Consumer Label for Tyres in Europe

By Ulf Sandberg
Swedish National Road and Transport Research Institute
(VTI)

Final report
10 March 2008

Sponsored by the European Federation for Transport and Environment (T&E)

CONTENTS

EXECUTIVE SUMMARY

Consumer Label for Tyres in Europe
By Ulf Sandberg, Swedish National Road and Transport Research Institute (VTI)

In our society, many large-volume consumer products are associated with systematic consumer information, in some way including objective quality ratings. Consider, for example, a computer, a TV & sound system, a refrigerator, a vacuum cleaner, almost any type of food product: they all have some declarations or specifications which aid the consumer in his/her choice of product. More and more consumer products are also environmentally or health rated according to some objective schemes. Even cars, vans, busses and trucks have rather detailed specifications which the consumer may use to determine his/her choice of vehicle.

But for European tyres there is generally no objective quality-related information; despite their substantial influence on us personally and on our global environment. From a quality-point-of-view the consumer goes blindfolded through the tyre shop. Not even a consumer with great awareness can find objective quality information; except perhaps for a handful of tyres subjected to special tests.

It is commonly agreed that we need to urgently turn or strengthen some environment trends in our society to avoid a future climate disaster. Most obviously, this applies to CO_2 emissions from road traffic, something which is strongly related to rolling resistance. One would look for methods to faster obtain a reduction in rolling resistance than the present methods provide. Consumer interest and selections based on objective information may be such a method.

In this report, it is emphasized that similar advantages as for rolling resistance and fuel consumption apply to noise emission from road traffic.

This report has the following objectives:

- To examining the feasibility of a multi-criteria consumer / quality label for tyres, including tyre/road noise, rolling resistance (fuel efficiency) and safety aspects.

- To play an active role in the process of developing the concept and engaging key stakeholders.

First, the report describes how tyres are marked today in Europe as well as in USA. It further explains the current interest in tyre labelling and how consumers are informed about tyre performance at the present time. The plans of the European Commission for more stringent noise limits, connected with limits for wet grip and rolling resistance, as well as for a rolling resistance classification system, are described. The UTQG system for quality rating of tyres with respect to wet braking performance, tread wear and high-temperature endurance in USA is described as well as the plans there to introduce also a rolling resistance parameter.

The Nordic Swan and the German Blue Angel environmental labels are described and how they relate to tyre performance. How consumer information may be provided today and in the future is a subject of a relatively comprehensive chapter. Further, the measurement methods for the parameters considered are discussed in some detail and several shortcomings of them are identified.

One chapter reports the performance of present tyres on the market in terms of wet grip, rolling resistance and noise emission. Later, these performances are compared with existing and proposed future limits. Schemes for classification of tyres with respect to rolling resistance and noise emission are presented.

Based on the data and considerations in the report, a number of conclusions and recommendations are presented. A summary of these follows.

A common feature to all the parameters considered for a European limit and consumer information system, namely wet grip, rolling resistance and noise emission, is that the measurement methods and/or the reference conditions for all three have serious shortcomings which need improvements in order to create a cost-efficient system. Over the longer term, these problems must be solved to reduce the degree of randomness, and optimise the methods to the most important conditions.

In general, the author thinks that currently the testing is designed for the lowest testing costs, at the expense of reproducibility and representativity, and therefore the resulting system is not in the optimal interest of European consumers.

It is concluded that for the wet grip test the measurement method specified in ECE Regulation 117 and intended to be adopted also by the EU Commission, has such serious shortcomings that it is technically more or less useless in its present form. This is not due to a poor measuring principle, but due to much too wide tolerances on a number of critical topics.

It must also be recognized that the wet grip test in ECE Regulation 117 does not characterize the most critical safety performance of tyres. More critical performances not tested and not regulated include aquaplaning, wet grip at much higher speeds than in the test, wet grip for worn-out tyres as well as friction on icy or snow-covered roads. Furthermore, the limits for the wet grip tests are fairly liberal.

Nevertheless, in order not to further delay any measures to improve noise and rolling resistance performance, it may be necessary to accept the deficiencies of the method during a first phase. This shall then include a commitment to improve the method to accompany a second phase, where limit values should also be tightened. Therefore, for the wet grip test some of the recommendations are:

- Accept the wet grip method and minimum requirement in ECE R117 for political reasons, but realize that the technical quality of the method is limited until it has been improved in its details
- Give high priority to improving the method, considering detailed suggestions in this report.
- In a long-term perspective it would be preferable that the wet grip test would include also a reproducible condition when the drainage properties of the tyre tread are the most important
- Consider the practicability of including a wet grip test also for tyres which have been worn down to (say) a tread depth of 3 mm
- Include wet grip in a labelling system, but wait to do so until the measurement method has been improved

The wet grip test should include C1 tyres, as is the case in ECE Regulation 117. However, also C2 tyres should be included since many such tyres are used on vehicles driven in similar ways as cars, such as SUV:s.

It has been estimated that the potential fuel consumption and CO_2 reduction with low rolling resistance tyres is 3 %, and another 2.5 % may be obtained with tyre pressure monitoring systems, which would be a welcome contribution to achieving the CO_2 reduction goal of the EC. The author suggests that the labelling of tyres, together with a campaign to make vehicle owners aware of the new consumer information, would be the most important measure to achieve this goal.

It is proposed that the rolling resistance coefficient (RRC) is included in a tyre labelling and consumer information scheme for tyres for both light and heavy vehicles.

Of crucial importance to the efficiency of limiting and providing consumer information about rolling resistance is that appropriate measurement methods are used. This author thinks that the work to produce a more accurate method (ISO 28580) is promising and seems to be the method most suited to use for any tyre labelling or regulation regarding rolling resistance.

However, as justified in the report, it is urgent to work out modifications to the ISO method for reducing its remaining shortcomings, such as:

- To introduce a more realistic surface on drum, including unevenness and a more realistic road texture imitation.
- Calculate the air drag contribution by means of a simple model and add it. In the ISO methods, air drag is not included which means that narrow and wide tyres are not classified against each other in a fair way

The author further suggests that test speeds for C1 and C2 tyres are defined as 80 and 120 km/h. In ISO 18164 and in the coming ISO 28580 the speed of 80 km/h is already the preferred single reference speed. Without the air drag contribution, the speed has little influence, and thus it is enough to test at 80 km/h, but with the air drag considered, speed becomes in important factor and must be defined also at a higher level typical of motorway driving.

Realizing that the majority of vehicles will still have slightly lower pressures than the ideal, consumers shall be informed to adjust the inflation pressure a little higher than the ideal one from an overall point of view (i.e. as presently recommended by tyre and vehicle manufacturers). The intention is that the inflation pressure over the tyre lifetime should be as close as possible to the ideal one.

As a consumer labelling system the A, B, C, D class system proposed by the European Tyre and Rim Technical Organization (ETRTO) and essentially copied by the European Commission gives little incentives for further improvements and it is totally "stiff". It will therefore not be very effective. This author recommends a system according to which tyres are labelled with the actually measured value. However, if a class system is chosen, the author proposal another system for classes and limits which corresponds well to the actually measured RRC and has full flexibility and is easy to adapt to a changing world.

The limit levels for RRC proposed by ETRTO and the Commission are not stringent enough to be effective; their justification is poor. On the other hand, the author believes that the consumer information on RRC is much more effective.

The author proposes that the limit levels for noise emission suggested by the Commission are introduced in 2012 without exception or change. The proposed new noise limits are by no means a final solution to the noise problem. The next step may be suitable to take at about year 2020. The author proposes to establish a so-called "70 dB goal" for year 2020. It would imply that "no tyre shall emit more than 70 dB at the test conditions in the year 2020". Politically, it is important to work towards such a long-term goal, even if a few tyre types will not be able to meet it already in 2020.

It is proposed that also the exterior noise emission is included in a tyre labelling and consumer information scheme. However, the limit as well as the labeling scheme shall apply not only to new and replacement tyres, but also for retreaded tyres. Unless this is done, one will miss a large percentage of the tyre fleet and the scheme will be less efficient.

Arguments why the consumers are interested in noise include the following:

- As demonstrated in this report, when consumers have been asked about their interest in various tyre performances, noise has come up as a parameter of interest and where consumers have expressed willingness to purchase low noise tyres, even if such tyres would cost a little extra.

- There is plenty of evidence that manufacturers recognize consumer interest in low-noise tyres. These features appear increasingly frequently in marketing, especially internet marketing: some examples are shown in the report. The manufacturers obviously consider that these characteristics are of interest to customers.

- Almost all tyre tests made by car and other technical magazines contain information about noise. If this was not of interest to the readers, why care to test and report it?

- The arguments for consumer interest in the replacement market are even more valid for OE and public procurement markets, where a higher level of expertise can be expected from purchasers. This is especially important with a view to green purchasing requirements for public authorities and transportation companies run by or under control of these.

- Low-emission zones are becoming increasingly popular in European cities and low tyre noise emissions are a likely future parameter for vehicles allowed to enter such zones.

It is suggested that the really measured value is labelled, rather than classifying tyres into quality classes. However, the author also presents a classification system based on a "star" label.

As for wet grip and rolling resistance, there are shortcomings in the measurement methods and conditions which limit the efficiency of the system. This applies most importantly to the reference surface used for tyre noise testing. Some aspects related to the reference surface urgently need to be improved, namely:

- The ISO reference surface must be specified more in detail with tighter tolerances and using better measurement methods
- A second reference surface, with a rougher macro- and megatexture shall be specified and used
- It is suggested also to use a reference tyre for normalization of differences between different test tracks, the tyre of which may be the new SRTT defined in ASTM F2493-06 [ASTM, 2006]. This is a similar principle to that intended for improving the RRC test.

For the mentioned suggestions the author has listed a proposed timetable.

The author suggests a number of policy considerations. For example, it is pointed out that already today there are national policies for the use of low-noise road surfaces. That is not to say that a common European framework could not enhance the system, but one must recognize the substantial economic consequences which current policies already have and the benefit they offer to society, since knowledge about this fact is missing among some actors on the scene. Now is the time that the economic consequences of noise reduction (if any) are shared also in the tyre sector rather than only in the road sector.

The author also points out the limitations on noise reduction that are imposed by current lack of speed limits on some German motorways, as well as the effects of current marketing of vehicles in which high power and high speed performance, often hidden behind clichés such as "driving pleasure", are highlighted above all. The author thinks that a discussion should take place between authorities, consumer organizations and the industry on a code of conduct in future marketing of vehicle performance.

It is extremely important for the efficiency of the low-noise tyres that consumer information of noise and not only of rolling resistance is included in the future system. In fact, the inclusion of both parameters may encourage the consumer to select tyres which shift the costs from both consumers and noise sufferers towards higher quality tyres which utilize a higher level of technical sophistication, resulting in a shift of overall transportation costs from oil, CO_2 and noise annoyance to an improved product; and yet with a net benefit to the consumer himself.

If a system is chosen in which the tyres are marked only with a label (a class) and not with the actually measured values, the actually measured values of wet grip, rolling resistance and noise shall be reported in a publicly available document. It is proposed that such values be reported to some common European organization, such as the European Environment Agency, which shall publish them on a website and keep this database updated. It is also suggested that the website will contain some statistical information of the values, such as frequency distribution of the values for each tyre category.

The author has listed several hints on how the consumer information can be aided by for example pasted notes on the new tyres, consumer information leaflets at the tyre dealers, computer databases that will make it possible for a consumer to see what the tyre dealer has in stock on a scale of rolling resistance or noise values, and on-line systems connected with the central European database. By clever design such systems may be made relatively easy to understand and use by the tyre dealers as well as by the common tyre consumer. The central European organization that would handle the database might also provide suitable computer programs for use by tyre dealers to aid in their consumer information.

The possibilities for future consumer information are outstanding and mainly limited by imagination and the possibility to provide the information in an understandable way for the consumer. As shown in an example in the report, environmentally friendliness is a relative concept and some definitions seem to be confusing and easy to misinterpret.

1 INTRODUCTION AND PROBLEM IDENTIFICATION

The choice of tyres on our vehicles influences us substantially in several ways. It influences our safety, since vehicle dynamics and skid resistance under various conditions are affected. It influences our economy, since purchase costs are significant and, moreover, different rolling resistance affects our fuel costs. It also influences our comfort and wellbeing by the noise and vibrations transmitted into our vehicles. Finally, but not the least; it influences our exterior environment; both locally, as noise emission, as well as globally, since CO_2 and other air pollution are strongly related to the rolling resistance.

Thus, each road vehicle owner, by his/her choice of tyres, has a substantial influence on his own life as well as that of others; and even on our global environment. What is there then to aid the consumer in selection of tyres? The answer is: practically nothing. The consumer can check by the markings on the tyre that it fits his/her vehicle in terms of dimensions and use (speed rating, winter operation, etc), but once this selection has been made, after which there are hundreds of brands and types available to choose from, the only information is generally the price tag and the visual appearance. At least, this is the case in Europe; in North America there are indeed some quality criteria also. As reported later in this report, this is largely reflected in the consumers' choice, where price tag, visual appearance and brand name are very important criteria for the tyre purchase.

In our society, many other large-volume consumer products are associated with consumer information, in some way including objective quality ratings. Consider, for example, a computer, a TV & sound system, a refrigerator, a vacuum cleaner, almost any type of food product: they all have some declarations or specifications which aid the consumer in his/her choice of product. More and more consumer products are also environmentally or health rated according to some objective schemes. Even cars, vans, busses and trucks have rather detailed specifications which the consumer may use to determine his/her choice of vehicle.

But for European tyres there is generally no objective quality-related information; despite their substantial influence on us personally and on our global environment. From a quality-point-of-view the consumer goes blindfolded through the tyre shop. Not even a consumer with great awareness can find objective quality information; except perhaps for a handful of tyres subjected to special tests. It is rather likely, if not sure, that this results in the choice of lower quality and cheaper tyres than if appropriate consumer information were available. But it is also likely that for some other consumers it results in the choice of tyres which look attractive or "sporty", but which need not necessarily be of high technical quality; in fact such choices may be counterproductive.

It is commonly agreed that we need to urgently turn or strengthen some environment trends in our society to avoid a future climate disaster. Most obviously, this applies to CO_2 emissions from road traffic, something which is strongly related to rolling resistance. One would look for methods to faster obtain a reduction in rolling resistance than the present methods provide. Consumer interest and selections based on objective information may be such a method. It was estimated in [TNO/IEEP/LAT, 2006] that the potential fuel consumption and CO2 reduction with low rolling resistance tyres is 3 %, and another 2.5 % may be obtained with tyre pressure monitoring systems, which would be a welcome contribution to achieving the CO2 reduction goal of the EC.

In this report, it is emphasized that similar advantages as for rolling resistance and fuel consumption apply to noise emission from road traffic.

Tyre/road noise has been identified as one of the most severe environmental nuisances in Europe [Com, 1996]. It reduces the quality of life for hundreds of millions of Europeans; for many millions it even provides potential health hazards. Progress to reduce the noise emission from the tyre/road interaction has been made mainly in terms of quieter road surfaces. No trends for reduced exterior noise from tyres of newer versus older types have yet been demonstrated; although there seems to be on the market tyres which are considerably less noisy than the majority of tyres. Does it need to be so?

The limiting levels for noise emission by tyres which were introduced a few years ago in the EU Directive 2001/43/EC have been demonstrated to be largely in-effective, and only very few of the ”worst” tyres have disappeared [FEHRL, 2006-1]. Unfortunately, if only a few per cent of tyres on the market are replaced by ”quieter” tyres, this produces no appreciable reduction in the total sound level of the traffic. In order to achieve an effective reduction, the majority of tyres must be replaced but, with the present tyre noise regulations, this is most unlikely to occur within the foreseeable future. New limits presently being discussed will, if introduced, have an effect, but will mean a reduction in the traffic noise overall levels far from what would be needed in order to substantially improve the environment for the European citizen.

From the standpoint of society, a faster change to ”quieter” tyres is needed, and this applies to the majority of tyres and not only to the very ”worst” ones which are affected by maximum noise limits in the present regulatory system. Such a development can be accelerated by promoting the purchase and use of low-noise tyres by consumers, by making available appropriate consumer information.

Today, the only labelling of European tyres are marks that say that the tyre is type approved with respect to fatigue endurance and noise (although tyres in USA have some quality-related labels; see below). However, there is no real information for the consumer in this, since any car, van or truck tyre for road use which does not have these marks should not at all appear on the market.

This report examines the feasibility and justifications for introducing some quality-related labelling on European tyres and/or providing objective consumer information publicly available.

2 THE OBJECTIVES OF THIS WORK

This project has the following objectives:

- To produce a report examining the feasibility of a multi-criteria consumer / quality label for tyres, including tyre/road noise, rolling resistance (fuel efficiency) and safety aspects.

- To play an active role in the process of developing the concept and engaging key stakeholders.

The feasibility report is to be used by its sponsor, the European Federation for Transport and Environment (T&E), as the basis for a submission to the European Commission, DG Enterprise, and European Parliamentarians putting forward a concept for a consumer label to be included in the forthcoming directive on tyres (to replace 2001/43/EC on tyre/road noise).

The report will also be used as an interim report to the Swedish Road Administration (SRA) for a project related to this work, named "Environmental Characteristics of Tyres".

3 INFORMATION MARKED ON TYRES TODAY

3.1 Tyre design and manufacturing information

It is required by authorities that information which identifies and describes the fundamental characteristics of a tyre and also provides an identification number for safety standard certification and in case of a recall are marked on the tyre sidewalls. Actually it is required on only one of the sidewalls, although at least some basic data such as tyre brand and dimensions usually appear on both sidewalls. Fig. 1 shows the markings that are mandatory for car tyres (so-called class C1) in regions such as Europe and North America.

As appears in Fig. 1, the markings numbered 1-12, 14 and 16 show data regarding the tyre brand, dimensions, speed class, load, construction, main use, main type, time of production, etc; all of these being design, manufacturing or construction parameters. Number 13 is one or two marks showing that the tyre is type approved with respect to durability and to noise emission according to some European Directive or UN ECE Regulation. Marking No. 15 in the figure is not required in Europe; it is unique to the United States (see more below), although it often appears on tyres in Europe too.

Tyres in Japan do not need to show the E-markings (No. 13 in Fig 1) , and neither the quality markings shown as No. 15 in Fig. 1.

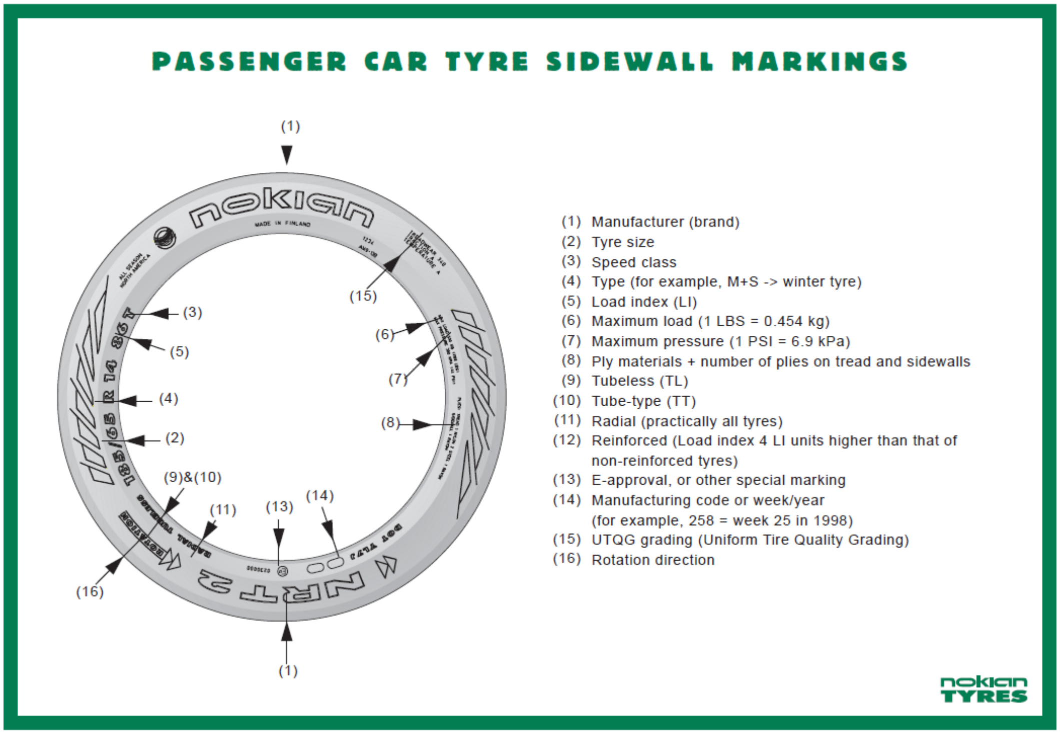


Fig. 1. Tyre sidewall markings used in Europe and North America (a few of them are not mandatory in Europe, see the text). The figure is from [Nokian, 2007].
Van ("light truck") tyres and truck tyres have slightly different markings; mainly related to the load capacity in various tyre configurations.

Based on this, the user can purchase his/her tyre to fit the requirements of his/her vehicle. However, there is no information among the mentioned markings that shows the performance or quality of the tyre. One may argue that the markings represented by No. 13 shows performance of the tyre since they mean that the tyre has been tested to meet a durability requirement and a noise requirement; however, all (new) tyres on the market must have such a label, so it shows no additional quality rating.

3.2 Quality-related labelling

In Europe there is no requirement of marking of any performance or quality rating of a car, van or truck tyre for on-the-road use. However, in USA it is required to include a quality marking called UTQG (see marking No. 15 in Fig 1), according to a special grading system. This grading system, known as the Uniform Tire Quality Grading System (UTQGS), allows consumers to compare tyre treadwear, traction performance, and temperature resistance. The system applies only to passenger car tyres and not to light truck or heavy truck tyres. The US federal government requires tyre manufacturers to grade their tyres in three subject areas and place the information on the sidewall. The UTQGS includes the following three gradings:

- **Treadwear** (the resistance to wear of the tyre tread rubber; the higher the treadwear number is, the longer it should take for the tread to wear down)
- **Traction** (the tyre's ability to stop on wet pavement; in Europe the terms “wet grip”, "adhesion" or "skid resistance" are more common)
- **Temperature** (the possibility to endure sustained high temperatures; for example, driving long distances in hot weather)

The grading scales are described below [NHTSA, 2007]:

Treadwear: A control tyre is assigned a grade of 100. Other tyres are compared to the control tyre. For example, a tyre grade of 200 should wear twice as long as the control tyre. Current tyres in USA have treadwear numbers of 100-600 (with some extremes below and above); for example 32 % are rated 301 - 400.

Traction: Traction (in Europe one would mostly say “wet grip”) is graded from highest to lowest as "AA", "A", "B", and "C". Of current US tyres, 75 % are in grade A, 22 % in grade B and 3 % in grade AA.

Temperature: From highest to lowest, a tyre's resistance to heat is graded as “A”, “B”, or “C”. Of current US tyres, 27 % are in grade A, 59 % in grade B and 11 % in grade C.

An evaluation of the UTQG labelling system, which had been in use since 1968, was made in 1991 by questionnaires to 500 individual consumers and 300 tyre dealers and presented in [Weiss, 1992]. The findings were that 38-75 % of individual consumers knew about the gradings (percentages relate to the type of grading), as well as:

- More than 50 percent of the surveyed potential consumers rated information about all three UTQG items important in tyre purchase decisions (treadwear rating - 83 percent, traction rating - 79 percent, and temperature resistance rating - 54 percent).

- Less than 50 percent of the surveyed recent consumers rated information about the UTQG items important in influencing their last tyre purchase decision (treadwear rating - 29 percent, traction rating - 27 percent, and temperature resistance rating - 12 percent).

According to this author’s interpretation, the results indicate that the gradings indeed have a significant influence of the tyre choice, especially that about treadwear and traction; although most probably more could be achieved if consumers were better informed. The large difference between “potential consumers” and “recent consumers” might indicate either that the trend was an increasing awareness (perhaps by the questionnaire?), or that “talking is one thing and action is another thing”.

3.3 Public availability of measured noise levels

The type approval system in accordance with 2001/43/EC implies that all (new) tyres must be subjected to a noise measurement. Each tyre is then assigned a sound level. One problem, however, is that the tyre manufacturer is not obliged to mould this sound level on the wall of the tyre. As shown above, a lot of other parameters are moulded, and the addition of the sound level cannot be difficult. The lack of any marking of noise level means that those who want to publish data for tyres on the market will encounter difficulties since sound level data are not readily accessible. Such data must be obtained from the authority that has issued the type approval, and this may be anywhere in the EU, and it is a huge work to compile all these levels for the thousands of tyre brands and dimensions available.

The system would however be much more manageable if a requirement were added to the EU Directive as soon as possible, to the effect that the sound level must be displayed on the sidewall of the tyre.

Noise labelling is of current international interest. For example, there is a Technical Study Group on “Noise labels for Consumer and Industrial Products” under the International INCE (Institute for Noise Control Engineering). In an oral presentation at Inter-Noise 2005 in Rio de Janeiro the groups' chairman gave numerous examples of noise labels on products. A status report is available as a paper at the 2004 Inter-Noise conference [Berry, 2004].

4 RECENT INTEREST IN TYRE LABELLING

4.1 European Commission

In its recent "Consultation Document" [Com, 2007], the European Commission writes the following related to labelling:

"However[1], development and use of LRRT needs to be encouraged and accelerated if they are to make a significant contribution to the CO2 reduction strategy. This could be achieved by a combination of mandatory requirements and consumer information (e.g. through tyre labelling). The proposed approach is to define four rolling resistance performance bands (A to D) each with a specified maximum rolling resistance value. D would be the minimum requirement for type approval. However, consumers would be encouraged to purchase tyres in categories A or B. Vehicle manufacturers specifying tyres for new vehicles would be encouraged to specify tyres with a lower RR value in order to improve a car model's CO2 rating. After-market consumers would be guided by means of a labelling scheme. The proposed rolling resistance bands are set out in Annex II."

The Annex II proposal is shown in Table 1; where only the part related to labelling is included.

Table 1. Proposed classes ("bands") of rolling resistance; from [Com, 2007].

Annex 2 – Proposed Tyre Rolling Resistance Limits

In addition, tyres in categories C1 and C2 are to be graded according to the following bands.

Tyre Category	Maximum rolling resistance coefficient per band (kg/tonne)			
	Band A	Band B	Band C	Band D
C1	9.0	10.5	12.0	13.5
C2	7.5	9.0	10.5	12.0

With regard to noise levels, the document does not mention any labelling. Since the FEHRL report suggested noise level labelling, see 4.4 below, the interpretation by this author is that the Commission rejected the noise labelling proposal.

[1] Text in blue colour and with a grey background is a direct citation from a referenced document

4.2 United Nations Economic Commission for Europe (ECE)

The United Nations Economic Commission for Europe has a "World forum for harmonization of vehicle regulations" (WP29). WP 29 has a Working Party on Brakes and Running Gear (GRRF) and another on Noise (GRB). In GRRF Russia proposed in 2003 that the rolling resistance coefficient (RRC) of tyres shall be measured during the type approval process and this should be used as consumer information to the end users [GRRF 2003/30, 2003]. This author thinks that it meant that tyres shall be marked with its RRC but this is not expressed in the documents. Since then, the Russian Federation, ETRTO and others have worked with the matter and in September 2007 the work was reported as close to ready for a formal change in the regulations to require the measurement of RRC according to a new ISO method being prepared [GRRF-62-39, 2007]. It is still unclear to this author if the intention is to label the tyres with the measured RRC, but from what is written in the next paragraph and Table 2 it seems that the intention is to mark tyres with an RRC category letter.

At the same GRRF session, a paper was presented which summarized the status of the work [GRRF-NAMI, 2007]. In this presentation two grading schemes for RRC of tyres were presented, see Table 2. It appears from this, that the Commission's proposal in Table 1 is a copy of the ETRTO proposal in Table 2.

Table 2. Proposed categories of rolling resistance; from [GRRF-NAMI, 2007]. The values in the table are expressed as promille (one-thousands) of the RRC. The NAMI column is a proposal from the Russian Federation (RF) and the ETRTO column is proposed by the European Tyre and Rim Technical Organization (ETRTO). PC = passenger cars, LT = light trucks, CV = commercial vehicles.

TYPE	CATEGORY	NAMI (RF) 2002	ETRTO 2007
PC	A		<9.0
	B	<11.0	9.0–10.5
	C	11.0–13.0	10.5–12
	D	13.0–15.0	12–13.5
	off-range	>15	
LT	A		<7.5
	B		7.5–9.0
	C		9.0–10.5
	D		10.5–12.0
CV	A		
	B	<10.6	
	C	10.6–11.8	
	D	11.8–13.0	
	off-range	>13.0	

4.3 European tyre manufacturers

In its answer to the above-mentioned Consultation Document, the ETRMA[2] writes [ETRMA, 2007-1]:

"Our comments to the EC proposal are as follows:

1. The limit values in both tables (max values and grading) should be increased by 1 kg/t for all the M+S tyres of each tyre category: C1, C2, C3, and not only for the special tyres, as indicated.

2. The maximum value for the C1 tyre category (footnote 7) should not be reduced from 13.5 to 12 kg/t before at least 4 years and an impact assessment of further reduction has been performed. As a result of that, the grading system cannot be reduced to 3 classes.

Providing those two points above are taken into account in the future, we agree with the limits proposed."

Although the ETRMA does not directly say "yes" or "no" to the grading system for rolling resistance, this author interprets the answer as an indirect approval of the grading system, although there are concerns about some of the limits.

However, the ETRMA is clear about a grading system for "wet grip", which the organization suggests, as follows:

"To enable consumers to make an informed choice taking into consideration environment and safety, the Tyre Industry requires a mandatory grading system on wet grip that will be implemented in parallel to RR grading for Passenger car and light-truck tyres. When available, the information on the grading will be shown on a label or similar way of consumer information."

As far as this author knows, the ETRMA has not officially commented on the FEHRL proposal to introduce noise labelling (see 4.4 below). However, at one of the meetings between FEHRL and ETRMA during the production of the FEHRL report, the ETRMA representatives rejected noise labelling with the argument that there was not enough space on some tyre sidewalls to add more markings than presently. Since then, evidently, the ETRMA has found out that there is space for rolling resistance and wet grip labelling, so the efforts to find space for a third label should not be too difficult; bearing in mind that in the USA they already have three quality gradings marked on the tyre sidewalls.

The author made a small survey of the sidewalls of low-profile tyres on parking places. It was noticed that for 45 % and 40 % aspect ratio tyres, which were the lowest aspect ratios found, there was still plenty of space for new labels on

[2] ETRMA = European Tyre & Rubber Manufacturers' Association

"normal" sidewalls; i.e., sidewalls with no particular sidewall reinforcement. However, on one 40 % aspect ratio tyre, having a pronounced sidewall reinforcement running around the sidewall and dividing the sidewall area into two halves, of which only one was suitable for labels (approx 30 mm wide), there was a slight problem with markings. One side of this tyre was full of text and other types of labels, but the other side had approximately 30^o of its circumference empty. This tyre, in terms of available sidewall space, would be rather similar to the tyres with the lowest aspect ratios on today's market, which would be the 25 and 30 % tyres used on extreme sports cars. Therefore, the author's conclusion is that there is not yet a problem in finding space for a few more labels on the tyre sidewalls.

4.4 FEHRL

Following a commitment to review the tyre noise limits in connection with the establishment of Directive 2001/43/EC, which set up tyre noise limits for the first time, the European Commission in 2005 awarded a project to FEHRL[3] with the main objective [FEHRL, 2006-1]:

> To investigate whether and to what extent technical progress would, without compromising safety, allow the introduction of more stringent limit values regarding tyre/road noise emission limits compared to the limits given in Annex V section 4.2.1., column A of Directive 92/23/EEC as amended by Directive 2001/43/EC. The limit values indicated in columns B and C in Directive 2001/43/EC shall be used as reference.

It was also stated that FEHRL should present conclusions and recommendation for the further development of the Directive.

FEHRL produced a final report [FEHRL, 2006-1], as well as a comprehensive book of Appendices, most of which was a Literature Review [FEHRL, 2006-2]. The final report recommended new noise limits; a proposal which essentially was taken over by the Commission and subject to the Public Consultation mentioned in Section 4.1 above. However, FEHRL also suggested to the Commission to introduce a noise labelling of the tyres. This Section is copied below:

> 6.2 Labelling tyres with their type approval noise levels
>
> Some consumers may wish to demonstrate environmental responsibility by choosing tyres that have scored well in the type approval test. A low noise level in the test might also be an indicator to consumers of tyres that would provide lower noise levels within their vehicles and therefore provide and additional degree of comfort during driving.
>
> Two forms of noise labelling could be considered:

[3] FEHRL was formed in 1989 as the Forum of European National Highway Research Laboratories. The institutes performing this study were: TRL Ltd, BASt, VTI and (as subcontractor) TÜV Nord.

1. Tyres could have a number stamped on the side wall, indicating the noise achieved in the tyre noise test.

2. A threshold could be set for a tyre to be considered ‘low noise’. (eg 3 dB(A) below the limit value). If the noise level measured in the test equalled or was below the threshold, the manufacturer would be entitled to stamp the words ‘low noise’ on the tyre, and use this in advertising materials.

Both methods would enable consumers to identify the noise performance of tyres at the point of sale. This would have particular advantages in the replacement tyre sector. This approach would also bring tyres into line with many other sectors, such as household ‘white goods’, which are provided with both energy and noise rating labels.

Such labelling schemes could, in principal, be implemented in the same way as information on tyre size, tyre ‘speed rating’ etc., which is incorporated on the sidewall of the tyre. However, it should be noted that the tyre industry representatives did raise a concerns over the costs of labelling and on the availability of space on the sidewall of the tyre to incorporate noise level ratings (see Chapter 4). However, it should be noted that at the IEA workshop in Paris in 2005 (see section 4.6.3) the tyre industry representatives indicated they were very keen on introducing some kind of labelling of the energy efficiency of tyres.

A further point is that if tyres were stamped with the noise level that they scored in the type approval test, this would assist member states that are considering incentive schemes to create a market for low noise products. Such schemes already exist in Germany (the Blue Angel labelling scheme) and the Nordic countries of Sweden, Denmark, Norway, Finland and Iceland (the Nordic Swan; see www.svanen.nu for further details).

It is recommended, therefore, that consideration is given, when revising the current Directive, for including a requirement for tyre manufacturers to label tyres according to their noise emission. This could be in the form of a noise level stamped on the sidewall. An alternative could be a label stating that tyres are ‘low noise’ provided they meet an agreed threshold that is set below the agreed noise limit.

In the chapter with conclusions and recommendations, the FEHRL group included the following two points referring to labelling:

20. Consideration should be given, when revising the current Directive, for including a requirement for tyre manufacturers to label tyres according to their noise emission. This could be in the form of a noise level stamped on the sidewall. An alternative would be to label tyres as ‘low noise’ provided they meet an agreed threshold that is set below the agreed noise limit. Threshold levels could be set at 3 dB(A) below the proposed limit values. (Further details are given in Section 6.2).

28. The Directive should specify that tyres must be stamped (labelled) with the noise level achieved in the type approval test. This would assist member states that are considering incentive schemes and would improve consumer choice. See also recommendation 20 under Work Package 3 above.

4.5 Views expressed by various other organizations

Support for improved consumer information was given in the very comprehensive tyre study made for the EU Commission by TÜV Automotive from Germany and published in 2003, where it was stated [TÜV Automotive, 2003]:

"Introduction of a consumer information system (quality ranking) since, at present, consumers can only classify tyres according to their performance and scope of application. This would enable them to buy products which satisfy their specific requirements based on specialist knowledge of tyre development processes and marketing policies (i.e. there is a specially developed OE tyre for my vehicle, can a certain aftermarket guarantee the same safety performance?). In this field, as already mentioned previously, consumer information roughly in line with the American UTQGS system could be of assistance. Within the scope of such a system, criteria and evaluations must be given thorough consideration and agreed with industry."

Other major reports and papers suggesting noise labelling of tyres include [Kropp et al, 2007], [Watts et al, 2005] and [TNO/IEEP/LAT, 2006]. In the Consultation process mentioned in section 4.1, several responses have proposed the introduction of a noise labelling scheme. This includes, e.g., the following organizations:

- Chalmers University of Technology
- Conference of European Directors of Roads (CEDR)
- European Federation for Transport and Environment (T&E)
- United Kingdom Department for Transport
- Swedish Road Administration
- Swedish Road and Transport Research Institute (VTI)

The author does not know about any organization that has rejected noise labelling in its answer to the Commission.

The International Energy Agency (IEA) in November 2005 organized in Paris a Workshop named "Energy Efficient Tyres: Improving the On-Road Performance of Motor Vehicles". The participants included experts in tyres, materials and roads, government officials, representatives of major tyre manufacturers, NGOs and other interested groups. The summary of this workshop contains one particular paragraph on labelling, which reads [IEA, 2005]:

"Several different labelling schemes for tyres were proposed, explored and demonstrated to be technically feasible. A labelling scheme is attractive because it addresses the market failure arising from lack of information to the consumer. Manufacturers noted that individual efforts to label rolling resistance had been ineffective, perhaps because consumers preferred a thirdparty labelling system or perhaps because consumers considered fuel efficiency a low priority. For maximum effect, a label needs to take into account other features of the tyres and be linked to new or existing regulations."

It also contains one paragraph which indirectly addresses the need for labelling, or at least consumer information:

"Savings from low rolling resistance tyres may justify a procurement specification by government agencies. Government procurement specifications can have an enormous impact on the market because the government is typically the largest customer in a country. Furthermore, the impact may be amplified because the national specifications are often adopted by local governments."

4.6 The National Tire Efficiency Study in the USA

In 1994 the National Highway Traffic Safety Administration (NHTSA) proposed adding a fuel economy label for passenger tyres as part of the Uniform Tire Quality Grading (UTQG) system. Most tyre companies, however, opposed the proposal in comments submitted to the agency. Michelin was the only major tyre company to approve of the proposed addition to the UTQG [TRB, 2006].

In 2003, California enacted a law (AB 844) requiring tyre manufacturers to report the rolling resistance properties and fuel economy effects of replacement tyres sold in the state [AB 844, 2003]. The aim was that the tyres on the replacement market should be at least as fuel efficient as the tyres sold in California as original equipment on new vehicles. This bill has resulted in the collection of such data since then in California. Federal legislators have at times tried to introduce a similar bill nationally, but failed in doing so. The California law requires the establishment of labels (info program) and minimum efficiency standards. There is a delay in the implementation of AB 844 but the California Energy Commission has recently re-dedicated staff to the effort and held a public workshop[4] on 7 December 2007[5].

There has been a proposal for an amendment to the 2005 Energy Policy Act requesting NHTSA to establish a national tyre efficiency program to set policies and procedures for tyre fuel economy testing and labelling and for promoting the sale of replacement tyres that consume less energy. However, this proposal was soon withdrawn [TRB, 2006]. Nevertheless, in February 2005, in response to a request from the United States Congress and with funding from the NHTSA, the National Research Council (NRC) formed a Committee for a so-called National Tire Efficiency Study. The committee consisted of 12 members with expertise in tyre engineering and manufacturing, mechanical and materials engineering, as well as statistics and economics.

---

[4] The agenda can be downloaded from http://www.energy.ca.gov/transportation/tire_efficiency/documents/2007-12-07_workshop/2007-12-07_AGENDA.PDF

[5] The author is grateful to Mr L. Tonachel of the National Resources Defense Council (NRDC), website http://www.nrdc.org/, for informing about the AB 844 bill and its progress

The objectives of the Committee were to develop and perform a national tyre efficiency study and literature review to [TRB, 2006]:

- Consider the relationship that low rolling resistance replacement tyres designed for use on passenger cars and light trucks have on fuel consumption and tyre wear life;
- Address the potential for securing technically feasible and cost-effective replacement tyres that do not adversely affect safety, including the impacts on performance and durability, or adversely impact tyre tread life and scrap tyre disposal;
- Fully consider the average American "drive cycle" in its analysis;
- Address the cost to the consumer including the additional cost of replacement tyres and any potential fuel savings.

A comprehensive report was issued by the Committee in 2006 [TRB, 2006]. The conclusions of the study included a statement that "A 10 percent reduction in rolling resistance can reduce consumer fuel expenditures by 1 to 2 percent for typical vehicles". It is further stated in [TRB, 2006] that:

"Tire technologies available today to reduce rolling resistance would cause consumers to spend slightly more when they buy replacement tires, on the order of 1 to 2 percent or an average of $1 to $2 more in tire expenditures per year. These technologies, however, may need to be accompanied by other changes in tire materials and designs to maintain the levels of wear resistance that consumers demand. While the effect of such accompanying changes on tire production costs and prices is unclear, the overall magnitude of the fuel savings suggests that consumers would likely incur a net savings in their combined fuel and tire expenditures."

The report [TRB, 2006] contains a rather comprehensive statement regarding improved consumer information, which is cited below due to its high relevance to this report:

"As a general principle, consumers benefit from the ready availability of easy-to-understand information on all major attributes of their purchases. Tires are no exception, and their influence on vehicle fuel economy is an attribute that is likely to be of interest to many tire buyers. Because tires are driven tens of thousands of miles, their influence on vehicle fuel consumption can extend over several years. Ideally, consumers would have access to information that reflects a tire's effect on fuel economy averaged over its anticipated lifetime of use, as opposed to a measurement taken during a single point in the tire's lifetime, usually when it is new. No standard measure of lifetime tire energy consumption is currently available, and the development of one deserves consideration. Until such a practical measure is developed, rolling resistance measurements of new tires can be informative to consumers, especially if they are accompanied by reliable information on other tire characteristics such as wear resistance and traction.

Advice on specific procedures for measuring and rating the influence of individual passenger tires on fuel economy and methods of conveying this information to consumers is outside the scope of this study. Nevertheless, the committee is persuaded that there is a public interest in consumers having access to such information. The public interest is comparable with that of consumers having information on tire traction and tread wear characteristics, which is now provided by industry and required by federal regulation.

It is apparent that industry cooperation is essential in gathering and conveying tire performance information that consumers can use in making tire purchases. It is in the spirit of prompting and ensuring more widespread industry cooperation in the supply of useful and trusted purchase information that the committee makes the following recommendations.

Congress should authorize and make sufficient resources available to NHTSA to allow it to gather and report information on the influence of individual passenger tires on vehicle fuel consumption. Information that best indicates a tire's contribution to vehicle fuel consumption and that can be effectively gathered, reported, and communicated to consumers buying tires should be sought. The effort should cover a large portion of the passenger tires sold in the United States and be comprehensive with regard to popular tire sizes, models, and types, both imported and domestic.

NHTSA should consult with the U.S. Environmental Protection Agency on means of conveying the information and ensure that the information is made widely available in a timely manner and is easily understood by both buyers and sellers. In the gathering and communication of this information, the agency should seek the active participation of the entire tire industry.

The effectiveness of this consumer information and the methods used for communicating it should be reviewed regularly. The information and communication methods should be revised as necessary to improve effectiveness. Congress should require periodic assessments of the initiative's utility to consumers, the level of cooperation by industry, and the resultant contribution to national goals pertaining to energy consumption."

In summary, the Committee did not suggest tyre labelling. Instead, it recommends the establishment of a kind of national database of fuel consumption-related tyre data that will be widely available to the public.

In June 2006, the U.S. House of Representatives Committee on Energy and Commerce approved the National Tire Fuel Efficiency Consumer Information Program suggested in the TRB report in its Bill No. 5632 [GovTrack H.R. 5632, 2006]; i.e., essentially what is outlined above. One month later The Tire Industry Association (TIA) announced its support to the bill. But, according to [GovTrack H.R. 5632, 2006], this bill never became law. The reason was that it was proposed in a previous session of Congress. Sessions of Congress last two years, and at the end of each session all proposed bills and resolutions that have not passed are cleared from the books.

Instead, the prepared legislation made it into the ongoing session of the US Congress, as the recently-passed Energy Independence and Security Act of 2007, H.R. 6, the so-called "Energy Bill" [Library of Congress, 2007]. This Act does NOT require tyre labelling, but it requires that the rulemaking shall include:

A. a national tire fuel efficiency rating system for motor vehicle replacement tires to assist consumers in making more educated tire purchasing decisions;

B. requirements for providing information to consumers, including information at the point of sale and other potential information dissemination methods, including the Internet;

C. specifications for test methods for manufacturers to use in assessing and rating tires to avoid variation among test equipment and manufacturers; and

D. a national tire maintenance consumer education program including, information on tire inflation pressure, alignment, rotation, and tread wear to maximize fuel efficiency, safety, and durability of replacement tires.

This federal rulemaking will prohibit states from enacting its own tyre efficiency rules, unless they were enacted before 1 January 2006. The California law was enacted in 2003, so it is not affected. The federal Energy Bill language requires the development of a tyre consumer information program; the California law, however, requires the establishment of labels (info program) and minimum efficiency standards. A question is whether the California label system can be designed similarly to the current labels for tyre traction and wear and if the California and federal rules can be coordinated as much as possible.

5 PRESENT CONSUMER INFORMATION

5.1 Tyre producers' and dealers' information

In the tyre shop the consumer can check by the markings on the tyre that it fits his/her vehicle in terms of dimensions and use (speed rating, winter operation, etc), and he/she can have a discussion with the tyre dealer about the priorities. For European tyres there is generally no objective quality-related information available. Once selection of dimension and use have been made, in a large shop there might be hundreds of brands and types available to choose from; yet the only further information is generally the price tag and the obvious visual appearance.

The tyre manufacturer may indicate what kind of priorities his various tyre types are designed for. For example, Tyre A is designed to have low rolling resistance, Tyre B is designed for premium high-speed performance, Tyre C is designed for best wet grip, and Tyre D is designed to be quiet. However, with few exceptions, such claims are never quantified; at least not in any way which is comparable with other tyres.

A consumer with great awareness, or even the dealer, can hardly find any objective quality information; except perhaps for a handful of tyres which have been subjected to special tests. The tyre manufacturer may in his brochures present some comparison between various tyres in certain aspects, but such information is usually very vague and the tyres used for reference (which are mostly assumed to be inferior to the new ones) are seldom if ever defined and cross-comparisons are rarely possible. From an objective point of view such information is almost worthless. The dealer may also have collected some articles in magazines (see below) that may have some objective-looking information, but it is always very limited in extent; covering only few tyres and few dimensions.

From a quality-point-of-view, therefore the consumer goes blindfolded through the tyre shop.

On the tyre manufacturer websites, the reader can mostly find a lot of practical advice for tyre use and tyre selection. But some kind of tyre technical specifications is generally missing. An example of the sort of "semi-quality" information that one may find is the following, copied from one of the major manufacturer's websites (XXXX is used by this author to make the information anonymous):

> (XXXX is) Number 1 for fuel economy***
>
> *** Measured rolling resistance advantage of 20% on average compared to principal European competitors. Tests carried out in 2006 by XXXX testing centre with tyres purchased on the open market and covering the major ranges. Lower tyre rolling resistance leads to reduced fuel consumption

It is possible that the above is true, although the difference quoted seems extremely large to this author, but the reader has no chance to check the information or to see how this relates in detail to some defined tyre X in comparison to another Tyre Y.

5.2 Technical journals and popular magazines

On the Dunloptyres.uk website it is stated:
"Magazine tyre tests are an ongoing and important process to establish and rank tyre performance not only for the automotive industry, but also for the consumer - our drivers. It provides everyone with a good assessment of the performance of a tyre manufacturer and results are an important selling argument as they are the seal of approval for product performance and quality."

"Such tests are made in all markets, but Germany stands out as being what many consider the harshest tyre testing market in the world. Here independent magazine testers from AutoBild, Auto Motor und Sport and the ADAC (the German Car Drivers Association) - put tyres through extensive and rigorous testing. They often compare the tyres that are supplied by the manufacturers for tests with tyres taken at random from a dealer's stock, ensuring that they are testing the same tyres that the consumer buys."

The above citations quite well summarize the situation. The many tests presented can aid the consumer to make his/her tyre selection. There are many more magazines of technical nature than the ones mentioned above, mostly with a focus on cars. These articles find millions of readers each year. In fact, some magazines may have these tests as their major selling or subscription argument. The existence and popularity of these tests perfectly illustrate the fact that objective consumer information on tyres is missing and that this is something which the consumers want to have.

The magazines usually test quality-related parameters such as:

- Vehicle handling (driving on curves, wet and/or dry)
- Wet skid resistance ("wet grip", "wet braking" or "adhesion")
- Aquaplaning speed
- Noise (mostly it is not explicitly written, but usually only interior noise in one vehicle is considered)
- Rolling resistance (sometimes)

Most probably, the magazines that often publish such tests would not be very happy if such information would be available to the consumers in a labelling scheme; since some of the tests would then not be needed.

The value of the magazine-published tests is not totally indisputable. Although the testing is ideally free from producer bias, their value depends on which testing organization they rely on as well as on the test setup and conditions. Not every testing organization is doing high-quality job; and sometimes they are forced to do it too fast; not allowing meeting quality requirements. But, foremost, the problem is that each such test mostly covers only very few tyre brands, types and dimensions; making it possible to compare only very few of the tyres available on the market. The reason is that such testing is rather expensive and takes a lot of time, neither of which many magazines can afford. For example, one test covered 6 tyre brands, another one 16 tyre brands, etc; usually including a sample set of only around 10 tyres (and usually with a set of four tyres for each one to allow testing on a car). One should also be aware of that a similar test made on another dimension of the same tyre brands might not give the same results. It goes without saying that this may give the consumer a rather limited choice.

Nevertheless, these magazine-published tests are very important for the marketing of tyres and are very popular reading among car owners.

5.3 Web-based databases

There are a couple of databases published on the web which contain rather comprehensive information, namely these:

IPG tyre list: On the website for the Dutch IPG research programme, there is a list of tyres and their noise levels measured according to the EU Directive presently containing 229 tyres. The document is in pdf format and the web address is:
http://www.innovatieprogrammageluid.nl/data/files/algemeen/IPG-lijst%20Stille%20personenwagenbanden%2001062007.pdf

Umweltbundesamt tyre list: On the website of the German Federal Environment Agency (Umweltbundesamt), there is a similar list of noise levels of tyres, at the website: http://www.umweltbundesamt.de/laermprobleme/reifen.html
The list contains also rolling resistance, skid resistance and aquaplaning data, but is not up-to-date and the number of tyres in it is lower than in the Dutch list.

A third database, covering a number of parameters related to various aspects of tyre performance and based on (subjective) consumer surveys (probably in North America only), is published by Tire Rack at:
http://www.tirerack.com/tires/surveyresults

On behalf of the California Energy Commission, Ecos Consulting prepared a database for tyres in California [CEC, 2003]. They write about the database:

Ecos Consulting gathered available data from tire manufacturers and conducted market research to determine which tire manufacturers and models represent the largest share of sales in the US and California. We expanded this database by adding information provided by the National Highway Traffic Safety Administration (NHTSA) regarding the federal Uniform Tire Quality Grading

System – (UTQGS). These include measures of tires' tread wear, traction, temperature resistance, and speed ratings.
We requested rolling resistance data from tire manufacturers individually and collectively through their trade association (the Rubber Manufacturers Association). A few manufacturers provided a handful of data points, but the industry as a whole (acting through RMA) refused to provide this information when it was requested by the CEC. This greatly compounded the difficulty of making meaningful comparisons between tire rolling resistance and other aspects of tire performance.

We supplemented the database with other readily available public data sources regarding tire price, performance, efficiency, and customer satisfaction.

Unfortunately, this database was never published. However, limited data from it appears in a table with 17 recommended low-rolling-resistance tyre models in [CGR, 2003], which is published on the web. The mentioned table also contains other data than rolling resistance, see Table 3 below.

Table 3. Small tyre database with "recommended tire models" appearing in [CGR, 2003]. Note that it was published in 2003, so some tyres may now be difficult to obtain. The tyres are from the U.S. market which means that they may not necessarily be identical to similar tyres in Europe.

TABLE 1: RECOMMENDED TIRE MODELS

BRAND	MODEL	SIZE	RRC AVERAGE	PRICE	TRACTION COMPOSITE	WOULD BUY AGAIN	COMPOSITE TREAD WEAR	COMPOSITE PERFOR-MANCE SCORE
Bridgestone	B381	185/70R14	0.0062	$62.00	8.00		5.96	6.98
Nokian	NRT2	185/70R14	0.0085	$67.00	8.00		5.72	6.86
Sumitomo	HTR 200	185/70R14	0.0092	$36.00	8.15	8.30	7.05	7.83
Dunlop	Graspic DS-1	185/70R14	0.0092	$46.00	7.50	7.90	6.60	7.33
Dunlop	SP40 A/S	185/70R14	0.0103	$41.00	8.00		7.18	7.59
Bridgestone	Blizzak WS-50	185/70R14	0.0103	$68.00	7.91	8.70	6.04	7.55
Goodyear	VIVA 2	185/70R14	0.0104	$47.96	7.00		6.52	6.80
Continental	ContiTouring Contact CH95	205/55R16	0.0083	$64.00	7.46	6.10	7.29	6.95
Michelin	Pilot Alpine	205/55R16	0.0090	$125.00	7.56	8.60	8.00	8.05
Michelin	EnergyMXV4 Plus	205/55R16	0.0090	$118.00	7.64	6.00	6.87	6.84
Dunlop	SP Winter Sport M2	205/55R16	0.0102	$98.00	8.55		7.80	8.17
Michelin	Arctic AlpineXL	235/75R15	0.0081	$79.00	8.10	8.50	7.10	7.90
Dunlop	Axiom Plus WS	235/75R15	0.0088	$43.00	8.00		5.88	6.94
BF Goodrich	Long Trail T/A	245/75R16	0.0092	$76.00	7.94	6.20	7.11	7.08
Michelin	XPS Rib	LT245/75R16	0.0101	$167.90	6.70	8.10	8.00	7.60
Michelin	LTX M/S	245/75R16	0.0103	$139.00	7.97	8.30	7.37	7.88
Bridgestone	Dueler A/T D693	245/75R16	0.0103	$104.00	8.00		7.20	7.60

NOTE: The lower the rolling resistance coefficent (RRC), the more efficient is the tire; all tires listed here meet Green Seal's criterion for rolling resistance of less than 0.0105 and are among the most efficient available in the market today. In contrast, the higher the value of Traction Composite, Would Buy Again, Composite Treadwear, and Composite Performance Score, the better in those measures the tire is; however, all tires listed here have a greater than average performance score in these respects.

It may also be interesting to note that regarding vehicles, there are several data-bases; for example, the German one at http://www.kba.de/ is worth noting. However, it does not seem to include data on tyres. Also, the United States Department of Energy has a database at http://www.fueleconomy.gov/ and California Energy Commission has an interesting (low-emission) vehicle database; see: http://www.consumerenergycenter.org/transportation/index.html.

5.4 The Nordic Swan environment label

The Nordic Swan labelling system is organised under the Nordic Council of Ministers, which has established eco-labelling on a variety of products in all the five Nordic countries (Sweden, Denmark, Norway, Finland and Iceland), see [Svanen, 2008-1]. This system has gained considerable success with regard to several product types.

Tyres, for light as well as for heavy vehicles, were added in 2002 as a product for which the label can be obtained. The product group consists of new and retreaded tyres of passenger vehicles and bus and truck vehicles for road use during summer and winter. The load index (LI) for the heavy vehicle tyres must be over 121 and for passenger vehicle tyres LI must be 121 or lower than 121, as described in ECE Regulation 54. The Swan label is shown in Fig. 2.

Thus, the system also includes retread tyres. As a matter of fact, the retread tyre industry is rather positive to this system and a number of retread companies were quick to apply for labelling of some of their tyres, see Fig. 3. Since this eco-labelling system is the only one in the world in which there are eco-labelled tyres, this justifies a rather detailed description.

The Nordic system specifies requirements for environmental parameters, such as noise emission and rolling resistance (plus some material properties), as well as for skid resistance. The aim was originally that about 30 % of all tyres (in 2002) would be able obtain the Swan label. This means that the requirements for each individual environmental parameter must be less stringent than it would be if one parameter alone was to be complied with, since all requirements must be met at the same time.

Fig. 2. The Nordic Swan label.

The criteria for approval are different for passenger vehicle tyres and bus & truck tyres [Svanen, 2008-2]. Passenger vehicle (car) tyres are tyres with a Load Index (LI) ≤121 and bus & truck tyres are tyres with LI > 121. The quality parameters considered are the same for both tyre categories:

- Noise emission (see Table 4)
- Rolling resistance (see Table 5)
- Safety (either skid resistance, or durability)

These quality parameters are described more below. In addition, there are several material and waste management requirements, relating to:

- Working security, health and environment in the factory
- Reuse of manufacturing waste material
- Marking of tyres
- Production chemicals (polycyclic aromatic compounds (PCA))
- Hazardous substances (anti-ozonants and anti-oxidants)
- Lead and cadmium impurities of zinc oxides
- Organic solvents used in the production (e.g. hexane, heptane)
- Weight deviation of retreaded tyres
- Consumer information (consumer information paper must be available)

Table 4. Requirements on noise emission in the Nordic Swan, compared to corresponding maximum noise limits in the EU Directive 2001/43/EC (which is equal to corresponding UN ECE Regulations). Noise testing is made according to the method in 2001/43/EC (amending Directive 92/23/EC), or ISO 13325 Annex 1, which is the ISO method on which the Directive is based. Note that measured levels are reduced by 1 dB and are truncated to the nearest whole value, which effectively means that measured levels may exceed the limits by up to 1.9 dB. Note also that retreaded tyres are not subject to any limits in the EU Directive but must meet the same limits as new tyres in the Nordic Swan.

Passenger car or van or bus/truck tyre?	Tyre class or use, in the EU Directive	Tyre section width [mm]	Noise limit Nordic Swan [dB]	Noise limit EU Directive [dB]
Car	C1a	≤145	72	72
Car	C1b	>145 ≤165	72	73
Car	C1c	>165 ≤185	73	74
Car	C1d	>185 ≤215	74	75
Car	C1e	> 215	75	76
Van[6]	C2b	≤165	72	75/77/78[7]
Van	C2c	>165 ≤185	73	75/77/78
Van	C2d	>185 ≤215	74	75/77/78
Van	C2e	> 215	75	75/77/78
Bus/truck	C3 Normal[8]	any	76	76
Bus/truck	C3 Snow[9]	any	78	78
Bus/truck	C3 Special[10]	any	78	79

[6] Van tyres (C2), often referred to as "light truck (LT)" tyres, are treated in the Nordic Swan as car tyres (C1). They are often used on e.g. SUV:s, vans, pick-up trucks and mini-busses.
[7] 75 dB for normal tyres, 77 dB for snow tyres and 78 dB for special tyres
[8] Called "Free-rolling" tyres in the Nordic Swan
[9] Called "Driving/traction" tyres in the Nordic Swan
[10] "Special tyres" are mostly off-road tyres or tyres used on trucks in extreme heavy duty work

Table 5. Requirements on rolling resistance coefficient (RRC) in the Nordic Swan, expressed in percentage (rolling resistance in percent of the vertical load). Note that van tyres are treated as passenger car tyres in the Nordic Swan. The measurement method shall be the ISO 8767 or any corresponding test.

Passenger car or van or bus/truck tyre?	Tyre use	Tyre load index (LI)	RRC for new tyres	RRC for retreaded tyres
Car		< 80	1.20	1.25
Car		80-90	1.10	1.15
Car		> 90	1.00	1.05
Van[11]		< 80	1.20	1.25
Van		80-90	1.10	1.15
Van		> 90	1.00	1.05
Bus/truck	Normal[12]		0.60	0.60
Bus/truck	Snow[13]		0.70	0.70
Bus/truck	Special[14]		0.70	0.70

Table 6. Requirements for tyre safety considerations in the Nordic Swan. See the text regarding measurement methods. For this criterion, it is sufficient to comply with one of the two alternatives.

Passenger car tyres New and retreaded	Bus and truck tyres New and retreaded
Alternative 1: Safety and quality aspects	Alternative 1: Safety and quality aspects
The frictional properties of the tyres (i.e. their grip in the wet or winter grip on ice/snow) must be as good as or better than other equivalent tyres on the Nordic market.	The frictional properties of the tyres (i.e. their grip in the wet or winter grip on ice/snow) must be as good as or better than other equivalent tyres on the Nordic market. Retreaders must also follow the process quality guidelines as laid down in ECE Regulation 109 concerning the preparation, retreading and inspection of tyres.
Alternative 2: Durability and quality aspects	Alternative 2: Durability and quality aspects
New tyres have to be tested according to ECE Regulation 30, C-type tyres according to ECE 54 and retreaded tyres must be tested according to ECE Regulation 108. The requirements of ECE regulations concerning the durability must be fulfilled.	New tyres have to be tested according to ECE R54 and retreaded tyres must be tested according to ECE R109. The requirements of ECE regulations concerning durability must be fulfilled. Retreaders must also follow the process quality guidelines as laid down in ECE R109 concerning the preparation, retreading and inspection of tyres.

[11] Van tyres (C2), often referred to as "light truck (LT)" tyres, are treated in the Nordic Swan as car tyres (C1). They are often used on e.g. SUV:s, vans, pick-up trucks and mini-busses.
[12] Called "Free-rolling" tyres in the Nordic Swan
[13] Called "Driving/traction" tyres in the Nordic Swan
[14] "Special tyres" are mostly off-road tyres or tyres used on trucks in extreme heavy duty work

Fig. 3. The first licences for tyres are awarded in the Nordic countries: Representatives of the retread companies Fighter, Green Diamond, MacRipper, AGI and Galaxie show their licences.

The measurement methods for safety considerations are:

For Safety: Friction properties shall be measured by means of a single wheel test, or the tests described in ECE Regulation 13, or EEC Directive 71/320, or other corresponding tests.

For Durability: Durability shall be measured according to the "load/speed performance/endurance test" in the existing ECE regulations R30 (new tyres) or R108 (retreaded tyres) for passenger car tyres, and R54 (new tyres) or R109 (retreaded tyres) for bus & truck tyres.

This author thinks that it is strange that the two alternatives are exchangeable; i.e. that the tyre producer can choose to meet one of them only. In fact the Durability requirement must be met by every tyre to be legal, anyway.

The author would also like to comment on the noise criteria. The finally chosen limits are 0-1 dB more stringent than the legal noise limits for new tyres. Since most tyres are well below the limits, this means that almost all new tyres will comply with the noise criteria. Tyres which so easily qualify are not really worth an environmental label award. This author originally suggested setting the Swan limits at 3 dB below the legal limits which was accepted in the first version of the criteria document. However, at some later revision, the limits had been raised; the reason for which are unknown to this author.

What was written above for new tyres is not valid for retreaded tyres, since there are no legal noise limits for such tyres, which means that the Swan criteria are unique to them. However, as was shown in [FEHRL, 2006-2], the noise emission of retreaded tyres is not significantly different from that of new tyres, so in practice the Swan limits for retread tyres are no problem to comply with for the majority of retreads.

The rolling resistance limits for car tyres seem to be reasonably well chosen, while they seem to be very stringent for the truck tyres, as will be shown later in this report.

The first version of the criteria document was adopted by the Nordic Eco-labelling Board the first time in June 1999 and was intended to remain in force up to and including 14 June 2002. However, later on, modifications were made and the validity was prolonged correspondingly. The current version, from which the data above are taken, is valid until 30 June 2009 [Svanen, 2008-2].

By January 2008, three tyre retread companies held licences for car and truck tyres, covering several tread patterns, dimensions and speed classes; both for normal ("summer") and winter ("M+S") tyres. In addition, two (Asian) manufacturers of new tyres have winter tyres approved. The dimensions covered are 155 to 235 mm section width, 13 to 17 inches of rim width and 40 to 80 % aspect ratio. One company in 2002 declared on its website that the tyre with the Swan label was a huge success and was sold out very quickly during its first season. Currently, however, the retread companies think that the value of the Swan label on their tyres is small, but that it will increase in the future with increased attention to the climate crisis [Bengmark, 2008].

Figures 20 and 23 show examples of how the Nordic Swan label is used in commercial advertisements. See also the last paragraph of 7.3.

5.5 The German Blue Angel environment label

Established already in 1977, the Blue Angel environmental label (in German "Der Blaue Engel") is organised under the Deutsches Institut für Gütesicherung und Kennzeichnung e.V. (RAL). This eco-labelling system, called "Umweltzeichen - weil lärmarm und kraftstoffbesparend", was developed with support from the German Federal Environmental Agency (Umweltbundesamt - UBA). Vehicles and tyres which meet certain requirements are entitled to use the Blue Angel symbol; see Fig. 4.

The system with regard to tyres is named "Low-Noise and Fuel-Saving Automobile Tires - RAL-UZ 89" [Blaue Engel, 2008-1]. To qualify for the label a number of criteria must be complied with (see also Tables 7-8):

- Tyre weight
- Noise emission
- Rolling resistance coefficient
- Mileage (service life in km, as specified by the NHTSA UTQG criteria)
- Braking distance ("wet grip")
- Aquaplaning speed

Fig. 4. The symbol of the German Der Blaue Engel environmental label

Table 7. The criteria regarding noise, rolling resistance and tyre weight to qualify for the Blue Angel label. From [Blaue Engel, 2008-2].

	Tire Size	Pass-by Noise in dB(A)	Measuring Method for Pass-by Noise	Rolling Resistance Coefficient in %	Measuring Method for Rolling Resistance and Weight	Weight in kg
Summertire	175/70R13	≤ 72	91/23/EEC	≤ 1.10	ISO DIN 8767	≤ 7.0
Summertire	195/65R15	≤ 72	accor. to Appendix 1[4)]	≤ 1.10	according to Appendix 2[4)]	≤ 9.0
Wintertire	175/70R13	≤ 72	92/23/EEC	≤ 1.10	ISO DIN 8767	≤ 7.0
Wintertire	195/65R15	≤ 72	accor. to Appendix 1[4)]	≤ 1.10	according to Appendix 2[4)]	≤ 9.2

Table 8. The criteria regarding "service" parameters to qualify for the Blue Angel label. From [Blaue Engel, 2008-2].

	Tire Size	Mileage/ Kilome-trage	Measurement Method for Mileage/ Kilometrage	Braking distance in m	Determination of Braking Distance	Aquaplaning in km/h	Determination of Aquaplaning
Summer Tires	175/70R13	≥ 400	DOT Code of NHTSA, UTQG Test according to Appendix 3[4)]	≤ Average/ reference value of the respective tire material tested according to Appendix 6[4)] accor.to Appendix 4[4]	accor.to Appendix 4[4)]	Aquaplaning limiting speed 5% lower at the most than average/reference value of the respective tire material tested according to Appendix 6[4)] according to Appendix 5[4)]	according to Appendix 5[4)]
Summer Tires	195/65R15	≥ 400			accor.to Appendix 4[4)]		according to Appendix 5[4)]
Winter Tires	175/70R13	not applicable	not applicable	≤ Average/ reference value of the respective tire material tested according to Appendix 7[4)]	accor. to Appendix 4[4)]	Aquaplaning limiting speed 5% lower at the most than average/reference value of the respective tire material tested according to Appendix 7[4)]	according to Appendix 5[4)]
Winter Tires	195/65R15	not applicable	not applicable		accor.to Appendix 4[4)]		according to Appendix 5[4)]

The noise levels are much more stringent than for the Nordic Swan, while the rolling resistance limits are similar. Fig. 5 shows how the current Nordic and German eco-labelling requirements regarding tyre/road noise are in relation to each other and to the EU formal maximum limits, as well as in relation to current measurements. All measurements have been made in accordance with the measuring method in the EU Directive 2001/43/EC.

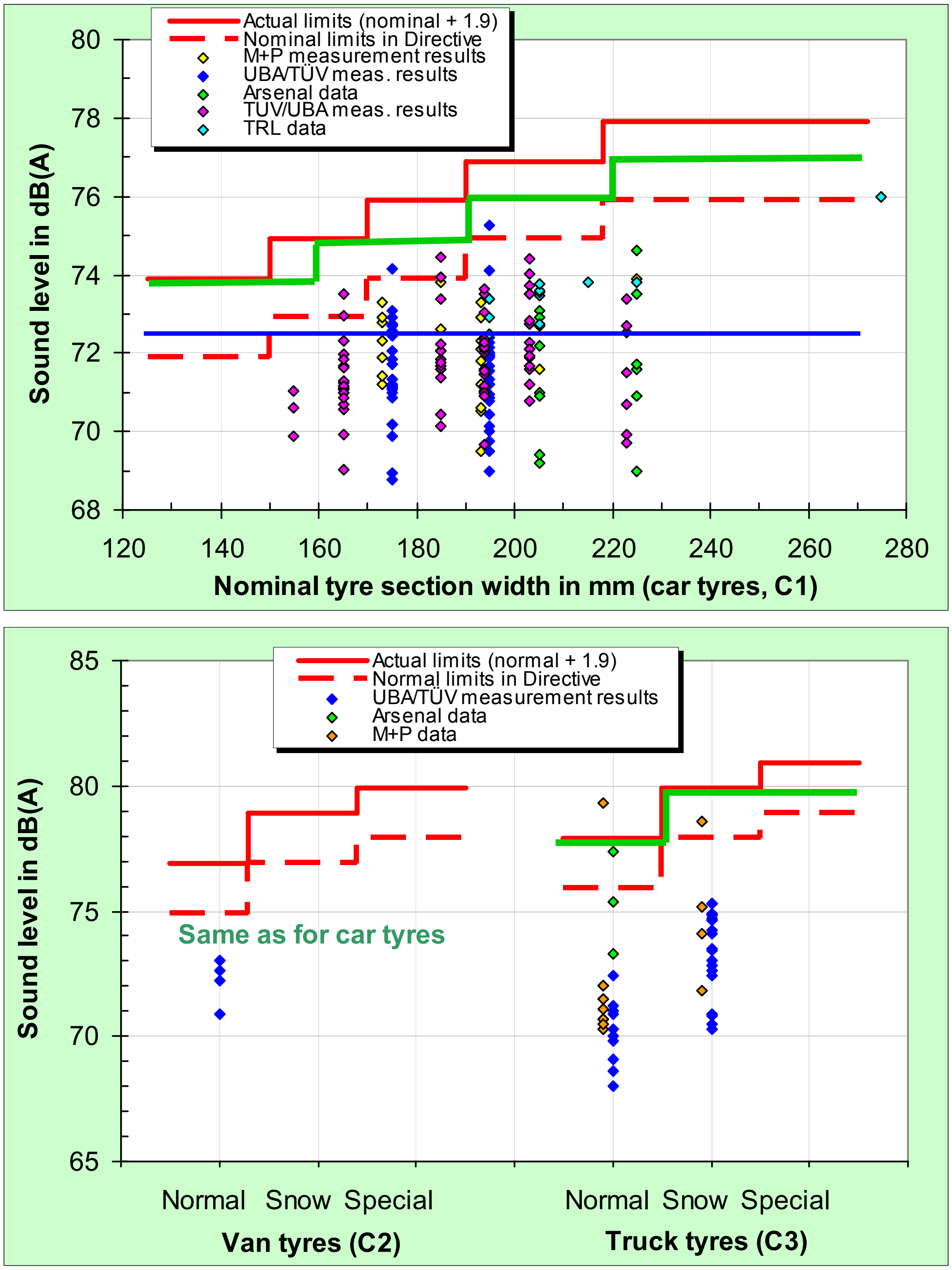


Fig. 5. Measured sound levels of 174 car and 45 truck tyres on ISO surfaces in the Netherlands, Austria, Norway, U.K. and Germany, compared to EU limits (red), Blue Angel limit (blue) and Nordic Swan limits (green). For the data, see Fig. 39. Subtraction of 1 dB and truncation not made to measured values.

In January 2008, there seemed to be no tyre approved for the label. The interest of the tyre industry seems to be null. However, in 1999, the first tyre was awarded the Blue Angel label in Germany. This was the Dunlop SP Sport 200 E tyre that was approved in 10 dimensions. Also the Dunlop SP Winter Sport M2 was claimed to meet the requirements. However, Goodyear bought Dunlop GmbH and owns it from 1 September 1999. Following the take-over, the contract for the environmental label was cancelled by initiative of Goodyear [Stenschke, 2001].

In the summer of 2002, one retread company held a licence for car tyres (probably for 7 tyre types). However, in January 2008, there seems to be no tyre approved.

5.6 European environment label

Since 1992, the European Union has a similar environmental labelling system, organised under the European Union Eco-labelling Board (EUEB) – the European Eco-label, a Marguerite flower. The homepage of the European Eco-label is: http://ec.europa.eu/environment/ecolabel/index_en.htm. The symbol is shown in Fig. 6.

Fig. 6. The flower symbol of the European Eco-label

As of January 2008, tyres have not been included in the system. However, work has been conducted on the prioritisation of new EU eco-label product groups which has included tyres. A feasibility study concerning tyres was conducted by AEA Technology in the U.K. and a report was produced as preparations for a meeting 5 October 1999 [Mistry & Ogilvie, 1999]. The document contains interesting data regarding new and retread tyres and the industries involved, as well as an interesting discussion of conditions and arguments for eco-labelling. A report was published also after the 1999 meeting, in March 2000[15].

As a result of discussions which the EUEB undertook regarding this product group, the Commission gave a mandate to the EUEB to establish ecological

[15] This report no longer seems to be available (and the author's saved copy is corrupted)

criteria for tyres[16]. By the end of 2004, tyres were still on the agenda, as a product group in the medium-priority range [Dolley et al, 2004] and in the latest (?) Working Plan 2005-2007 [OJ, 2006], tyres as a product group is listed as "Possible new product group".

The major European tyre manufacturers have been opposed to the eco-labelling systems.

5.7 Other environment labels

Japan has an own label (http://www.ecomark.jp/english/nintei.html), but it does not include tyres. The same applies to the French label called "Marque NF" (http://www.marque-nf.com/Default.asp?Lang=English).

In the USA, since 1989 there is the "Green Seal" (http://www.greenseal.org), which is a private eco-label introduced without any government involvement, although its principles resemble those of government-supported national eco-labelling systems. The "Green Seal" label has been awarded to over 300 products in 31 product categories; but tyres are not included.

[16] The author got this information in 2002 from a now forgotten source and cannot find any confirmation of this information in January 2008.

6 WAYS OF PROVIDING TYRE CONSUMER INFORMATION

6.1 Alternative ways

Information regarding environmental quality parameters of tyres may be provided to the consumer in the following major ways:

- Tyre label, moulded on the sidewall
- Note pasted on the (new) tyre
- Consumer information leaflet
- Publicly accessible database
- Tyre label or pasted note, combined with information leaflet or database
- TPMS or RFID system combined with some "monitoring" system

The alternatives are described and commented on below.

6.2 Tyre Label

Information is moulded on the tyre sidewall consisting of plain text, a value (number) with unit, or a symbol:

- The text could, for example, say "Noise level 72.5 dB" and "Rolling resistance coeff. 0.85 %".
- The value/unit could for example say "72.5 dB" and "0.85 %".
- The symbol could be a character or a combination of a few characters of some kind; for example, NO 6 might mean "Noise quality class No. 6" and RR 3 might mean "Rolling resistance quality class No. 3".

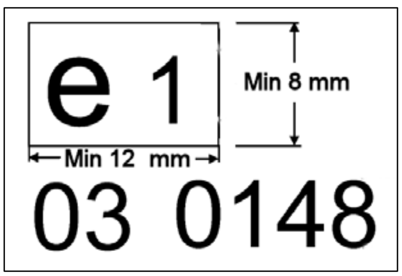
An example appears in Fig. 7, which shows the mark for type approval according to ECE Regulation E30, where the number 4 within the circle informs about the country in which the approval was awarded (where 4 = the Netherlands) and the 7-character code on the right gives the approval document number in the Dutch system. The number at the left is the week of manufacturing (week 19 of 2005).

Fig. 7. Example of tyre label moulded into the sidewall.

For noise type approval according to Directive 2001/43/EC, the type approval mark shall look as described in the Directive:

The EC type-approval mark will consist of a rectangle surrounding the lower case letter "e" followed by the distinguishing number of the Member State which has granted the type-approval as per Annex VII to Directive 70/156/EEC. The EC type-approval number will consist of the EC type-approval number shown on the certificate completed for the type, preceded by two figures : "00" for commercial vehicle tyres, "02" for passenger car tyres.

The rectangle forming the EC type-approval mark must have a minimum length of 12 mm and a minimum height of 8 mm. Letter(s) and number(s) must be at least 4 mm in height.



The author does not yet have any photo of this mark but Fig. 8 shows a drawing of it.

Fig. 8. The type approval mark for noise according to EU Directive 2001/43/EC.

The text alternative may look as in Fig. 9, which is the UTQG as required in USA and very often appearing also (voluntarily) on European tyres.

Fig. 9. Example of quality-related information text moulded into the sidewall (upper row).

The information could be given in the form of quality classes (as in Fig. 9 for Traction and Temperature) or in the form of a quantitative statement (as in Fig. 9 for Treadwear).

6.3 Pasted Note

The information according to the previous section may alternatively be printed on a note which is pasted on the tyre before it leaves the plant. This note may be torn away before the tyre is mounted on its vehicle the first time. Such labels are very common (although they rarely contain qualitative information); see Fig. 10.

If such a note is fitted for the purpose of supplying objective and unbiased information, it should be standardised in some way and it should be stated on it that it is a standard note according to some rule, in order to give the consumer more confidence in the information.

Fig. 10. Pasted notes on imported tyres from the United States and Japan.

6.4 Consumer Information Leaflet

The information may be printed on a leaflet that should be made available together with the tyre in the tyre dealer's shop, as probably intended according to the US Energy Bill [Library of Congress, 2007]. Such a leaflet may obviously contain more detailed information, such as easy-to-understand diagrams and tables, and where on the web to find more information.

6.5 Publicly accessible database

Some organization may produce and maintain a database with information about all, or at least most, tyres available on the European market, containing the measured value related to noise, rolling resistance, etc. In [TNO/IEEP/LAT, 2006] an EU-based, or coordinated, 'Consumer Guide to Cleaner Vehicles' website is proposed.

The database by Umweltbundesamt mentioned in 5.3 might give a hint on how such a database might be constructed although it must of course contain many more tyres. It should also be easier to find and bookmark on the internet.

The most appropriate organization to host such a database might be the European Environment Agency (EEA) based in Copenhagen (http://www.eea.europa.eu/). On the EU Commission's webpage[17], EEA writes "The European Environment Agency is the EU body dedicated to providing sound and independent information on the environment. We are a main information source for those involved in developing, adopting, implementing and evaluating environmental policy, as well as the general public".

6.6 Tyre label or pasted note, combined with leaflet or database

Of course, even if the alternatives with tyre label or pasted note are used, it would be preferred also to have some database available, or the tyre dealers would have some brochure describing the system and maybe including some selected (typical) data from the database.

6.7 Presenting tyre quality classes or measured values?

As reported in 4.1, the EU Commission has proposed to specify four different classes of rolling resistance for car and van tyres in the coming Directive, and there are similar plans in ECE as reported in 4.2. This is meant to encourage the consumers to purchase tyres which will give lower fuel consumption of the traffic.

[17] See http://europa.eu/agencies/community_agencies/eea/index_en.htm

This principle is similar to that used for traction in the UTQG system in USA where there are also four classes.

The author thinks that such classes are better than no consumer information at all, but it is not a sufficiently efficient concept.

The alternative would be a "scale system", in which the actually measured value for the parameter in question is labelled; although maybe presented in some simplified way. This is already in use for treadwear in the UTQG system in USA. Both systems approach each other if the number of classes is increasing.

The advantages with a "class system" in relation to one with a continuous scale and indication of the actually measured value are:

- It is easy for the consumer to understand; provided he/she gets some basic information about the scale, such as which are the symbols. For example, Class A intuitively sounds better than Class B which sounds better than Class C, and so on. Class A gives an impression of high quality. Some may have the idea that a class-based system may be more user-friendly and potentially more accepted by the general public because the public won't really understand the measured values.

- Marking on the tyre is easy, since it may in its simplest form be only one symbol (one letter)

The disadvantages with a "class system" compared to a continuous scale are:

- There is an incentive to try to improve a tyre type, only if one will move into a class of lower rolling resistance. The width of the bands proposed in [Com, 2007] is approximately 15 % (higher limit divided by lower limit). It means that often an improvement of 10 % will not count as a visible improvement to the consumer and the tyre manufacturer cannot count on any better sales for such an improvement. This is a pity since a 10 % improvement is very substantial for the customer and the environment.

- If the symbols chosen are not very logical, the consumer may be confused and have difficulty in knowing which class that is the best. For example, if one would introduce a class AB, would this be better or worse than Class A or Class B? Would Class AA be better than Class A? Would Class I be better than Class II? An example is the categorization of clean vehicle classes of European vehicles, EURO I, EURO II, EURO III and so on, which do not give common people any clue regarding which one that is better, according to this author. Consider for example that III is more than II but First class is better than Second class.

- The performance of tyres will improve with time, in particular for rolling resistance. Since the classes are designed to fit the scale of today's tyres, they will then not fit the scale of tomorrow's tyres. In perhaps 10 years time; for example, the car tyres may well all lie in the Classes A and B in Table 1. What is then the value of the classes, if there are only two classes - "good" and "bad"? This is perfectly illustrated by the example described for refrigerators in Chapter 7.4. The problem will call for a redefinition of classes after a certain time period and for some years there will be two systems of classes in operation.

Rolling resistance is perhaps the tyre performance parameter which has changed most rapidly of all over the last decades. It is reported that the rolling resistance of the best high-volume mass production Michelin tyres has improved from around 1.6 % in 1980 to approximately 0.8 % in 2000; i.e., a halving in just 20 years [Hall & Moreland, 2001].

That the rapid development towards lower rolling resistance will continue is illustrated by a recent statement by the President of the world's leading supplier of highly dispersive silica for tyre rubber, which is one of the main ingredients to reduce rolling resistance. He said: "In five years I predict higher silica content in tires will attain a further 4% energy saving. We are working on new products to attain these figures" [Noyrez, 2007]. To achieve a 4 % saving on energy (fuel consumption), rolling resistance would need to be reduced by approximately 20 %. Already this, if it happens for the entire product range, would mean that the class system proposed by the European Commission [Com, 2007] would be more than one class offset already in five years time; i.e. probably before it is in force.

Mercedes-Benz already reports about having tyres for a research car with special potential for reducing CO2 emissions due to a relatively narrow tyre in combination with a tread made entirely of silica-reinforced blend of rubber which have outstandingly low rolling resistance at about 17 % less than with conventional car tyres [Mercedes-Benz, 2007]. For a labelling system to be long-term effective it must encourage the development also beyond the presently premium-graded tyres. This and the refrigerator story above should illustrate that the class system may work fine for a static parameter but not for one which undergoes rapid changes such as is the case here.

To avoid the disadvantages, the author prefers to label tyres with their actually measured rolling resistance value (in %) or noise level (in dB); although the values shall be rounded to suitable values. For noise, for example, the values could be 70, 71, 72, 73, etc, dB (only integer numbers). For rolling resistance coefficient, the value could be expressed in %, as for example 0.84, 0.85, 0.86,….1.03, etc. Alternatively, one could call it "rolling resistance index" and multiply the coefficient by 10 000, to use only integer numbers, such as 84, 85, 86,…..103, etc.

Whether it is better or worse with high numbers should be clear to most people for both noise and rolling resistance, since both are units for something "bad" and one would like to have as little as possible of this "bad" thing. If one would include a wet grip value, one may for example convert it to stopping distance index, in order that one would like to attain as low value as possible also in such a case.

To avoid the possible problem that the general public won't really understand the measured values and have no idea of the scales, one might produce an information poster in (say) A2 or A1 size that can be posted on the wall of any tyre workshop, in which the present scales are shown for each parameter. It would also be natural that the potential buyer looks at a few tyres in the rack and checks what numbers they have in the label and he/she will find that some or low and some are high. To see how these compare with the general scales, the buyer may look at the mentioned poster.

A clever tyre dealer may in his inventory system include the rating of his/her tyres, which may then be used to print out a statistical distribution of his tyre ratings in the current tyre stock. Such an inventory program may even be produced by the government for free download by any tyre dealer. Such statistics would give the consumer a good overview of what is available and he/she would immediately get a grasp of each scale. The program could even make it easy to search for which tyres in stock that would meet a certain quality desired by the buyer; here the possibilities are almost unlimited.

If one would choose a class system, the only one this author considers as suitable and unanimous in a dynamic world would be a system in which one uses "stars" (*) to indicate quality. The poorest quality would be class * while the best quality would be (say) class ******. In such a system one may all the time extend the scale in the high quality end by adding an extra star. One might design it for three parameters as this (only the items in red would appear on the tyre sidewall):

NR: ****	(NR = Noise reduction)
EN: *****	(EN = Energy saving)
SA: ***	(SA = Safety rating)

Note: The more stars, the better performance

In a "scale system", the corresponding might look like this:

NL: 72 dB	(NL = Noise level)
RR: 93	(RR = Rolling resistance index)
SD: 85 %	(SD = Stopping distance - Wet)

Note: The lower values, the better performance

6.8 Possibilities with TPMS and RFID devices in the tyre

Rolling resistance is largely influenced by tyre inflation pressure. By putting a Tyre Pressure Monitoring Systems (TPMS) in the tyre, the driver can be notified when tyre inflation is lower than the optimum and in this way tyre inflation can be kept closer to the optimum than nowadays, which will reduce fuel consumption. This is not within the subject of this report.

However, the TPMS system may easily be supplemented with consumer information about the tyre, including measured values of wet grip, rolling resistance and noise. This information could then be read by a receiving and data processing system, here named "monitor", in a tyre workshop and at the annual vehicle inspection. The monitoring system may be connected with a database in which one may compare the values of the particular tyres with values representing the market as a whole. The position of the particular tyre within the frequency distribution of all tyres tested within the same group of dimensions or (better) load index could then be indicated.

Given some input from the vehicle owner about his/her vehicle and driving habits, the system may also include provisions for calculating the potential annual fuel savings, and/or reduced stopping distance in wet weather, if the vehicle would get new tyres of a certain better quality. This type of information may encourage vehicle owners to try to upgrade to tyres with better performance. This system may also be used at the annual vehicle inspection, if the actual tyre inflation can be typed in, to calculate how much the vehicle owner may save if his tyre inflation was the ideal one.

It is not even necessary to have a TPMS for the above. An alternative is a so-called Radio Frequency Identification (RFID) chip mounted within the tyre, which may contain arbitrary information about the tyre.

The above points at possibilities of another type of consumer information being possible in the near future, with a potential to increase consumer awareness in order to eventually result in better safety, economy and environment.

7 CONSUMERS' INTERESTS IN TYRE PERFORMANCE

7.1 General issues

Note first that what the consumer may be able to directly influence is the "aftermarket", or the "replacement tyres", as well as the retreaded tyre market, since the tyres on the new vehicles (usually referred to as OEM tyres) come integrated with the vehicle and the consumer can influence this tyre choice only by choosing another vehicle. On the other hand, the replacement tyres on the European market constitute about 75 % of the total amount of tyres in the car fleet, so it is a substantial part.

7.2 Private vehicle owners

What determines consumers' choice of a tyre? A German study indicated that characteristics relating to traffic safety are very significant, but that the appearance of the tyre is also important. See Fig. 11, which is based on an investigation by [Power and Associates, 2003] but was presented by [Miyabe, 2005]. Of the parameters among which consumers could choose, all except Fuel economy and Appearance are related to traffic safety. Noise was not included among the response options but is probably included indirectly, together with road holding characteristics, in the sector "Ride & Handling", which is the second largest sector.

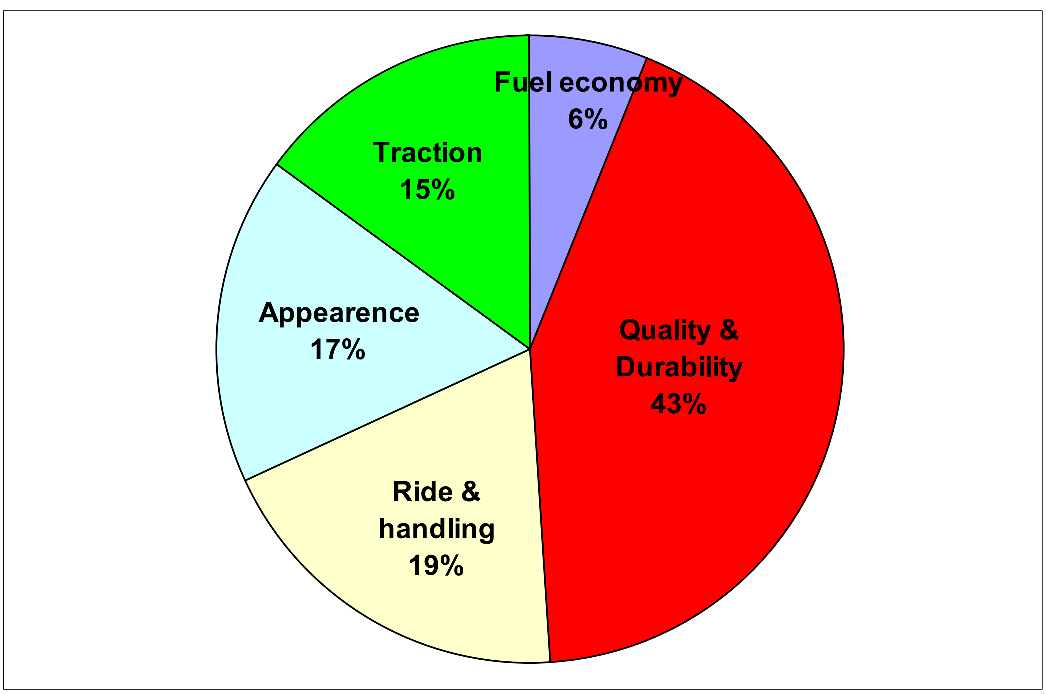


Fig. 11. Criteria governing consumers' choice of tyre, according to a German study [Power and Associates, 2003], reported by [Miyabe, 2005].

The fact that ”Appearance” has such a high percentage is one of the reasons that the tyre industry gives a relatively high priority to the appearance of its products and that this characteristic is often tailored to the vehicle the tyre is designed for [Miyabe, 2005]. As an example, it was stated in [Apollo, 2007] that "…we found that 90% of people who buy SUVs want a tire that reflects their car". From the technical, traffic safety and environmental standpoints the influence of styling and appearance is very unfortunate, but it is a consumer and marketing behaviour that cannot be ignored.

Fig. 11 did not explicitly deal with how important the consumer considers noise to be. However, an Austrian study shows a number of results that are of interest here; Figs. 12 and 13 are examples of this. Data have been obtained from [Haider, 2005] but originate from [Fallast, 2004]. According to Fig. 12, noise plays only a minor role in the consumer's choice. However, this author speculates that this might be influenced by the lack of any objective information about this parameter in a tyre shop. The same might apply to fuel consumption or rolling resistance which are not even in the chart. "Safety" might receive such dominating value since it is the main marketing argument for many if not most of the tyres and the consumer might have some confidence in those statements.

Figs. 12-14 in this report have been translated from German and have been cosmetically modified by this author.

7.4 Willingness to buy environmentally friendly products

Fig. 13 shows that the Austrian respondents to the survey are indeed willing to consider purchasing low-noise tyres [Fallast, 2004]. Irrespective of how annoyed they feel about noise, more than 90 % are willing to purchase low-noise tyres. It is of course understood that in order to do so they must be informed about which tyre that is a low-noise tyre.

But what if the consumer has to pay more for the low-noise tyres? Do low-noise tyres cost more than other tyres? A Danish study indicates that this is NOT the case; it rather appeared that there was a weak tendency the other way [Miljø-styrelsen, 2003-2]. In spite of this, Miljøstyrelsen, in an evaluation of different noise control strategies, applied a cost increase of 10 % for low-noise tyres in comparison with normal tyres, together with the assumption that there was 2 dB difference between these [Miljøstyrelsen, 2003-1]. This figure had been taken from a previous Norwegian investigation (5 % per dB), but it seems as though the Norwegian investigation had no technical basis. With this approach, however, a clear macroeconomic gain was found in favour of greater use of low-noise tyres.

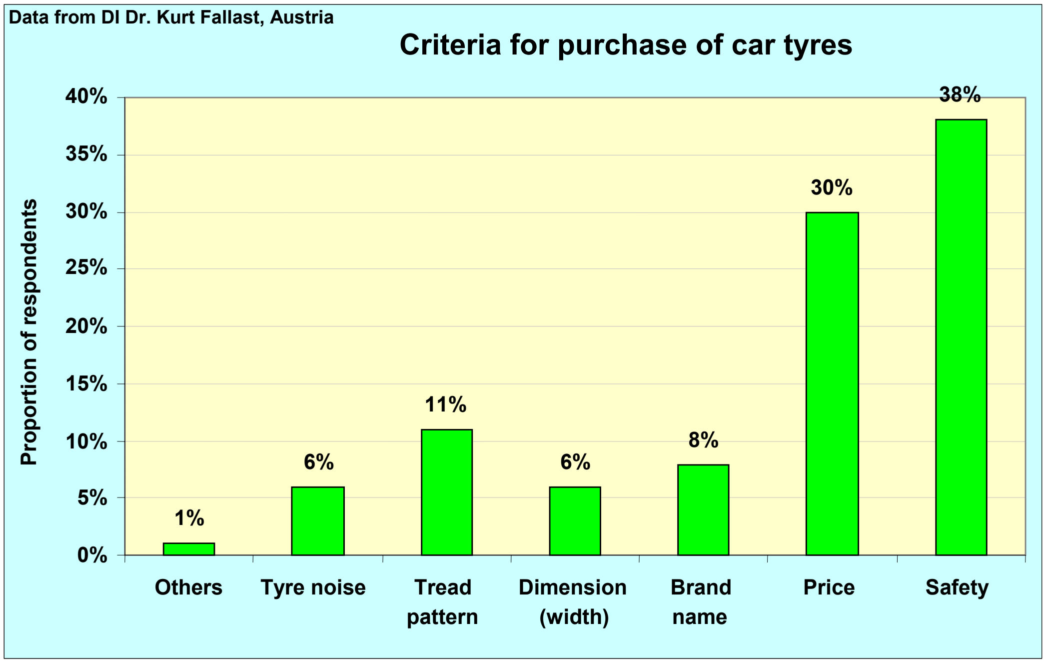


Fig. 12. The most important criteria for consumers' choice of car tyre, according to an Austrian study [Fallast, 2004].

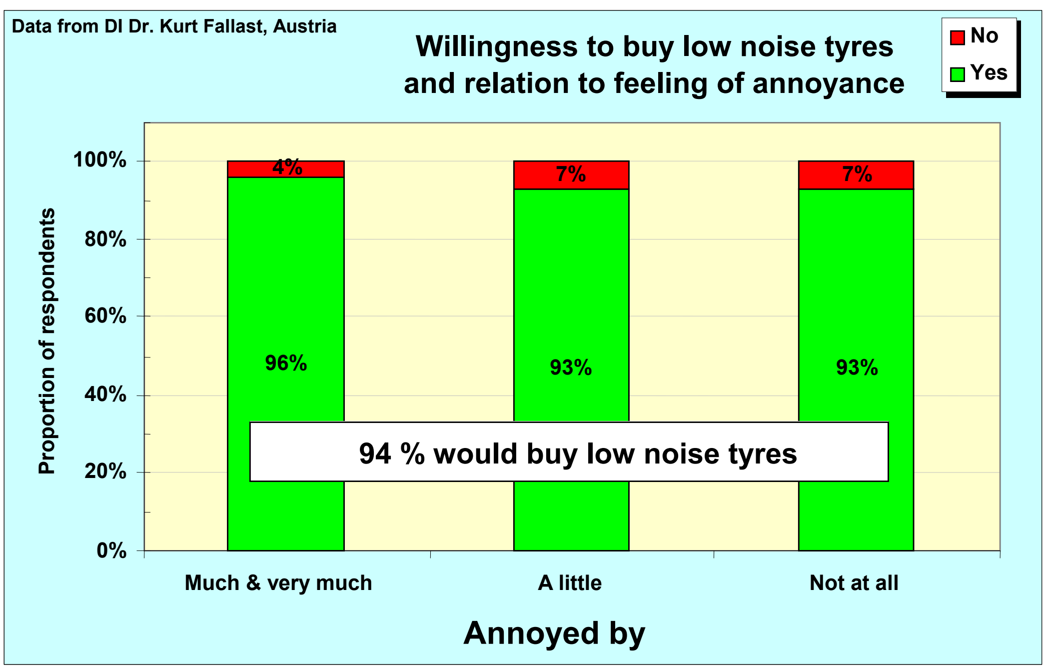


Fig. 13. Willingness to buy low-noise tyres, coupled with degree of annoyance by noise, according to an Austrian study [Fallast, 2004].

According to information received, for the 82 German tyres in Fig. 39, it was found that there was no correlation between noise level and purchase cost [Stenschke, 2005]. This issue has also been studied in the Netherlands, both by looking at Danish and German experiences and by studying the relationship between noise level and cost for their own tyres (those denoted M+P in Fig. 39). It was found that the result is the same as for Germany and Denmark; i.e., no relationship could be found between noise level and purchase cost [Roovers, 2005]. The same appeared to be the case for the recently measured tyres in Fig. 41 [de Graaff & van Blokland, 2007].

In a brief report from Austria, the results of a study of the willingness to pay for (presumably) more expensive but quieter tyres were presented; see Fig. 14 [Anon, 2004]. It showed that 3 % of those asked were willing to pay ca 20 % more, 36 % to pay ca 10 % more, while 30 % were not willing to pay anything extra at all. A clear majority were thus willing to pay extra for lower tyre noise.

People are presumably more aware of the noise they hear inside the vehicle than the noise emitted to the roadside. For example, it was reported in [Yukawa, 2007] that a new tyre marketed as having lower interior noise has been very successful, primarily on the Japanese market, expecting to sell 1.5 million such tyres in 2007.

Regardless of this, it is reasonably clear (especially in view of Figs. 13 and 14) that consumers of tyres for private vehicles are prepared to buy low-noise tyres if such tyres are identifiable and available.

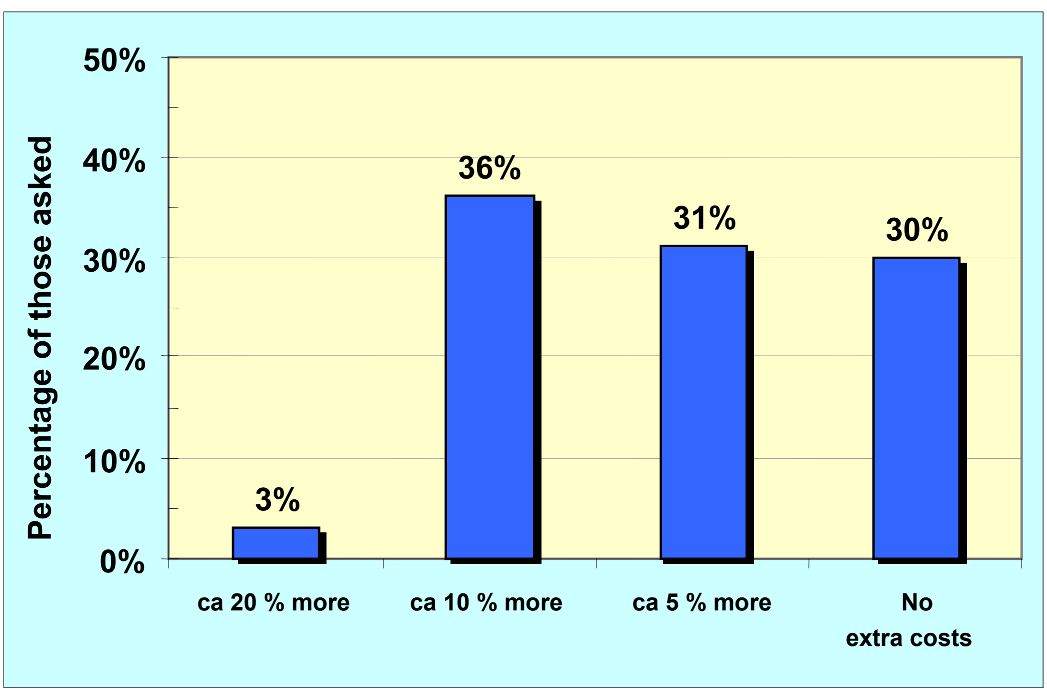


Fig. 14. Willingness to pay for quieter tyres, according to an Austrian study [Anon, 2004].

7.3 Procurement policies of vehicle fleet owners and operators

Private heavy vehicle owners favour economy; i.e. purchase price, treadwear and rolling resistance. Noise would be secondary, at most. However, more and more companies work out an environment policy, in which sometimes noise might be included, since they know that a respected environment policy is a marketing argument and sometimes it is even a requirement from public customers.
Publicly owned companies or public transportation companies, at least in northern Europe, often have an outspoken environment policy, which mostly includes low fuel consumption but sometimes also noise emission. Such organizations would most certainly be interested in rolling resistance and noise-related information for the tyres they plan to purchase. Noise is mostly a concern in the urban areas they serve and by selecting quiet vehicles and tyres they can help in reducing such nuisances to the citizens who indirectly are their employers.

Politicians in cities and regions have a tool for reducing noise emission at the source by making sure that the officials who implement their decisions select vehicles and tyres which meet high standards of noise emission; but only provided there is consumer information including objective noise values available.

What is said above for heavy vehicles, partly also applies to light vehicles. Politicians and their officials may require taxi companies to use environmentally friendly vehicles ("clean vehicles") in order to get a permit to operate as taxi owners. There are several examples of this already in Sweden, where a great proportion of the taxi cars therefore run on bio fuels or some other fuels which are classified as environmentally friendly. This has also spread to private companies; for example the multinational company Skanska recently announced such an environment policy, with a target that 100 % of their company cars and vans soon shall be clean vehicles.

Low-emission zones are becoming increasingly popular in European cities and low tyre noise emissions are a likely future parameter for vehicles allowed to enter such zones. The problem is that the definition of clean vehicles does not currently include low-noise tyres or vehicles, but the latter is a matter of a political decision, which so far has been impossible to take with the lack of noise-related consumer information.

Already, Stockholm City recommends the purchase of light tyres which are awarded the Nordic Swan. If other tyres are offered or selected, a special documentation shall be provided [Anon., 2005]. There are also several private and public organizations with focus on the environment that recommends their members to select Swan-labelled tyres.

7.4 The strength of stimulated market forces

In the Netherlands there was a system some years ago to promote the introduction of environmentally more favourable refrigerators. There were a number of environmental classes for refrigerators, AA, A, B, C, D and E; with AA being the best and E the worst. The vendors received ca EUR 100 for class AA refrigerators and ca EUR 50 for class A refrigerators. After some time there were hardly any refrigerators on sale other than classes AA and A. The system was then discontinued since it was too expensive for the government. The effect however persisted: refrigerators in the shops are still mostly classed AA and A (for consumers there is no appreciable price difference between classes). More detailed information on this is to be found in [KPMG BEA, 2003].

Somewhat similar things happen in the transport sector. The latest developments to encourage the shift from high- to low-pollution vehicles have demonstrated the dramatic effects of the market forces. An economic favour in combination with a reasonable environmental consciousness has shown that the market can be re-painted. For example, when this is written, it is reported in newspapers that the Toyota's Prius hybrid car outsold Ford's best-selling Explorer SUV in 2007. For the American vehicle industry this is shocking news. The Prius is subject to economic stimulation in many US states, but the fuel consumption advantage alone would justify the change to such a vehicle for many vehicle owners.

There appears to be a great interest in financial incentive schemes for cleaner vehicles and the development of these. The incentives that exist today and/or are under discussion, especially those relating to congestion charges and parking charges, represent, for quite a number of vehicle owners, a financial benefit that may be substantial, and this has already been found to have a strong effect on the market. The benefits for clean vehicles in Sweden can in some cases be worth as much as SEK 10,000-30,000 annually (EUR 1100-3200). The highest value applies to a hybrid vehicle in Stockholm that is exempt from the congestion charge and parking charges, and for which the taxable benefit value is also reduced. Some cities or regions also give direct subsidies for purchase of clean vehicles. The Swedish government recently introduced a subsidy for the purchase of new clean vehicles of SEK 10000-20000 per vehicle.

Among the national authorities, the interest in clean vehicles also relates to quieter tyres and thus quieter vehicles. From a technical standpoint, it would be obvious to include a requirement concerning external noise emission in the definitions of clean vehicles as soon as noise levels are declared.

Even private companies may offer contributions for clean vehicles. Volvo Cars pays SEK 6000-10000 as a "Renewal Premium" when a customer purchases a new clean Volvo vehicle and leaves an old (not clean) Volvo car in return. SEK 10000 is approximately EUR 950. The company might need to clean its reputation of manufacturing mainly high-fuel-consumption private cars. In a press release 2007-01-14, Volvo writes that a customer may receive the following economical incentives when purchasing a Volvo Flexifuel car [Volvo, 2008]:

- SEK 10 000 as a Volvo Renewal Premium
- SEK 10000-20 000 as a Swedish governmental clean vehicle subsidy
- SEK 10000+ if the customer accepts all other Volvo "green offers"

The advantages offered for clean vehicles, especially in Stockholm with its congestion charges, have resulted in a rush for such vehicles; the latest statistics show that 21 % of all new vehicles sold in Stockholm in October 2007 were clean vehicles. This illustrates that if such vehicles are given the right encouragement they become a selling success and the market will rapidly adapt to this. Reasonably, the same should be valid for tyres.

In summary: With a small stimulation of market forces, there are great possibilities for creating new markets for clean products. When this now is becoming obvious to politicians, this development is likely to accelerate. This will no doubt need appropriate and objective consumer information relating to environmental performance.

7.5 Marketing of the acoustic performance of tyres

Low noise performance is often featured in marketing by tyre manufacturers and tyre dealers; especially on the internet. The author has compiled a lot of examples. Figs. 15-23 below just show some snapshots from this business. The intention by including them in this report is to illustrate that noise and quiet are selling features; i.e., wanted by the customers.

Many more examples are shown in Annex A.

From a consumer's point of view the value of such statements may be limited since they are obviously biased and the information is subjective. The value of such statements should be several times higher if they were accompanied by some quantitative information comparing the particular tyre with some standard or with a set of other well known tyres.

Figure 20 and Figure 23 show examples of how the Nordic Swan label is used in commercial advertisement.

Fig. 15 "Best choice for low noise"; excerpt from the website of Continental Tyres in Germany: http://www.conti-online.com/generator/www/uk/en/continental/transport/general/news/tyre_noise_en.html

Fig. 16 "Ultimate Silence"; excerpt from the website of Yokohama Tires: http://www.yokohama.co.nz/dna_db_es501.html

Fig. 17 "SilentArmor" and "Strong, Silent Type"; excerpt from Goodyear website: http://www.goodyearwrangler.com/goodyearwrangler/html/silentarmor/technology.jsp

Fig. 18 "Exceptionally comfortable and quiet"; excerpt from a Michelin website: http://www.michelin.co.uk/uk/front/index.jsp?codeRubrique=20060301154455&lang=EN

Fig. 18a "Refined and quiet comfort"; excerpt from a Bridgestone website: http://www.bridgestone.eu/bfe/v/index.jsp?vgnextoid=5b49fc68a9fbf010VgnVCM1000005101a10aRCRD (picture edited by the author to save space)

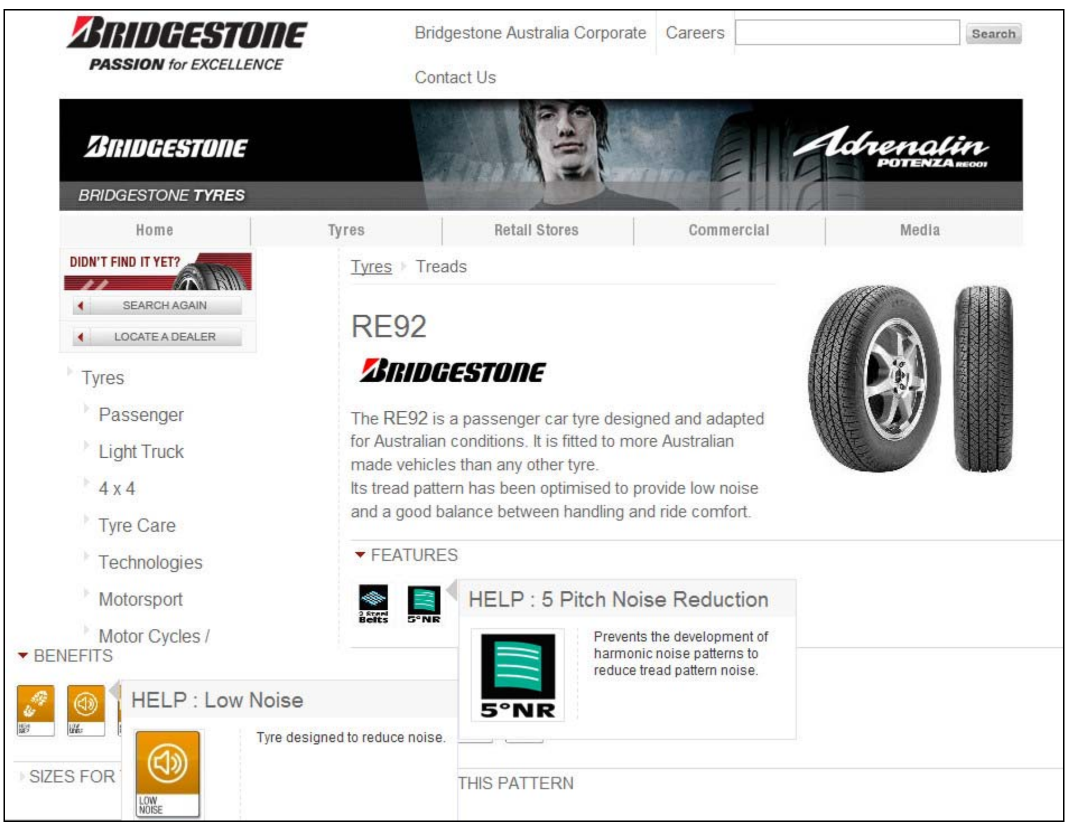


Fig. 18b. Bridgestone RE92, Australia's most popular tyre, marketed as "low noise". http://www.bridgestone.com.au/tyres/treads/re92.aspx

<u>Fig. 20</u> Swedish tyre dealer referring to the Nordic Swan label for AGI tyres, saying "Sweden's best-selling environment-friendly tyre". Photo from Malmö in Sweden by the author.

<u>Fig. 21</u> Former Swedish tyre producer Gislaved announcing a quiet tyre on billboards at petrol stations and elsewhere in the 1980's.

Fig. 22 Tyre dealer in Sweden announcing Fulda tyres outside his shop, saying "Safe, strong, quiet", with the last word in the biggest letters. Photo by the author.

Fig. 23 Hankook Tires announcing on their website (in Swedish) that they have one winter tyre awarded the Nordic Swan label. The Swan labels are presented to Hankook representatives in the lower left insert. From the website: http://www.hankook.se/om_sv.asp

8 TYRE PERFORMANCE PARAMETERS TO CONSIDER

8.1 General

Regarding the environmental aspects of tyre usage, Williams writes in an editorial in Tire Technology International in June/July 2007 that "There would be five items you would consider as fundamental: chemical release, noise, rolling resistance, wear resistance and end-of-life recovery". This well summarizes which environmental concerns that should have the highest priority. Of these, end-of-life recovery and chemical release are "go/no go" characteristics suitable for handling by legal limiting requirements; i.e., all tyres shall meet a specified requirement and there is no "grey zone". They should also be included in any general environmental label, such as the Nordic Swan and the Blue Angel, if not already limited by legislation. Chemical release, in terms of polycyclic aromatic hydrocarbons (PAHs), is already subject to coming regulations by the EU Commission.

However, noise, rolling resistance and wear resistance are quantitative parameters where there is no absolute "good" or "bad", although a minimum or maximum limit may be assigned, but rather a scale of performance over which the consumer may have a choice at a certain level, which is in balance with other parameters he/she values, such as price and safety.

Thus noise, rolling resistance and wear resistance are parameters that are useful for consumer information and labelling. In USA, already wear resistance (in this case the same as treadwear) is subject to labelling and rolling resistance is underway. In this report, noise and rolling resistance, but not wear resistance, are suggested to be considered. Noise and rolling resistance both have very substantial and direct effects on our environment, which justifies the choice of these for labelling and consumer information.

Why not wear resistance too? Wear resistance affects the consumers' economy by the frequency at which the tyre must be replaced. It also affects the use of raw material resources and the emission of particulates into air, water and soil. Thus, it is absolutely both economically and environmentally a parameter which it is justified to inform about.

However, there is a trade-off between wear resistance and safety. If the consumer selects tyres with high wear resistance, he/she may use such a tyre for an extended period of time, maybe 10 years or longer. During such a time, the chemical ageing of tyres may increase the tyre stiffness by 15-20 units of Shore A. This will generally mean a significant impairment in the tyre's safety performance. A treadwear test will fail to show this effect. The author does not yet have any answer with regard to how one may handle this unwanted effect of a consumer's treadwear consideration.

Perhaps, in a longer time perspective, wear resistance or "treadwear" shall be added as a parameter for consumer information, but in the short time perspective, the problems with the wear mechanisms and test methods that rank tyres in a fair way are not sufficiently explored to justify adding treadwear immediately. It is true that the US has a method for testing treadwear, but this is not widely used in Europe. The trade-off with safety is another issue speaking against including a treadwear label. See further Chapter 10.

8.2 Wet grip

"Wet grip" represents the ability to brake with of a tyre on a wet road, which is a parameter with many names. In the NHTSA requirements in USA it is called "traction", in the EU Commissions documents and in ISO 23671 it is called "wet grip" but in the UN ECE Regulation 117 it has two names: "Adhesion on wet surfaces" in the title and in the scope, but "wet grip" in the main text and in the measurement method annex. In the CEN work with focus on road surfaces and in many US documents the same thing is called "(wet) skid resistance". "Wet friction" is another term.

Anyway, wet grip or whatever it is called, is a safety parameter of great concern; which in present or planned regulations is measured only for new tyres. The UN ECE Regulation 117 which is the ECE version of EU Directive 2001/43/EC already includes a minimum requirement with regard to wet grip for car tyres [ECE R117, 2007], measured at 65 km/h or at deceleration from 80 to 20 km/h. The EU Commission states that it intends to include the same thing in a coming Directive [Com, 2007]; i.e., "wet grip" there will be based on ECE R117. There is also an ISO standard, ISO 23671, which is largely the same method as the method in ECE R117.

But the wet grip as it is measured in ECE R117, on new tyres only, is not the only safety-related parameter of importance. One may even argue that it is not even necessarily the most critical safety parameter; it is just the one which is the easiest to measure. The four worst conditions when tyre/road skid resistance or friction is at its lowest levels in legal driving conditions are the following:

- Conditions when aquaplaning may occur; i.e., when water depth is very high
- When roads are snow- or ice-covered
- Wet weather braking when using worn tyres with low tread depth
- Wet weather braking at very high motorway speeds

All these four are unfortunately much more difficult to measure than wet grip for new tyres. As argued in Chapter 9 the wet grip test mainly measures the quality of the tread rubber compound; except for the combination of very low macrotexture and high water depth when tread drainage may also play a role. When driving on wet roads at very high speeds, say at 195 km/h, three times as much water must be displaced from the tyre/road interface per time unit than at the condition of the test speed (65 km/h). It is clear that then the drainage properties become important.

Thus, to represent braking performance of a certain tyre under various maximum critical conditions, the wet grip test is of limited value. For example, under winter conditions, tyres behave very differently than in the wet grip test. Also in dry or in flooded conditions, tyres will behave in a way which will not necessarily be well correlated with the wet grip test. Furthermore, it shall not be forgotten that maybe the most important wet grip aspect of all, for example demonstrated in the EU project VERT, is the skid resistance of tyres worn down near the legal tread depth limit, and this is unlikely to be affected by a wet grip Directive or Regulation relating to new tyres. Finally, the aquaplaning characteristics are not necessarily well correlated with the wet grip performance (compare Figs 35-36 in [FEHRL, 2006-2]. It means that the four worst conditions, when skid resistance is at its lowest levels in legal driving conditions (aquaplaning, snow- or ice-covered roads, worn-out tyres, driving at very high speed on wet roads), are not well represented by the wet grip test.

Therefore, the wet grip test has serious limitations and one shall not be too optimistic of how well or completely it paints the truth. For tyres which are intended to operate under winter conditions with ice and snow on the road, or for worn-out tyres its usefulness is highly questionable.

So, is it justified to measure "wet grip" (for new tyres) and require them to comply with a certain limit? This author thinks that, in principle, it is reasonable and desirable to require that tyres on the European market meet a minimum level of wet grip, since the wet grip condition is (arguably) the most common condition that European drivers will normally experience. It is not the worst condition but it may be the most common condition. However, it should preferably require testing of tyres also in near worn-out condition. For winter tyres, a test on ice should also be used.

The wet grip test for new tyres will not rank tyres in the same way as the other critical safety conditions may do even if the test methods were perfect. But, as argued in 9.1 the test method in ECE R117 has serious shortcomings, making it more or less meaningless even for its present use.

As argued in Chapter 10, the author does not think that the wet grip is so unanimously important for the tyre consumer that it alone should be the basis of a safety-characterising consumer label.

8.3 Rolling resistance and fuel consumption

As for wet grip, there seems to be a determination to introduce a rolling resistance test in the type approval system. This is clear in the latest proposal from the EU Commission [Com, 2007] and in discussions within ECE/WP29/GRRF [GRRF 62-39, 2007], and is already a fact in USA. The tyre industry both in Europe and USA support this idea. The EU Commission intends to combine it with a maximum limit. This author thinks that all this is good.

The EU Commission and the GRRF also want to introduce quality classes ("categories" or "bands") of rolling resistance. This ambition is shared by the California Energy Commission and the European tyre industry. This author thinks that this is also good, although it would be better not to define classes but to present the actually measured value (see Chapter 6.7).

The only concern is: Is the test method sufficiently good; so that it will rank or classify tyres in a fair and correct way which is representative of on-the-road performance? There are serious concerns about this and work is ongoing to rectify the problem (see Chapter 9.2) but the author's view is that these are not sufficiently serious to justify a rejection of the test.

8.4 Exterior noise emission

There is already a noise test in the EU directive and in the corresponding UN ECE regulation combined with requirements regarding maximum noise limits. The tyre industry was not happy when it was introduced in 2001 but accepts it now. In the USA there are no similar plans and Japan seems to wait for what happens in Europe.

The first limits, still in force, have been subject to widespread disappointment since they were set at such a high level that they removed almost no tyres at all from the market [FEHRL, 2006-1]. The influence on road traffic noise levels has thus been totally negligible.

There is, therefore, agreement (in Europe) that the limits shall be tightened within a few years, although the degree of tightening is very much disagreed on, and where the tyre industry stands far away from the Commission and other organizations. New and significantly reduced limits have been proposed by the EU Commission [Com, 2007], based on a study and proposal made by FEHRL [FEHRL 2006-1].

The tyre industry has expressed serious concerns over the Commission's proposal. In its comments to the proposal, the ETRMA writes, for example [ETRMA, 2007-1]:

"The noise limits proposed in Annex 1 of the Consultation Document are unrealistic and simply cannot be achieved by the Tyre Industry. Tightening the limits more than suggested by the industry in its proposal (see Annex 1), in order to be more environmentally friendly, will make it impossible to keep tyre performances well balanced and to maintain safety performance."

"We support the commission indications for complementary measures concerning improvements in road surface technology. Road surfaces have been identified as having higher potential for rolling noise reduction, up to 10 dB(A), therefore we urge the European Commission to initiate the road-related measures simultaneously to tyre noise requirements."

This author offers the following comments to the ETRMA statements:

- There are already tyres of several brands and all dimensions which meet the new limits and still have good safety performance.

- All tyres shall not be able to comply with the limits. The very idea of the limits is to influence the market in order that the "noisiest" tyres are replaced by quieter ones. Therefore, it is absolutely necessary that all tyres shall not comply with the limits. In order to have a reasonable influence on the road traffic noise levels, approximately 50 % of the present tyres must be removed from the market and replaced with quieter ones.

- With regard to road surfaces, the ETRMA has totally unrealistic expectations regarding the effect of low-noise road surfaces. Present state-of-the-art for road surfaces is a noise reduction of 5-6 dB seen as a life-time average; something that will increase the cost of the surface by perhaps a factor 2 or 3. This is something already being applied by some road authorities, without the pressure of any regulations, and with acceptance of the extra costs. If quiet tyres would cost 2-3 times as much as normal tyres today, the ETRMA would probably be most concerned.

Yet, the European tyre manufacturers, through ETRMA, recently committed themselves to "lowering tyre noise levels by two decibels" [ETRMA, 2007-2]. To lower tyre noise levels by 2 dB is almost the same as the expected effect of the FEHRL proposal[18], so in this way the ETRMA seems to accept FEHRL's and the Commission's proposals. However, there is a possibility that ETRMA does not actually mean to reduce tyre noise levels by 2 dB but to reduce the limiting levels by 2 dB, which is a completely different thing. The latter would have no significant effect on traffic noise levels.

This author supports the proposal submitted by FEHRL (and was actually part of the FEHRL project team) and thus by the Commission; although the Commission has failed to make it clear that also retreaded tyres shall be included and the time schedule is too defensive.

8.5 Other parameters?

As argued above, other parameters of concern would be chemical release, wear resistance and end-of-life recovery. Refer to 8.1 with regard to these. No other parameters are of interest for the purposes of this report.

[18] FEHRL in its calculations assumed that the effect would be on the average 3 dB "across the different classes for C1 tyres" (page 52 in [FEHRL, 2006-1]), but this author thinks that this is too optimistic and 2.5 dB would be more realistic.

9 TECHNICAL ISSUES RELATED TO TESTING

9.1 Wet grip

Wet grip test methods are specified in ISO 23671 "Passenger car tyres — Method for measuring relative wet grip performance — Loaded new tyres" [ISO 23671, 2006] and in ECE Regulation 117 which deals with "sound emissions and to adhesion on wet surfaces" [ECE R117, 2007]. These methods are essentially the same; probably they have been developed in parallel. None of them treats the problem of uncertainty of measurement which is normally required in ISO standards. Perhaps this is related to the serious shortcomings that the methods have due to wide tolerances in measurement conditions which cause high uncertainty of the results.

The wet grip test for type approval of passenger car tyres as required in [ECE R117, 2007], which in reality consists of two alternative test methods, is intended to be required also by the EU Commission. In order to describe the shortcomings it is first necessary to describe the test method briefly.

The test is essentially a comparison of the wet braking performance of a certain tyre with that of a standard reference test tyre (SRTT). The final value is a "Wet grip index (G)" which is the ratio between the performance of the candidate tyre and the performance of the standard reference test tyre. The performance of both the candidate tyre and the SRTT is measured on the same test surface as close in time as practical. So far, the wet grip test and the requirements concern only car tyres, but a corresponding procedure for truck tyres is being considered and a testing project has been conducted [DfT, 2004].

As mentioned above, the measurement method allows the use of either one of two types of measurements:

- Peak friction coefficient (called peak brake force coefficient, pbfc, in ECE R117) measured at 65 km/h for a tyre braking from no slip to full slip (blocked), using a special test vehicle on which the candidate tyre is mounted.
- Stopping distance S when braking from 80 to 20 km/h using a car or van with ABS in operation. The stopping distance is re-calculated to a "mean fully developed deceleration (mfdd)". The R117 does not say so, but it is probably meant that all 4 tyres on the test vehicle shall be the candidate test tyre type.

The pbfc or the mfdd values are then divided by the corresponding value for the SRTT to give the Wet Grip Index. The author believes that the possibility to use any of the two methods is acceptable, when only the performance relative to the SRTT is considered and the accuracy requirement is medium, since tests have showed a relatively good correlation between the methods [Nordström, 2008].

The test surface shall be a dense asphalt surface with a maximum chipping size of nominally 10 mm, but 8-13 mm when including tolerances, and the texture depth (called "sand depth" in R117) measured as specified in ASTM E-965 shall be between 0.4 and 1.0 mm, including the tolerances. This is the first problem.

According to this author's experience[19] this would allow any surface from stone mastic asphalt (SMA) with 13 mm max chipping size and having a relatively rough texture to a dense asphalt concrete with maximum 8 mm chippings having a very smooth surface (even smoother than an ISO 10844 surface). This includes practically the entire asphalt surface range appearing on European roads except those which have chipping sizes of 14 or 16 mm. It may be noted that the accuracy of the outdated texture measuring method chosen is so poor that this actually gives an even wider range than the figures show (ISO has developed a much better method, also accepted by CEN). With the wide range which is allowed, and the chosen method, the texture measurement is in practice meaningless.

There are also requirements regarding "surface friction", tested either as pbfc using an SRTT (value should be within 0.6 and 0.8) or with the pendulum method (BPN) according to the ASTM 303-98 standard (value should be within 40 and 60). These measurements only restrict the microtexture of the chippings, but still within a wide range, and do not significantly restrict the surface type.

The author believes that a measurement on the roughest type of surface which is allowed will rank tyres quite differently from a measurement on the smoothest type allowed, even when using the SRTT running on the same surface for comparison, since such largely different surfaces favour different features of a tyre tread. The rough surface will favour a tread with a premium rubber compound and be essentially insensitive to drainage properties of the tread, while the smooth surface will tend to change the emphasis from the rubber compound to drainage properties, especially if water depth is high at the same time.

Therefore, the method already here leaves the doors open for "cycle-beating". A really poor tyre can be approved in the wet grip test if the optimum surface for this purpose is selected.

Furthermore, the test shall be performed on a wetted surface, with a water depth 0.5-1.5 mm. This is the second major problem, somewhat related to the first one. Water depth is very difficult to measure and even not easy to define. There is no definition in ECE R117, which means that different test conductors may interpret the requirement differently. Therefore, there is room for a very large range of water depths. The author believes that a test using 0.5 mm water depth as compared to another one using 1.5 mm (plus measurement and interpretation errors), in combination with the very large range of surface texture allowed (0.4 to 1.0 mm, plus measurement errors), will cause different characteristics of tyre treads to be favoured. This is the case even when the SRTT is used for comparison, tested on the same surface and with the same wetting of the surface.

[19] The author is Convener of the ISO/TC 43/SC 1 Working Group 39 that has developed modern standards for texture measurement

This wide range of water depth requirement enhances the possibilities of the "cycle-beating" mentioned above.

When using the test car with ABS, the load requirements of the tyres are surprisingly liberal. This is the third major problem. Consider an example where a car tyre with a load index LI of 600 kg shall be tested. It is then possible for one test organization to choose a load on the SRTT of 381 kg, while the load on the candidate tyre can be chosen for example at 540 kg (90 % of LI). However, another test organization can choose a load on the SRTT of 572 kg, while the load on the candidate tyre (CT) can be chosen at 324 kg (60 % of LI). The comparison of the wet grip index of these two cases (with same candidate tyre) will be made with a load ratio CT/SRTT of 540/381 = 1.42 in the first case while it will be 324/572 = 0.57 in the second case. The Regulation assumes that the effect of the load on wet grip is negligible, but when a change in load ratio between the two compared tyres of 1.42/0.57 = 2.5 occurs, this can no longer be negligible. The author thinks that the reason why such a wide range of loads has been chosen is that it allows one single test car to be used for a very wide range (dimension and load) of car tyres. From a practical/economic point of view this is understandable, but then the sacrifice in accuracy of the method is much too high.

The minimum performance of wet grip is required only for Class C1 tyres (car tyres) and is expressed as appears in Table 9. It is likely to be the same in a new EU Directive. It appears that any "normal" tyre (in northern Europe we would call them "summer tyres") must have at least 10 % higher wet grip than the SRTT. For high-speed winter tyres ("snow" tyres) no tyre must be worse than the SRTT and for low-speed winter tyres a tyre may have 10 % lower wet grip than the SRTT.

Table 9. Minimum values for Wet Grip Index (G) in [ECE R117, 2007].

Category of use	**Wet grip index (G)**
Normal (road type) tyre	≥ 1.1
Snow tyre with a speed symbol ("R" and above, plus "H") indicating a maximum permissible speed greater than 160 km/h	≥ 1.0
Snow tyre with a speed symbol ("Q" or below minus "H") indicating a maximum permissible speed not greater than 160 km/h	≥ 0.9

The SRTT is the Standard Reference Test Tyre specified in the standard ASTM E1136-93. This is an old type of SRTT designed as an "all-weather" type more than 25 years ago and standardised already more than 20 years ago. Today, the ASTM has defined a new and more modern tyre of similar type in its standard F2493-06. The wet braking performance of the ASTM E1136 SRTT tyre is very poor, according to several tests made at VTI; it is actually one of the worst measured by VTI [Nordström, 2008]. Therefore, the limits in Table 9 are very liberal and will only remove tyres which would be totally unsuitable for European roads. To comply with such a limit is in no way a proof of quality.

The author is aware of the huge number of measurements made in tests preparing for the wet grip requirement, as well as the very respectable companies, organizations and institutes participating in such tests [GRRF 56-28, 2004]. This author's hypothesis is that each of the participating laboratories have had quite closely controlled test conditions, not being near the extremes allowed in R 117 and that extreme cases have not been tested. As long as this is the case and the SRTT tolerances are close the method is excellent.

It is interesting to note that whereas the test made by TÛV/ETRTO on 106 tyres indicated that no tyre failed to pass the limits in Table 9, in a compilation of further measurements presented in the same document over 25 % of the "normal use" tyres would fail to comply with the 1.1 limit in Table 9 [GRRF 56-28, 2004]. See Figs. 28-29. For "snow" tyres the situation looks even worse. The latter figure may perhaps include some low-quality imports (?) while perhaps the first one did not do so. Nevertheless, for such a large tyre sample, a difference that large is suspect.

Although the use of an SRTT for normalisation of results is clever and worth using, this author considers the wet grip test method as being totally insufficient for its purpose due to its many and serious shortcomings. It is true that the method was preceded by substantial research in e.g. the UK, the Netherlands and Germany [DfT, 2004], but when implemented in the Regulation it is unsatisfactory. It may give almost any "desired" result for a particular tyre, if performed by a test conductor who is skilled in tyre/road interaction and road surface characteristics and who would be willing to "play" a little.

The wet grip test and the minimum requirement, therefore, have no significance for tyre safety in the version appearing in ECE R117. It may even be counterproductive, since the existence of a safety (wet grip) minimum requirement may lead to a false confidence in the safety performance of all the tyres approved for use in Europe. When the EU Commission takes over the wet grip part of ECE R117 it should change to using the new SRTT instead of the old SRTT (which may require a re-definition of limits), as well as take note of the measurement method problems mentioned above. The Commission have at its hands very competent people for this purpose in CEN/TC 227/WG 5, for example.

9.2 Rolling resistance

9.2.1 Brief description of the measurement methods available

The rolling resistance value should be closely related to the fuel consumption of a vehicle using such tyres and driving on a mix of "typical" road surfaces; at least when comparing tyres. Rolling resistance measurements are assumed by "everybody" in Europe to be made on laboratory drum facilities, using an ISO procedure or something very similar to it. Competing procedures might only be the SAE procedures (see 11.2).

The three already standardised methods designed for measurement of rolling resistance of tyres and recognized internationally, plus one revision underway and one new method being worked-out are listed below:

- ISO 18164:2005: "Passenger car, truck, bus and motorcycle tyres — Methods of measuring rolling resistance" [ISO 18164, 2005]. This standard, which in 2005 replaced the old now withdrawn ISO 8767 and ISO 9948, specifies four "sub-methods" (force, torque, power and deceleration) for measuring rolling resistance under controlled laboratory conditions for new tyres designed for use on passenger cars, trucks, buses and motorcycles.
- Revised ISO 18164, to be published in 2008 or 2009, containing an improved "deceleration" sub-method.
- ISO 28580, to be published in 2008 or 2009, based on ISO 18164:2005 but with tightened tolerances and with the intention to include an inter-laboratory calibration procedure. It still contains four "sub-methods" as in ISO 18164 [ISO/CD 28580, 2007].
- SAE J2452:1999: "Stepwise Coastdown Methodology for Measuring Tire Rolling Resistance" [SAE J2452, 1999]. This standard described a laboratory method using a coast-down method with a primary intent described as "estimation of the tire rolling resistance contribution to vehicle force applicable to SAE Vehicle Coastdown recommended practices J2263 and J2264."
- SAE J1269:2000: "Rolling Resistance Measurement Procedure for Passenger Car, Light Truck, and Highway Truck and Bus Tires" [SAE J1269, 2000]. This standard is actually much older than J2452, first introduced in 1987, but reconfirmed in 2000. J1269 is also a laboratory method but it uses a constant speed test.

The ISO 18164 and the SAE methods give a certain freedom in choosing the parameter to measure; i.e. there are "sub-methods" in them (e.g. spindle torque, force, power and deceleration are all allowed in the ISO method). All five methods specify a measurement with a test tyre rolling against a drum surface, the drum diameter normally being 1.7 m and measurement of a parameter related to the energy loss in the rolling tyre which then can be re-calculated to a rolling resistance coefficient. A machine for conducting such measurements is shown in Fig. 24. That facility has provisions also for measurement of noise, which is why there are some extra structures and covers around the test tyre.

It is also possible to measure the rolling resistance with a trailer-mounted tyre, such as with the trailer shown in Fig. 25. In such a case there is no curvature on the surface which may be a road with typical surface texture and unevenness. On the other hand, measurements will be more affected by temperature and ambient conditions as well as deviations from a perfectly horizontal plane. But the main problem is that there is presently no standard method available for this.

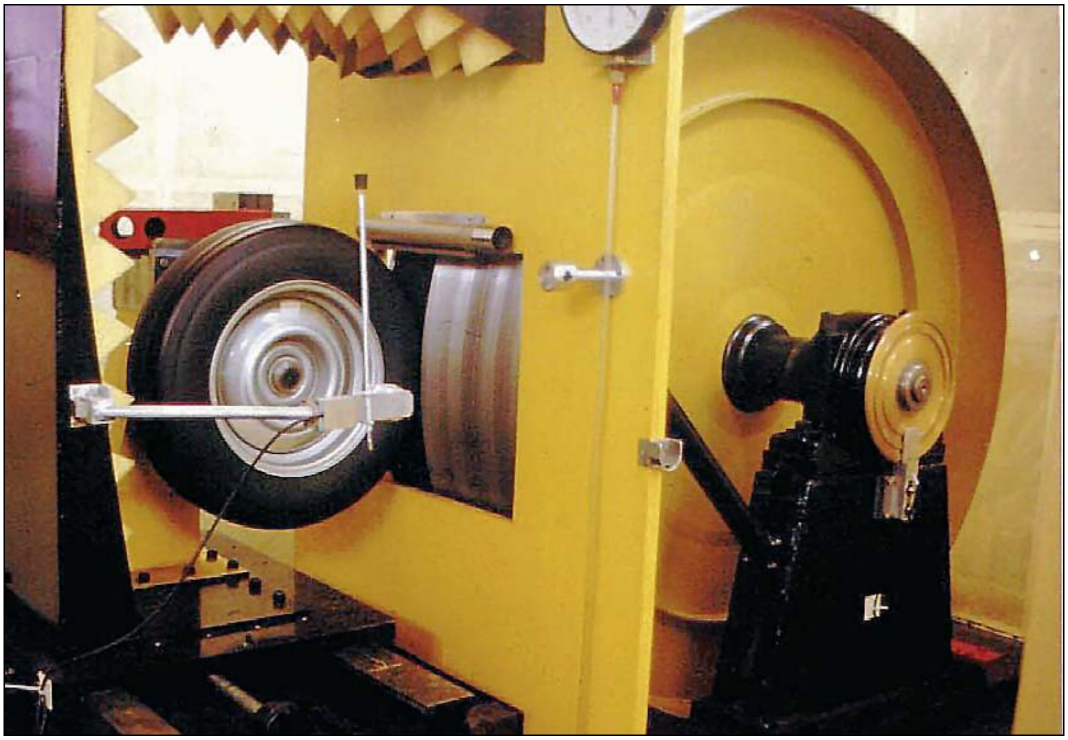


Fig. 24. Equipment for measuring rolling resistance using the torque "sub-method". Drum facility at the Technical University of Gdansk in Poland. The drum has a sand-paper-like surface at the left and a smooth steel surface on the right part of the drum width. Drum diameter is 1.7 m.

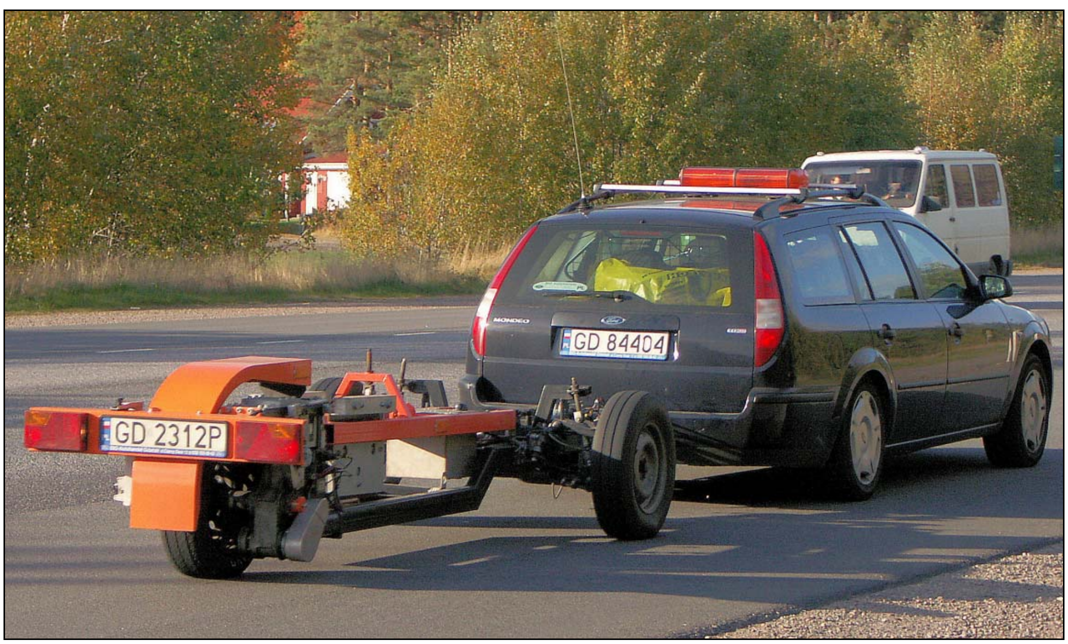


Fig. 25. Trailer for measurement of rolling resistance on test tracks or real roads. The trailer is constructed and owned by the Technical University of Gdansk in Poland.

9.2.2 Current attempts to improve the measurement method

The European tyre industry was not totally happy with the ISO 18164 for the purpose of labelling tyres. As mentioned above, this standard allows four variations of the method (here called "sub-methods") with respect to testing conditions or for physical quantity measured. The consequence is that the results of measurements carried out properly according to the applicable standard on the same physical tyre may differ by as much as 2 kg/t (0.2 %) for radial passenger car tyres [GRRF 56-24, 2004]. Thus, it was considered as not giving sufficiently good reproducibility to allow a number of grades (see e.g. Table 2) to be used and a tyre being classified within it with a high level of confidence.

Therefore, the ETRTO initiated work to produce a similar method based on ISO 18164 but with fewer sub-methods allowed and tighter specifications, and to make a round robin test to see how well it performs. The ETRTO work was continued in 2006 under the ISO umbrella, with the designated number 28580, and a first working draft was available in 2004; an ISO Committee Draft was approved 2007-04-30 [ISO/CD 28580, 2007] and a Draft International Standard (DIS) for ISO 28580 is expected in March 2008 [GRRF-ETRTO, 2007]. However, it seems that the original idea of reducing the number of "sub-methods" has been abandoned, since the latest CD still contains all the four "sub-methods" (force, torque, deceleration and power); instead it is now the intention to add a procedure to calibrate various testing machines against some common standard which can eliminate the potential systematic difference between them.

When this is written the mentioned round-robin test for the new ISO/DIS 28580 is in its final stages involving 24 testing machines in the EU, USA and Japan [GRRF-ETRTO, 2007].

Simultaneously, the Russian Federation in GRRF suggested to modify one of the sub-methods in ISO 18164 (the deceleration method) and this was established as a new work item in ISO, with work progressing rapidly, as a DIS is being prepared in 2008. Another shortcoming of the ISO 18164:2005 is that the authors have forgotten (?) to include any specification of what shall be reported and how it shall be made. This is strange and unsatisfactory. Also missing is the nowadays mandatory treatment of uncertainty problems. Thus it seems that the producers of the ISO 18164 have managed to bypass some of the normal mandatory features in today's ISO standards. Hopefully, these short-comings will be corrected in the revised ISO 18164, although the latest CD (of 2007-01-18) does not contain such improvements.

This author thinks that the work to produce a more accurate method (ISO 28580) is promising and it seems to be the currently best method to use for any tyre labelling or regulation regarding rolling resistance.

9.2.3 Problem with the poor representativity of the drum surface

The surface of the laboratory drum against which the test tyre shall roll is either smooth steel (only allowed in the ISO method) or an 80-grit sand-paper-like surface (all methods). In reality such a surface never exists on roads; not even close to it. Since we know that rolling resistance is the result of an interaction between the tyre and the road surface, using a totally unrepresentative surface puts a serious question-mark to the procedure.

Comparison of drum testing and on-the-road testing made by the Technical University of Gdansk (TUG) in cooperation with the Swedish Road and Transport Research Institute (VTI) has highlighted some potential problems in the representativity of the laboratory drum method. These were reported in [Sandberg, 2005], where the problems were summarized as follows:

- Measurements of RRC for a range of tyres on a smooth steel and a sand-paper-like drum surface have far from perfect correlation; thus, one shall not allow both surfaces but only the sand-paper-like surface (as SAE does). A difference between these surfaces of between 2.5 and 11 %, depending on tyre, and with 5.3 % as an average has been measured [DeRaad, 1978]. Measurements at TUG indicated a difference of 3 %[20]. It is very surprising that both ISO 18174 and the coming ISO 28580 allow both types of surfaces.
- Despite the above, the very unrepresentative texture of the drum surface with sand-paper-like surface in the ISO procedure, however, seems to have a rather limited effect when it comes to ranking of tyres; in that most (but not all) tyres seem to rank in the same way on a smooth sand-paper-like texture as on a rough "road-like" texture.
- When not taking air drag into account (such as on a drum) one gives wide tyres an unjustified favour.
- The correlation between measurements of RRC for a range of tyres on an even, realistic road surface with corresponding measurements on a drum having a sand-paper-covered surface is only about $R^2 = 0.6$, which means that up to 40 % of the variation between tyres on a drum is uncorrelated with real-world conditions on a road; i.e. the drum surface will not classify tyres in an appropriate way.
- There is a much smaller difference between tyres on uneven, realistic road surfaces than on a surface with unrealistically low unevenness (such as the almost perfectly even surface of a steel or sand-paper-covered drum), which means that the differences measured between tyres on a drum will not be so large in a "real-world situation". Fuel-consumption improvements by the use of low-rolling-resistance tyres will therefore tend to be overestimated.

---

[20] Unpublished data, measurements made in January 2008 as requested by this author

- The smaller difference is probably caused by the unevenness contribution to rolling resistance which "masks" some of the texture and tread-related rolling resistance.

The effects of the above are the following:

- The lack of unevenness on a drum may mean that tyres are sub-optimized, since the unevenness-caused extra tyre deflections are neglected. Different tyres may have different relative sensitivities to such deflections compared to the deflections on a flat surface. The author has failed in finding a validated figure on how much the unevenness-caused tyre deflections can contribute to rolling resistance, but as macrotexture may contribute by at least up to 45 % [Michelin, 2003], the unevenness contribution should be far from negligible. The observations by VTI/TUG mentioned above support this hypothesis.
- The same goes for macrotexture, at least if a plain steel surface is used, although for macrotexture it is commonly recognized that its influence is paramount [Michelin, 2003] and [Sandberg, 2005].
- The lack of air flow on the drum also will mean that tyres are sub-optimized because air drag is neglected. It means that one of the major features of tyres influencing fuel consumption is totally neglected and the larger car tyres becoming more popular, often having lower hysteresis losses, will not be "punished" for the greater air drag they cause. This is something which consumers ought to be very frustrated about.
- The points above will mean that consumers will NOT be correctly informed about how their tyres will perform in real driving on actual roads. Maybe the information will only be "half-true" at best.

It is reported in [Michelin, 2003] that the air drag accounts for 0-15 % of the rolling resistance, and since tyres have become much larger in later years (wider section and larger rims) while rolling resistance has decreased, the air drag component today is probably more like at least 0-20 %. In [Duleep, 2005] it is reported that the tyre air drag accounts for 20-25 % of the total vehicle air drag. One of the most prestigious technical articles written about rolling resistance writes "In addition, aerodynamic drag, which is usually included in rolling resistance…." [Hall & Moreland, 2001]. It is evident that it would be wrong to neglect the tyre air drag in any regulation, labelling or limiting scheme.

A simple solution to the unevenness problem would be to introduce a more realistic surface on drum. Regarding the air drag, one could calculate the air drag contribution by means of a simple model and add it. Unfortunately, the coming ISO 28580 does not seem to realize this problem, recommending the plain steel drum surface and optionally the 80-grit sand-paper-like surface.

Note that of course the unevenness also causes extra losses in the tyre suspension system of the vehicle. This shall not be mixed with the losses in the tyre itself.

Furthermore, recent unpublished research made at the TUG suggests that the correction for drum curvature in the ISO procedure (in relation to when driving on a plane road) may be too inaccurate. It was determined more than 30 years ago based on tyres which are very different from today, not the least aspect ratios and sidewall heights and probably even based on diagonal or bias-belted tyres, and it is possible or even probable that for today's tyres another correction should be used.

9.3 Noise

9.3.1 General

The labelling system should specify the sound level of the tyre in such a way that the community sound level (equivalent and/or maximum sound level) noticeably decreases if the system is introduced. This poses three demands for the system:

- Labelling of sound level: For each new tyre type and dimension on the market, a sound level must be measured and recorded.
- Representativity: The sound level that has been measured for a tyre and which is assumed to represent the tyre must be reasonably representative of the behaviour of the tyre in real traffic.
- Measurement accuracy: The margins of error in measurement must be so small that they do not have a deleterious effect on representativity.

9.3.2 Sound level labelling

All new tyres on the market which have been introduced since 4 August 2003 must be type approved for noise emission according to EU Directive 2001/43/EC. Tyres that are not (yet) affected are retreaded tyres and tyres whose type had been launched on the market prior to 2003. From 1 October 2009 onwards, tyres of the latter type must also be type approved. This means that for a few more years there will be quite a lot of tyres on the market which do not have to undergo noise measurement. Retreaded tyres make up about 50 % of all tyres for heavy traffic, and about 25 % for light vehicle traffic in Sweden (less in most other EU countries). It is therefore desirable that type approval with respect to noise emission should be introduced for retreaded tyres also as soon as possible. This was underway in the ECE[21] in 2004-2006 and was intended to be followed-up by a corresponding EU Directive [BLIC/BIPAVER, 2005], but this process has currently stopped. In the proposal for new limits by the Commission [Com, 2007] there is nothing indicated of whether this work is intended to be continued or discontinued.

[21] United Nations Economic Commission for Europe (ECE)

New tyres intended for special car models (OEM tyres) may be produced for up to 5-6 years after their introduction on the market, and they are often stocked by makers and dealers for about 3-4 years after production has ceased [STRO, 2005]. In principle, their lifetime (availability) is about the same as that of a car. In the case of new tyres made for the aftermarket, the above times are shorter; perhaps only one half of the above. A certain tyre may thus remain on the market for about ten years after its introduction, and a few types may live on for perhaps 15 years. It is therefore not until 2015 that almost all tyres in traffic have been measured for noise emission.

9.3.3 Representativity

The sound level reported in conjunction with type approval is only one single decibel value. This is measured over a speed range of 70-90 km/h (car tyres) or 60-80 km/h (lorry tyres). These values that have been normalised to 80 and 70 km/h, respectively, may be considered to be acceptably correlated with values at 50 and 110 km/h. There are some problems regarding representativity; especially for tyre condition and road surface; see below. The fact that measurements are made only on free-rolling tyres can be ignored; if measurements were made on driven tyres at cruise-by, there would be no major differences.

One problem concerning representativity is that the sound level is measured only on tyres in new condition. It is known that noise emission changes with wear, and this is therefore a problem in the type approval system. VTI has studied the influence of tyre wear and ageing on noise levels within the EU project ”SILENCE”, in cooperation with BASt and Continental Tyres in Germany. A new report about this is published in the SILENCE project as [Sandberg et al, 2008].

Another evident defect in the representativity is the effect of water on the road. Wet roads produce a different sound at higher frequencies than dry roads and (as far as we know) they tend to reduce the difference between different tyres. Tyres classified on a dry surfacing will therefore emit a sound on wet roads that is different from what is represented by their measured sound level.

Another problem is the lack of noise values for studded tyres, since during about one third of the year in Sweden (with the exception of the southernmost region) it is noise from studded tyres that dominates the acoustic environment. There is however no easy way to produce sufficiently representative and reproducible noise values for studded tyres, due, inter alia, to changes in stud projection and stud wear over time, and therefore this is a defect that cannot be avoided.

The problems presented by wet roads and the use of studded tyres are ignored in existing surveys of tyres. It is usually stated that on wet roads or in winter when studded tyres are used, sensitivity to annoyance and other disturbance is reduced since most people have their windows and ventilation openings closed and do not spend time outdoors, except for necessary journeys. The same argument for ignoring the problem can be used in this study.

9.3.4 Problem with the Reference Surface

A pronounced defect in the representativity occurs because of the road surface that is used in the vehicle noise homologation tests. Measurements are made on an ”ISO surface”; i.e., one that complies with the requirements in ISO 10844, which is usually a surface on a test track. This standard was drawn up 12-18 years ago[22], and since that time this is the surface that is used in all legal tests of vehicle and tyre noise all over the world. There are currently about 75 test tracks in Europe of this kind. Even at the time when the standard was drawn up, it was pointed out that the surface as designed was not suitable for tests of tyre/road noise[23], but when the EU Directive 2001/43/EC was formulated there was simply no other standardised surface, and the use of this surface was therefore stipulated for tyre/road noise tests also.

This gives rise to the following drawbacks in representativity[24]:

- The ISO surface consistently produces a slightly lower noise emission than the road surfacings which are largely used in the European and especially the Nordic[25] road network. However, this causes no problems as long as the ranking of tyres is the same on the ISO surface as on the surfacings in the road network.

- However, the ranking on the ISO surface is somewhat different from that on surfaces that are typical for the Nordic road network; the difference is however not so great that it is a critical defect.

- The ISO surface gives a slightly greater difference in noise emission between tyres than that given by surfaces typical for the European road network.

In spite of the above defects, the problem can be summarised by saying that although there is a problem with the ISO surface, this gives a relatively acceptable picture of the noise emitted by tyres, particularly over a major population of tyres. An Austrian study of this problem found that, in any case, a tyre classified as a low-noise tyre after tests on the ISO surface was also found to be a low-noise tyre on usual Austrian road surfacings [Haider et al, 2004].

Work is in progress in ISO/TC 43/SC 1/WG 42 on supplementing the ISO surface in accordance with ISO 10844 with a surface that is similar to an SMA 0/14[26];

---

[22] In a committee chaired by this author

[23] The task was to produce a relatively quiet non-absorbing surface for tests of vehicle noise at accelerating conditions

[24] See [Sandberg & Ejsmont, 2002] for further details

[25] In this sub-chapter of the report "Nordic" refers to Sweden, Norway and Finland. Normally, also Denmark and Iceland would be counted as Nordic countries.

[26] Swedish designation HABS14

i.e., a surfacing similar to the most typical surfacings on the Nordic road network. This work is, however, progressing very slowly.

To overcome the short-comings of the reference surface in its present specification, one should do as follows:

- The ISO reference surface must be specified more in detail with tighter tolerances and using better measuring methods. This can be based on the proposal in the ongoing work within ISO/TC 43/SC 1/WG 42.
- A second reference surface, with a rougher macro- and megatexture shall be specified and used
- It is suggested here to use a reference tyre for normalization of differences between different test tracks, the tyre of which may be the new SRTT defined in ASTM F2493-06 [ASTM, 2006]. A procedure for this needs to be worked-out.

9.3.5 Measurement accuracy

The shortcomings in the measurement methods which can have a deleterious effect on the representativity of the measured noise values for tyres are totally dominated by the variation which is presently found between measurements on ISO surfaces in different places. This variation was acceptable for the purpose for which the standard had originally been drawn up, but it is too large for the new purpose; namely tyre/road noise measurement. It appears that some users of ISO surfaces have introduced systems that try to make maximum use of the tolerances allowed by the ISO standard; i.e., to produce the lowest possible noise levels. Work is therefore in progress within the ISO to reduce this variation by narrowing the tolerances in the standard.

10 PROPOSAL FOR CONSUMER INFORMATION

10.1 Preferred consumer information scheme

This author recommends the tyre label alternative with moulded information on the tyre sidewall as mentioned in Chapter 6, but supplemented with a publicly available database, provided by the EEA. The reason is that such a system would combine two desires:

- to make it as easy as possible for the customer to find the consumer information and be sure to find it on any tyre in the shop
- to make it easy for the vast majority of consumers to find out how this particular tyre performs in relation to most other alternative tyre brands

The above solution is in line with the aim of the California Energy Commission, albeit it is intended only for rolling resistance, as far as this author understands it [AB 844, 2003].

However, the pasted note instead of tyre sidewall label is practically equally good. Pasted notes which are rather tricky to remove are already common on tyres. The author further assumes that each tyre dealer would normally have an internet connection making it possible to let the consumer check such information in the shop; or to have similar information available as a hard copy.

Finally, it shall be mentioned that a rather comprehensive discussion on these matters, but applied to rolling resistance, appears in the NRDC report [Tonachel, 2004]. The NRDC report also makes it clear that it is preferred to mark the tyres with some label; rather than "just" some written consumer information.

10.2 Proposal for each parameter of concern

10.2.1 Wet grip

The wet grip test, as specified in ECE R117 and intended to be used also by the EU Commission, has the purpose to make sure that a tyre with poor wet grip performance is not approved for use on the European market. As discussed in Chapter 9.1, the requirements in combination with serious shortcomings in the method make the wet grip test meaningless. In addition, even a "perfect" wet grip index is not alone sufficient for a consumer to determine which tyre that is best for him or her since it can only represent one of many safety characteristics.

The ETRMA, as mentioned in 4.3, advocates labelling tyres with a wet grip grading, and this authors thinks that this is a good idea when an appropriate method is specified, but the present method is far from suitable. The problem is equivalent to that which was the reason for not accepting ISO 18164 for rolling resistance but to work out a better method (ISO 28580). The principle of the method is good but many requirements in the method are much too liberal and need to be much stricter; unfortunately leading to higher testing efforts and costs.

Furthermore, the wet grip test should ideally only be one part of a more relevant overall safety index; also considering end-of-life wet grip performance (which would be dramatically different from new tyre performance), aquaplaning and for (at least) winter tyres an "ice grip" test. The latter two would likely rank tyres quite differently from the wet grip test. The various test results could be combined into one safety index by various weighting factors; for example for a "normal" tyre the ice grip test would have low weight (if none at all) whereas for a "snow" tyre the ice grip test should have a high weight. The safety index outlined above would be an index that would rank tyres with respect to stopping properties under (essentially) the most critical conditions.

Using only one of these parameters for a safety evaluation, such as for the wet grip requirement in ECE R 117, will give the consumer a grading for his tyre choice which would be relevant to only part of his critical driving situations, depending on how, where and when he drives. An overall safety index would in a much better way give a fair evaluation of the tyre relevant to a wider scale of driving situations, and thus it will increase traffic safety on European roads. Fig. 11 illustrates that the consumer already today, with a lack of objective safety information, selects tyres based on safety expectations. Once objective safety data are labelled on tyres, this author believes that the consumers will to a much larger extent consider this parameter in their choice, even when the more ambitious testing has increased the price of the tyre marginally. Hopefully, it will even lead to the safety issue becoming more important at the expense of the counter-productive appearance factor, and tyre choice will to a larger extent be based on technical performance rather than on fashion and appearance.

Therefore, this author recommends that the wet grip value is not presently included in the **consumer label or information**. The lack of a sufficiently well specified measurement method is the reason for rejecting wet grip for consumer information at this time. However, later on with a better measurement method specification it should be considered.

Although the present method has serious short-comings it is for **political** reasons probably necessary to keep the requirement for a minimum wet grip performance as it already exists in R 117. It will probably be hard for politicians to accept tyre labelling for rolling resistance and noise if there is no limit as to wet grip performance. However, one shall as soon as possible improve the method to make sure that it will really remove unsafe tyres from the European market. The method is principally good and has a potential to work as intended. The improvement of the method should be a primary and urgent objective of further work. It may even be possible to achieve this before the wet grip is formally implemented in an EU Directive.

10.2.2 Rolling resistance

It is proposed that the rolling resistance is included in a tyre labelling and consumer information scheme for tyres for both light and heavy vehicles.

It is suggested that the really measured value is labelled, rather than classifying tyres into quality classes. Thus, the classification system proposed by the European Commission in [Com, 2007] is rejected.

Consumer concern for rolling resistance is indeed a very important aspect that may replace purchase price as the most influential factor in the "typical" consumer's decision, provided the labelling scheme is accompanied by an information campaign in each country. This would benefit the consumer's fuel budget, the air pollution and the global climate effects favourably. In a general sense, since it has been suggested that only technically very advanced tyres may be able to provide excellent performance simultaneously for a number of important characteristics [Aimon, 2005-1], it will favour the choice of technically more advanced tyres, which should mean an advantage to the European industry. It is a clear win-win situation.

10.2.3 Noise

It is proposed that also the exterior noise emission is included in a tyre labelling and consumer information scheme. As reported in Chapter 7, this is a parameter which many consumers are interested in.

However, the labeling scheme shall apply not only to new or replacement tyres, but also for retreaded tyres[27]. Unless this is done, one will miss a large percentage of the tyre fleet and the scheme will be less efficient.

It is suggested that the really measured value is labelled, rather than classifying tyres into quality classes.

The inclusion of noise in the labelling scheme has two reasons: (1) the comfort in the car, since there is a certain (but far from perfect) correlation between the interior and the exterior noise, and (2) the environmental awareness of the consumer, affecting both his and others' acoustic environment. For the quality of life in Europe it is definitely one of the most important parameters of concern. Therefore, it is indeed a very important aspect that will be another factor in the "typical" consumer's decision, again if the labelling scheme is accompanied by an information campaign. For public procurement of vehicles and tyres, it is likely that there will be requirements for not only rolling resistance but also noise emission; as this is a way forward for cities and communities to reduce the traffic noise emission in their areas. This author believes that also this parameter in combination with rolling resistance and wet grip limits will favour the choice of technically more advanced tyres, which should mean an advantage to the high-

[27] It is not clear to this author whether the Commission has this intention or not in [Com, 2007].

level European and Japanese tyre industries[28]. This is also a win-win situation, with the exception of possibly some cost sacrifice for the consumer for some tyres if more advanced technologies must be used.

10.2.4 Treadwear

It is suggested, with hesitation, that in a longer time perspective, one shall consider adding wear resistance or "treadwear" as a parameter for consumer information. See the discussion in Chapter 8.1 about this. In the short time perspective, i.e. along with noise and rolling resistance, treadwear may appear as a voluntary label on tyre sidewalls or in notes or in consumer information leaflets. This information already exists on several European tyres, due to the US requirements.

Treadwear may in the interim period be measured according to the US system. In the meantime, work should be conducted to study the method for wear of a tyre and methods to measure the wear resistance. One shall also study the trade-off between wear resistance and safety.

10.3 Numerical values and thresholds in the labelling system

Refer to Chapter 13 for numerical values.

10.4 Tyres which need to be excluded from the labelling scheme

In Sweden, Finland and Norway a very large proportion of tyres in winter are studded. There is no mandatory testing of such tyres (with studs), and there are no requirements regarding noise characteristics. At the latest count, the proportion of studded tyres in Sweden in February varied between 73 and 94 % (depending on the Road Administration region[29]).

Producers of studded tyres may want to test their tyres for a noise label voluntarily. However, such testing should be made also at the speed of 50 km/h since the contribution to the overall noise of the studs is much greater at 50 than at 80 km/h.

As stated earlier, retreaded tyres are not yet subject to mandatory noise testing. Unless the makers of such tyres voluntarily carry out noise testing of such tyres (which is common in Sweden for the Nordic Swan label), they may have to be left out of a system that relies on noise labelling until noise testing has become mandatory.

---

[28] In an interview in Tire Technology International, Dec 2007, Yokohama director Wolfgang Schwiwietz says "We can have low noise. But it comes with bad wet grip. Our target is to get 100% for each category. We're on our way, but it'll take a few years to develop the 100% perfect tire. Our competitors are at the same level of advancement though"

[29] This excludes the southernmost region (Scania) of the Road Administration since the studded tyre frequency there is very different; only 37 %.

11 MEASUREMENT METHODS

11.1 Wet grip

As discussed in Chapter 9.1 the measurement method specified in ECE Regulation 117 and intended to be adopted also by the EU Commission, has such serious shortcomings that it is technically more or less useless in its present form. This is not due to a poor measuring principle, but due to much too wide tolerances on a number of critical topics. Such tolerances are always a trade-off between accuracy in the measurement against cost and practicability. In the case of ECE Regulation 117 it is the author's view that the accuracy has suffered much too much in this trade-off.

Since the ISO 23671 method is essentially similar to the one in ECE R117, it is no advantage to change to using the ISO method.

Both the Nordic Swan and the Blue Angel have specified other methods. The Nordic Swan is too vague in its specification to be very useful as a method. The Blue Angel methods have some similarity to the ECE R117 method. Unfortunately, it means that the Blue Angel methods suffer from some of the shortcomings of the ECE R117, such as test surface specification, but is more precise in certain aspects such as water depth and load. It has a much more complicated determination of the reference tyre value, which is a kind of market average value, and which is not very meaningful until a large amount of tyres has been tested. But the principle will be good for the purpose of a grading system once a market average has been determined (which will be continuously updated). Another advantage of the Blue Angel method is that it includes an aquaplaning test.

However, as the author's proposal in Chapter 10 is not to include wet grip labelling **at present**, there is no need to deal further with the measurement method.

11.2 Rolling resistance

This author thinks that the work to produce a more accurate method (ISO 28580) is promising and it seems to be the method most suited to use for any tyre labelling or regulation regarding rolling resistance.

In summary, for the purpose of tyre labelling, the ISO 28580 method is preferred by this author because:

- It is the most recent method, which has been developed with very active participation of the tyre industry, based on the experiences of using the older ISO methods

- It is based on ISO 18164 which seems to have considered issues in both the SAE methods, "picking things" from both of them; thus it may be considered as a further development compared to the SAE methods
- Already the ISO 18164 was better specified in many respects than the SAE methods, in cases where they differ; an exception being that the ISO method allows the use of either a smooth steel surface on the drum or a sand-paper-like surface (80 grit), while the SAE methods do not allow plain steel. The future ISO 28580 is likely also to allow plain steel.

However, as justified in Chapter 9.2, it is urgent to work out a modification to the ISO method for reducing its remaining shortcomings, namely:

- To introduce a more realistic surface on drum, including unevenness and a more realistic road texture imitation. Note that measurements by TUG and VTI have shown that 40 % of the RRC variation between tyres measured on a drum IS UNCORRELATED with measurements on a smooth asphalt surface. This number is much higher if considering a rough asphalt surface
- As a first and immediate step, a smooth and plain steel surface shall not be allowed to use. The correlation between measurements on a smooth steel and a sand-paper-like surface is far from perfect and tyres are not ranked the same on smooth steel as on sand-paper. The latter is preferred since it gives an RRC closer to that on a real road texture than plain steel does.
- Calculate the air drag contribution by means of a simple model and add it
- Check, and revise if needed, the correction for drum curvature

The final value should be valid for a flat surface; i.e. it shall be corrected for drum curvature (which is just an option in ISO 18164 and in the latest draft of 28580). The procedure to be adopted by any ECE regulation or EU directive must specify the reporting of values, which is not included in the ISO 18164 standard and neither in the latest draft for ISO 28580.

The author further suggests that test speeds for C1 and C2 tyres are defined as 80 and 120 km/h. In ISO 18164 and in the coming ISO 28580 the speed of 80 km/h is already the preferred single reference speed. Without the air drag contribution, the speed has little influence, and thus it is enough to test at 80 km/h, but with the air drag considered, speed becomes in important factor and must be defined also at a higher level typical of motorway driving.

These modifications to the ISO method, except the drum curvature correction which can just be corrected if needed, may be included as two normative annexes: "Drum surface" and "Air drag component". Hopefully, these can be worked-out as fast as the ISO 28580 method has been worked out so far.

11.3 Exterior noise emission

The tyre/road noise measurement method in the EU directive is based on the vehicle coast-by test in ISO 13325 and is well established and experienced. It has some imperfections, but they are not serious; thus the author recommends the method in 2001/43/EC and in ECE Regulation 117 to be used also for labelling purposes.

In the coast-by method the selected test vehicle is coasting through the test area. The engine is switched-off and the transmission put in neutral immediately before the vehicle reaches the measuring area. At the line A-A' there should be no sound from the engine any more. Along the test path between lines A-A' and B-B' in Fig. 26, the vehicle is powered only by inertia forces and is assumed to emit only tyre-/road noise which shall be measured by means of the microphone(s) positioned at the side of the vehicle path as the maximum level during the coast-by.

In a long-term perspective, this author thinks that it would be better to change the measurement standard to an indoor test method, using a drum facility with a replica road surface according to ISO specifications on the drum circumference.

11.4 Reference surface

The test track surface on which the coast-by measurement is run shall in the green area part in Fig. 26 be paved with a reference surface specified in the Directive 2001/43/EC (same as in ECE R 117 and also complying with the ISO 10844 standard). Fig. 27 shows one example of how the texture of such a surface may look like.

This surface has a relatively smooth texture, similar to that of an SMA 0/8 surface or a (dense) thin layer with maximum 8 mm chippings. This is a type of surface commonly used as a low-noise type in urban areas in recent years.

Whereas, in an interim period, the present noise test shall be used, some aspects of the noise test related to the reference surface urgently need to be improved, as described in Chapter 9.3, namely:

- The ISO reference surface must be specified more in detail with tighter tolerances and using better measuring methods
- A second reference surface, with a rougher macro- and megatexture shall be specified and used
- It is suggested here to use a reference tyre for normalization of differences between different test tracks, the tyre of which may be the new SRTT defined in ASTM F2493-06 [ASTM, 2006].

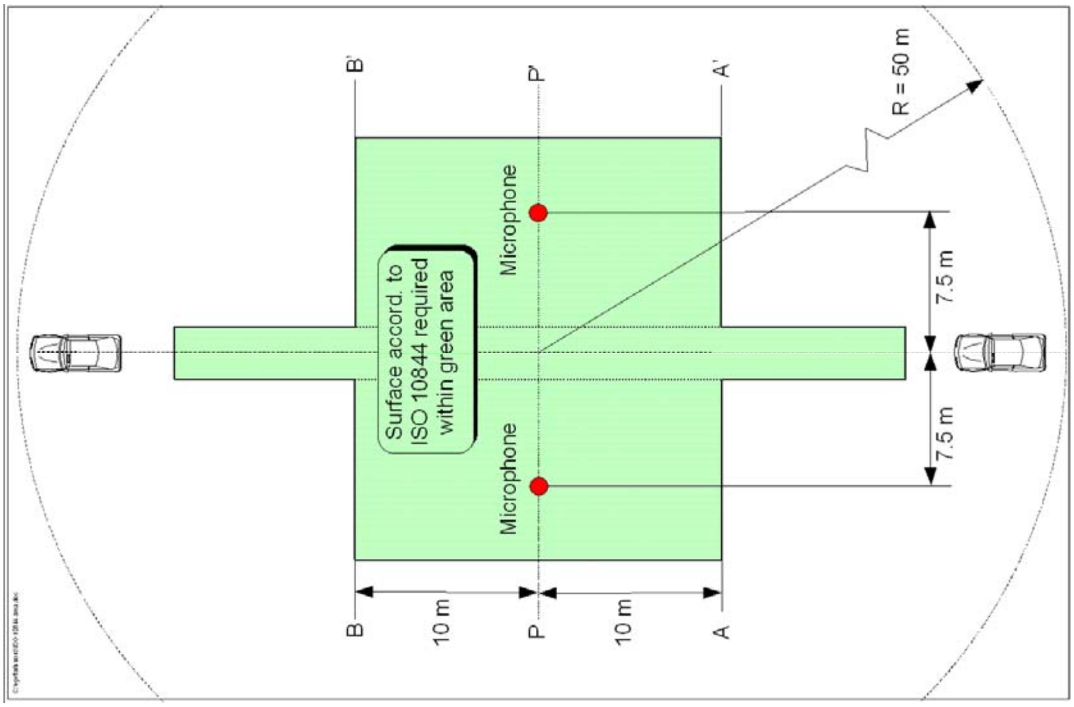


Fig. 26. The physical set-up for the coast-by measurements. The green area shall be paved with a reference surface specified in the Directive (also complying with the ISO 10844 standard).

Fig. 27. Illustration of how the texture of a typical reference surface as specified in the Directive and in ISO 10844 may look like. The picture is from the ISO surface at BASt in Bergisch-Gladbach in Germany. The coin is a one Euro coin.

12 PERFORMANCE OF THE CURRENT TYRE POPULATION

12.1 Wet grip

Very few documents can be found in the open literature which publish measurements of wet grip using the methods prescribed in ECE R 117 or in ISO 23671. The major document found by the author is a presentation to GRRF [GRRF 56-28, 2004]. Fig. 28 presents measurements on 106 tyres made by TÜV in south Germany (91 tyres) and the ETRTO (15 tyres). The method used seems to have been deceleration with a car having ABS, which is one of the two methods specified in ECE R 117. The results are plotted from the worst tyres (left) to the best tyres (right) with the vertical scale normalised to the values for the SRTT being 100 %; thus showing the wet grip index G specified in ECE R 117. Tyre dimensions ranged from 155/60R14 to 225/45R17.

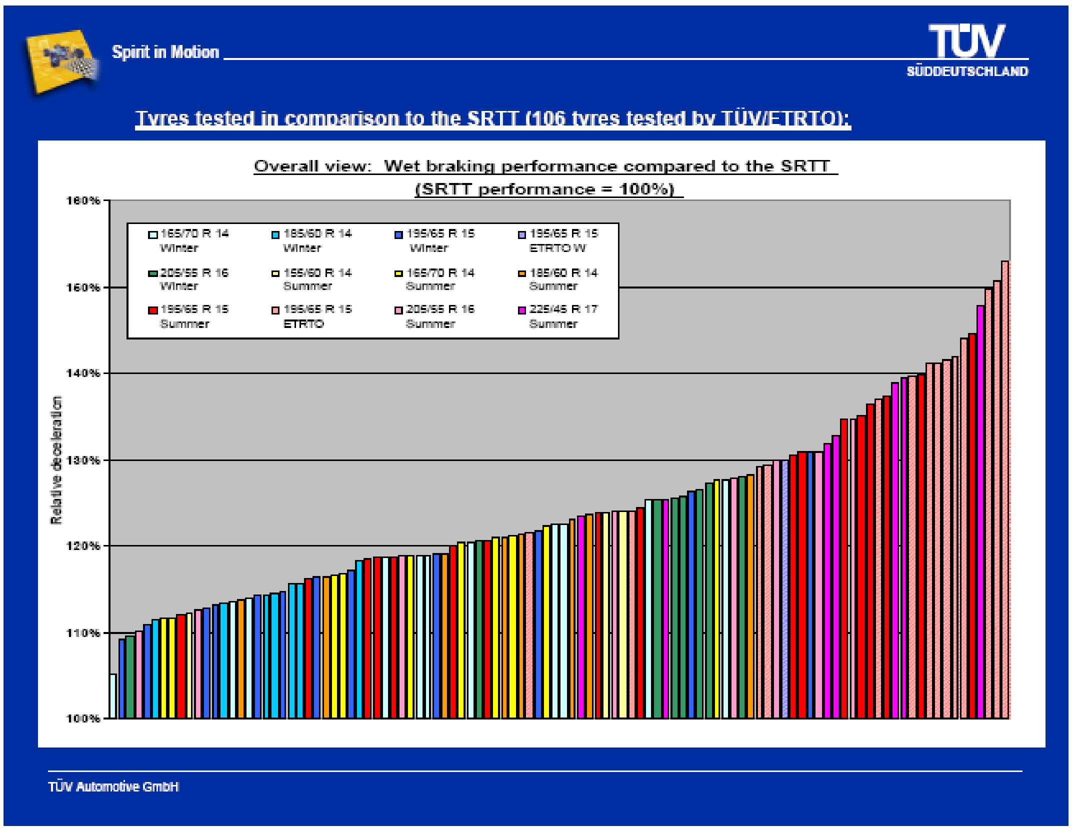


Fig. 28. Measurements of wet braking performance according to the ECE R 117 method (the deceleration method) on 106 tyres, made by TÜV and ETRTO [GRRF 56-28, 2004]. The results are normalised to the values for the SRTT, the latter of which are plotted as 100 %.

Some observations from the diagram are the following:

- The winter tyres (in green and blue) generally show lower performance than the summer tyres (in yellow, orange, red and lilac)
- No tested tyre is worse than the SRTT
- All tyres comply with the minimum limits required in ECE R 117
- The range between the worst and the best tyres is high; the best has 60 % higher deceleration value than the worst (the SRTT)

That the winter tyres in general show lower wet braking performance than the summer tyres is understandable and justifiable, since they are optimized for a different type of braking performance and for a different temperature range.

From the same document another diagram is of interest. Fig. 29 shows a cumulative frequency distribution of the wet grip index (G) for a large number of tyres on the European market. No detailed information is given.

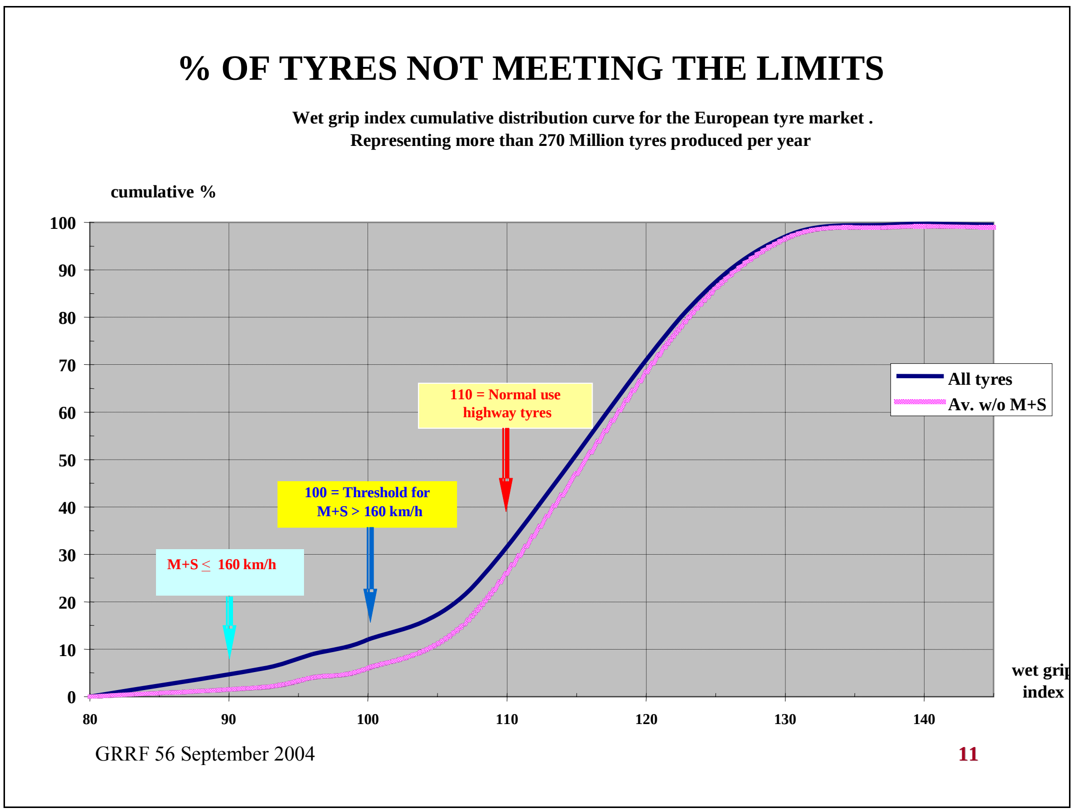


Fig. 29. Cumulative frequency distribution of the wet grip index (G) for a large number of tyres on the European market [GRRF 56-28, 2004]. The limiting values according to the ECE R117 are indicated. The curve in lilac colour (lighter) shows data for "normal" ("summer") tyres, whereas the blue curve (darker) shows data for all tyres together. Note that "M+S" are the same as "snow" or "winter" tyres.

Some observations by the author from the diagram of Fig. 29 follow:

- The values for this sample are generally substantially lower than that shown in Fig. 28. While the range of Fig. 28 is 105-165 %, the range of Fig. 29 is 80-135 %.
- Many tyres do not comply with the limiting values of ECE R117; for example about 25 % of the "normal" tyres are below the limit.
- The figure does not allow the calculation of the proportion of "winter" tyres not complying with the limits, but it seems to be even higher than for the "normal" tyres.

A third set of data is available. A Dutch study measured the wet grip of 26 car tyres according to the ISO 23671 and plotted it against the noise levels for the same tyres [de Graaff & van Blokland, 2007]. The values appeared to lie within the range 126-142 % (of the wet grip index of the SRTT). These values are therefore in the middle of the range in Fig. 28 but in the upper range of Fig. 30. Not one of the 26 tyres was even close to the limit in ECE R117.

The data presented above have the following two implications for the purposes of this report:

1. The difference between Figs. 28 and 29 might indicate that difference series of measurements may give very different results, even if more than 100 tyres drawn from the European market are included. This might be an indication of the problems with the wide tolerances in the measurement method as mentioned in Chapter 11, but there may also be other explanations for the differences not known to the author.
2. The large range of values shows that tyres on the European market have very different wet braking performance. Some of this difference is justified since tyres are optimised for different performance, but one would like to reduce the difference. In order to do that a labelling system also including wet grip would be favourable.

12.2 Rolling resistance

12.2.1 Tyres with ideal air inflation

RRC data typical for USA are presented in Fig. 30. These are measurements which were obtained with the SAE J1269 test procedure for new tyres, and compiled by the Rubber Manufacturers Association (RMA) in 2005 [TRB, 2006]. The SAE procedure probably gives results reasonably comparable to the ISO 8767 and ISO 18164.

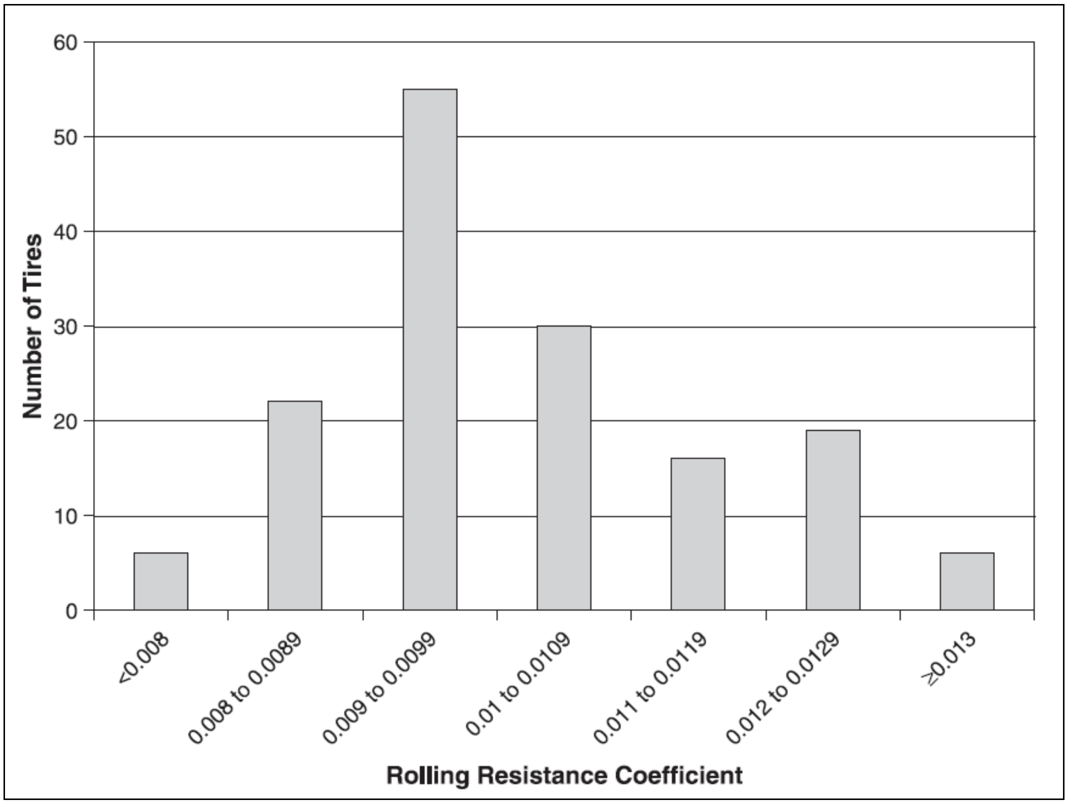


Fig. 30. Measurements of RRC obtained with the SAE J1269 test procedure for new tyres, and compiled by the Rubber Manufacturers Association (RMA) in 2005 [TRB, 2006].

Data of RRC for a mix of tyres from Europe, Asia and North America is shown in Fig. 31. The diagram is from [Aimon, 2005-2]. Some measurements were made with ISO 8767 some with ISO 18164 (they should give similar results). It shows the spread in data as being very considerable; the worst tyres have an RRC double that of the best tyres. One may also note that high-speed tyres generally have higher RRC than other tyres and that larger diameter reduces RRC. However, note that the air drag component is not included; thus tyre width, if correlated with diameter, might for some tyres balance the diameter influence.

Fig. 32 shows measurements made before 2002 by TÜV in Germany on behalf of the Umweltbundesamt (UBA) on 82 car tyres, using the ISO 8767 method and a plain steel drum surface [Stenschke & Vietzke, 2005]. The "Limit UZ 89" mentioned in the diagram is the limit for the Blue Angel requirement. Note that in order to compare with the newer ISO methods, one should add approx. 0,2 to the values on the vertical scale. It then follows that the values in the diagram are relatively high, in fact surprisingly high.

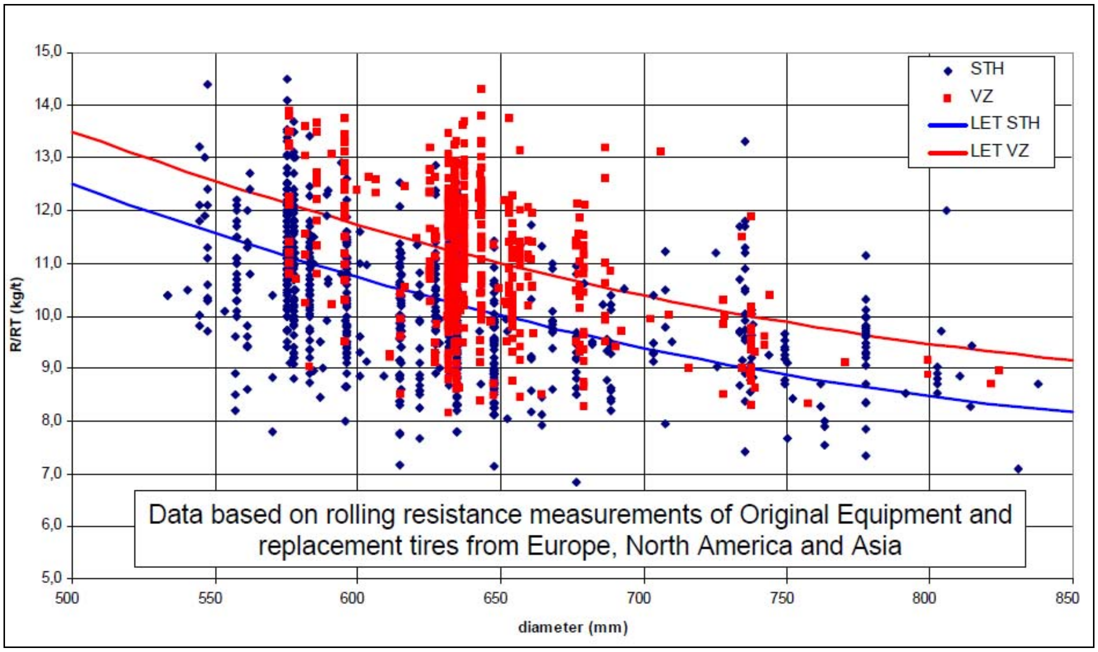


Fig. 31. RRC measured with ISO 8767 and ISO 18164. STHVZ are speed indices, LET = "Low energy tire". From [Aimon, 2005-2].

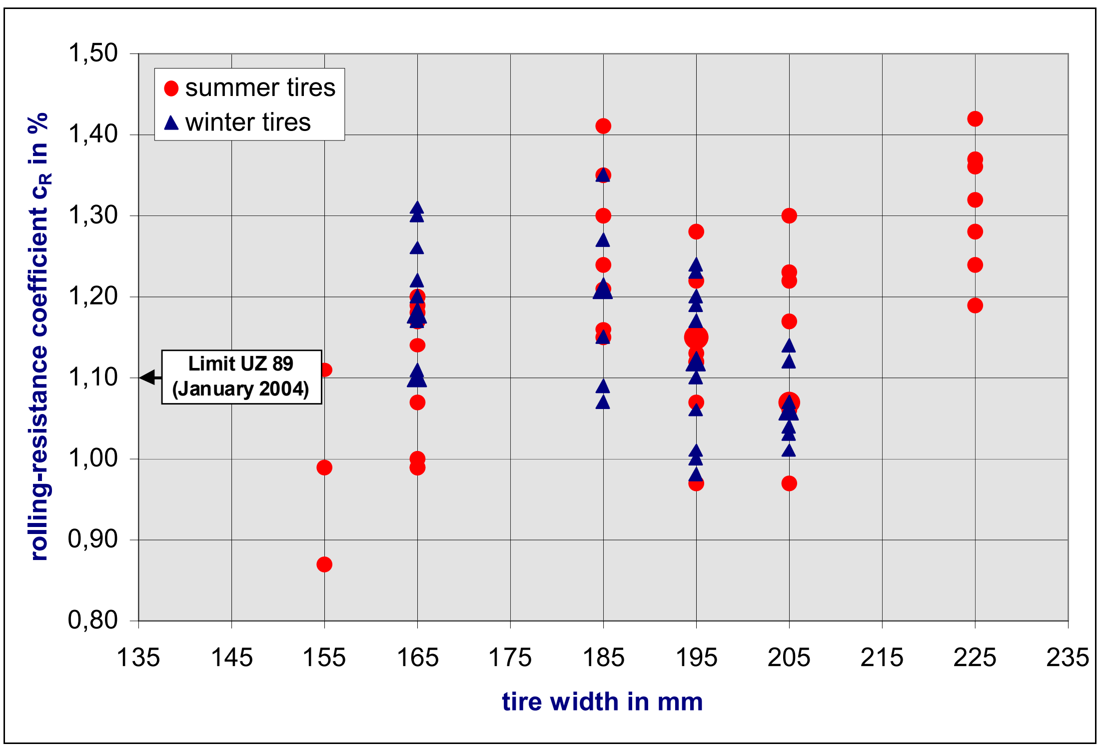


Fig. 32. Measurement of RRC in % by TÜV in Germany, on 82 car tyres, using the ISO 8767 method [Stenschke & Vietzke, 2005].

Measurements at TUG are presented in Fig. 33. These were made on 83 car tyres with a method similar to the ISO methods [Taryma et al, 2006]. Note that these were made a drum covered with sand-paper-like surface and to compare with the more common plain steel surface one should decrease all values by about 0.005. If one does so, these values compare well with those in Fig. 31. Mostly the same data are used in Fig. 34, but this diagram shows the frequency distribution of the RRC values. The tested tyres were new types on the Swedish market in the 1990's. Tyres from the latest decade would in general have somewhat lower RRC.

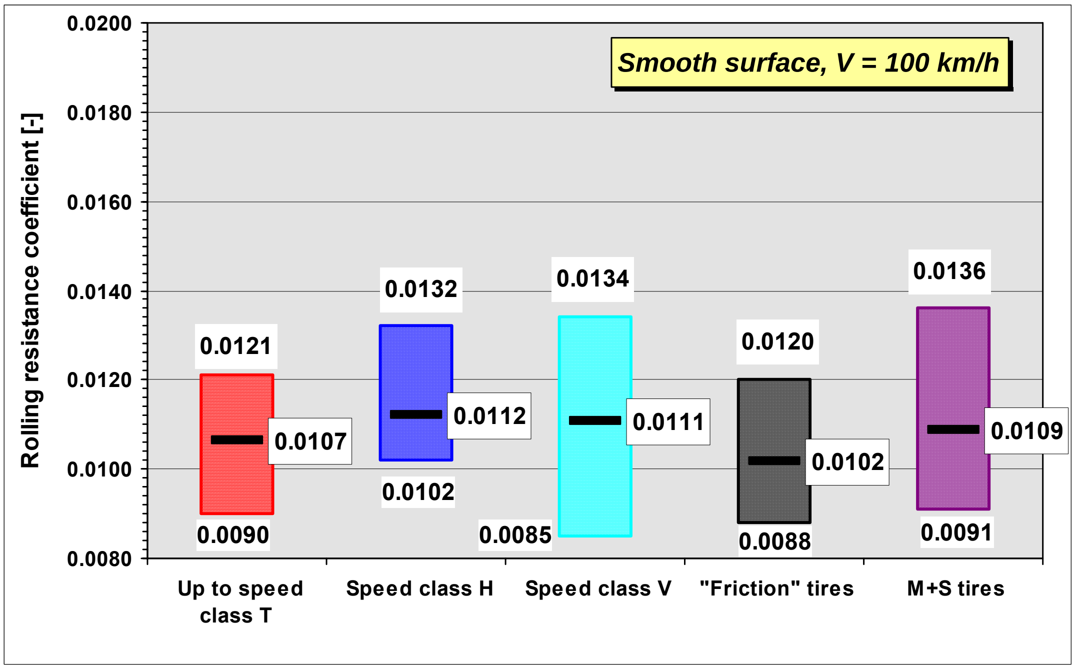


Fig. 33. RRC measured for 83 car tyres with a method similar to the newer ISO methods [Taryma et al, 2006].

Rolling resistance is correlated with noise for 26 car tyres (C1), 11 van tyres (C2) and 8 truck (C3, snow) tyres in [de Graaff & van Blokland, 2007]. Looking at just the rolling resistance values, the range for C1 tyres is 0.88-1.22 with an average of 1.05, the range for C2 tyres is 0.78-0.99 with an average of 0.86, and the range for C3 tyres is 0.62-0.87 with an average of 0.68 (values estimated from diagram).

Finally, data for truck tyres are shown in Fig. 35. These are from the same German study as the results in Fig. 32. The RRC was determined according to ISO 8767 (C2 tyres in the three groups at the left) or ISO 9948 (C3 tyres in the four groups at the right). Note that the values for the truck and bus tyres range between 0.45 and 0.70 %. The author does not know how to translate this to the newer ISO 18164 (ISO 9948 is withdrawn and no longer available) but probably it is no significant difference, as this is the case for passenger car tyres.

It may be mentioned that a large experimental program conducted by the ETRTO using the coming ISO 28580 method is due to be finished in March 2008.

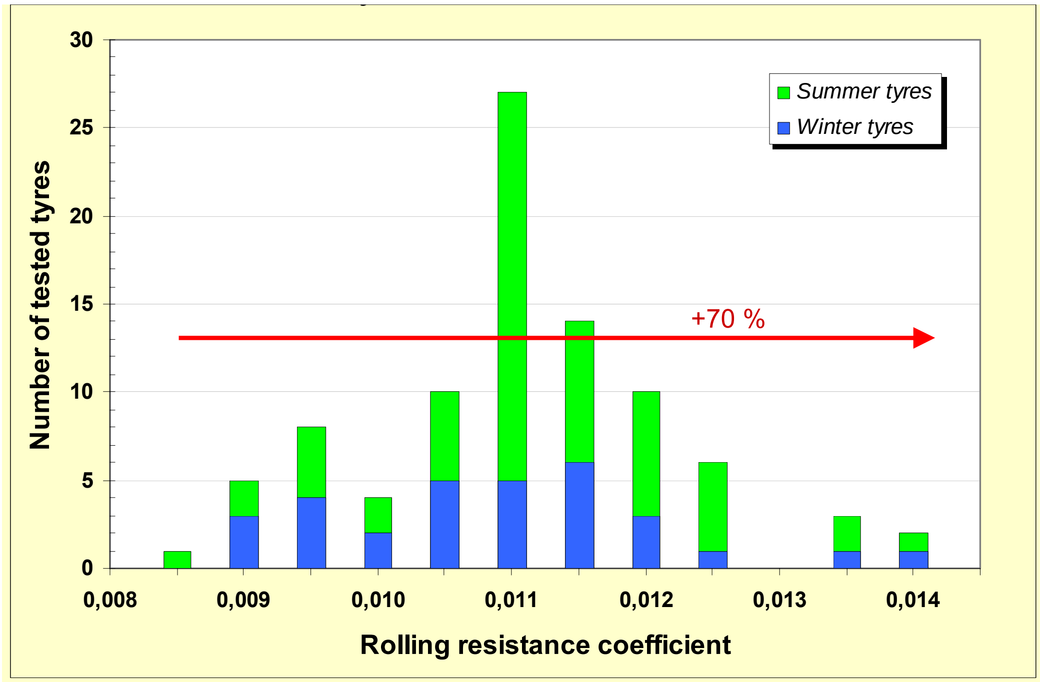


Fig. 34. RRC measured for 90 car tyres with a method similar to the newer ISO methods [Sandberg, 2005]. Tyres were new types on the market in the 1990's.

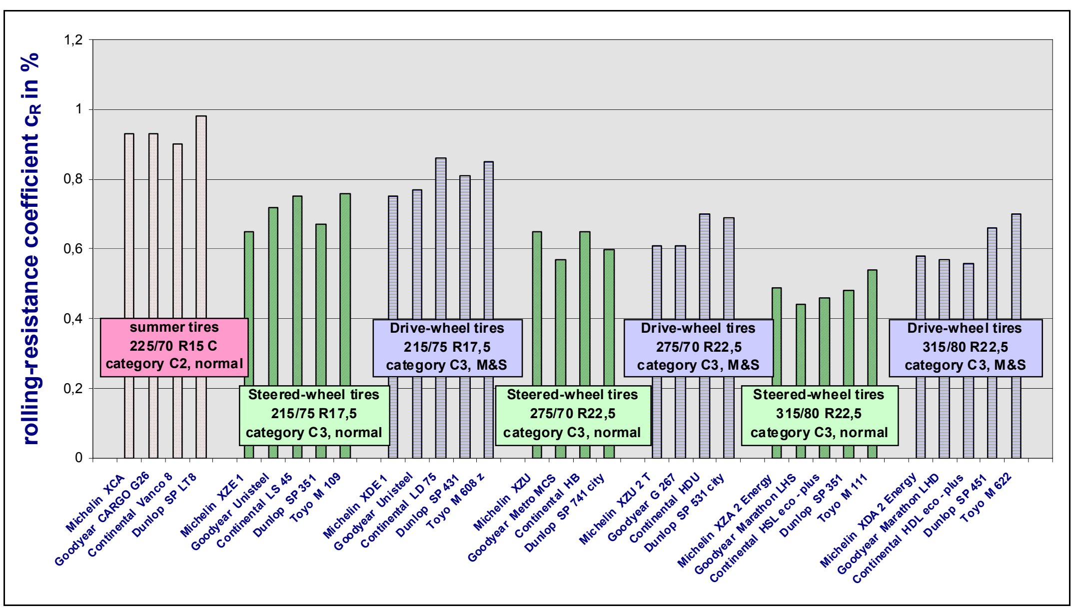


Fig. 35. RRC for van and truck tyres determined according to ISO 8767 (C2 van tyres in the three groups at the left) or ISO 9948 (C3 truck tyres in the four groups at the right). From [Stenschke & Vietzke, 2005].

12.2.2 Tyres with lower and higher air inflation

Most vehicles are driven with underinflated tyres, since the air pressure is adjusted by the tyre dealer when the tyre is purchased, and after that most vehicle owners or drivers check it too seldom. It is reported in [Michelin, 2003] that an extra 2 % of fuel is consumed on French roads due to underinflation. To eliminate this problem it is being discussed to require TPMS in all new vehicles; a regulation which is already in-force in USA. The main concern with the TPMS is the relatively poor accuracy of such systems in determining the air pressure.

But it has also been discussed whether one may reduce fuel consumption by overinflating tyres. This issue may be studied by looking at some data measured on the drum facility at the Technical University of Gdansk (TUG). Fig. 36 presents the difference between measurements with a "normal" inflation of 210 kPa and a severe overinflation of 270 kPa for one tyre and 320 kPa for another one. The higher pressures were chosen as being 30 kPa below the maximum recommended inflation (at maxium load). The double symbols are because tests were made at both 80 and 120 km/h and they gave rather similar values.

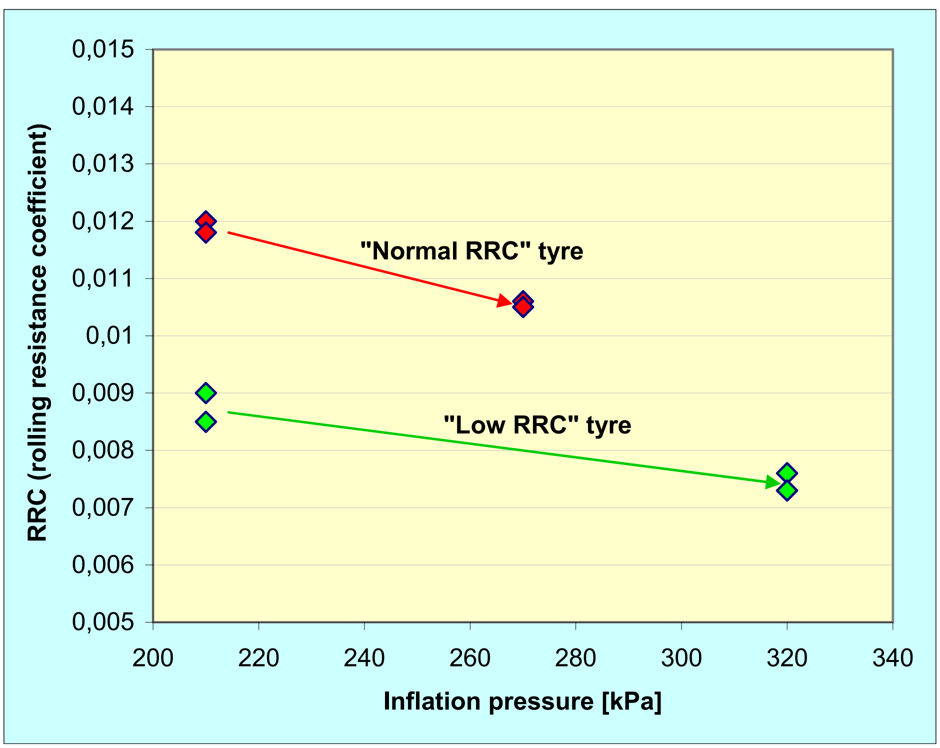


Fig. 36. Reduction in rolling resistance coefficient when changing from "normal" air inflation to an "overinflation". Measurements were made by TUG on two different new tyres at 80 and 120 km/h on a "Safety Walk" (80 grit) surface.

If the RRC reduction is normalized to the basic value (at 210 kPa) the reduction was 11 % for the "Normal RRC" tyre and 15 % for the "Low RRC" tyre. Very roughly one can say that an overinflation of around 90 kPa (300 instead of 210) reduces the RRC by about 13 %. This would correspond to up to 3 % in fuel consumption. If all vehicles would drive with such an overinflation, a very substantial fuel saving would occur in society.

What other effects would this have? Wet skid resistance, in particular aquaplaning would benefit, vehicle handling in critical situations in dry weather too[30]. Vehicle handling on very uneven roads, tyre wear, suspension wear and comfort would be significantly sacrificed. The effect on noise is uncertain. In case one would consider that the advantages would balance out the disadvantages, with climate change in view, one could perhaps recommend (say) 50-90 kPa higher inflation than the ideal in car tyres, which would mean that the actual inflation would be a little higher than the ideal inflation (but not as much higher as 50-90 kPa) seen as an average over a year and considering the gradual leakage of air from tyres.

12.3 Exterior noise emission

12.3.1 Measurements on about 100 car tyres in Sweden and Poland

As part of a study to explore the relations between noise, friction and rolling resistance of tyres, approximately 100 car tyres were selected for testing. Most of these tyres were tyres from the replacement market. It was attempted to include a great variety of tyres (although dimensions were normally 185/65R15 or 195/65R15), including tyres that were expected to be "quiet" as well as "noisy", and to include popular market tyres. The results are presented in Fig. 37. The figure is based on measurements at 80 km/h on a typical public road in Sweden in 1997-99 with the CPX[31] method. The chosen road surface was the most common one in Sweden on high-traffic roads in the late 20th century. Measurements were also made on two other public road surfaces.

The range of these measured noise levels is 10 dB, but when one excludes the "worst" tyres, which were studded, the range narrows down to 9 dB. Two thirds of the tyres are within 2.5 dB.

Most studies of tyre noise are made on the ISO 10844 surface. In this project such measurements were made on a replica of an ISO surface covering one of the drums of TUG. Fig. 38 shows the results on this surface. The range of these measured noise levels is 8 dB, excluding the smooth and pattern-less PIARC

---

[30] A US police website recommends always using the max. allowed inflation of 44 PSI (300 kPa): http://www.officer.com/web/online/Editorial-and-Features/Driving-Under-Pressure/19$27281

[31] CPX = **C**lose-**Prox**imity; a method in which two microphones are located close to a test tyre and the test tyre is run in free-rolling conditions for a certain distance under which the mean noise level is measured. Generally, such values are approx 20 dB higher than coast-by values at 7.5 m, due to the closer distance.

reference tyre. Studded tyres are not included here since such tyres make damage to drum surfaces. Two thirds of the tyres are, again, within 2.5 dB.

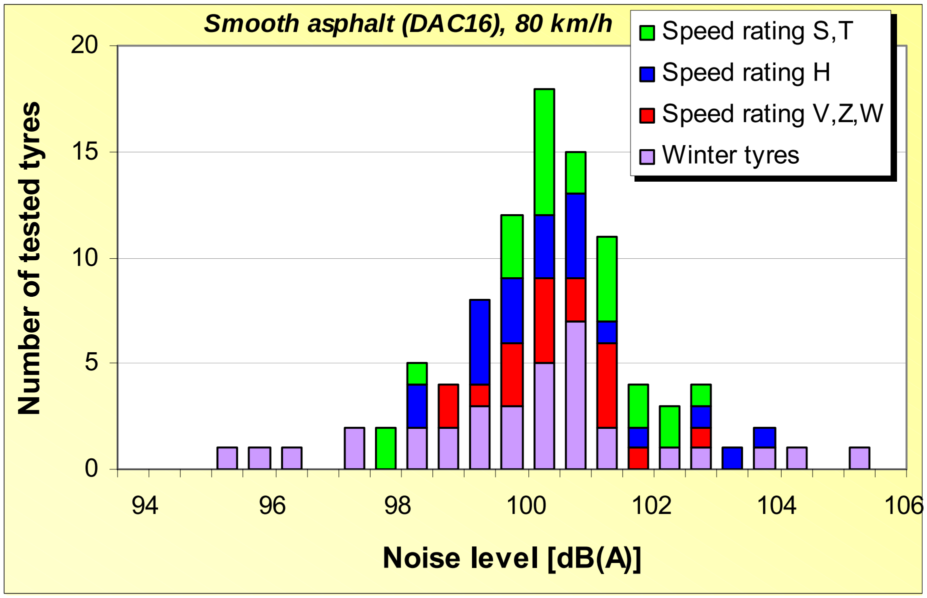


Fig 37. Tyre/road noise from approximately 100 car tyres, measured with the CPX method in 1997-99 by TUG and VTI in cooperation. The road surface was a dense asphalt concrete surface DAC 0/16 in "average" condition. From [Sandberg & Ejsmont, 2002].

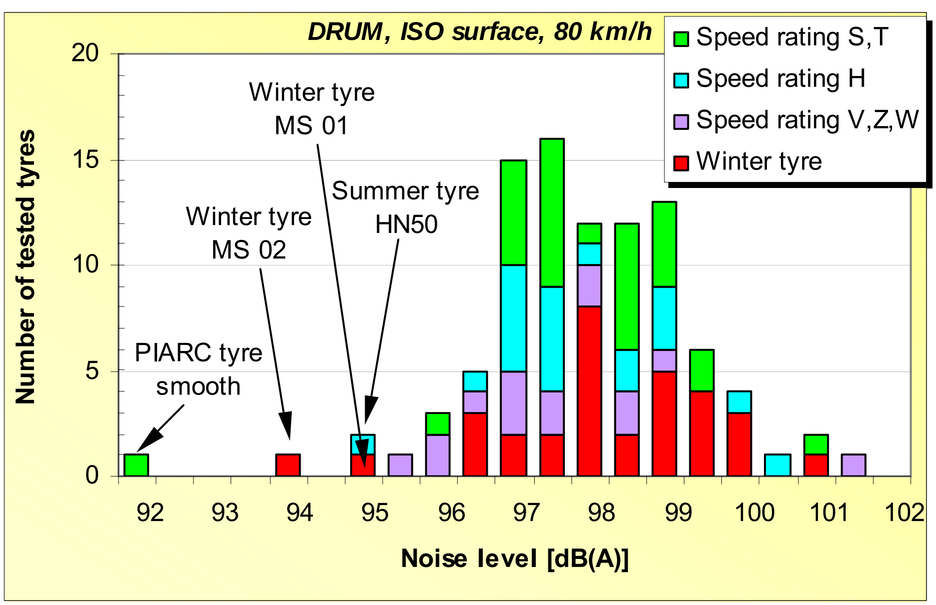


Fig. 38. Tyre/road noise from 94 car tyres, measured 1997-99 by TUG with the CPX method on a replica of an ISO 10844 surface. From [Sandberg & Ejsmont, 2002].

Smooth, pattern-less tyres are often considered as the ultimate tyres in terms of low noise. The measurement here indicated that if this would be the case, the technical potential for reduction by playing with the tread pattern is about 6 dB from the middle of the range and 2-3 dB from the quietest tyres found.

The results also showed that speed ratings do not correlate well with noise levels. They further showed that the quietest tyres are some winter tyres, whereas there are also noisy winter tyres. A further analysis showed that winter tyres prepared for studs as a group had the same average noise level as summer tyres, but winter tyres not intended to have studs were about 1 dB(A) quieter than summer tyres and than winter tyres intended for studs. Evidently, the principles used in winter tyres not intended to use studs are useful to create quieter tyres.

12.3.2 Compilation of results from a number of European countries

The author recently compiled the results of a number of studies into one diagram[32] which is reproduced in Figs. 39-40 [Sandberg, 2006]. In Fig. 39, recent data from TRL Limited have also been introduced [Watts et al, 2005]. Note that in order to avoid too many data points coinciding; some of the measurement points have been displaced marginally to the left or right of the nominal tyre width. Measured data have not been truncated or 1 dB subtracted; instead the nominal limits in Directive 2001/43/EC are shown together with the limits increased to the maximum measured noise level that would pass the limits (the solid red line). The figures include data for 174 car tyres and 45 truck tyres. It may be that a few of these tyres (but only very few) are duplicate measurements; i.e., one organization might have measured a tyre type which was already measured by another organization.

Some notes are justified for the M+P data for truck tyres. The point for C3 normal tyres exceeding the limit is a tyre containing pockets in the tread. Such a tyre is known to give exceptionally high air pumping noise and is no longer produced. Note also that two of the M+P tyres in the diagram are worn and one is a slick tyre (no tread pattern), see more details in Fig. 11 in [FEHRL, 2006-2].

12.3.3 Measurements on various tyres in the Netherlands

A Dutch study was recently presented, in which measurements performed by M+P and RDW in a series of eight sessions were compiled [de Graaff & van Blokland, 2007]. Some of the data (indicated as M+P 2003/2004) were already included in the FEHRL reports [FEHRL, 2006-1 and -2]. The number of tests and tested tyres are shown in Table 10.

---

[32] This sub-chapter as based on a text appearing in [FEHRL, 2006-2], although that in turn is largely based on [Sandberg, 2006].

Table 10. Summary of tests presented in the Dutch study [de Graaff & van Blokland, 2007]

nr	Measurement session/year	tyre class			Total number of tyres
		C1	C2	C3	
1	M+P 2002	23			23
2	M+P 2003			24	24
3	M+P for Sintef 2004	20			20
4	M+P 2004	7			7
5	M+P 2005			10	10
6	RDW 2005	26	11	8	45
7	RDW 2006	68			68
8	RDW 2006	40	1		41
	Total number of tyres	184	12	42	238

The compilation of results in the following Figs. 41-42 is approximately the same size of data as in Figs. 39-40, and together they constitute a good database.

The car tyre data show a statistical nearly perfect normal distribution with a standard deviation of 1.6 and an average value 3.6 dB below the limit value [de Graaff & van Blokland, 2007]. The Dutch researchers also compared their results (in this case tagged "IPG" but these values are also part of the database in Table 10) of similar measurements as reported in the FEHRL report [FEHRL, 2006-1] and in an ETRTO study [ETRTO, 2007]. The results are presented in Figs. 43-44. Note that the data set for ETRTO in these two figures is composed differently from the FEHRL and Dutch sets, since ETRTO presents type approval values, which according to the family principle represents the worst case of a tyre family, whereas both the Dutch and the FEHRL data present tyres randomly selected from the population. This is probably the reason why the ETRTO data set is about 0.5 dB higher than the other two.

The data sets are surprisingly similar and consistenly show that the majority of tyres are well below the present tyre noise limits.

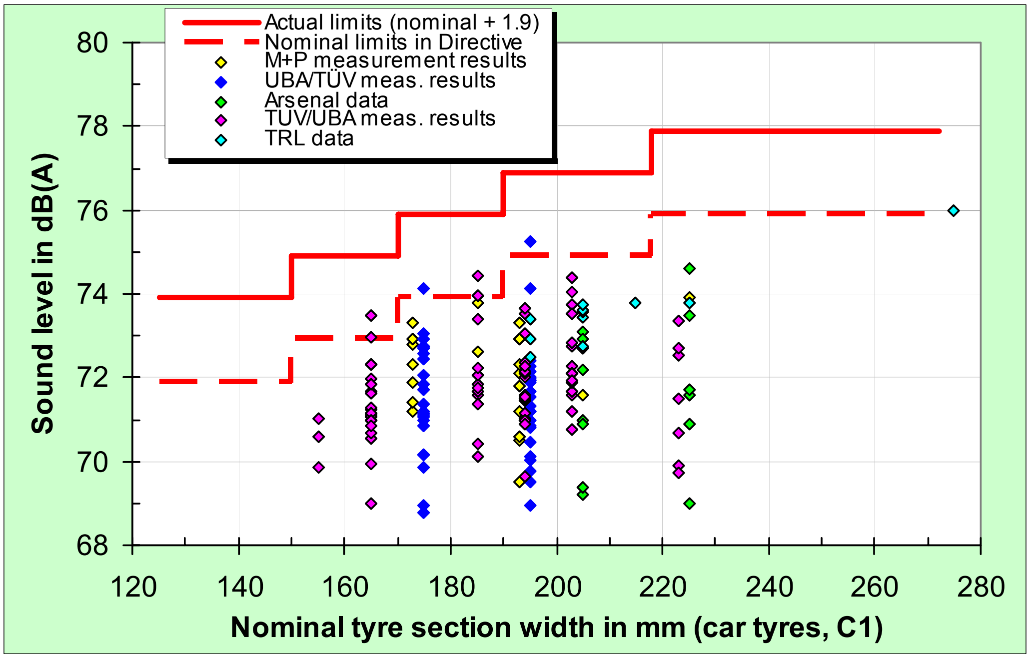


Fig. 39. Measured sound levels of 174 car tyres at 80 km/h on ISO surfaces in the Netherlands, Austria, Norway, U.K. and Germany, compared to the EU limits. Data from [Roovers, 2003], [Stenschke & Vietzke, 2001], [Reithmaier & Salzinger, 2002], [Berge et al, 2004], [Watts et al, 2005] och [Haider et al, 2004].

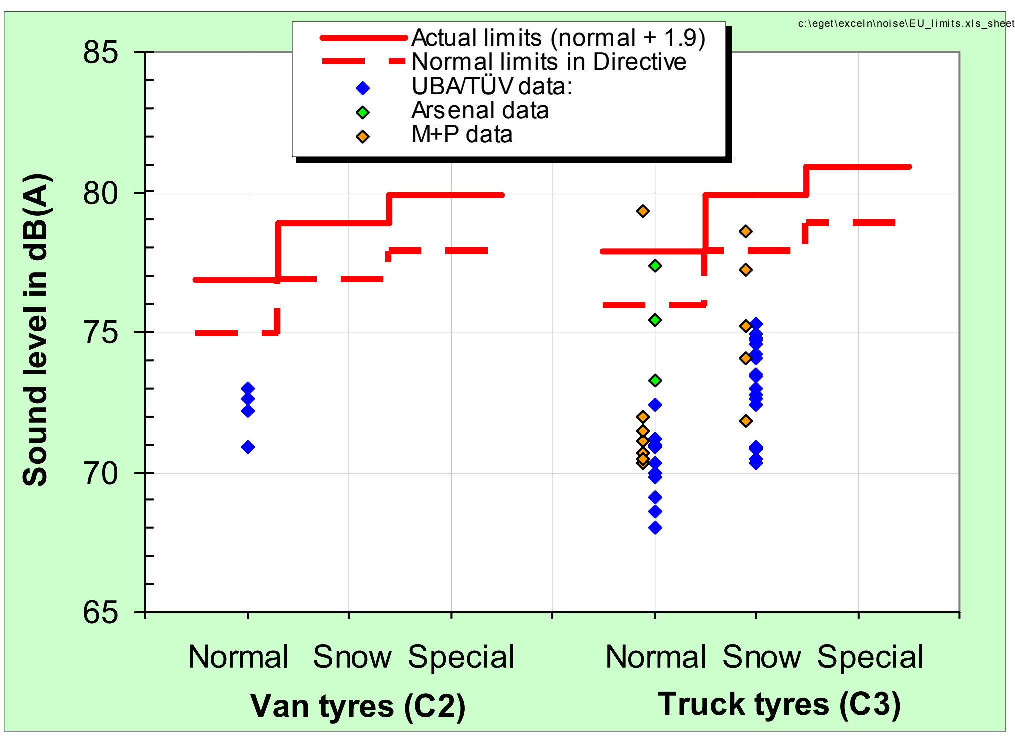


Fig. 40. Measured sound levels of 45 truck tyres at 80 km/h (C2 tyres) och 70 km/h (C3 tyres), on ISO surfaces in the Netherlands, Austria and Germany, compared to the EU limits. Data from [Stenschke & Vietzke, 2001], [Haider et al, 2004] and [Reinink et al, 2005].

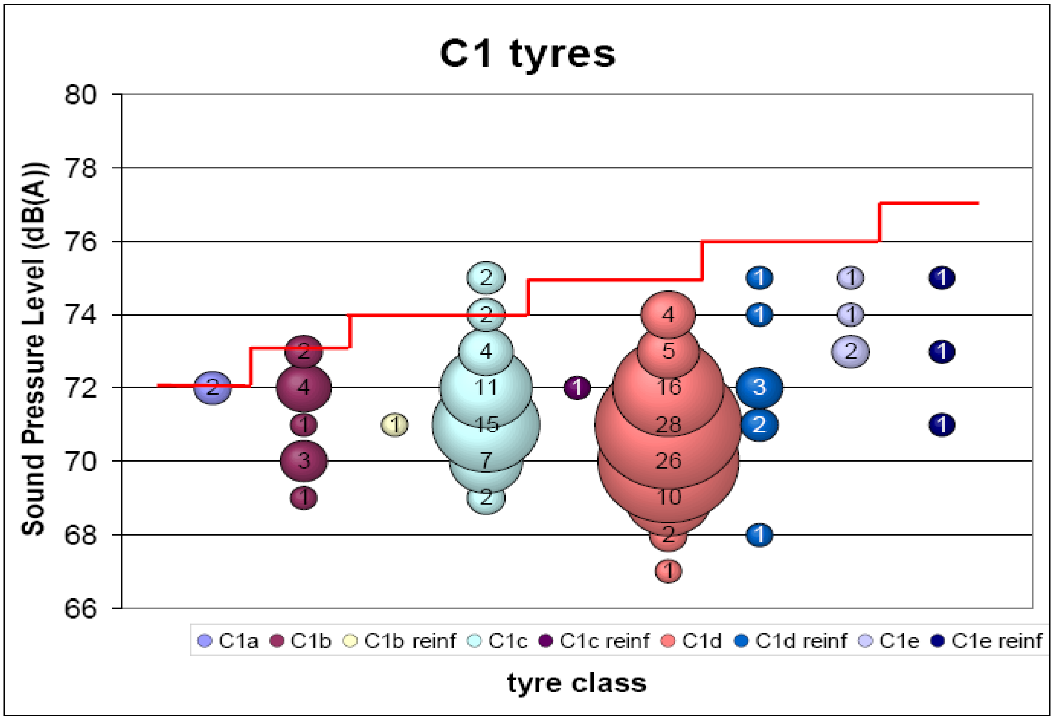


Fig. 41. Results of the Dutch noise measurements on car tyres, sorted as a function of their width and load class [de Graaff & van Blokland, 2007]. The red line represents the limit value in Directiv 2001/43/EC. The size of the circles and the numbers within it reflect the number of tyres measured with this value. The sound levels have been obtained after subtracting 1 dB from the measured value and rounding down to the integer. Figure from [de Graaff & van Blokland, 2007].

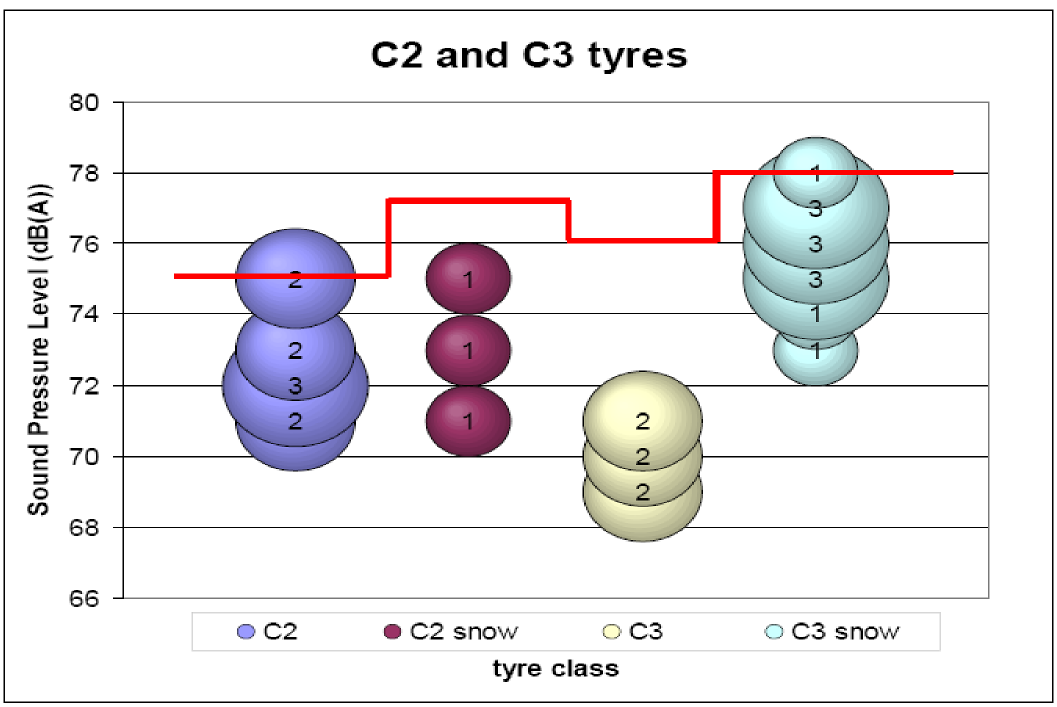


Fig. 42. As Fig. 41, but for van tyres (C2) and truck tyres (C3).

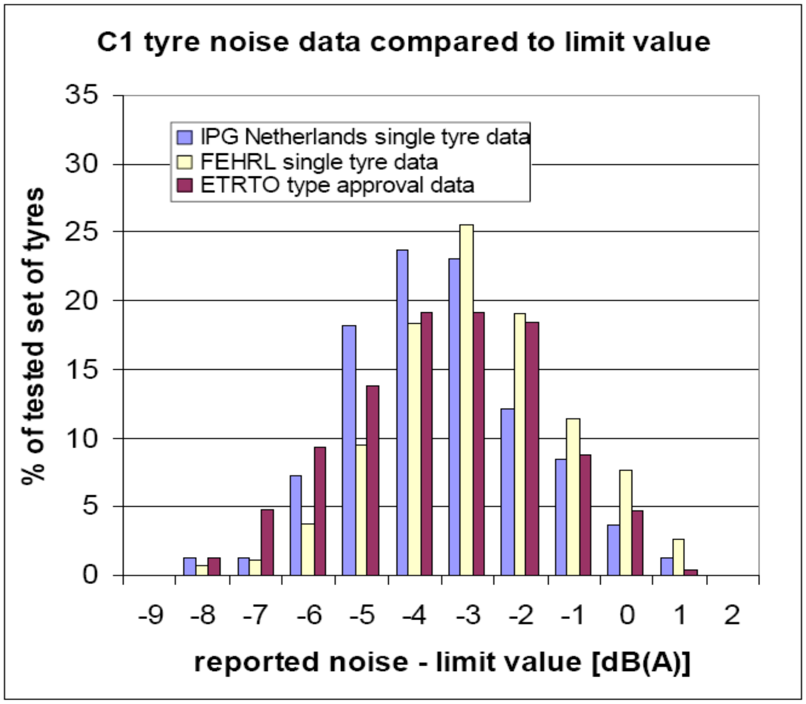


Fig. 43. Results of noise measurements on car tyres, from three different sources: (1) The IPG Netherlands with measurements on 165 single tyre sets as bought from the tyre shop, (2) FEHRL with measurements on 262 single tyre sets as bought from the tyre shop and (3) ETRTO with type approval data representing 536 tyre families. Figure from [de Graaff & van Blokland, 2007].

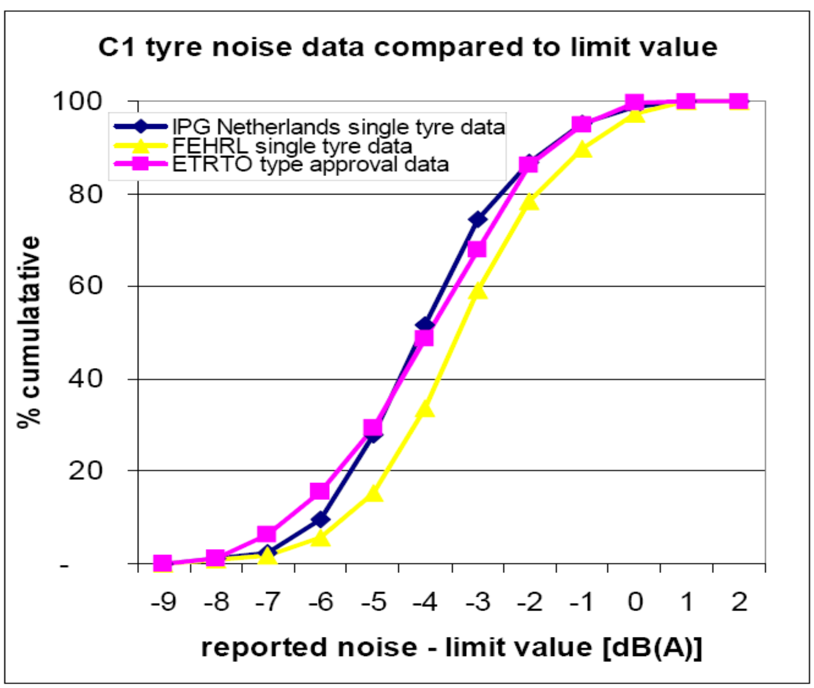


Fig. 44. Same as Fig. 43 but presented as a cumulative distribution. Figure from [de Graaff & van Blokland, 2007].

12.3.4 Measurements on various tyres in Sweden

In 2007, a special study was made by SP Technical Research Institute of Sweden regarding noise levels of market tyres of various types [Jonasson, 2007]. The most important results are presented in Figs. 45-47[33]. Note that in these figures there is no subtraction of 1 dB and no rounding to the nearest lower integer. However, a temperature correction according to the Directive 2001/43/EC has been made, but only to the ISO surface measurements. The levels for the case of "ISO" can be directly compared to those in Figs. 39-40.

There are two sets of values in each diagram, one measured on an ISO surface belonging to Volvo (Volvo Torslanda for the C1 tyres and Volvo Hällered for the C2 and C3 tyres) and the other on an actual road subject to traffic. The surface on the road was approx. an 8-year-old SMA 0/11 for the C1 tyres and a 7-year-old DAC 0/16 for the C2 and C3 tyres.

First the case for car tyres (C1) is studied. This SP study shows results remarkably different from all the other studies presented above. In Fig. 39 the average level is approx 72.0 dB, in Fig. 41 it is about 71.0; however, when the latter is compensated for the data treatment one shall add 1.5 dB to be able to compare with Figs. 39 and 45, which means that in Fig. 41 the average (of raw data) is approx. 72.5 dB, which is very close to the 72.0 dB of Fig. 39. This shall be compared with the approx. 75.0 dB average in Fig. 45. It means that the average level of the tyres in the SP study in Fig. 45 are 2.5 to 3.0 dB higher than in the other studies, the latter of which contain approx. 10 times as many tyres.

This author believes that the discrepancy is due to the ISO surfaces in Sweden being significantly "noisier" than the ones used in central Europe. It has been found in a round robin test including seven ISO surfaces that differences between ISO surfaces of 2-4 dB (max-min) for new tyres are rather common, and extreme cases of up to 7 dB may occur [van Blokland & Peeters, 2006]. The SP study compared the two Volvo ISO surfaces and found that the one at Torslanda was 2 dB noisier than the one at Hällered. If the latter one was 1 dB noisier than the ISO surfaces used in the tests reported in Figs. 39 and 41, the SP tyre set is no noisier than the ones tested in middle Europe and presented in Figs. 39 and 41. It is quite likely that the Hällered surface is noisier than the ones in middle Europe for car tyres, since it has a texture depth as high as 0.9 mm which is higher than usual.

There is also some bias in the SP measurements in Fig. 45 in relation to those in Figs. 39 and 41. Whereas a large majority of tyres in Figs. 39 and 41 have widths less than 220 mm, the SP tyre set is dominated by widths 225-255 mm.

[33] The figures have been produced by this author based on noise levels presented in [Jonasson, 2007] and with basically similar type of diagrams. The only technical difference is that the diagrams in this report show the tyres from left to right in the order of the sound level measured on the ISO surface rather than in the order of original SP test tyre number. The author believes that these diagrams are much clearer than the original ones in the SP report.

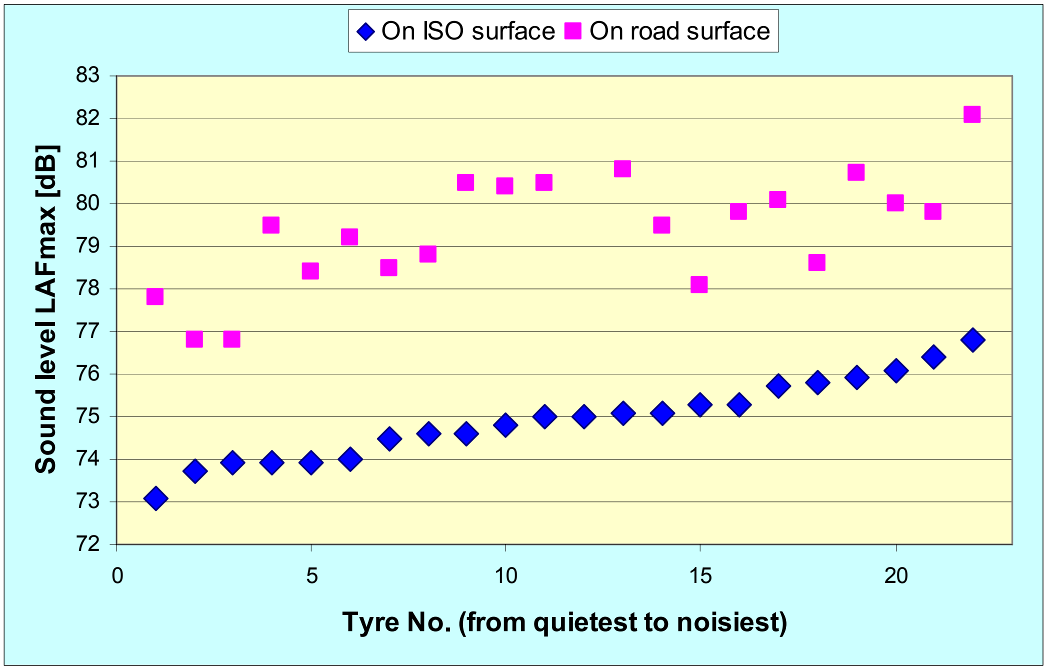


Fig. 45. Sound levels measured by SP in Sweden for 22 car (C1) tyres at 80 km/h, on an ISO surface (Volvo Torslanda) and on an actual road surface (old SMA 0/11). Data processed by this author from [Jonasson, 2007].

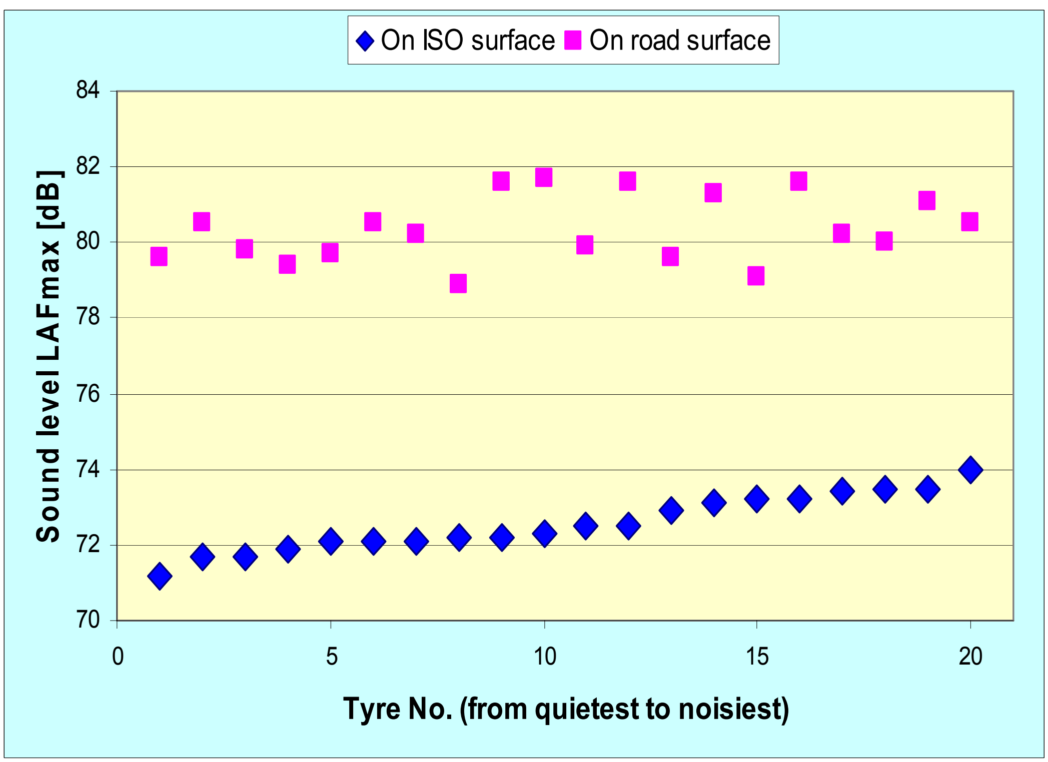


Fig. 46. Sound levels measured by SP in Sweden for 20 van (C2) tyres at 80 km/h, on an ISO surface (Volvo Hällered) and on an actual road surface (old DAC 0/16). Data processed by this author from [Jonasson, 2007].

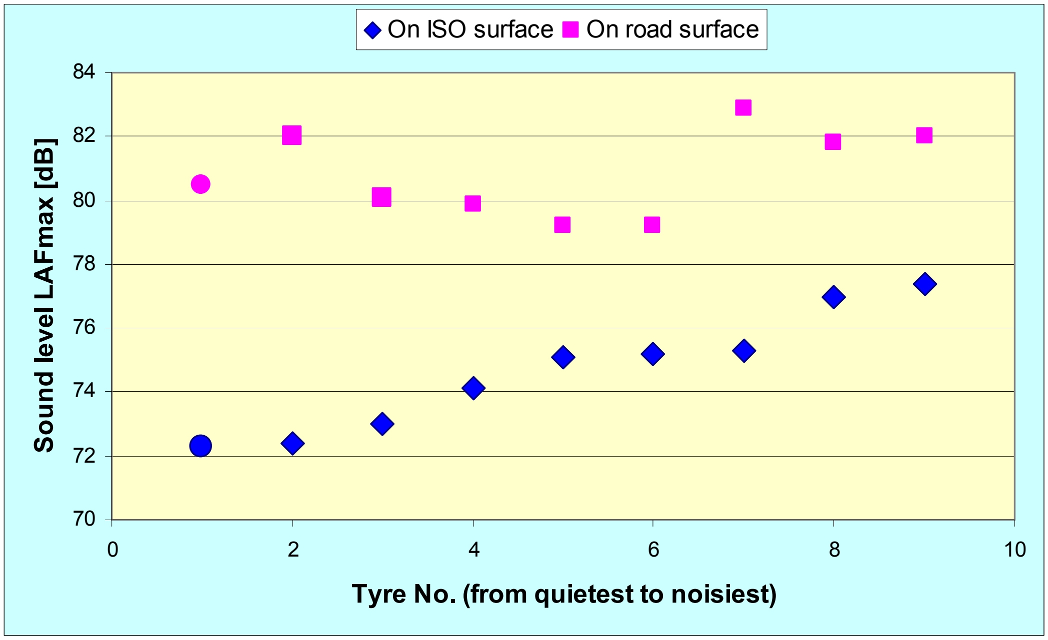


Fig. 47. Sound levels measured by SP in Sweden for 9 truck (C3) tyres at 70 km/h, on an ISO surface (Volvo Hällered) and on an actual road surface (old DAC 0/16). The rounded symbol is for a steering axle tyre (the leftmost data pair only), the other ones for either drive axle or M+S tyres (it also includes a super-single drive-axle tyre). Data processed by this author from [Jonasson, 2007].

Secondly, the case for van tyres (C2) is studied. The SP study gave an average sound level of 72.6 dB for the results presented in Fig. 46. In Fig. 40 the average level is approx 72 dB, in Fig. 42 it is about 72.5 dB; however, when the latter is compensated for the data treatment one shall add 1.5 dB to be able to compare with Figs. 40 and 46, which means that in Fig. 42 the average (of raw data) is approx. 74 dB. It means that the average level of the tyres in the SP study in Fig. 46 are approx 1 dB lower than in the other studies, the latter of which contain approx. 10 times as many tyres. The SP study contains more tyres than the C2 studies reported in Figs. 40 and 42.

Thirdly, the case for truck tyres (C3) is studied. The SP study gave an average sound level of 74.6 dB for the results presented in Fig. 47, with 72.5 for "normal" tyres and 75.5 dB for "snow" tyres. In Fig. 40 the average level for "normal" C3 tyres is approx 72 dB; for "snow" C3 tyres (similar to drive axle tyres in Fig. 47) it is approx. 73 dB. In Fig. 42 it is about 70 and 75 dB, respectively. When compensated for the data treatment one shall add 1.5 dB, which means that in Fig. 42 the average (of raw data) of C3 tyres is approx. 71.5 dB for "normal" tyres and 76.5 dB for "snow" tyres. It means that the average level of the tyres in the SP study in Fig. 46 is approx. 1 dB lower than in the other studies presented in Fig. 42 for both "normal" and "snow" tyres.

The above suggests that the Volvo Hällered surface is probably quite similar to the average ones in middle Europe (within ±1 dB), although it may be slightly noisier for car tyres and slightly quieter for truck tyres due to its high macro-texture; namely 0.9 mm compared to an average of 0.8 mm for the ISO surfaces in the round robin test reported in [van Blokland & Peeters, 2006]. This is exactly in line with what this author wrote in a background paper for the ISO 10844 [Sandberg, 1991].

Further than the discussion above related to the results on the ISO surface, some interesting things may be noted regarding the relation between the measurement results on the ISO surface and on the real road surface:

- The spread between various tyres is approx. the same on the ISO surface as on the real road surface; except for the truck tyres where it is slightly larger on the ISO surface.
- For all kinds of tyres, the real road surfaces gave substantially higher sound levels: 4 dB for the C1 tyres, 8 dB for the C2 tyres and 6 dB for the C3 tyres. Note that both the ISO and the road surfaces are different for the C1 cases versus the C2 and C3 case. Nevertheless; these are dramatic differences, implying that the ISO surfaces are indeed approx. as quiet as porous surfaces.
- The correlation between the results on the ISO surface and on the road surface is very poor. For C1 tyres it explains less than half of the variance and for C2 and C3 tyres it is statistically not significant. This shows again what FEHRL stressed: that the ISO surface is insufficient for characterizing traffic noise on roads with larger chippings.

12.3.5 Other measurements

Noise measurements made by a number of organizations and popular magazines in Europe as consumer tests have been compiled. These showed that of 198 tyres, 83 % already comply with the new limits proposed for 2012. However, it is not certain that all these measurements were made in full accordance with the standard requirements. This data compilation is not yet published [de Graaff, 2007].

12.3.6 Concluding discussion

The measurements in the Netherlands and Sweden made lately, as reported in Sections 12.3.3 and 12.3.4, essentially confirm the average levels and the spread for C1 tyres reported in the FEHRL study [FEHRL, 2006-1][FEHRL, 2006-2]. For C2 tyres, the newer studies suggest that the average values in the FEHRL study were approx. 1 dB underestimated (but the values there were too few). For C3 tyres, the newer studies suggest that the average values in the FEHRL study were "correct" for the "normal" tyres, but approx. 3 dB underestimated for the "snow" or "drive axle" tyres.

13 PROPOSED NUMERICAL VALUES AND THRESHOLDS

13.1 Wet grip

The wet grip test will be used, by those countries which have signed-up as contracting parties to the UN-ECE agreement, to make sure that any tyre with too poor wet grip performance is sorted out from the market. The threshold for this is specified in [ECE R117, 2007], differently for three categories of tyres, and is illustrated in Fig. 48. It is expected that the EC will also require these limits to be met in its coming directive. Neither Japan nor the USA are contracting parties, although they regularly and actively take part in the UN ECE negotiations.

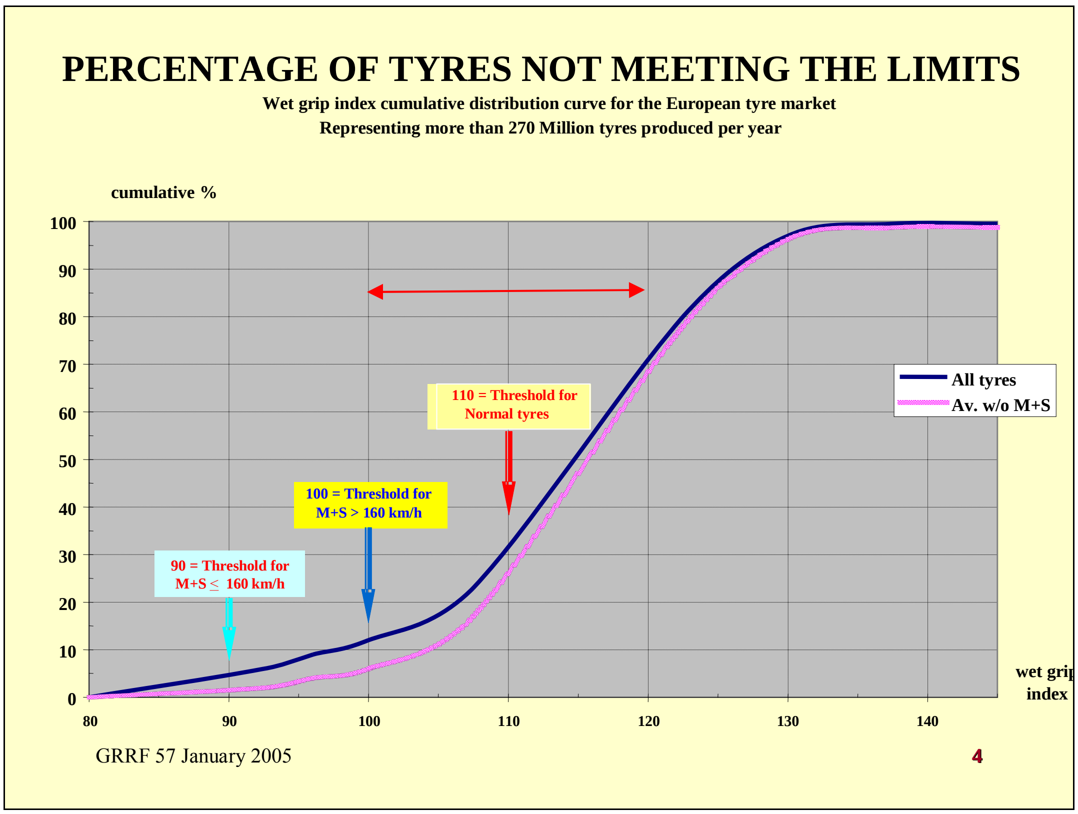


Fig. 48. Cumulative frequency distribution of the wet grip index (G) for a large number of tyres on the European market [GRRF 56-28, 2004], with the limiting values according to the ECE R 117 indicated. The red arrow in the top of the diagram is the author's speculative ± 95 % confidence interval (see the text).

The author speculates that 95 % confidence limits on the wet grip scale in Fig. 48 would extend at least over ±10 units, see the horizontal red arrow in the figure. Under such circumstances it is not meaningful to divide the scale above the limit into more "classes" than (say) two: "acceptable" and "excellent". This is of too limited value for the consumer. Therefore, no values or thresholds for labelling are proposed by this author, due to the poor accuracy of the measurements.

However, a further discussion of the implications of the poor accuracy is worthwhile. Assume that the author's estimated confidence interval in Fig. 48 is reasonable. A normal tyre which would have the true G index of 100, would then have a 5 % chance to be measured as 110 and thus be approved. Another tyre, with the true G index of 120 would have a 5 % risk of being measured as below 110 and thus not be approved. The tyre in the former case (approved) would be among the 5 % worst tyres, while the tyre in the latter case (disapproved) would be among the best third of all tyres; provided of course that the cumulative curve in Fig. 48 is correct. This should illustrate that an inaccuracy of 10 units in Fig. 48 would give very strange results. The author is unable to tell what the true uncertainty is but thinks that the indicated interval is the best guess.

13.2 Rolling resistance

Table 11 presents the proposal regarding rolling resistance that ETRTO has submitted to the EU Commission for four categories of tyres [GRRF-ETRTO, 2007]. The limiting values, to be met by all tyres, would be the upper limit of the D class. Note that the "snow" tyres consistently are suggested to have class limits one unit higher than the "summer" tyres.

The proposal from the EU Commission in [Com, 2007] is identical to the ETRTO proposal, except that the "Snow" categories in Table 11 are missing and that there is a limit for C3 tyres proposed at 8.0.

Table 11. The ETRTO proposal to the EU Commission regarding four classes of rolling resistance coefficient (Cr) for passenger car tyres (PC = C1) and light truck tyres (C2). The unit for Cr is kg/t (with is the same as the RR coefficient expressed in promille). Tyres for heavy vehicles ("T&B" = C3) are still under study.

CATEGORY	D	C	B	A
PC « Summer »	**13.5> Cr ≥12.0**	**12> Cr ≥10.5**	**10.5> Cr ≥9.0**	**Cr < 9.0**
PC « snow»	**14.5> Cr ≥13.0**	**13.0> Cr ≥11.5**	**11.5> Cr ≥10.0**	**Cr < 10.0**
Light Truck « Summer »	**12.0> Cr ≥10.5**	**10.5> Cr ≥9.0**	**9.0> Cr ≥7.5**	**Cr < 7.5**
Light Truck « snow»	**13.0> Cr ≥11.5**	**11.5> Cr ≥10.0**	**10.0> Cr ≥8.5**	**Cr < 8.5**
Grading for T&B tyre category are under investigation				

How these classes of RRC are chosen compared to measured values is shown in green colour in Fig. 49 for car tyres (C1) and in Fig. 50 for van tyres (C2). The former figure is based on Fig. 31 and the latter on Fig. 35, which are the most comprehensive ones for tyre categories C1 and C2 available to the author.

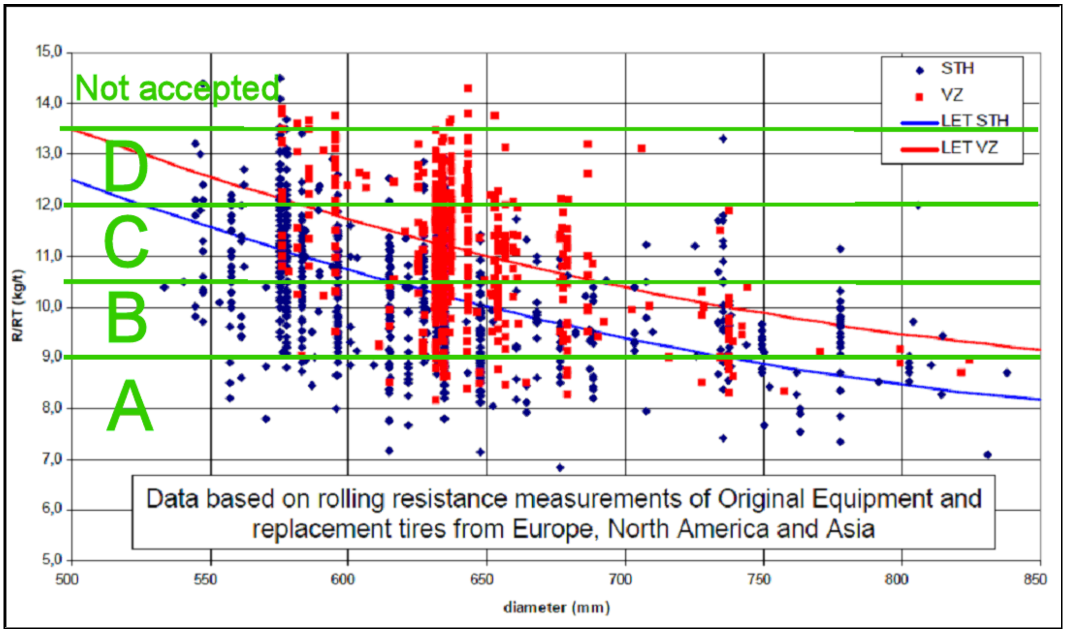


Fig. 49. RRC class limits for C1 tyres proposed by ETRTO (Table 11) imposed in green lines and letters by the author over the data compilation in Fig. 31; only considering summer tyres.

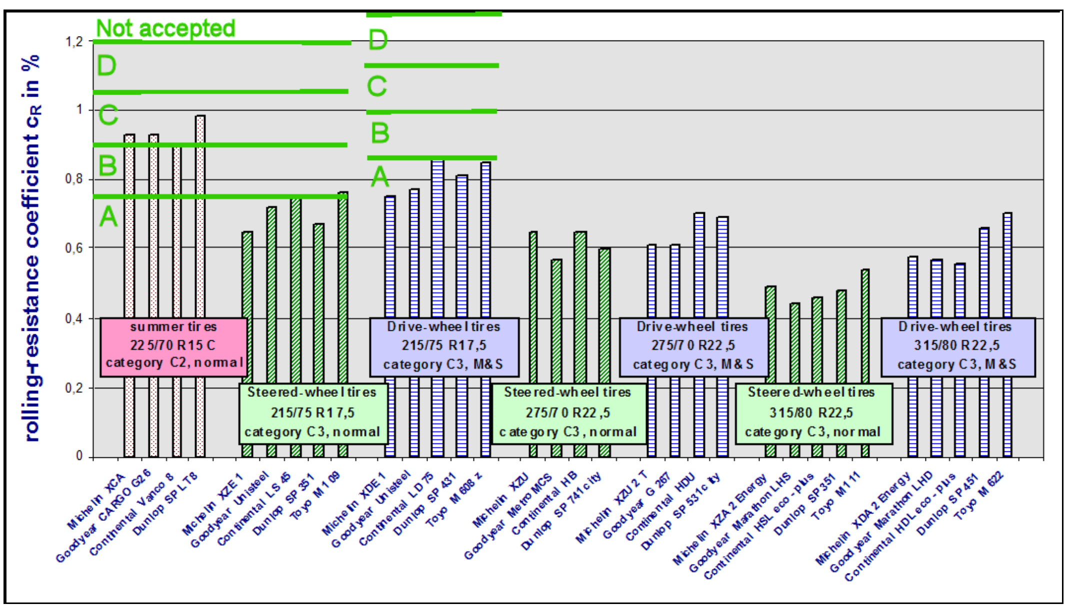


Fig. 50. RRC class limits for C2 tyres proposed by ETRTO (Table 11) imposed in green lines and letters by the author over the data compilation in Fig. 35. Summer tyres at the far left and winter tyres to the left of the middle.

It appears that the classes for car tyres are well chosen over the range (probably the same data has been used to determine the class limits) but the classes for van tyres seem to be totally displaced. However, the latter may also be due to the very few measurements available for C2 tyres.

Is there any justification for different RRC limits for winter tyres, such as the ETRTO has proposed, but the Commission dropped? There is no indication in the data found by this author that winter tyres have higher RRC than summer tyres (Figs. 32-34). In general, there should be no such effect, since winter tyres use softer rubber compound than summer tyres which gives lower RRC, which may balance out any increases from a higher air/rubber ratio on the tread pattern.

For a labelling system to be long-term effective it must encourage the development also beyond the presently premium-graded tyres. Note that there are already several tyres which would fall in the A group; for example, in [Michelin, 2003] it was reported that the best Michelin tyres had a Cr of approx 8.5, and this was published already in 2003. In Fig. 31 and 49 there are tyres even around 7.0; also confirmed by unpublished measurements made in 2007 by TUG. The statement by [Mercedes-Benz, 2007] also indicates that the potential in a short-term perspective is far below 8.5.

The A-D class system proposed by ETRTO gives no incentives for further improvements below the 9.0 level and it is totally "stiff". This author prefers the system outlined in Chapter 6.7 according to which tyres are labelled with the actually measured value. However, if a class system is chosen, the author's proposal for limits is shown in Table 12. This system has full flexibility and is easy to adapt to a changing world; it is just to add a lower category whenever development justifies it, and one may even divide a wide class such as 6 into finer 6.0 and 6.5 classes. It is very easy to understand what the class designations mean; i.e. the truncated RRC. Note that the measured values for categories C2 and C3 are too few and the maximum limit must be reviewed when more data becomes available.

One may, alternatively, consider the star system presented in Table 13.

Table 12. Classification of tyres into RRC classes suggested by the author.

RRC class (designation)	RRC range C1 (car tyres)	RRC range C2 (van tyres)		RRC class (designation)	RRC range C3 (truck tyres)
Max. limit	13.0	10.0		Max. limit	7.0
12	12.0-13.0			6.5	6.5-6.9
11	11.0-11.9			6.0	6.0-6.4
10	10.0-10.9			5.5	5.5-5.9
9	9.0-9.9	9.0-10.0		5.0	5.0–5.4
8	8.0-8.9	8.0-8.9		4.5	4.5–4.9
7	7.0-7.9	7.0-7.9		4.0	4.0–4.4
6	6.0-6.9	6.0-6.9		3	0 – 3.9
5	0 – 5.9	5.0–5.9			
4		0 – 4.9			

There is no need for any special classes of winter tyres, or to distinguish between steering and drive axle tyres, according to the present information and this is reflected in the system in Table 12. The system suggested here gives no incentives to change the categorization of tyres between C1 and C2 in order to obtain a more favourable RRC class, which is the case for the ETRTO/EUCommission proposal.

What about measurement uncertainty? There are two main kinds of uncertainty: poor representativity of the value, and uncontrolled variations. With regard to poor representativity, it is supposed by this author that the technical problems with the rolling resistance measurement method identified earlier in this report are eliminated as soon as possible. This is by far the worst problem, since it affects the validity of the entire rolling resistance measurement system rather than the details in the classification system.

With regard to uncontrolled variations the 95 % confidence intervals (incl reproducibility) are estimated by this author to be approx. ± 0.5 unit (RRC in promille), if no means of inter-laboratory calibrations or normalization occurs. This would mean that there is a risk for any C1 or C2 tyre to be classified in one class too low or too high, but not more (with a normal accepted risk of 5 %). However, provided one can decide to use only the sandpaper-like surface and not just plain steel (as in SAE standards), the uncontrolled variations will immediately shrink to half of the above estimation. This would reduce the risks of wrong classification to half of the present risk. In any case, it is impossible to reduce the risk to zero of wrong classification of a certain tyre by one class.

13.3 Exterior noise emission – Measured values compared to limits

In this Sub-chapter the effect of the coming tyre noise limits is analyzed on the background of available measurements of noise emission of modern tyres. The limits that are analyzed are the ones proposed by FEHRL [FEHRL, 2006-1] which the European Commission essentially has adopted as also the proposal of the Commission [Com, 2007]. The FEHRL proposal included a first step for 2008 but since this is already too late, only the limits of the second step which was suggested to be taken in 2012 are considered.

First, the data presented in Figs. 39-40 are compared with the limits; see Fig. 51. The green solid lines in the figure show where the limits are positioned. This is 0.5 dB above the integer value, since it is required that the measured value is rounded off to the nearest integer value. The rounding means that for example 72.4 becomes 72 and 72.5 becomes 73; thus the actual limit if counting also decimals will lie between 72.4 and 72.5.

It appears from Fig. 51 that 25-70 % of the tested tyres would already meet the new limits.

Figs. 52-54 present similar analyses of the Dutch and Swedish data in Figs. 41-47.

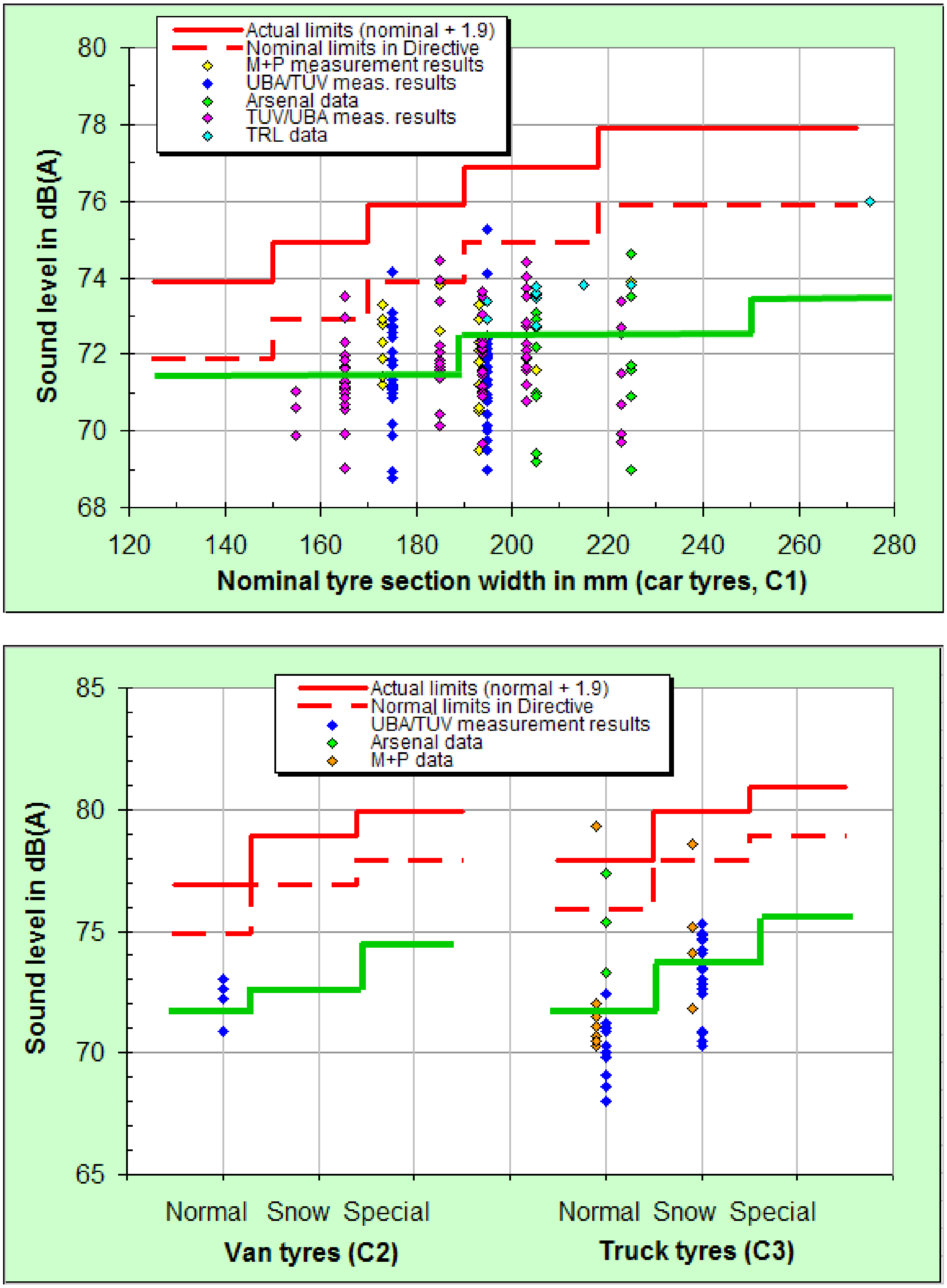


Fig. 51. Noise levels of tested tyres as compiled in Figs. 39-40, with proposed new limits superimposed as lines in green colour. The red lines are the existing limits (broken lines are nominal limits and solid lines are actual limits).

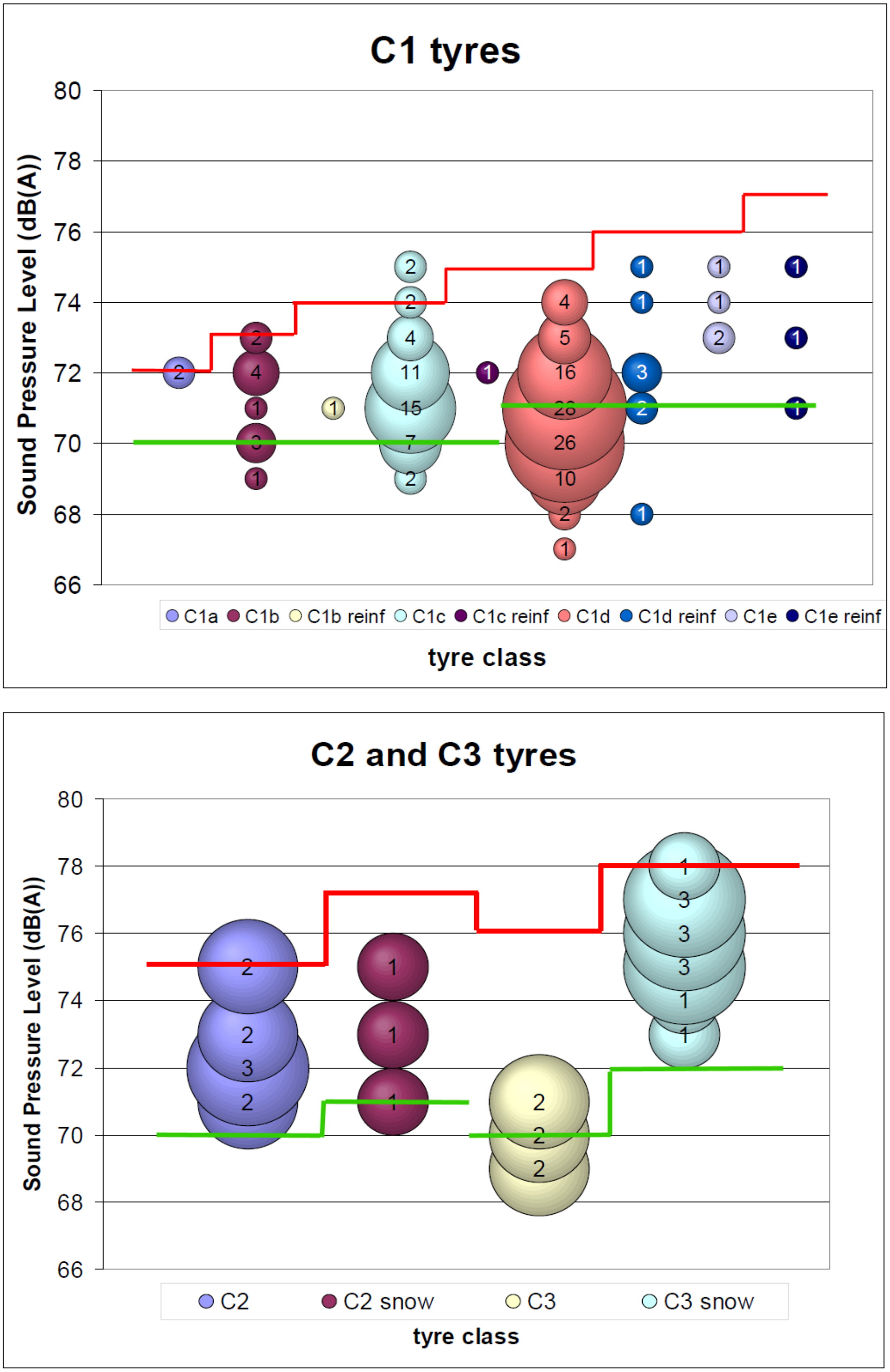


Fig. 52. Noise levels of tested tyres as compiled in Figs. 41-42, with proposed new limits superimposed as lines in green colour. The red lines are the existing nominal limits. Note that the values have been adjusted as described in the text.

Note that in Fig. 52, it is not the measured noise levels that are shown, but the reported type-tested values, which have been obtained from the measured noise levels by subtraction of 1 dB and truncation to the nearest lower integer in accordance with the existing Directive 2001/43/EC. This gives a problem when comparing with the new limits which will not allow a similar treatment of measured levels. The author has therefore adjusted the nominal limit values to fit into the format of the data in Fig. 52.

It appears from Fig. 52 that 0-50 % of the tested tyres would meet the new limits. The problem is the worst for the van and truck tyres, where only one C2 "snow" tyre and four "normal" C3 tyres will pass.

Figs. 53-55 show a corresponding analysis of the recently measured data by SP in Sweden, and presented in Figs. 45-47. These data are the actually measured ones which are compared with the new proposed limits; again indicated as lines in green colour. However, the measured values in Fig 53 (only) were first adjusted by subtracting 2.1 dB to correspond to the ISO surface of Volvo Hällered, which according to the report was in much better condition than the ISO surface at Volvo Torslanda that was used for measurement of the C1 tyres. The subtracted value is the difference which SP measured between the two ISO test tracks and by means of this adjustment the values in Fig. 53 are comparable with these of Figs. 54-55 since they refer to the same ISO surface.

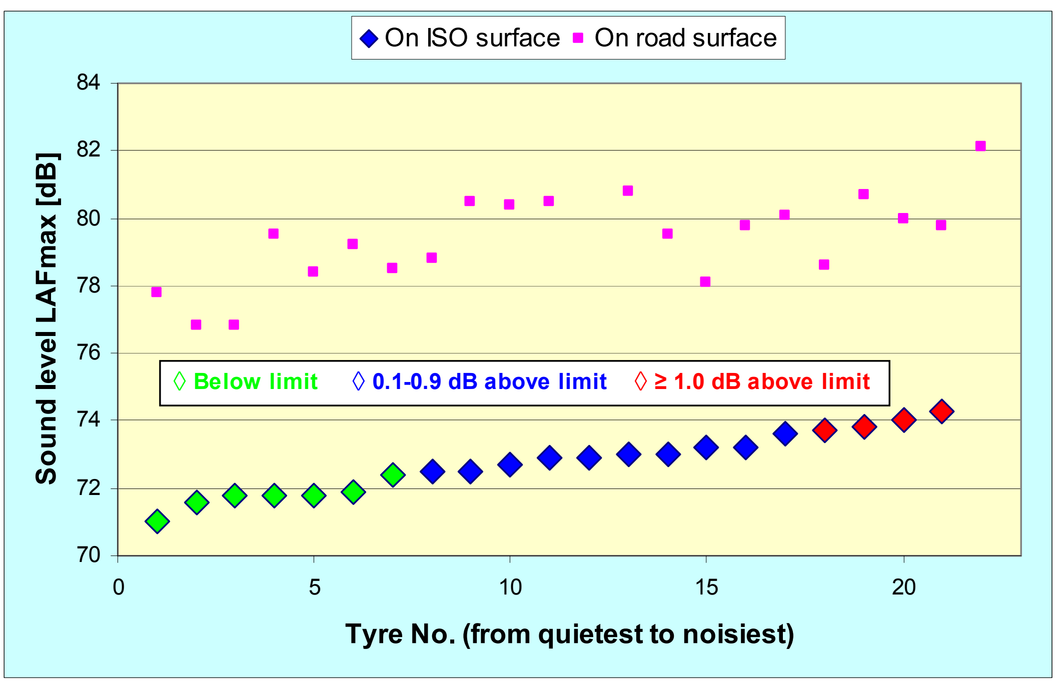


Fig. 53. Noise levels of tested car (C1) tyres as compiled in Fig. 45, with an indication of which tyres that will comply with the new limits by painting the respective symbol in green colour. The blue and red colours show how much the other tyres exceed the new limits. Note that the values have been adjusted for ISO surface differences as described in the text.

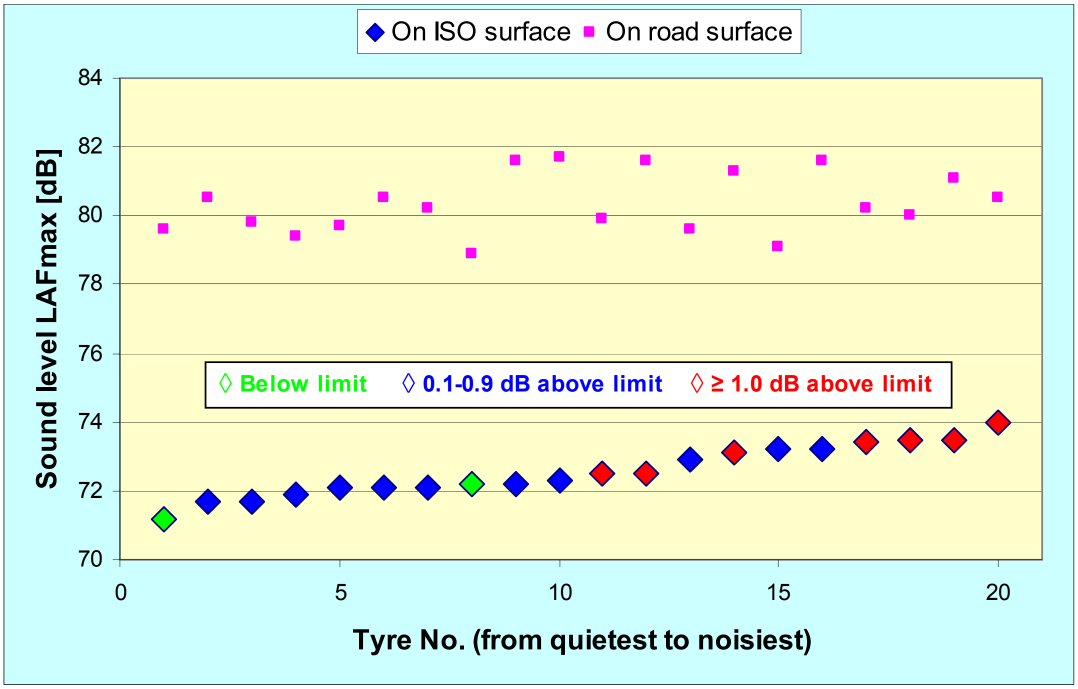


Fig. 54. Noise levels of tested van (C2) tyres as compiled in Fig. 46, with an indication of which tyres that will comply with the new limits by painting the respective symbol in green colour.

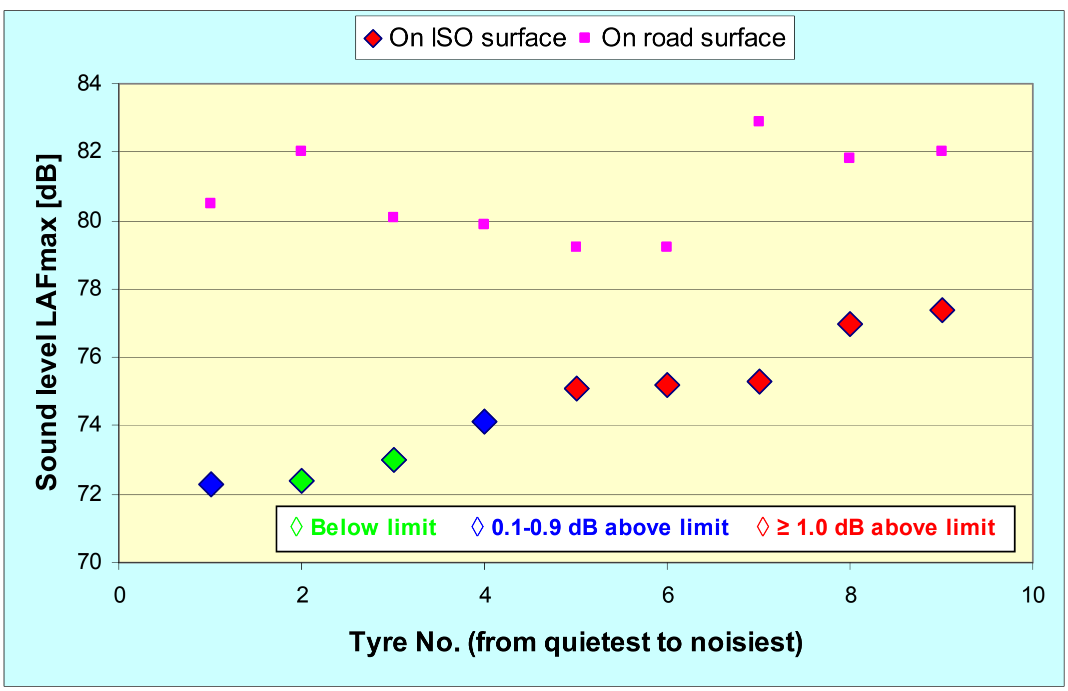


Fig. 55. Noise levels of tested truck (C3) tyres as compiled in Fig. 47, with an indication of which tyres that will comply with the new limits by painting the respective symbol in green colour.

It appears that 7 of the 22 car (C1) tyres meet the new limits. Of the remaining tyres, only four are 1 dB or more above the new limits. For C2 tyres, it appears that only two of the 20 tested tyres will meet the new limits, and for C3 tyres it appears that two of the 9 tested tyres comply with the new limits.

13.4 Exterior noise emission – Suggested adjustments to limits

When the FEHRL study was conducted, the data of Figs. 41-47 were not yet available. The proposed limiting values had to be determined based on the existing knowledge, which was very poor for C2 and C3 tyres. This was pointed out in [FEHRL, 2006-2].

Note that in order for noise limits to have some significant effect on future traffic noise levels, a substantial part of the existing tyres must be eliminated from the future market. In the FEHRL report it was calculated that at least the tyres in the noisier half of the noise level distribution need to be exchanged to quieter tyres in order to give meaningful effects. It was estimated, for example, that the new limits of 2012 would imply that approximately 35 % of the tyres tested in the beginning of this decade would comply with the new limits (Table 7.2 in [FEHRL, 2006-1]).

With the more recent data of Figs. 41-47 now available, the analyses presented in Figs. 52-55 seems to call for some adjustments to the FEHRL proposal (and consequently to the proposal by the Commission which is based on the FEHRL proposal). Based on the diagrams of this Chapter, with more emphasis on the newest rather than on the somewhat older data, the author proposes the following adjustments:

- Modify the requirement for C2 tyres to be the same as for the C1 tyres. The measured noise levels of the C1 and C2 tyres overlap perfectly, so there is no reason for distinction. It also simplifies the measurement procedure and avoids doubtful classifications of a tyre in the overlapping range as either C1 or C2. For example, in Figs. 52 and 54 together, this means that the limiting value will be complied with by 13 of the 32 tested tyres (16 of 36 if also Fig. 51 is counted). With the FEHRL proposal only 3 out of the 20 C2 tyres in Figs. 52 and 54 meet the limits.

- Further, it should be made clear that tyres designed for main use on a drive axle shall be counted as "Snow" tyres in the noise test, since tread patterns are similar.

Regarding C3 tyres of the "snow" type, only 11 of the 38 tested tyres in Figs. 51, 52 and 55 would comply with the new proposed limit and actually no tyre in the data set of Fig. 52 would be quiet enough. This may at first seem to require an adjustment of the limit upwards by perhaps 2 dB. However, the author thinks that this shall not be done; see the discussion in the next Section.

13.5 Exterior noise emission – Discussion of limit for C3 tyres

If one would modify the requirement for C3 tyres of the "snow" type by adding 2 dB to the limit proposed by FEHRL and the Commission, it would mean that in Figs. 52 and 55 together, the limiting value would be complied with by 8 of the 20 tested C3 Snow tyres. In Fig. 51 it would mean that 17 of 18 tested tyres would comply with the limit, bringing the total of Figs. 51, 52 and 55 to 25 tyres out of 38 that will pass the limit. Shall this be done? The author's answer is "no". The reasons are the following:

- Truck tyre/road noise plays an increasing role in road traffic noise. The ever-increasing heavy traffic in Europe means that along the major routes the noise at night time is dominated by trucks, and at highway speeds it is the drive axle tyres that make the biggest contribution to it; they are fewer than the other truck tyres but they are presently 3-6 dB noisier which makes them dominate the noise emission. On some routes also truck noise at daytime starts to become significant. In towns and villages in the newer EU countries such routes sometimes run through the most populated areas.
- Sometimes, truck tyre/road noise from drive axle tyres sound tonal; i.e. the tread pattern seems to have block elements the spacing of which is not randomized. This type of noise is particularly annoying and may be noticed over very long distances
- There is technology available that can reduce the noise of such tyres significantly, but it is not often used since it is not felt to be needed.

An example of a successful noise reduction design was presented in [Saemann et al, 2001]. Dr Saemann and his colleagues had produced a truck tyre, probably intended for use on steering axles (judged from the designation HS), that was equally quiet as a slick tyre, see Fig. 56. However, although the tyre had fully acceptable properties in other respects than noise, it was found that this tyre was not desired or needed by the vehicle industry, partly due to its visual appearance, partly due to that there was no need for any quieter tyre by the vehicle industry.

There is another and more recent example, showing low-noise truck tyre designs; namely from work within the large German research program Leistra2, in which it was reported in [Lorenzen, 2007] the following results of low-noise tyre design within the project (citation from the oral presentation): "As you can see two tyres do produce much less noise than the other four tires. We therefore do concentrate further efforts on these two tires. Unfortunately the tire with the lowest noise level does not show similar good performance in other tire features like wear and rolling resistance etc. For this reason in the moment it is rather likely, that the tire with the second lowest noise level will be the truck tire of the next generation. However, we are working on this and we hope that we can make alteration to this low noise truck tire, such, that the other tire features are also satisfactory."

Thus it is concluded that technology to produce truck tyres meeting the new limits already exists. The problem earlier has been that it has not been needed.

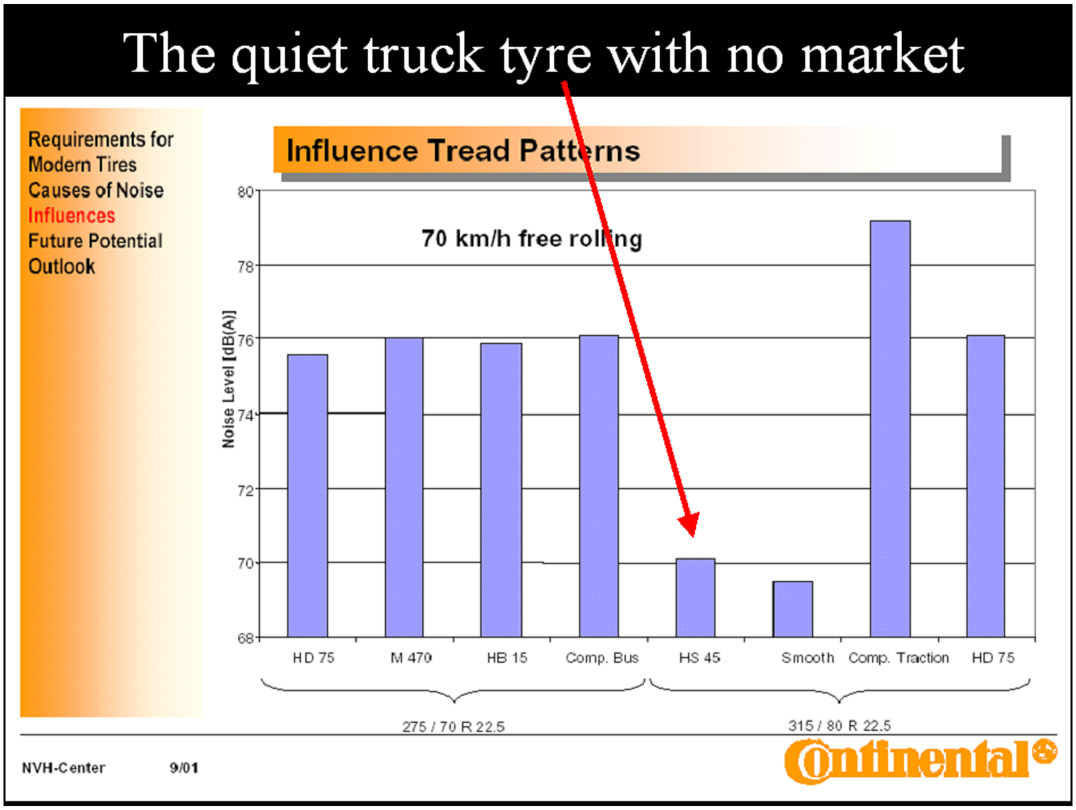


Fig. 56. Noise levels of some conventional truck tyres, a slick tyre and a low-noise truck tyre, according to [Saemann et al, 2001] (the black heading and arrow added by this author).

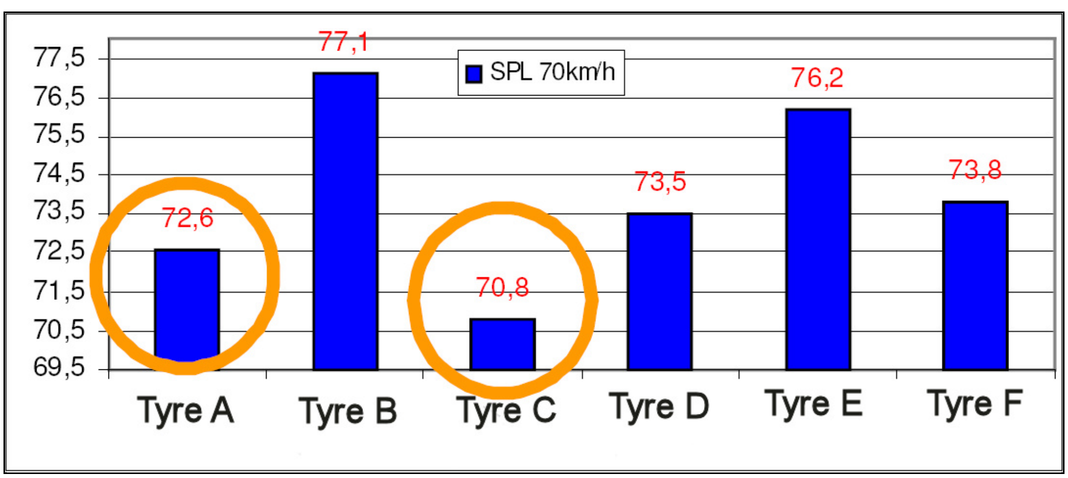


Fig. 57. Noise levels of some conventional truck tyres, and two low-noise truck tyres (in circles), according to [Lorenzen, 2007]. All tyres are intended for drive axles. Note that the proposed new limit values for snow and drive axle tyres is 73 dB (allowing up to 73.5 dB).

13.6 Exterior noise emission – Noise classes

This author prefers the system outlined in Chapter 6.7 according to which tyres are labelled with the actually measured value. However, if a class system is chosen, the author's proposal for limits is shown in Table 13. The class designation is based on the number of stars. The reasons are:

- Everybody would have the idea that to get a star is something positive; and the more stars, the more positive it is. This makes the star scale unambiguous, since fewer stars would mean higher noise levels and more stars would mean lower noise levels to "everybody".

- The system is fully flexible with respect to future development. In case there would in the future be a significant number of tyres at lower levels than what is required for six stars, one can simply establish a class of seven stars.

In this way, the star system is sustainable over the foreseeable future.

Note that in the proposal in Table 13 it is the intention that the widest tyres have the same class limits as the 250-275 mm wide tyres. This is because going to wider tyres than 275 mm should not be encouraged and it is difficult to understand that such wide C1 and C2 tyres would ever be needed.

Table 13. Classification of tyres into noise level classes (in dB), as suggested by the author.

Noise class	Noise range for C1 & C2 tyres				Noise range for C3 tyres	
	≤185 mm	190-245 mm	250-275 mm	> 275 mm	Normal tyres	Snow tyres Special tyres
Max. limit	71 (71.4)	72 (72.4)	73 (73.4)	75 (75.4)	71	75
☆	71	72	73	73-75	71	75
☆☆	70	71	72	72	70	74
☆☆ ☆	69	70	71	71	69	73
☆☆ ☆☆	68	69	70	70	68	72
☆☆☆ ☆☆	67	68	69	69	67	71
☆☆☆ ☆☆☆	≤ 66	≤ 67	≤ 68	≤ 68	≤ 66	≤ 70

With regard to measurement uncertainty, the situation is similar to that of rolling resistance: the representativity of the reference surface is questionable; at least as a stand-alone surface. This is a problem that shall be solved by standardization of a second and rougher textured reference surface.

Uncontrolled variations are mainly caused by the site-to-site variability between reference surfaces and is today, expressed as 95 % confidence intervals estimated by this author to be approx. ± 3 dB (based on the round robin test reported in [van Blokland & Peeters, 2006]). This is unacceptable. However, by applying the improved measurement methods already available today and tighter specifications for the reference surface, this may shrink to approx. half; i.e. ± 1.5 dB. This can be made before 2012.

This author also suggests the introduction of a calibration system based on an annual round robin test with four SRTT tyres (the latest ASTM version) by which the differences between various sites with reference surfaces can be reduced to less than ± 1.0 dB.

From 2012 and without site-to-site calibrations, there is a risk that a tyre may be classified up to two classes to high or too low. However, when site-to-site calibrations have been introduced, it would mean that there is a risk for any tyre to be classified in one class too low or too high, but not more (with a normal accepted risk of 5 %). In any case, it is impossible to reduce the risk to zero of wrong classification of a certain tyre by one class.

14 TIME SCALES

In the consultation process by the EU Commission in 2007 there was no firm indication of the intended time schedule except for the very near future. The following are two citations related to the time schedule from the Consultation document [Com, 2007]:

"We believe the proposed noise and rolling resistance values are realistic, bearing in mind the proposed introduction date of around 2012."

"Timetable
The Commission intends to introduce a formal proposal to Council and Parliament during 2008. In the meantime, an Impact Assessment will be prepared covering all aspects of the proposed Regulation."

The FEHRL reports were submitted in early 2006. It was then suggested that a first step in the tightening of noise limits would occur already in 2008; i.e. two years later. This was based on the belief that the matter was extremely urgent, bearing in mind the very tight time schedule required by the Commission for the FEHRL work, combined with the serious delay of the actions before this in relation to what was written in the Directive. In the Directive there were indications of changes in limits around 2007-2009 in the order of 1-2 dB, implying that the industry should already have been prepared for such changes. The new limits for 2008 proposed by FEHRL were therefore such that they were reasonably in line with the changes predicted in the Directive for 2007-2009 and, further, were so liberal that they would eliminate very few of the tyres already on the market. One might characterize the FEHRL proposal for 2008 as an adjustment of the limits to the reality without affecting the market significantly.

Then FEHRL suggested the second step to be taken in 2012. When the Commission considered the FEHRL proposal, the first step was left out but the second step (which is then the first step) was accepted as tentatively be made in 2012. This author would like to stress the importance of not delaying the introduction of the new limits further, since any delay means that in the meantime other noise-reducing measures may have to be made by road authorities, townships, etc, in order to meet standards for the acoustic environment; some of which may be more effectively replaced by tighter noise emission limits.

The author's proposal for timetable is the following:

- End of 2008: The Commission should make a decision about the future limits and timescales. Hopefully, the following items of actions and corresponding timetable might be helpful as a background for that decision.
- 2008: Results of extensive measurements of rolling resistance coefficients (RRC) of tyres on the market are presented (see 9.2.2)

- 2008: Work out method for calibration of RRC measurement laboratories (as planned within the ISO 28580 work; see 9.2.2)
- 2008-2009: ISO/(CD) 28580 on measurement of RRC to be improved and finalized
- 2008-2009: The Nordic Swan labelling system (for tyres) is revised
- 2009-2010: Work out a realistic standard drum surface for RRC measurements that can be fitted to all laboratory drum facilities and be reproduced whenever needed. It shall include a reasonable unevenness typical of a good European highway/motorway. This could for example become an annex to ISO 28580
- 2009-2010: Tighten the tolerances of ISO 26371 and ECE R 117 wet grip method regarding surface wetness, surface texture and tyre load
- 2009-2010: Revise ISO 26371 and ECE R 117 wet grip method to use the new SRTT tyre instead of the old one
- 2009-2010: Extensive testing to be made in order to validate the usefulness and accuracy of the improved methods, and to determine the performance of tyres in relation to the new SRTT tyre, as stated in the previous two bullets
- 2009-2012: Work out a European consumer quality label for tyres; so far including noise, RRC and wet grip
- 2008-2009: Revise the ISO 10844 standard for reference surface for noise testing and the corresponding parts of Directive 2001/43/EC and ECE R 117. A proposal for this already exists within ISO
- 2009-2011: Specify a second reference surface for noise testing of tyres; one which is more typical of European highways and motorways; i.e. having a higher macrotexture and megatexture than the present ISO 10844 surface.
- 2009-2011: Work out a method to calibrate reference surfaces at various test tracks against each other to reduce site-to-site variability (may be made using the new SRTT tyre)
- 2010-2011: The previous two bullets require extensive testing to be made
- 2010-2015: Consider introducing tyre wear properties as a new tyre label. Also consider introducing it in environmental labelling systems
- From 2010: Start labelling all type-approved tyres with the measured noise level. This does not need any long introductions times, and can be implemented well before the new noise limits are introduced
- 2012: Work out a new annex to the tyre directive requiring noise testing also on the 2nd reference surface, from approximately year 2016. The same should be worked into the corresponding part of the ECE Regulation.

- From 2012: Start to require tyres to meet the rolling resistance requirements (max. RRC and labelling)
- From 2012: Start to require tyres to meet the wet grip performance (min. wet grip index)
- From 2012: Start to require tyres to meet the new noise limits
- From 2013: Start implementing a European consumer quality label for tyres; so far including noise, RRC and wet grip
- 2014-2015: Study the feasibility of tightening the limits (wet grip, rolling resistance, noise) in a later step, considering also the increased requirements following the use of the 2nd reference surface
- From 2016: Start to require tyres to meet also new noise limits for the 2nd reference surface
- From 2020: Revised limits shall be implemented (for both reference surfaces)

15 COST-EFFECTIVENESS ISSUES

Cost-effectiveness is good only if the "right" tyres are eliminated or favoured by the system. If there is a considerable degree of randomness in this system, some good tyres will be unfairly rejected or downgraded and some poor tyres will be accepted or favoured. This is a great disadvantage both to the consumer and the society.

The FEHRL study clearly showed the significant cost-effectiveness of reducing tyre noise levels [FEHRL, 2006-1]. Already in that analysis it was pointed out that full cost-effectiveness was not obtained since the correlation between noise levels measured on the ISO 10844 surface and on roads with a more typical and rougher texture is poor. Once a requirement on a second mandatory reference surface is introduced and tyres will meet either both the requirements or a composite value, the cost-effectiveness will increase considerably.

The same applies to improving also the wet grip and rolling resistance methods; especially the rolling resistance method, where the lack of a representative surface on the drum substantially reduces the cost-effectiveness of the limiting and labelling system.

Currently, retreaded tyres are outside the type approval system. Since these tyres, at least for heavy vehicle tyres, but in northern Europe also for car winter tyres, have a very substantial share of the market, it goes without saying that the cost-effectiveness of the requirements on noise, rolling resistance and wet grip will be very limited. Evidently, it is important to include such tyres in the system, both regarding limits and labelling.

Another cost-effectiveness issue is whether or not the consumers will face an increased purchase cost for the improved tyres necessary to comply with the future multiple requirements? The few studies that have been made have all indicated a non-correlation between cost of the tyre and its performance, be it noise or rolling resistance. Already in Chapter 7.4 this was noted for the relation between cost and noise level of tyres from four different sources [Miljøstyrelsen, 2003-2] [Stenschke, 2005] [Roovers, 2005] [de Graaff & van Blokland, 2007].

It should be noted that a large part of the tyres already on today's market comply with the coming noise limits and there is nothing that suggests that these tyres are more expensive than the tyres that will be rejected. This shows that the consumer will have the choice to purchase such tyres without any extra cost.

When it comes to rolling resistance, the comprehensive US tire energy efficiency study concluded [TRB, 2006]: "In sum, the results from empirical data do not indicate that consumers will necessarily pay more for replacement tires having lower rolling resistance." Fig. 58 shows a diagram exploring the price – RRC relation which was a major basis for the statement above

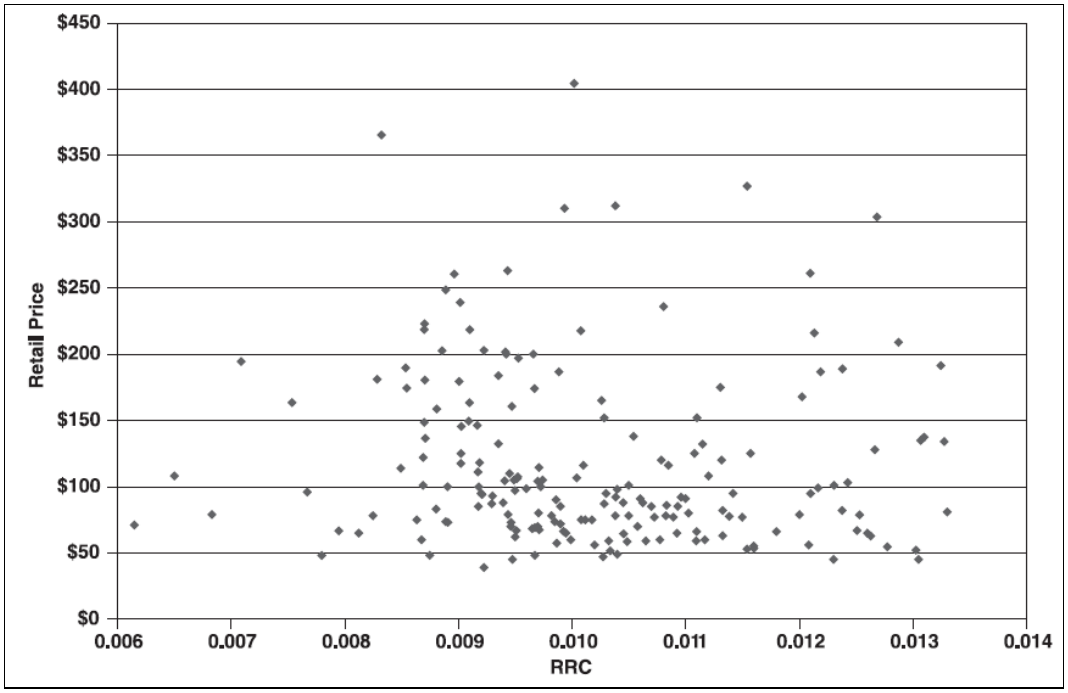


Fig. 58. Retail price versus RRC for tires in combined Ecos Consulting and RMA (Rubber Manufacturers Association) data; from [TRB, 2006].

It is remarkable that one can/could purchase a tyre with an RRC of 0.0062 for just USD 70. What a deal for the long-distance driver! Of course, we do not know anything about the other important tyre features here, but with the consumer information system proposed in this report, the consumer will have such options.

Thus, at present it looks very promising for the consumer's wallet. But after 2012 the situation might change a little. First, it must be realized that the new testing required will cause extra costs to the tyre industry, and this is most probably reflected in consumer prices. Secondly, to meet a number of requirements simultaneously is likely to require increased R&D efforts and increased costs for more advanced materials and more advanced technology. This will probably also be at the expense of the consumer. The author believes that the increased requirements also mean an advantage to the more advanced industries in the world, most notably the European and Japanese tyre industries.

At the same time, the consumer will have direct economic advantages, in terms of lower fuel consumption. But there is also an indirect advantage which is difficult to put a price or discount tag on; i.e. when the consumer can make a more knowledge-based choice of tyre, he/she will get what he/she wants rather than something which relies entirely on subjective or biased information.

Even if there is a certain increased purchase cost after all, which the author believes, it seems that people have no problem to accept to pay a little more, as was shown in the study from Austria in Chapter 7.4 [Fallast, 2004]. Irrespective of how annoyed they felt about noise, more than 90 % were willing to purchase low-noise tyres.

The society of course is the big winner of the new requirements and improved consumer information in terms of reduced accidents[34], reduced energy consumption, reduced CO_2 emission and reduced noise-related effects.

Finally, it shall be mentioned that a very comprehensive treatment of the issue of cost-effectiveness with respect to labelling of rolling resistance or fuel efficiency of tyres in the USA is presented in [Tonachel, 2004].

[34] Although the wet grip requirement as it is specified currently is very weak and not effective according to this author's view, a future improved requirement should have a positive effect on accidents

16 FORESEEABLE OBSTACLES

The obstacles that may delay or obstruct the implementation of the labelling scheme presented in this report are the following:

Refusal to improve the measurement methods: The labelling scheme is effective only if the measurements on which the labels are based have a sufficient relevance and accuracy. As the author has pointed out, the measurement methods for all the considered parameters have serious problems and need improvement before one can say that they classify the tyres correctly with a high confidence. However, the author has also suggested a way forward to deal with all these problems. In all cases the improved methods will mean that more efforts have to be devoted to the measurement of tyres.

Coordination EC – ECE: It is a little unclear to the author how the roles of the Commission and the UN/ECE/WP29 are intended to be; how will they interact on this issue? Anyway, if they will interact, there is always the risk that this will mean a time delay.

Political obstacles: Obviously, the ETRMA is very negative to the new noise limits and it will probably use its lobbying capacity as much as possible against the proposal. In the case of the future CO_2 requirements the vehicle industry was successful in its lobbying against the Commission proposal, 120 g/km by 2012, resulting in the Parliament relieving the requirements somewhat.

Failure to supply the market with proper consumer information: Once a labelling system is legally introduced, the consumers will need to be well informed about the system. The consumers must be informed about the principles, the scales of the labels and the importance that the parameters have on the consumers' economy and their contribution to saving the climate and the environment. If the responsible organizations fail in doing this the system will have very little effect.

Tyre dealer education: The same as above applies also and even more to the tyre dealers.

17 SUMMARY OF ANTICIPATED EFFECTS

17.1 Wet grip of future tyres

The author does not believe that the wet grip requirement will have any practical effect since the required performance is too weak, the method is too inaccurate and the unsafest conditions are not at all characterized by the chosen parameter. The only effect is political: some decision-makers may believe that they protect the European market from unsafe tyres with the wet grip requirement.

However, it can easily be developed into a reasonable requirement and even a label by improving the measurement method and adding other types of friction measurements.

Furthermore, one shall be aware of the risk that the wet grip limit may result in some people getting a false sense of safety, with the belief "the tyre is approved for safety, which is a guarantee that it is a safe tyre". With this false belief they might drive faster than if they had no "guarantee" that the tyre is safe.

17.2 Rolling resistance of future tyres

The maximum limit to the RRC will have a negligible effect. Estimated from the diagrams earlier in this report, the author's best guess is that approx. 3 % of the tyres typical of the market around 2000-2003 will be rejected. Assume that 3 % of the tyres have an RRC of 13.7 kg/ton, whereas the average for all other tyres (97 %) is 10.7 kg/ton. If the 3 % at 13.7 are replaced with "average" tyres at 10.7, the overall average will be reduced from 10.79 to 10.70, which is just 0.8 %. In fuel consumption this would be a saving of less than 0.2 %. This is negligible and means that also the maximum limits for RRC only have a political effect, at most. As for wet grip and noise, the first limits are chosen at such a level that they are meaningless.

It is different regarding the RRC label. Assume that the effect of the label is that 50 % of the consumers will choose one class better tyres than they would choose without the label. For the type of classes that the author prefers (Table 12), this would mean that 50 % of the tyres would have 1 kg/ton lower RRC. This would mean that the overall average RRC would be reduced from an original average of 10.70 kg/ton to 10.20 kg/ton, which is 4.7 %; i.e. six times as much as the effect of the maximum limit which in actual traffic may mean almost 1 % in fuel consumption saving. The author believes that the potential long-term effect of the labelling scheme is at least twice as great; i.e. that 50 % of the consumers would choose 2 kg/ton lower RRC, or equivalently that 100 % of the customers choose 1 kg/ton lower RRC. But this depends crucially on how much effort the responsible public and private organizations and the industry puts into consumer information about the labelling scheme. For example, extra economic incentives based on the label would most likely result in dramatic effects, such as has been demonstrated for the subsidized "clean vehicles" mentioned earlier in this report.

In addition there would be the effect of the ongoing technical development towards lower rolling resistance for all tyres which will occur independently of the labelling scheme and maximum limits.

17.3 Exterior noise emission of future tyres

It has already been shown in the report that the current tyre noise limits have been totally ineffective. The new limits proposed by FEHRL and the Commission were calculated in the FEHRL report to have an effect of between 0.9 and 2.3 dB of traffic noise reduction (L_{den}) as an average across different scenarios, depending on the degree of optimism. However, this calculation was for the assumption that only C1 tyres were affected. It is clear that C2 and C3 tyres will also be affected. Including also the heavy vehicle tyres, the most optimistic value increased from 2.3 to 3.0 dB.

The author's personal estimation is that the average traffic noise reduction of the new limits of 2012 expressed as L_{den} would be 1.3-1.8 dB around year 2020.

What could the effect of a noise labelling scheme become? Assume that the effect of the label is that 50 % of the consumers will choose two classes better tyres than they would choose without the label (Table 13). This would mean that 50 % of the tyres would have 2 dB lower noise levels. This would mean that the overall tyre noise level (equivalent to L_{den}) would be reduced from an original average of (say) 71.0 dB to 70.1 dB; i.e. by 0.9 dB. The author believes that the potential long-term effect of the labelling scheme is at least 50 % greater; i.e. that 50 % of the consumers would choose 3 dB lower noise. But this depends crucially on how much effort the responsible public and private organizations and the industry puts into consumer information about the labelling scheme. For example, as for rolling resistance, extra economic incentives based on the label would most likely result in dramatic effects, such as has been demonstrated for the subsidized "clean vehicles" mentioned earlier in this report.

18 STRICTER LIMITS NEEDED IN THE FUTURE

18.1 Wet grip of future tyres

As expressed earlier, the wet grip limits are too liberal, partly due to the very poor tyre which is the reference, partly due to the wide tolerances in the measurement. The author suggests that first the methods are improved (tighter tolerances and use of the new SRTT tyre as a reference instead of the old one). Then one shall look for a new limit which refers to the new SRTT. The author's view is that such a new limit shall be based on a target for eliminating the 25 % unsafest tyres on the market. This is the same ambition as the apparent effect of the limits if the results shown in Fig. 29 are correct (which however differ substantially compared to Fig. 28).

In a long-term perspective (10-20 years) this shall apply to each of the parameters of a composite safety index including not only wet grip but also the other critical situations outlined earlier in this report. This may mean that perhaps approximately one half of today's tyres would fail to comply with the limits 10-20 years from now; i.e. the unsafest half would be rejected (of course these would not be today's tyres by corresponding tyres of tomorrow). That would really mean a substantial improvement to traffic safety, provided the drivers will not use the increased safety to drive faster.

18.2 Rolling resistance of future tyres

The author has the view that limits to rolling resistance have negligible effect unless they are very strict. Since there is currently a clear trend for a development towards rolling resistance due to technological evolution, mostly regarding improved rubber compounds and additives to such and this trend is likely to continue for several years, limits will soon be obsolete. However, if they are progressively tightened, they may have the effect of speeding up the phasing-out of old technology and old tyres at the favour of newer and improved ones.

Therefore, any new and tighter limits in about five years after the first limits are introduced shall be substantially lower than the ones proposed now (13.5 kg/ton for C1 tyres as proposed by the Commission and 13 kg/ton as proposed by this author). It will not be meaningful to change this limit to (for example) 12; it should rather be changed to 11. When this will happen the continuing improvement in rolling resistance characteristics have automatically moved most of the RRC distribution by perhaps one unit downwards, so that a change from 13.5 or 13 to 11 would be required in order to achieve a reasonable effect on top of the "automatic" development taking place. But any numbers are just speculations, since the actual development the next few years will show what a reasonable future limit shall be. The ambition should be to reject at least 25 % of the worst tyres in order to get a significant effect. The rest of the development will be driven by the labelling system and consumer interest in lowering fuel costs and CO_2 emissions.

18.3 Exterior noise emission of future tyres

For noise, maximum limits are more justified than for rolling resistance, since noise exposure effects are more serious with regard to maximum levels than with regard to average levels. One reason is the logarithmic scale of noise which gives the higher noise levels of passing vehicles an unproportionally large impact on the L_{den}. Therefore, maximum tyre noise limits shall continue to be the major noise control measure, along with a labelling system and consumer information.

The proposed noise limits are intended to be in force from 2012. They are by no means a final solution to the noise problem. The next step may be suitable to take at about year 2020. At that time a limit change of roughly 2 dB for all tyre categories seems reasonable, based on the assumed technological development. There are already a few tyres today which would meet such limits but around year 2020 most tyres would probably do so.

The author proposes to establish a so-called "70 dB goal" for year 2020. It would imply that "no tyre shall emit more than 70 dB at the test conditions in the year 2020". Politically, it is important to work towards such a goal, even if a few tyre types will not be able to meet it already in 2020.

The 70 dB goal

No tyre shall emit more than 70 dB at the test conditions in the year 2020

19 POLICY CHANGES TO IMPROVE PROGRESS

19.1 Introduction

The noise reduction measures on tyres may be made more efficient if a number of policy changes are undertaken. By policy changes are meant not only legal requirements by authorities but also changes in the actions of other players in the field. This chapter discusses these issues; leaving behind the changes in the EU Directive which have been dealt with earlier in the report.

This discussion focuses on noise but some of the aspects are common also to rolling resistance.

19.2 OE, replacement and retreaded tyres

In order to avoid any uncertainty on this matter, it should be made totally clear that the new limits shall apply simultaneously to tyres for both the OE and the replacement market. This is the basic assumption in the FEHRL reports but it is not totally clear to this author in the text of the Commission's consultation document.

As mentioned earlier in this report, retreaded tyres are not yet subject to noise limits and the work with the aim to introduce similar limits to them that took place in the GRB has been halted. In terms of the effect on road traffic noise levels, this means that the efficiency of the Directive is poor, since replacement tyres are a substantial part of all tyres used in traffic; about 50 % of all truck tyres are replacement tyres and a non-negligible part of winter tyres are so too.

It may be concluded that replacement tyres should have to meet similar noise limits as OE and replacement tyres as soon as possible. This requires a policy change.

19.3 Road surface policy

The tyre industry takes every opportunity to point out that not only tyres but also, and moreover, road surfaces should be subject of noise-related limitations. The author agrees that the burden of noise reduction shall be shared between the tyre and the road sectors and each one must face restrictions. However, with regard to road surfaces, this is already the case since a quite long time and in many cases very hard restrictions. In practice, the road sector has faced restrictions regarding noise for a longer time than the tyre sector, and in many countries much harder restrictions. It is just that it has not been necessary to formalize such policies in terms of international regulations; instead it has been the subject of national road policies.

The work with introduction of low-noise surfaces has been ongoing successfully without international regulations, since this work is managed and pushed by public authorities, which are pushed by politicians who are pushed by their voters. The R&D work related to noise reduction in the road sector has been extremely intensive; as an example one can mention the Dutch IPG program with a budget of 54 million Euros over a 4-year period, of which the most has been devoted to road surface research. A similar program has been and is run in Germany, albeit somewhat smaller. Other countries with very extensive work to produce low-noise surfaces are Denmark, France, and Italy. Most European countries (at least the EU15) now have restrictions requiring the use of low-noise road surfaces on roads and streets where noise is a major problem, and where such surfaces have a potential of being effective.

In contrast to the tyre sector where there is serious concern over the price tag of tyres, the extra cost related to the use of low-noise road surfaces is very high. Surfaces which give moderate reduction may cost up to 50 % more, while surfaces with the best noise reduction may cost 2-3 times as much as the conventional materials. This is now becoming accepted by more and more road authorities and the development and progress are very rapid.

Therefore, when comparing the cost-benefits of noise reduction in the tyre and road sectors, one shall not hesitate to accept quite substantial cost increases for low noise tyres, although as pointed out in a previous chapter, there are at present no indications of such cost increases. However, if there will be a low-noise tyre emitting 5 dB lower noise level and this means double the cost of this tyre in comparison to conventional tyres, this should not be considered is an unacceptable obstacle; bearing in mind that this is already accepted in the road sector. The question is rather "who shall pay", since the tyre industry of course must operate under normal market conditions and the majority of vehicle owners would hardly be prepared to pay twice as much for tyres that save the neighbours' environment. Therefore, the author thinks that the national governments and the Commission shall start discussing how low-noise tyres (if they turn out to be more expensive) may be favoured by for example tax incentives.

19.4 Using the "right" tyre

Today, vehicle manufacturers are allowed to use different tyres in type approval than those sold with the vehicle. For instance, for the purposes of the fuel consumption test or the noise emission test, it is possible that since not all model variants are tested, the manufacturer will choose to test a model with the most favourable tyres available. As a consequence, the manufacturers may equip type approval variants with low rolling resistance tyres or low noise tyres in order to benefit from them, and then use standard tyres with other variants or models that reach the market. It was noticed in [TNO/IEEP/LAT, 2006] that there seemed to be a systematic difference between tyres used during type approval and tyres supplied on the same type of new vehicles (RRC of 0.009 as compared to 0.011-0.012) for a significant part of the vehicle models. If this is typical, it indicates a substantial potential for lowering rolling resistance in "real-world" driving, just by a simple and most logical change in the policy.

There should consequently be a policy change saying that to supply new vehicles with other tyre types than those used in the type approval is allowed only if the tyres on the vehicle when it is distributed from the manufacturer have equal or lower rolling resistance and equal or lower noise levels than the tyres used during type approval.

19.5 The global connection

From a global climate point of view, it is important that not only Europe, Russia and USA embark on a program to lower rolling resistance, but that this is also done in Japan, China, India and other parts of the world making substantial contributions to the global CO_2 emissions from road transportation. Therefore, efforts should be made to spread this labelling system and educate tyre consumers worldwide.

Another point is that the tyre market is international. To have common international regulations that give the same conditions for all tyre manufacturers worldwide is clearly favourable. The larger market a tyre may be adapted to the lower the costs may be.

19.6 Speed limits on all motorways in Europe

There are tyres on the market that allow motorway speeds of around 300 km/h, since some of the cars on which they may potentially be fitted are capable of running at such speeds. There are exclusive sports cars on the market, for road use, which have top speeds 330-370 km/h. In fact most of the car tyres on the market are designed to endure speeds of at least 200 km/h. In 2004 the market share in Germany of tyres with a speed index of 240 or more was 35 %.

Most European high-performance cars, excluding sports cars, have the top speed limited at 250 km/h, even though the power allows higher speeds by a gentlemen's agreement. In Japan, the national automobile manufacturers (organized in JAMA) have voluntarily agreed to mount speed limiters in their cars sold in Japan, limiting top speeds at 180 km/h. It was recently reported that Nissan built a speed-limiter for its GT-R car which is connected to the car’s GPS system, and the GPS will send a signal to the car’s ECU to disable the 180 km/h limit when it detects that the car has entered a race track.

In Europe, except for a part of German motorways, the maximum legal speed is 100-130 km/h. Thus, one cannot claim that there is really a transportation need for travelling at higher speeds. Fig. 59 is an attempt to illustrate the incoherence between legal maximum speeds and the actual top speeds of vehicles today.

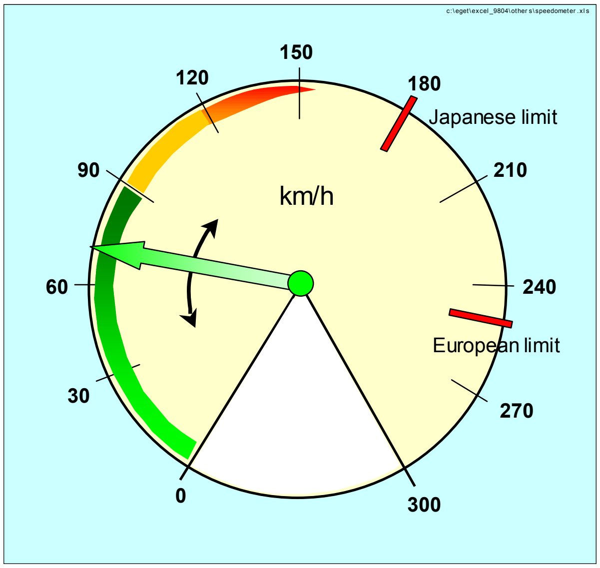


Fig. 59.
Illustration of the legal speed range in most countries (marked left part of the circle) and the range of top speeds of modern cars (right part of circle), with the position of voluntary speed limiters in some European and Japanese cars indicated.

In Germany, if there is no speed limit, the recommended speed limit is 130 km/h, referred to in German as the "Richtgeschwindigkeit"; this speed is not a binding limit, but being involved in an accident at higher speeds can lead to being deemed at least partially responsible due to "increased operating danger". On average, about 75 % of the total length of the German Autobahn network has no speed limit, and about 25 % has a permanent limit [Wikipedia, 2008].

Is not this an internal German affair? No, it is not since the existence of the possibility to drive at high speeds justify the design of high-performance cars and SUV:s with high top speeds. The high top speeds make it necessary to mount tyres than may endure these speeds for a considerable time. "Safe" driving at 200-300 km/h requires construction solutions and material specifications that may be quite far from optimal at normal operating speeds and not even optimal at the maximum legal speeds in most countries.

Several times it has been pointed out by tyre manufacturer representatives at conferences and in discussions that the optimization of tyres for extreme high speeds makes it much more difficult to design them with low noise. It is known in the industry that some low-noise solutions for tyres applied in Japanese tyres (for the domestic market where legal speeds do not exceed 110 and there are top speed limiters at 180) cannot be used in Europe. There are low-noise tyres in Japan which are impossible to purchase in Europe; for example this author had to use a friend in Japan to purchase the two most important of these and send them to Sweden. If Europe had similar speed conditions as Japan also tyres in Europe could be designed with lower noise emission. Thus the German freedom of high speed driving makes the entire Europe suffer from higher tyre/road noise than "necessary".

The situation is indirectly similar for CO_2 emissions. High top speeds need high engine power, and high engine power gives higher fuel consumption and CO_2 emissions.

The French government once considered an in-vehicle speed limiter, starting to operate at 140 km/h, but this is something which was preferred to introduce in harmonization within the EU. Citroën has introduced cruise control functions, which are now widely available across the Citroën range, including a speed limiter which prevents the vehicle from exceeding a given speed that is set by the driver. On European trucks (articulated vehicles), speed limiters set at 85 km/h are mandatory.

From an environmental point of view, as well as for safety reasons, the international community should agree on limitation of top speeds of vehicles to (say) 150 km/h, also including sports cars, by introducing top speed limiters and these should be constructed in a way which is extremely difficult to manipulate. In this way no tyres need to be designed for higher top speeds than the present Q class.

The author thinks that this may be the single most efficient policy change to reduce traffic noise in Europe, and it would not cost one Euro; instead it would save a lot of money as well as lives and human suffering.

19.7 Marketing code of conduct

There is also a need for a code of conduct in advertising of environmental properties of tyres and vehicles. This was suggested in [TNO/IEEP/LAT, 2006] from which the following is cited: "This could take the form of something similar along the lines of the voluntary French code for safety or the EACA initiative, or it could be more prescriptive. Given that there is already legislation concerning how information regarding the CO2 emissions and fuel efficiency of passenger cars is communicated to the public, i.e. Directive 1999/94, the option of expanding the scope of this Directive should be considered. Currently this Directive focuses on the provision of information at the point of sale to which potential buyers are only exposed at the end of their decision making process. Consequently, to ensure that potential car buyers are more aware of the impact of the climate impact of their purchasing decision, consideration should be given to ensuring that information on CO2 emissions and fuel efficiency is given wherever and whenever cars are promoted. In other words, thought should be given to expanding the scope of Directive 1999/94 to cover car advertising in all media, i.e. including TV and radio, as well as newspapers and magazines."

19.8 Industry and media ethics

As pointed out in [FEHRL, 2006-2] styling of tyres is nowadays an important part of tyre and vehicle design and sometimes overrules technical improvements. Styling with respect to tyres means that wider tyres are preferred to narrower ones; not because of technical advantages but due to the fancy that wider tyres means "sporty" tyres. But wider tyres have an advantage in high-speed driving only in ideal (dry) weather.

The styling problem is a market reality. It is similar to the increased popularity to buy SUV:s instead of cars, not because that type of vehicle is needed by most people but because it is fashion, they are often very comfortable and demonstrates an economic capacity of the owner. In practice, of course, this is an economic capacity to pollute the environment and speed up climate change. The strength of this trend could be reduced if most people would realize the compromises of the environment they make when they are selecting an SUV instead of a conventional car and when they select a powerful car instead of a "normal" powered car. Even if a vehicle owner personally would not agree, he/she might then feel a pressure from the neighbours not to use "over-polluting" vehicles. Simply, the mentality of people must be changed, and here national government campaigns, consumer information and international coordination are important.

The same applies to the marketing policy of the light vehicle industry and marketing organization. In the advertisements the dealers mostly emphasize the extreme power, acceleration and top speeds of the vehicles, and what is often referred to as "driving pleasure" [Spolander, 2007].

Automobiles optimized for our real transportation needs rather than for motor journalists and motor shows usually get little attention in the mass media. Motor journalists tend to prefer testing and writing about sports cars and high-performance cars, rather than the cars that the majority of people would need for simple transportation needs. Thus, this sector of the car and SUV industry gets extra attention and publicity free of charge; also on TV prime time. Furthermore, these motor journalists often are believed by the readers and viewers as "unbiased" and reliable, and consequently the impact of their preferences is higher.

The national governments, maybe in international cooperation, should consider discussing these ethical problems with the industry, journalists and the marketing organizations. Maybe some kind of voluntary agreements can be reached which would dampen the emphasis on "driving pleasure" and turn it into an increased attention to the real needs of people and of the society to satisfy the obviously high demand for safe and environmentally responsible transportation by private vehicles.

19.9 Selling higher powered cars by environmental argument?

One of the major European car manufacturers presently has a campaign, named EfficientDynamics, in which the new cars are advertised as having "less emissions" but at the same time providing "more pleasure" (it probably refers to more "driving pleasure"; i.e. higher power, speeds and accelerations); see Fig. 60.

Fig. 60. Car on exhibit in February 2008 at Brussels International Airport, advertising more (driving) pleasure and lower emissions; according to the environmentally-awarded concept EfficientDynamics.

This concept, more power and less emissions, has recently won an environmental award; "Grünes Lenkrad" presented to the company by the German Minister of the Environment[35]. When studying a 12-page advertisement supplement in a magazine distributed in Sweden for the EfficientDynamics concept, it reads in the text that all petrol cars meet the environmental class 2005 and all diesel cars meet the environmental class 2005 PM of the about 140 petrol and diesel models listed. What does this say to the general consumer? Is it a way of selling higher-powered cars by environmental arguments or a way of selling lower emissions by increased engine power arguments? The average consumer probably thinks that this sounds very good indeed ("*all 140 models must be environmentally friendly cars*"), but probably has no idea what it really means. In the 12-page advertisement it does not say anywhere how much lower the emissions are, and to what it is compared, only that the emissions are "lower". But it is obvious that the argument is selling, since it got the Grünes Lenkrad award. When looking at the listed CO_2 values, it turns out that about half the cars emit more than 200 g/km, and a few are even above 300 g/km. The highest engine powers are above 500 hp and one of the cars accelerate 0-100 km/h in 4.7 s; and even these extremes are "environmentally friendly"; i.e. meet the environmental class 2005 (PM). It is interesting that higher power (albeit along with lower emissions), is a concept awarded an environmental prize. This may illustrate that environmental friendliness is a relative concept.

35 http://www.bmw.com/com/en/insights/technology/efficient_dynamics/phase_2/gruene_lenkrad/introduction.html

20 CONCLUSIONS AND RECOMMENDATIONS

20.1 Introduction

In the recommendations below, measures are considered at various future times. The following time schedule is considered (with 2008 as the zero time level):

Time scale term:	Means:
As soon as possible	Within 1-2 years, say 2010
Step 1	Probably in 3-5 years, say 2012
Step 2	Probably in 7-10 years, say 2016
Step 3	Probably in 7-10 years, say 2020

A common feature to all the parameters considered for a European limit and consumer information system, namely wet grip, rolling resistance and noise emission, is that the measurement methods and/or the reference conditions for all three have serious shortcomings which need improvements in order to create a cost-efficient system. By cost-efficiency, the author does not primarily think of inexpensive measurements, but rather on measurements which have sufficiently tight tolerances to create a fair ranking or labelling of tyres, plus that the methods must be representative of the most common conditions appearing on or being typical of European roads.

If the above-mentioned features are not achieved the tyre classifications will have too high a degree of randomness, or they will be sub-optimized for conditions which are not the most important ones.

In general, the author thinks that currently the testing is designed for the lowest testing costs, at the expense of reproducibility and representativity, and therefore the resulting system is not in the optimal interest of European consumers.

20.2 Wet grip and safety

It is concluded that for the wet grip test the measurement method specified in ECE Regulation 117 and intended to be adopted also by the EU Commission, has such serious shortcomings that it is technically more or less useless in its present form. This is not due to a poor measuring principle, but due to much too wide tolerances on a number of critical topics. Such tolerances are always a trade-off between accuracy in the measurement against cost and practicability. In the case of ECE Regulation 117 it is the author's view that the accuracy has suffered much too much in this trade-off.

It must also be recognized that the wet grip test in ECE Regulation 117 does not characterize the most critical safety performance of tyres. More critical performances not tested and not regulated include aquaplaning, wet grip at much higher speeds than in the test, wet grip for worn-out tyres as well as friction on icy or snow-covered roads. Furthermore, the limits for the wet grip tests are fairly liberal.

Although the wet grip test and corresponding limits should remove a few low-quality tyres from the market, it is important to make tyre users aware of that the wet grip test in no way guarantees that the tyres they purchase on the European market are safe tyres, referring to the previous paragraph. These facts should, for example, be more stressed in driving schools and be part of tests that new drivers have to pass for a driver's licence.

Nevertheless, for political reasons and in order not to delay measures against noise, it may be necessary to accept the deficiencies of the method until improvements have been accepted. Therefore, for the wet grip test the following recommendations are given:

- Accept the wet grip method and minimum requirement in ECE R117 for political reasons, but realize that the technical quality of the method is limited until it has been improved in its details. Timing: Step 1.
- Give high priority to improving the method, considering more detailed suggestions earlier in this report. Note: the method has a good potential for improvement but it will require more care in measurement conditions, plus using the new SRTT tyre. Timing: as soon as possible. In principle it should be possible to have the improved method available until Step 1 is taken (2012) but at the moment this can only be seen as a desirable option.
- In a long-term perspective it would be preferable that the wet grip test would include also a reproducible condition when the drainage properties of the tyre tread are the most important. Timing: Step 2
- Consider the practicability of including a wet grip test also for tyres which have been worn down to (say) a tread depth of 3 mm. Timing: Step 2
- Include wet grip in a labelling system, but wait to do so until the measurement method has been improved. Timing: Step 1 or maybe Step 2
- In a labelling system, in a long-term perspective, it would be preferable that also measurements according to bullets No. 3 and 4 above are included. Timing: Step 2
- In a long-term perspective, it would be preferable to include for winter tyres a braking test on icy roads. It is difficult to do such testing with high reproducibility but it should be possible to achieve a reasonable method when using comparison with a reference tyres. For this reason such a reference tyre should be developed. Timing: Step 2

The wet grip test should include C1 tyres, as is the case in ECE Regulation 117. However, also C2 tyres should be included since many such tyres are used on vehicles driven in similar ways as cars, such as SUV:s.

For C3 tyres, the wet grip test is not needed, due to the high load of such tyres in combination with lower speeds, but a test for grip on icy roads could be useful. In Sweden, for example, a number of serious accidents involving busses on icy roads have started a discussion of requirements on tyres for some heavy vehicles, since many of them run on tyres made for non-winter conditions in severe winter climates. The author recommends that a discussion about this is initiated.

20.2 Rolling resistance

It was estimated in [TNO/IEEP/LAT, 2006] that the potential fuel consumption and CO_2 reduction with low rolling resistance tyres is 3 %, and another 2.5 % may be obtained with tyre pressure monitoring systems, which would be a welcome contribution to achieving the CO_2 reduction goal of the EC. This author suggests that the labelling of tyres, together with a campaign to make vehicle owners aware of the new consumer information, would be the most important measure to achieve this goal.

It is proposed that the rolling resistance coefficient (RRC) is included in a tyre labelling and consumer information scheme for tyres for both light and heavy vehicles.

Consumer concern for rolling resistance is indeed a very important aspect that may replace purchase price as the most influential factor in the "typical" consumer's decision, provided the labelling scheme is accompanied by an information campaign in each country. This would benefit the consumer's fuel budget, the air pollution and the global climate effects favourably.

Of crucial importance to the efficiency of limiting and providing consumer information about rolling resistance is that appropriate measurement methods are used. This author thinks that the work to produce a more accurate method (ISO 28580) is promising and seems to be the method most suited to use for any tyre labelling or regulation regarding rolling resistance.

However, as justified in Chapter 9.2, it is urgent to work out modifications to the ISO method for reducing its remaining shortcomings, namely:

- To introduce a more realistic surface on drum, including unevenness and a more realistic road texture imitation.
- As a first and immediate step, until the previous paragraph can be implemented, a smooth and plain steel surface shall not be allowed to use. As in the existing SAE methods it is better to use the sand-paper-like surface since it gives an RRC closer to that on a real road texture than plain steel does.
- Calculate the air drag contribution by means of a simple model and add it. In the ISO methods, air drag is not included which means that narrow and

wide tyres are not classified against each other in a fair way, and the trend towards wider tyres is not discouraged like it should be.

- Check, and revise if needed, the correction for drum curvature

The final value should be valid for a flat surface; i.e. it shall be corrected for drum curvature (which is just an option in ISO 18164 and in the latest draft of 28580). The procedure to be adopted by any ECE regulation or EU directive must specify the reporting of values, which is not included in the ISO 18164 standard and neither in the latest draft for ISO 28580.

The author further suggests that test speeds for C1 and C2 tyres are defined as 80 and 120 km/h. In ISO 18164 and in the coming ISO 28580 the speed of 80 km/h is already the preferred single reference speed. Without the air drag contribution, the speed has little influence, and thus it is enough to test at 80 km/h, but with the air drag considered, speed becomes in important factor and must be defined also at a higher level typical of motorway driving.

These modifications to the ISO method, except the drum curvature correction which can just be modified if needed, may be included as two normative annexes: "Drum surface" and "Air drag component".

Part of consumer information shall be that consumers shall check the tyre inflation pressure as frequently as possible, or at least once per month.

Realizing that the majority of vehicles will still have slightly lower pressures than the ideal, consumers shall be informed to adjust the inflation pressure a little higher than the ideal one from an overall point of view (i.e. as presently recommended by tyre and vehicle manufacturers). The intention is that the inflation pressure over the tyre lifetime should be as close as possible to the ideal one. For example, one might add 20 kPa to the nominal pressure.

Even if TPMS are introduced, one may adjust the pressure a little bit higher to account for air leakage and that the TPMS will not alarm until the pressure is significantly lower than the nominal one.

As a consumer labelling system the A-D class system proposed by ETRTO and essentially copied by the Commission gives no incentives for further improvements below the 9.0 level and it is totally "stiff". It will therefore not be very effective. This author recommends the system outlined in Chapter 6.7 according to which tyres are labelled with the actually measured value. However, if a class system is chosen, the author's proposal for classes and limits is shown in Table 12. This system corresponds well to the actually measured RRC and has full flexibility and is easy to adapt to a changing world. An alternative, although less preferred, is a star system outlined in Table 13.

The limit levels for RRC proposed by ETRTO and the Commission are not stringent enough to be effective; their justification is poor. On the other hand, the author believes that the consumer information on RRC is much more effective.

20.3 Noise emission

The author proposes that the limit levels suggested by the Commission are introduced in 2012 without exception or change. It has been considered whether the limits for truck tyres are too stringent, but the author argues that this is not the case bearing mind that technological progress in terms of noise reduction measures has not yet been utilized for such tyres.

The proposed new noise limits are by no means a final solution to the noise problem. The next step may be suitable to take at about year 2020. At that time a limit change of roughly 2 dB for all tyre categories seems reasonable, based on the assumed technological development. There are already a few tyres today which would meet such limits but around year 2020 many tyres would probably do so.

The author proposes to establish a so-called "70 dB goal" for year 2020. It would imply that "no tyre shall emit more than 70 dB at the test conditions in the year 2020". Politically, it is important to work towards such a long-term goal, even if a few tyre types will not be able to meet it already in 2020.

It is proposed that also the exterior noise emission is included in a tyre labelling and consumer information scheme. As reported in Chapter 7, this is a parameter which many consumers are interested in.

However, the limit as well as the labeling scheme shall apply not only to new and replacement tyres, but also for retreaded tyres. Unless this is done, one will miss a large percentage of the tyre fleet and the scheme will be less efficient.

It is suggested that the really measured value is labelled, rather than classifying tyres into quality classes. However, the author also presents a classification system based on a "star" label; see Table 13.

The inclusion of noise in the labelling scheme has two reasons: (1) the comfort in the car, since there is a certain correlation between the interior and the exterior noise, and (2) the environmental awareness of the consumer, affecting both his and others' acoustic environment. For the quality of life in Europe it is definitely one of the most important parameters of concern. For public procurement of vehicles and tyres, it is likely that there will be requirements for not only rolling resistance but also noise emission; as this is a way forward for cities and communities to reduce the traffic noise emission in their areas.

As for wet grip and rolling resistance, there are shortcomings in the measurement methods and conditions which limit the efficiency of the system. This applies most importantly to the reference surface used for tyre noise testing. Whereas, in an interim period, the present noise test shall be used, some aspects related to the reference surface urgently need to be improved, as described in Chapter 9.3, namely:

- The ISO reference surface must be specified more in detail with tighter tolerances and using better measurement methods
- A second reference surface, with a rougher macro- and megatexture shall be specified and used
- It is suggested also to use a reference tyre for normalization of differences between different test tracks, the tyre of which may be the new SRTT defined in ASTM F2493-06 [ASTM, 2006]. This is a similar principle to that intended for improving the RRC test.

20.4 Common features

For the suggestions above, the author has listed a suggested timetable in Chapter 14.

The author suggests a number of policy considerations. For example, the author points out that already today there are national policies for the use of low-noise road surfaces. That is not to say that a common European framework could not enhance the system, but one must recognize the substantial economic consequences which current policies already have and the benefit they offer to society, since knowledge about this fact is missing among some actors on the scene. Now is the time that the economic consequences of noise reduction (if any) are shared also in the tyre sector rather than only in the road sector.

Another policy consideration is that tyres used during type approval of vehicles shall not be exchanged to other types when they are sold, unless these tyres can be shown to offer better performance in the relevant aspects than the tyres used during type approval.

The author also points out the limitations on noise reduction that are imposed by current lack of speed limits on some German motorways, as well as the effects of current marketing of vehicles in which high power and high speed performance, often hidden behind clichés such as "driving pleasure", are highlighted above all. The author thinks that a discussion must take place between authorities, consumer organizations and the industry on a code of conduct in future marketing of vehicle performance.

It is extremely important for the efficiency of the low-noise tyres that consumer information of noise and not only of rolling resistance is included in the future system. In fact, the inclusion of both parameters may encourage the consumer to select tyres which shift the costs from both consumers and noise sufferers towards higher quality tyres which utilize a higher level of technical sophistication, resulting in a shift of overall transportation costs from oil, CO_2 and noise annoyance to an improved product; and yet with a net benefit to the consumer himself.

If a system is chosen in which the tyres are marked only with a label (a class) and not with the actually measured values, the actually measured values of wet grip, rolling resistance and noise shall be reported in a publicly available document. It is proposed that such values be reported to some common European organization, such as the EEA, which shall publish them on a website and keep this database updated. It is also suggested that the website will contain some statistical information of the values, such as frequency distribution of the values for each tyre category.

The author has listed several hints on how the consumer information can be aided by for example pasted notes on the new tyres, RFID chips, consumer information leaflets at the tyre dealers, computer databases that will make it possible for a consumer to see what the tyre dealer has in stock on a scale of RRC or noise values, and on-line systems connected with the central European database. By clever design such systems may be made relatively easy to understand and use by the tyre dealers as well as by the common tyre consumer. The central European organization that would handle the database might also provide suitable computer programs for use by tyre dealers to aid in their consumer information.

The possibilities for future consumer information are outstanding and mainly limited by imagination and the possibility to provide the information in an understandable way for the consumer. As shown in an example in the report, environmentally friendliness is a relative concept and some definitions seem to be confusing and easy to misinterpret.

21 ACKNOWLEDGEMENTS

This main sponsor for this report is the European Federation for Transport and Environment (T&E). However, it must also be acknowledged that part of the report is based on work made within a Swedish project sponsored jointly by the Swedish Road Administration and SIS Ecolabelling AB. Furthermore, smaller parts in the report are based on work within Work Package C4 of the European project SILENCE. The author is grateful to all these direct and indirect sponsors.

A substantial part of the measurement reported here and in which the author has been directly involved have been made in cooperation with the Technical University of Gdansk (TUG) in Poland, under the direction of Prof. Jerzy A. Ejsmont; usually performed by means of TUG equipment and with TUG staff. The author is very grateful for this cooperation and for all work performed by TUG.

Finally, the author would like to acknowledge the constructive discussions with, in particular, the following individuals:

Ms Nina Renshaw at T&E
Dr Erik de Graaff, M+P, the Netherlands.
Mr Luke Tonachel, NRDC, USA
Mr Olle Nordstrom, retired from VTI, Sweden

22 REFERENCES

AB 844 (2003): "Legislative Counsel's Digest AB 844, Nation. Replacement Tire Efficiency Program". Assembly Bill No. 844, Chapter 645, California Legislative Counsel, Sacramento, California, USA (website: http://www.leginfo.ca.gov/).

Aimon, Dominique (2005-1): "Are safety and long wearlife compatible with fuel efficient tires?" Presentation at the IEA workshop on "Energy Efficient Tyres: Improving the On-Road Performance of Motor Vehicles", 15 Nov. 2005, Paris, France. The presentation is possible to download from the website: http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=227

Aimon, Dominique (2005-2): "Supporting the development of Low Energy Tires". Presentation at the IEA workshop on "Energy Efficient Tyres: Improving the On-Road Performance of Motor Vehicles", 15 Nov. 2005, Paris, France. The presentation is possible to download from the website: http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=227

Anon. (2004): "Kurzfassung: Definition und Erarbeitung eines Systems zur Förderung lärmarmer KFZ-Reifen, Variante 2, bezogen auf Österreichische Fahrbahndecken und lärmmindernde Fahrbahndecken auf dem letzten Stand der Technologie". Endbericht Proj. Nr. FFF 806231-SP/TU, Proj. Nr. Arsenal: 2.05.00127.1.0, Arsenal, Vienna, Austria (in German).

Anon. (2005): "Rulla Rätt - Lätta fordon: Guide till krav på miljöanpassade däck". Stockholm City, SE-10535 Stockholm, Sweden. Downloadable at: http://www.stockholm.se/upload/F%C3%B6r%20f%C3%B6retagare/upphandling/Handla%20smart/pdf/Rulla%20latt.pdf

Apollo (2007): Statement by Raghuraj Ananthoj, Apollo Tyres, India, reported in Tire Technology International, December 2007 (p 42).

ASTM (2006): "Standard Specification for P225/60R16 97S Radial Standard Reference Test Tire". ASTM Standard F2493-06, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States.

Bengmark, David (2008): Personal communication with Mr David Bengmark, MD of Fighter AB in Staffanstorp, Sweden.

Berge, Truls; Ustad, Asbjørn (2004): "Støymålinger på bildekk i henhold til EU-direktiv 2001/43/EC. Foreløpige måleresultater fra 2003 og 2004". SINTEF Rapport STF90 A04083, SINTEF IKT, Trondheim, Norway (in Norwegian).

Berry, Bernard (2004): "I-INCE Technical Study Group 2 on "Noise Labels for Consumer and Industrial products"- an update on progress". Proc of Inter-Noise 2004, Prague, the Czech Republic.

Blauer Engel (2008-1): “Low-Noise and Fuel-Saving Automobile Tires RAL-UZ 89”. Blauer Engel, Germany. Website: http://www.blauer-engel.de/englisch/produkte_zeichenanwender/vergabegrundlagen/ral.php?id=86

Blauer Engel (2008-2): “Basic Criteria for Award of the Environmental Label”. Blauer Engel RAL-UZ 89 (version April 2007). Downloadable from http://www.blauer-engel.de/englisch/vergabe/download_uz_e/e-UZ-089.zip

BLIC/BIPAVER (2005): "Retreaded Tyres – Tyre to road rolling sound emissions". Informal document No. GRB-42-7, 42nd GRB, 5 – 7 September 2005, ECE/WP29/GRB, Geneva.

CEC (2003): “California State Fuel-Efficient Tire Report: Volume II”. Consultant report 600-03-001CR Volume II (January 2003), California Energy Commission (see: http://www.energy.ca.gov/reports/2003-01-31_600-03-001CRVOL2.PDF).

Com (1996): "Future Noise Policy - European Commission Green Paper". Document COM(96) 540, published 4 November 1996 by DG XI Environment, the European Commission, Brussels, Belgium. See the following website for a brief summary (unfortunately the link to the full paper in WORD format that they provide at the bottom of the page is no longer correct):
http://ec.europa.eu/environment/noise/greenpap.htm
When this is written; instead, the full paper can be downloaded in pdf format at:
http://aei.pitt.edu/1204/01/noise_gp_COM_96_540.pdf

Com (2007): “Public consultation on outline proposals for a Regulation of the European Parliament and of the Council on Advanced Safety Features and Tyres - Consultation document”. European Commission, DG Enterprise and Industry, Brussels, Belgium (22 August 2007). Downloadable from:
http://ec.europa.eu/enterprise/automotive/pagesbackground/safety/consultation/consultation_document.pdf

de Graaff, Erik (2008): Personal communication with Dr Erik de Graaff, M+P raadgevende ingenieurs, Vught, the Netherlands.

DeRaad, L.W. (1978): ”The Influence of Road Surface Texture on Tire Rolling Resistance”. SAE Technical Paper 780257, Society of Automotive Engineers, Pennsylvania, USA.

DfT (2004): "DfT Research Database: (A) Primary Safety" (*look for project group S340D/VD*). Department for Transport, London, UK. Website:
http://www.dft.gov.uk/rmd/subprogramme.asp?intProgrammeID=74&intSubProgrammeID=134

Dolley, Phil; Oldman, Louise; Hidri, Sadok (2004): "Prioritisation of New Ecolabel Product Groups - A Report for the European Commission, DG Environment". Report number ED24255, AEA Technology Environment, Oxon, U.K.. Downloadable from:
http://ec.europa.eu/environment/ecolabel/pdf/prioritisation/prioritisation_final_0504.pdf

Duleep, K.G. (2005): "Tires, Technology and Energy Consumption". Presentation at the International Energy Agency Workshop on Low Rolling Resistance Tyres, Paris, France, 11/2005. Can be downloaded from
http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=227

ECE R117 (2007): "Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and to adhesion on wet surfaces". Regulation 117, including amendments 15 June 2007, United Nations Economic Commission for Europe (ECE), Geneva.

ETRMA (2007-1): "European Tyre Industry Response to DG ENTR Public Consultation on outline proposals for a Regulation of the EP and of the Council on Advanced Safety Features and Tyres". October 16 2007, ETRMA, Brussels, Belgium.

ETRMA (2007-2): "European Tyre Manufacturers. Commitments assumed with the EU relative to reductions in CO2 and noise levels". Press release, 18 October 2007, ETRMA, Brussels, Belgium.

ETRTO (2007): "European Tyre Industry Contribution to Revision of Directive 2001/43". ETRTO, January 2007.

Fallast, Kurt; Strohmayer, Doris (2004): "Maßnahmen zur Steigerung des Ausrüstungsgrades von Kfz mit lärmarmen Reifen". PowerPoint-presentation from Institut für Straßen- und Verkehrswesen, Technische Universität Graz, Graz, Austria (in German).

FEHRL (2006-1): "Study SI2.408210 Tyre/Road Noise – Volume 1: Final Report". FEHRL, Brussels, Belgium. Downloadable from:
http://ec.europa.eu/enterprise/automotive/projects/report_tyre_road_noise1.pdf

FEHRL (2006-2): "Study SI2.408210 Tyre/Road Noise – Volume 2: Appendices". FEHRL, Brussels, Belgium. Downloadable from:
http://ec.europa.eu/enterprise/automotive/projects/report_tyre_road_noise2.pdf

GovTrack H.R. 5632 (2006): "GovTrack.us. H.R. 5632--109th Congress (2006): To amend Chapter 301 of title 49, United States Code, to establish a national tire fuel..., GovTrack.us (database of federal legislation) (accessed Jan 3, 2008)
http://www.govtrack.us/congress/bill.xpd?bill=h109-5632

GRRF 2003/30 (2003): "Proposal for Draft Amendments to Regulations Nos. 30 and 54 (Pneumatic tyres and pneumatic tyres for commercial vehicles). Transmitted by the expert from the Russian Federation". Document number TRANS/WP.29/GRRF/2003/30, 24 July 2003, GRRF, WP29, ECE, Geneva. See http://www.unece.org/trans/main/wp29/wp29wgs/wp29grrf/grrfage.html

GRRF-56-24 (2004): "Tyre rolling resistance. ETRTO activity". Informal Document No. GRRF-56-24, GRRF, WP29, ECE, Geneva. See the GRRF website: http://www.unece.org/trans/doc/2004/wp29grrf/TRANS-WP29-GRRF-56-inf24e.doc

GRRF-56-28 (2004): "Wet Grip Regulation. Ad hoc GRRF Conclusions". Informal Document No. GRRF-56-28, GRRF, WP29, ECE, Geneva. See the GRRF website:
http://www.unece.org/trans/doc/2004/wp29grrf/TRANS-WP29-GRRF-56-inf28e.ppt

GRRF-62-39 (2007): "Proposed Amendments to Regulations Nos. 30 and 54 Regarding Manufacturer's Information on Rolling Resistance Coefficient". Informal Document No. GRRF-62-39, GRRF, WP29, ECE, Geneva. See the GRRF website:
http://www.unece.org/trans/main/wp29/wp29wgs/wp29grrf/grrfage.html

GRRF-ETRTO (2007): "ETRTO Update on Rolling Resistance". Unnumbered Informal Document (Presentation) by C. Penant – ETRTO 27/09/2007 at the 62nd GRRF session, GRRF, WP29, ECE, Geneva. See the GRRF website:
http://www.unece.org/trans/doc/2007/wp29grrf/Presentation_ETRTO_62GRRF.pdf

GRRF-NAMI (2007): "Automotive Tyre Rolling Resistance Regulation". Unnumbered Informal Document (Presentation) by V.Petrushov – NAMI(RF) 24/09/2007, GRRF, WP29, ECE, Geneva. See the GRRF website:
http://www.unece.org/trans/main/wp29/wp29wgs/wp29grrf/grrfage.html

Haider, Manfred (2005): Personal communication with Dr Manfred Haider, Arsenal Research, Wien, Austria.

Haider, Manfred; Fallast, Kurt; Strohmayer, Gerhard (2004): "Definition und Erarbeitung eines Systems zur Förderung lärmarmer KFZ-Reifen, Variante 2, bezogen auf Österreichische Fahrbahndecken und lärmmindernde Fahrbahndecken auf dem letzten Stand der Technologie". Endbericht Proj. Nr. FFF 806231-SP/TU, Proj.Nr. Arsenal: 2.05.00127.1.0, Arsenal, Vienna, Austria (in German).

Hall, David. E.; Moreland, J. Cal (2001): "Fundamentals of Rolling Resistance". Rubber Chemistry and Technology, 74 (3), pp 525-539, July-August 2001.

IEA (2005): "Energy Efficient Tyres: Improving the On-Road Performance of Motor Vehicles". Workshop organized by the International Energy Agency (IEA), Paris, 15-16 November 2005. The URL of this workshop is as follows:
http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=227

ISO 18164:2005 (2005): "Passenger car, truck, bus and motorcycle tyres — Methods of measuring rolling resistance". International Organization for Standardization (ISO), Geneva, Switzerland.

ISO 23671:2006 (2006): "Passenger car tyres -- Method for measuring relative wet grip performance -- Loaded new tyres". International Organization for Standardization (ISO), Geneva, Switzerland.

ISO/CD 28580 (2007): "Tyre Rolling Resistance measurement method designed to ease international cooperation and, possibly, regulation building". Document No. ISO/TC 31/ SC N 743, Secretariat of ISO/TC 31 Tyres, rims and valves, American National Standards Institute, Washington, DC 20036, USA.

Jonasson, Hans (2007): "Rolling Noise Emission of Tyres – A Market Survey". SP Report: 2007:70, SP Technical Research Institute of Sweden, Borås, Sweden.

KPMG BEA (2003): "Haalbaarheid stimulering stille banden – Eindrapport". Investigation by KPMG Bureau voor Economische Argumentatie (KPMG BEA) on behalf of VROM (Ministry of Housing, Spatial Planning and Environment), Project Number 3547, 31 January 2003, Hoofddorp, the Netherlands (in Dutch).

Kropp, W.; Kihlman, T.; Forssén, J.; Ivarsson, L. (2007): "Reduction potential of road traffic noise", Royal Swedish Academy of Engineering Sciences, report 2007. http://www.iva.se/templates/page.aspx?id=4354

Library of Congress (2007): "Energy Independence and Security Act of 2007 (Enrolled as Agreed to or Passed by Both House and Senate) – Section 111 Consumer Tire Information". US Congress Bill H.R.6, Section 111, Library of Congress, Washington, DC, USA. Can be read on-line at the following website:
http://thomas.loc.gov/cgi-bin/query/D?c110:8:./temp/~c110ZcqFXT

Lorenzen, Arne (2007): "Low Road Traffic Noise - The German research program "Leistra2"". Proceedings of Inter-Noise 2007, Istanbul, Turkey. However, the diagram in this report is not in the paper; it was only in Mr Lorenzen's audio-visual presentation.

Mercedes-Benz (2007): "2007 IAA International Motor Show: The Mercedes-Benz F 700 Research Car. The technology of the F 700: Forward-looking combination of refinement and environmental friendliness". Weblog posted September 11th, 2007, on the following website:
http://www.emercedesbenz.com/Sep07/11_2007_IAA_International_Motor_Show_The_Mercedes_Benz_F_700_Research_Car_3.html

Michelin (2003): "The tyre – Rolling resistance and fuel savings". Book published by Michelin, Clermont-Ferrand Cedex 09, France.

Miljøstyrelsen (2003-1): "Förslag til strategi för begränsning av vägtrafikbuller". Miljøstyrelsen (Danish Environmental Protection Agency), Ministry of Environment, Copenhagen, Denmark (in Danish), see website: http://www.mst.dk/transport/03020100.htm

Miljøstyrelsen (2003-2): "Notat om forbrugeroplysning og afgifts/tilskudssystem til fremme af brugen af støjsvage dæk (5. udgave)". Miljøstyrelsen (Danish Environmental Protection Agency), Ministry of Environment, Copenhagen, Denmark (in Danish), see website: http://www.mst.dk/transport/03020100.htm

Mistry, Prab; Ogilvie, Steve (1999): "Feasibility study for a tyre ecolabel". Report produced for the Adhoc Working Group meeting on Tyre, on 5 October 1999, at the DGXI offices in Brussels (the authors were affiliated with AEA Technology Environment, E6 Culham, Oxfordshire, OX14 3ED, U.K.).

Miyabe, Subaru (2005): "Modern passenger car tires in view of technology and design". Presentation at the Tire Technology Expo 2005, Cologne, Germany.

NHTSA (2007): Website http://www.safercar.gov/tires/pages/TireLabeling.htm

Nokian (2007): "Passenger car tyre sidewall markings". Page downloadable from http://www.nokiantyres.com/files/nokiantyres/pdf_tiedostot/tyre_sidewall_markings.pdf . Further information at http://www.nokiantyres.com/sidewall-markings

Nordström, Olle (2008): Personal communication in January 2008 with Mr Olle Nordström, retired tyre and friction expert at the Swedish Road and Transport Research Institute (VTI) and well known in international tyre and friction research and standardisation.

Noyrez, Eric (2007): Interview with Rhodia Silcea President Eric Noyrez, in article "Filler up" in Tire Technology International, June/July 2007 (p 16).

OJ (2006): "Commission Decision of 9 February 2006 establishing the Community Eco-label working plan (Text with EEA relevance) (2006/402/EC)". Official Journal (OJ) of the European Commission, L 162/78, 14.6.2006, Brussels, Belgium. Can be downloaded from: http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_162/l_16220060614en00780090.pdf

Power and Associates (2003): "JD Power and Associates 2003 Germany Original Equipment Tyre Customer Satisfaction Index Study". J D Powers and Associates, http://www.jdpa.com/studies/

Reithmaier, Walter; Salzinger, Thomas (2002): "Determination of the state-of-the-art concerning rolling noise, rolling-resistance and safety properties of modern passenger car tyres". Research report 201 54 112, TÜV Automotive GmbH, Tire-/Wheel-Test-Center, Munich, Germany.

Roovers, M. S. (2003): "Tyre/road noise measurements for passenger cars according to EU directive 2001/43". January 16th, 2003, M+P Noise and Vibration Consultants, the Netherlands.

SAE J2452 (1999): "Stepwise Coastdown Methodology for Measuring Tire Rolling Resistance". SAE Handbook, Soc. of Automotive Engineers, USA.

SAE J1269 (2000): "Rolling Resistance Measurement Procedure for Passenger Car, Light Truck, and Highway Truck and Bus Tires". SAE Handbook, Soc. of Automotive Engineers, USA.

Saemann, E.-U.; Liederer, W.; Schmidt, H.; Fornefeld, W. (2001): "Tire/road noise – causes, influences, potential for improvements and target conflicts". Presentation by Continental Tyres in Hanover, Germany, at Workshop "Further Noise Reduction for Motorised Road Vehicles", organized by Umweltbundesamt, 17-18 September 2001 in Berlin, Germany.

Sandberg, Ulf (1991): "Standardization of a Test Track Surface for Use During Vehicle Noise Testing". SAE Paper 911048, Soc. of Automotive Engineers, USA.

Sandberg, Ulf; Ejsmont, Jerzy A. (2002): "Tyre/Road Noise Reference Book". Informex, 59040 Kisa, Sweden (www.informex.info).

Sandberg, Ulf (2005): "Rolling resistance measurements on laboratory drum versus measurements on road surfaces". Presentation at the Energy Efficient Tyres Workshop in Paris 15-16 November 2005; see [IEA, 2005]. (In cooperation with Jerzy Ejsmont, Stanislaw Taryma and Grzegorz Ronowski, Technical University of Gdansk (TUG) Poland).

Sandberg, Ulf (2006): "Financial Incentives to Encourage the Use of Low-Noise Tyres". Report to be published, Swedish Road and Transport Research Institute (VTI), Linköping, Sweden.

Sandberg, Ulf; et al (2008): Deliverable regarding "Study on the effect of tyre wear and ageing on tyre/road noise", for the EU project SILENCE (under production).

Spolander, Krister (2007): "Kör glädje - om fart och bilar i transportsystemet" (in Swedish; translation of title into English: "Driving Pleasure - on speed and cars in the transport system"). NTF Förlag, Stockholm, Sweden.

Stenschke, Reiner (2001): Personal communication in 2001 with Dr Reiner Stenschke, Umweltbundesamt, Berlin, Germany.

Stenschke, Reiner (2005): Personal communication in 2005 with Dr Reiner Stenschke, Umweltbundesamt, Berlin, Germany.

Stenschke, R.; Vietzke, P. (2001): "Tyre/Road Noise Emissions, Rolling Resistance and Wet Braking Behaviour of Modern Tyres for Heavy-Duty Vehicles (State of the Art)". Proc. of Inter-Noise 2001, the Hague, the Netherlands.

Stenschke, Reiner; Vietzke, Peter (2005): "Tire/road noise emission and rolling resistance of tires - status of legislation". Presentation at the "Tire Technology Expo 2005", 22-24 February 2005, Cologne, Germany.

STRO (2005): Personal communication with Mr Torsten Johansson, Secretary for The Scandinavian Tire & Rim Organization (STRO), Uppsala, Sweden.

Svanen (2008-1): Nordic Ecolabelling has the postal address Miljömärkningen Svanen, SE-11880 Stockholm, Sweden. There is a website with information in English about the Nordic Swan label at http://www.svanen.nu/Default.aspx?tabName=StartPage.

Svanen (2008-2): "Ecolabelling of Vehicle Tyres - Version 2.3 - 6 June 2001 – 30 June 2009" (translation from the basic Swedish version). Nordic Ecolabelling, 18 December 2006, Miljömärkningen Svanen, SE-11880 Stockholm, Sweden. Downloadable from the Nordic Swan website at http://www.svanen.nu/sismabmodules/criteria/getfile.aspx?fileid=92757001

Taryma, Stanislaw; Wozniak, Ryszard; Sandberg, Ulf (2006): "Laboratory and road measurements of tire/road rolling resistance". Presentation at the "Tire Technology Expo 2006", 7-9 March 2006, Stuttgart, Germany.

Tonachel, Luke (2004): "Fuel-Efficient Replacement Tires – Guidelines for Transforming the Marketplace". Report from the National Resources Defense Council (NRDC), with headquarters at 40 West 20th Street, New York, NY 10011, USA. Website http://www.nrdc.org/

TNO/IEEP/LAT (authors: Richard Smokers, Robin Vermeulen and 9 more) (2006): "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO2-emissions from passenger cars". Final Report, Contract nr. SI2.408212, October 31, 2006, TNO Report 06.OR.PT.040.2/RSM, TNO Science and Industry, Delft, the Netherlands.

TRB (2006): "Tires and Passenger Vehicle Fuel Econiomy: Informing Consumers, Improving Performance": TRB Special Report 286, available from the TRB Bookstore www.TRB.org/bookstore or can be downloaded from www.TRB.org/publications/sr/sr286.pdf

TÜV Automotive (2003): "Survey on motor vehicle tyres and related aspects, Ref: ENTR/02/045, commissioned by the European Commission, DG-Enterprise, Unit F5. Downloadable at the following web address: http://ec.europa.eu/enterprise/automotive/projects/report_motor_vehicle_tyres.pdf

van Blokland, G.J.; Peeters, B. (2006): "Comparison of surface properties of ISO 10844 test tracks". Report number M+P.MVM.04.2.1, M+P Noise and Vibration Consultants, the Netherlands.

Volvo (2008): "Volvo premierar miljöbilar genom utskrotning av äldre bilar - 10000/6000 kr i "skrotpremie" vid köp av ny Volvo etanol- eller dieselbil". Press release from Volvo Personbilar in Sweden 2008-01-14. See the website: http://www.volvocars.se/tools/NewsEvents/News/news.htm?item={A8927399-B8FB-48A0-B31A-BFD374836096}

Watts, G.R.; Nelson, P.M.; Abbott, P.G.; Stait, R.E. and Treleven, C. (2005): "Tyre/road noise – Assessment of the existing and proposed tyre noise limits". Published project report, PPR 077, PPAD 9/107/22 SO325/VB, TRL Limited, Crowthorne, England.

Weiss, Sandra (1992): “An Evaluation of the Uniform Tire Quality Grading Standards and Other Tire Labeling Requirements”. NHTSA Report Number DOT HS 807 805, NHTSA/DOT, Washington, DC, USA. May be downloaded from: http://www.nhtsa.dot.gov/cars/rules/regrev/evaluate/807805.html

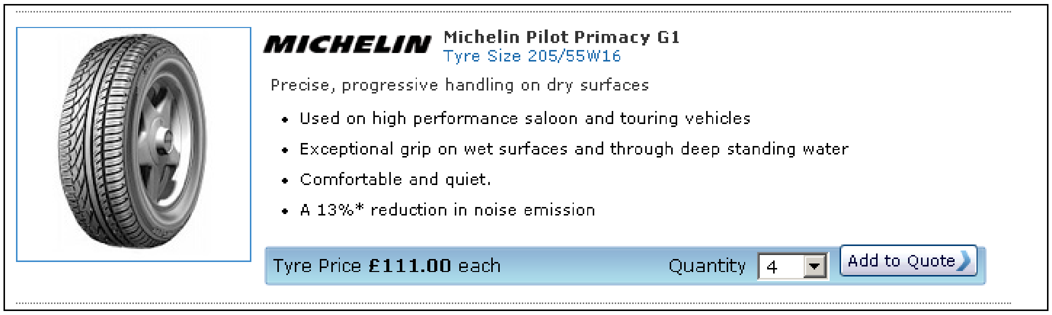
Wikipedia (2008): Article about Autobahn. Wikipedia on-line at http://en.wikipedia.org/wiki/Autobahn

Yukawa, Naoki (2007): "Noise reduction technology for radial passenger car tires". Tire Technology International 2007, The Annual Review 2007, pp 16-18, UKIP Media & Events Ltd, Dorking, Surrey, United Kingdom.

Annex A: Tyre marketing citing energy efficiency, low CO2 emissions and/or low noise

The following is a compilation made 28 February 2008 by Transport & Environment by just a few hours of search on the internet.

Source: http://www.kwik-fit.com/tyre-search.asp
Search for models for Ford Focus II. Zetec Deisel. The tyre size shown is 205/55W16.



Search for models for Mercedes C Klass Combi. The tyre size shown is 195/65H15:

Firestone TZ200 Fuel Saver
Tyre Size 195/65H15

High performance touring tyre for powerful executive models

- Silica compound
- Optimized block contact
- Improved wet handling
- Smoother ride with minimum vibration

Tyre Price **£59.00** each Quantity 4 Add to Quote

Firestone Firehawk 700
Tyre Size 195/65H15

This tyre is designed to provide superb manoeuvrability and durability

- Outstanding grip during braking, steering, and accelerating
- Wet or dry weather conditions
- Tough construction
- Low noise level

Tyre Price **£60.00** each Quantity 4 Add to Quote

Pirelli P6
Tyre Size 195/65H15

New STEP Project (Safety from Technically Engineered Profile)

- Comfort tyre for the latest generation of saloons, estate cars and MPV
- Extra Low Rolling Resistance (ELRR) system: flexibility and smoothness
- Fuel saving Low sound emission for a quiet and relaxing driving
- Mileage and Longevity

Tyre Price **£74.00** each Quantity 4 Add to Quote

Michelin Energy 3a
Tyre Size 195/65H15

The best grip in its class, on wet and dry roads

- Asymmetric tread pattern with textured sipes
- A new more ridged belt construction and rubber compound
- The new reference for tyre life
- Fuel saving technology

Tyre Price **£82.00** each Quantity 4 Add to Quote

Continental Conti-Eco Contact 3
Tyre Size 195/65H15

Targeted at mini, super-mini and lower medium vehicle class

- Asymmetric tread pattern
- excellent traction on wet and dry roads
- Safety when braking and cornering
- Lower fuel consumption due to reduced rolling resistance

Tyre Price **£72.00** each Quantity 4 Add to Quote

Search for models for Toyota PRIUS II/ PLATZ II. The tyre size shown is 195/55H16:

SPECIAL OFFER

GOODYEAR **Goodyear Eagle NCT5 EMT Run Flat Tyre RSC**
Tyre Size 195/55H16

Reduced fuel consumption/Increased mileage

- Significant reduction in CO2 emissions
- Maximum savings of energy and resources in production
- Improved mileage & minimised noise levels
- Resistance to aquaplaning

Tyre Price **£115.00** each Quantity 4 Add to Quote

Buy 2 of these Goodyear tyres for £97.75 each
Buy 4 of these Goodyear tyres for £86.25 each
This offer ends on 1st March.

Search for models for BMW 3 Series Cabriolet. The tyre size shown is 205/55H16:

MICHELIN **Michelin Pilot Primacy**
Tyre Size 205/55H16

Precise, progressive handling on dry surfaces

- Used on high performance saloon and touring vehicles
- Exceptional grip on wet surfaces and through deep standing water
- Comfortable and quiet.
- A 13% reduction in noise emission

Tyre Price **£105.00** each Quantity 4 Add to Quote

BRIDGESTONE **Bridgestone ER30**
Tyre Size 205/55H16

A perfect marriage of pampering and performance.

- unbelievably quiet road noise
- high speed stability
- high level of comfort
- precision handling

Tyre Price **£98.00** each Quantity 4 Add to Quote

MICHELIN **Michelin Energy 3a**
Tyre Size 205/55H16

The best grip in its class, on wet and dry roads

- Asymmetric tread pattern with textured sipes
- A new more ridged belt construction and rubber compound
- The new reference for tyre life
- Fuel saving technology

Tyre Price **£105.00** each Quantity 4 Add to Quote