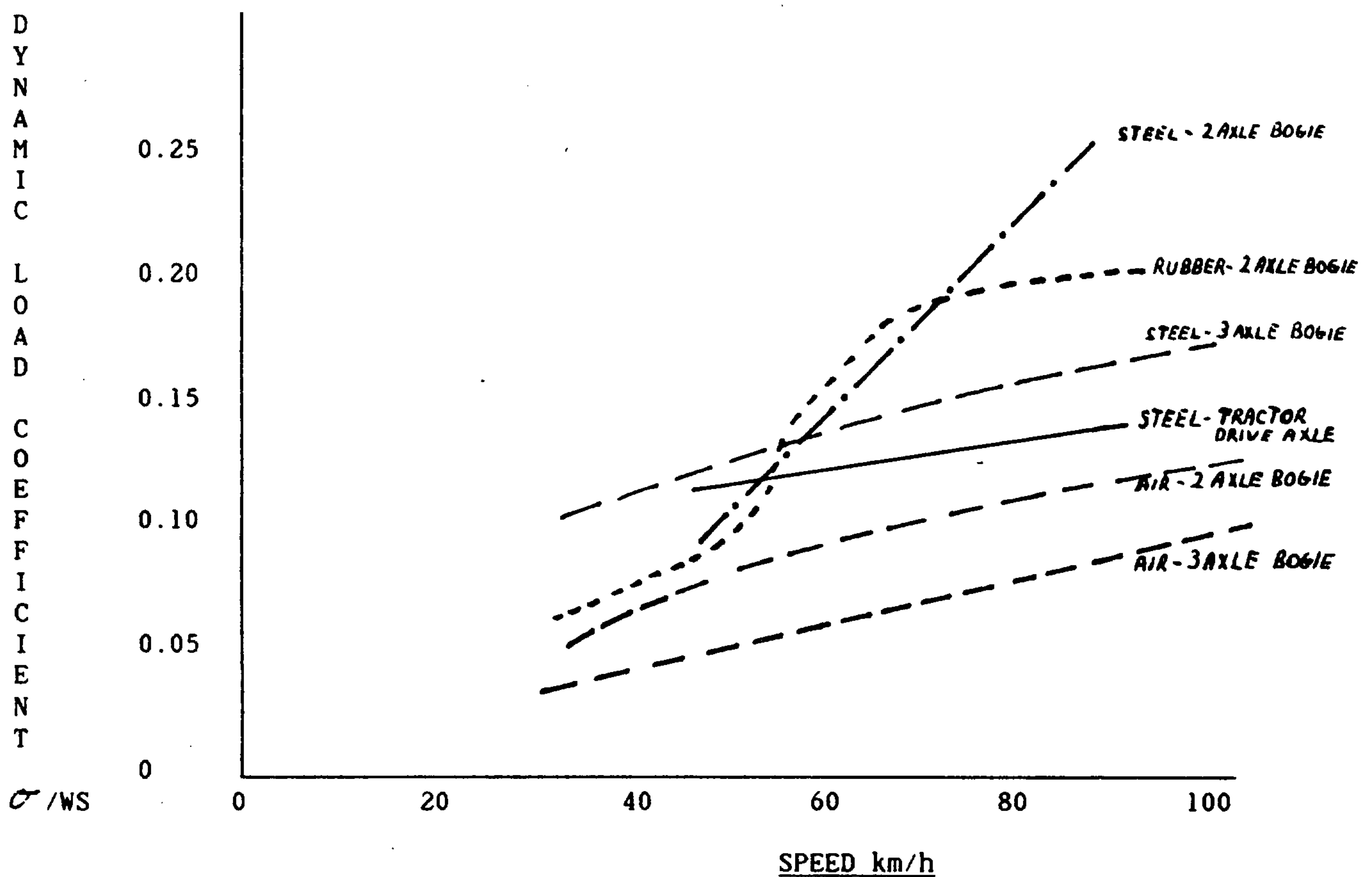


FIGURE 3

DYNAMIC LOAD FACTOR AGAINST SPEED FOR VARIOUS TYPES OF SUSPENSION

"MEDIUM" ROAD ROUGHNESS



Dynamic load coefficients for the tractor drive axle and 2 and 3 axle semi trailer bogies on the "medium" section of test track. Vehicles fully loaded.

On a "smooth" motorway type surface the dynamic effects of the air sprung 2 and 3 axle bogies were reduced by 50% throughout the speed range. The tractor drive axle effect was reduced by 50% at slow speed but rapidly increased to almost that on a medium surface at high speed. Very little improvement if any was seen with the steel or rubber bogie suspension.

On a rough surface the relative positions were maintained but at a higher level. The effect of the air suspended bogies approached that of the drive axle. Steel suspended bogies were relatively more marked in their effects with rubber suspension worst of all.

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THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 75 thereof,
Having regard to the proposal from the Commission [1],
Having regard to the opinion of the European Parliament [2],
Having regard to the opinion of the Economic and Social Committee [3],

Whereas, in the light of decisions made at the adoption of Council Directive 89/338/EEC [4] it is necessary to give an objective technical definition to the equivalence of air suspension,

Whereas, in order to mitigate the negative effect on the road pavement and on certain bridge structures of the 11.5 tonnes drive axle of heavy commercial vehicles, that drive axle should be fitted with twin tyres and air suspension or suspension considered to be equivalent,

Whereas the increased benefit of twin tyres and air suspension or its equivalence should permit the use of the 11.5 tonnes drive axle and whereas if the drive axle is not equipped with twin tyres and air suspension or its equivalent its maximum authorized weight should be limited to 10.5 tonnes,

Whereas measures to reduce the adverse effect of axle weight (both static and dynamic) on the road pavement and bridges should not prejudice the vehicles safety, in particular its stability and braking characteristics, indeed these qualities should be enhanced,

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(1) OJ No C
(2) OJ No C
(3) OJ No C
(4) OJ No L 142, 25.5.1989, p. 3.

Whereas this proposal can be considered as the first step towards prescribing requirements for vehicle axles and axle groups that take full account of the need to mitigate as far as possible the negative effect of the total vehicle on road and bridge structures;

Whereas Council Directive 85/3/EEC[5], as last amended by Directive 89/461/EEC[6], should be amended accordingly,

HAS ADOPTED THIS DIRECTIVE:

Article 1

Directive 85/3/EEC is hereby amended as follows:

1. The following third and fourth paragraphs are added to Article 4:

"For vehicles refered to in Annex I which are first put into circulation from January 1993 the provisions of Article 3(1) shall apply when the drive axle is at its maximum authorized weight of 11.5 tonnes and where it is equipped with twin tyres and air suspension or suspension recognized as being equivalent within the Community as defined in Annex III.

Where the drive axle of any vehicle referred to in the third paragraph is not equipped with twin tyres and air suspension or suspension recognized as being equivalent within the Community as defined in Annex III then the maximum authorized weight of that drive axle shall be limited to 10.5 tonnes."

2. Annex I is amended as follows:

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(5) OJ No L 2, 3.1.1985, p. 14.

(6) OJ No L 226, 3.8.1989, p. 7.

Paragraph 2.2.4.2 :

"2.2.4.2. is greater than 1.8 m	36 tonnes + 2 tonnes of margin when the MAW of the motor vehicle (18 tonnes) and the MAW of the tandem axle of the semi trailer (20 tonnes) are respected and the driving axle is fitted with twin tyres and air suspension or suspension recognized as being equivalent within the Community as defined in Annex III."

Paragraph 2.3.2 :

"2.3.2.	Three-axle motor vehicles	- 25 tonnes - 26 tonnes where the driving axle is fitted with twin tyres and air suspension or suspension recognized as being equivalent within the Community as defined in Annex III."

Paragraph 2.3.3 :

"2.3.3.	Four-axle motor vehicles with two steering axles	- 32 tonnes where the driving axle is fitted with twin tyres and air suspension or suspension recognized as being equivalent within the Community as defined in Annex III."

Paragraph 3.5.3 :

"3.5.3 1.3 m or greater but less than 1.8 m ($1.3\ m \leqslant d < 1.8\ m$)

- 18 tonnes
- 19 tonnes where the driving axle is fitted with twin tyres and air suspension or suspension recognized as being equivalent within the Community as defined in Annex III."

3. A new Annex III is added as set out in the Annex hereto.

Article 2

1. The Member States shall, after consultation with the Commission, bring into force the laws, regulations and administrative provisions necessary to comply with this Directive not later than 1 January 1993.

   When Member States adopt these provisions, these shall contain a reference to this Directive or shall be accompanied by such reference at the time of their official publication. The procedure for such reference shall be adopted by Member States.

2. Member States shall forthwith communicate to the Commission the provisions of national law which they adopt in the field covered by this Directive.

Article 3

This Directive is addressed to the Member States.

Done at Brussels, For the Council

The President

"ANNEX III

Conditions relating to the use of the 11.5 tonnes drive axle (or any drive axle with a maximum authorized weight above 10.5 tonnes).

1. Drive axles

The drive axle at a maximum authorized weight above 10.5 tonnes shall be fitted with twin tyres and be supported by a suspension system as defined in paragraphs 3 and 4.

2. Tyre contact pressure

Tyre contact pressure must not be greater than 8 bar.

3. 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.

4. Equivalence to air suspension

A suspension recognized to be equivalent to air suspension must conform to the following:

4.1 During free transient low frequency vertical oscillation of the sprung mass above a drive axle or bogie, the measured frequency and damping with the suspension carrying its maximum load must comply with the limits defined in paragraphs 4.2 to 4.5.

4.2 Each axle must be fitted with hydraulic dampers. On tandem axle bogies the dampers must be positioned to minimise the oscillation of the bogies.

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

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

4.5 The frequency of the sprung mass above the drive axle or bogie in a free transient vertical oscillation must not be higher than 2.0 Hz.

4.6 The definition of the frequency and damping of the suspension is given in paragraph 5 and the test procedures for measuring the frequency and damping are laid down in paragraph 6.

5. Definition of frequency and damping

In this definition a sprung mass M kg above a drive 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

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

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 $C = Co$, where

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

The damping ratio as a fraction of critical is C/Co.

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 cyles of oscillation as can be observed. The damping can be estimated by measuring the heights 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

$$D = \frac{C}{Co} = \frac{1}{2\pi} \ln \frac{A_1}{A_2}$$

ln is the natural logarithm of the amplitude ratio.

6. 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 slow speed (5 km/hr +/- 1 km/hr) over an 80 mm step with the profile shown in Figure I. The transient oscillation to be analysed for frequency and damping occurs after the wheels on the drive axle have left the step;

or b) be pulled down by its chassis so that the drive axle load is 1.5 times its maximum static value. The vehicle hold down is suddenly released and the subsequent oscillation analysed;

or c) be pulled up by its chassis so that the sprung mass is lifted by 80 mm above the drive axle. The vehicle hold up is suddenly dropped and the subsequent oscillation analysed.

The vehicle should be instrumented with a vertical displacement transducer between drive axle and chassis, directly above the drive 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 drive axle and the chassis directly above it.

FIGURE 1

STEP FOR SUSPENSION TESTS

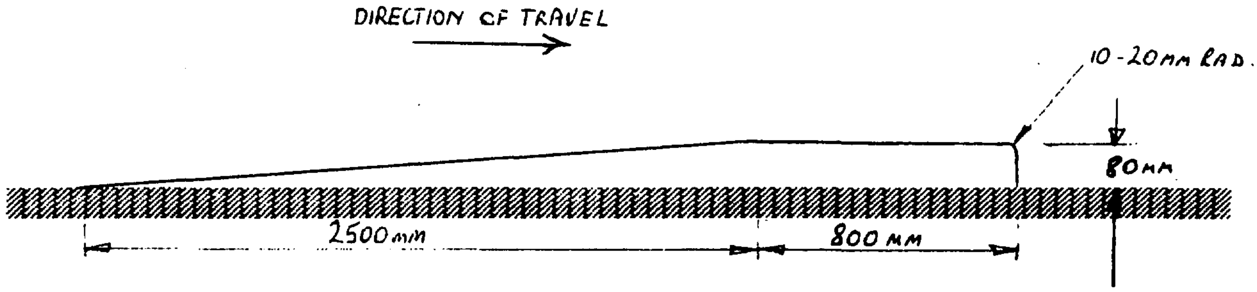
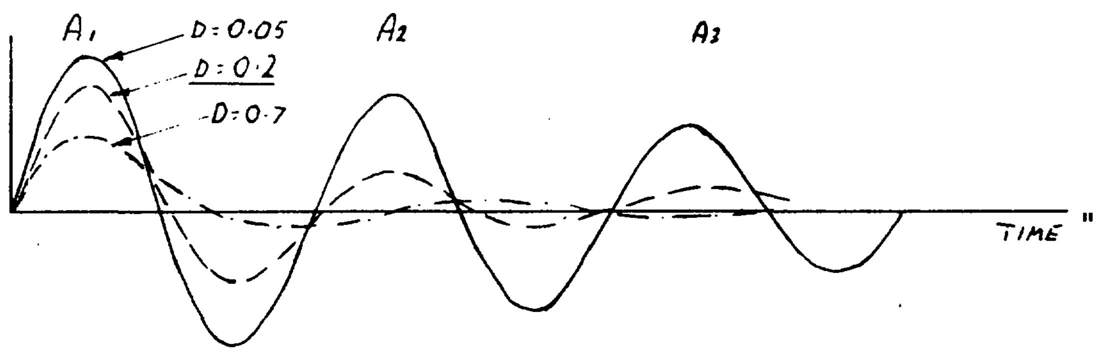


FIGURE 2

A DAMPED TRANSIENT RESPONSE



COMPETITIVENESS AND EMPLOYMENT IMPACT STATEMENT

I. What is the main reason for introducing the measure ?

This proposal concerns the requirements to fit twin tyres (as opposed to the wide single tyre), air suspension or its equivalent as defined to the 11.5 tonnes drive axle of heavy motor vehicles manufactured after 1 January 1993. The significant benefit of the proposal is the effect that such a "road friendly" drive axle suspension will have on reducing the road wear and tear that will come about through the introduction of the 11.5 tonnes drive axle limit in 1992. Most Member States currently have a drive axle limit of less than 11.5 tonnes because they are mindful of the additional wear and tear to roads and bridges that will be caused by the heavier axle. The first part of the proposal relates only to 3 and 4 axle rigid and 4 axle articulated vehicles. This is because Directive 89/338/EEC placed these parameters on their drive axles and requested the Commission to define the equivalence of air suspension, this has now been done. However, 3 and 4 axle rigid and 4 axle articulated vehicle are of relatively little importance in total international traffic (perhaps 12%) and so the greatest benefit can be gained by prescribing twin tyres and air suspension or its equivalence to all heavy motor vehicles in international transport, in particular the 5 axle and 6 axle combinations.

II. Features of the business in question

All enterprises which use these vehicles for transfrontier operations, and vehicle manufacturers.

III. What obligations does this measure impose directly on businesses ?

In order that an operator of heavy goods vehicles may use his truck at its maximum authorized weight (gross and/or drive axle) in international transport, the truck will need to be equipped with twin tyres (as opposed to wide single tyres), air suspension or its equivalent on its drive axle. This could increase the initial cost of the motor vehicle but should reduce the amount of wear and tear caused to the vehicle and to its load and thus reduce operating costs and provide a "softer" ride for the driver.

The vehicles industry, both vehicle and suspension component manufacturer, will have the choice of supplying trucks with air suspension or designing and approving an equivalent suspension; probably metal. This should not be a significant burden to industry as most manufactures are using air suspension drive axles already for the above reasons.

For the first part of the proposal, 3 and 4 axle rigid and 4 axle articulated vehicles, in order to take advantage of their maximum permitted gross weight in international traffic, their drive axles must be equipped with twin tyres and air suspension or its equivalence.

The full proposal extends the scope of the above to cover all heavy motor vehicle engaged in international transport and manufactured from 1 January 1993, in order that their drive axle can be loaded at a maximum authorized weight of 11.5 tonnes, that drive axle must be equipped with twin tyres and air suspension or its equivalent.. Where these parameters are not met then the vehicle drive axle shall be limited to a maximum authorized weight of 10.5 tonnes.

IV. What indirect obligations are national, regional or local authorities likely to impose on business ?

Implementation of the obligations are described in III.

V. Are there any special provision in respect of SME's ?

Where these enterprises are engaged in the manufacture of steel sprung suspension systems then they will need to ensure that the performance of those suspensions meets the parameters described in Annex III of Directive 85/3/EEC.

VI. What is the likely effect on:

a) The competitiveness of business

Whereas these measures could increase the cost of developing and manufacturing vehicles that are not currently equipped with air suspension, it will give both vehicle and suspension manufacturers the choice of either installing air suspension or developing and approving an equivalence. Air suspension drive axles are gaining popularity as their initial relative price reduces, their durability increases and the beneficial effects on both the driver and his load are realised. Competitiveness need not be adversly affected as a "steel suspension" manufacturer will still be able to supply suspensions for the 11.5 tonnes drive axle provided he meets the required design parameters. EFTA countries that manufacture trucks (in particular Sweden) are positive towards this proposal.

b) Employment

Neutral

VII. Have the relevant representation organisations been consulted ?

The representative organisations of vehicle manufacturers, operators have been consulted. Their opinion can be considered as favourable to this proposal.

ISSN 0254-1475

COM(90) 486 final

DOCUMENTS

EN 07

Catalogue number : CB-CO-90-535-EN-C
ISBN 92-77-65197-0

PRICE	1 - 30 pages: 3.50 ECU	per additional 10 pages: 1.25 ECU

Office for Official Publications of the European Communities
L-2985 Luxembourg