Study on some safety-related aspects of tyre use

Stakeholder information and discussion document
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1 Introduction

1.1 Definition

The European Commission has contracted a consortium to assess various aspects of the tyre use and quality related to road safety, by means of a study "Study on some safety-related aspects of tyre use". The consortium is led by TNO (Netherlands) with TML (Belgium) as partner.

The current document presents a summary of the project work containing example results and preliminary findings to inform stakeholders for the consultation meeting planned on June 10th 2014 in Brussels.

1.2 Objectives

The purpose of the contract is to assist the Commission in its assessment of various aspects of the tyre use and quality related to road safety, including where appropriate, recommendations for EU measures. The aspects targeted in the study are the following:

a) The role of tyres as an accident factor,

b) The drivers' awareness and behaviour in relation to the safety role of tyres and their adequate choice and use,

c) The benefits, particularly for safety, derived from the use of the most appropriate tyres according to the weather conditions,

d) The minimum tread depth requirements,

e) The measures that could be effective to ensure adequate choice and use of tyres,

f) The measures that could be effective to ensure that tyres are used with the correct inflation pressure.

The expected output can be summarised as follows:

a) An evaluation of the safety problems related to various aspects of tyre choice and use, like the adequate tyre characteristics according to the climatic conditions, the minimum tyre tread depth and the adequate tyre pressure; this will include an assessment of the safety benefits that could result from improvements in these areas,

b) An analysis of the drivers' awareness concerning the importance for safety of the various aspects of tyre choice and use referred to in a) and an analysis of the potential safety benefits that can result from increased drivers' awareness concerning these safety aspects,

c) Policy recommendations for measures aimed at addressing the safety problems identified above concerning tyre choice and use. For each of the measures recommended an assessment of its cost and benefits.

1.3 Aim and approach

The overall aim of the project is to define measures concerning the use of tyres for improvement of traffic safety.

Centrally in this, is the idea that end users need to make the correct assessment in relation to tyre choice in order to achieve an as high as possible level of safety. Within this context, tyre choice needs to be considered in relation to four technical elements (tyre inflation pressure, tyre tread depth, tyre age and meteorological influences) and one information element (driver awareness).

First the influence of technical elements on tyre performance is summarized in order to understand the physical mechanisms under-laying the existing legislation and recommendations concerning tyre use for specific operating conditions, and this is followed by a discussion of the relation with safety aspects. Next it is discussed what regulation exists for tread depth and winter tyres, and finally an overview is given on weather conditions and accidents in different EU member states. The results are then summarized, and in a final chapter a list of possible actions is provided which are mainly based on the technical assessments.

The information is obtained from replies on questionnaires, general statistical data, (scientific) literature and a variety of related studies. A discussion about the state of the art and possibilities for improvement with stakeholders is part of the process, and this document is providing an overview of the assessments to prepare stakeholders for the discussions.

2 Tyre performance and operating conditions

The tyre is the only contact between the vehicle and the road. Every controlling function (steering, braking and accelerating) that is initiated by the driver and active safety systems (anti-lock braking system ABS, electronic stability control ESC, traction control TCS) is transmitted eventually by the tyres. Therefore the tyre is a key component in vehicle safety. The main factor for safety is ensuring that the tyre grip on the road is sufficient under all relevant operating conditions. Next of being a key safety component, the tyre also plays a significant role in fuel consumption and vehicle emissions due its rolling resistance. Further, tyre-road noise is one of the main sources of traffic noise. Finally, (truck) tyres play a major role in road surface wear.

Irrespective of grip, rolling resistance or noise, the interaction of the tyre with the road surface is of importance. Think of the type of surface (roughness) and the condition of the surface (dry, water layer, icy, snow-covered). Further, the ambient temperature influences the tyre performance. At last, tyre performance also depends on the vehicle type. It is obvious that requirements and consequently tyre types for passenger cars, trucks and motorcycles are different. Designing a tyre that performs well under all operating conditions is a task of making compromises. Basically the tyre designer decides on rubber compounds, tread design (grooves and sipes[1]) and carcass design (belt and casing plies, bead, etc.). Unfortunately the performance of a specific tyre cannot be assessed by just 'looking' at the product. However, based on knowledge of the physical mechanisms involved and tyre performance test results, it is possible to characterize how the performance of the tyre is influenced by the use conditions and to quantify the characteristics and performance of 'winter tyres' and other tyres in relation to the weather conditions.

2.1 Summer versus winter tyres

Summer tyres and winter tyres mainly differ by the used rubber compounds and the tread patterns. For simplicity we define the winter tyre as a tyre designed for winter conditions as currently a variety of tyre types are considered as a winter tyre (see section 7.2). In Figure 1 examples of a typical winter and summer tyre tread pattern are shown. The different tread patterns can clearly be distinguished. The tread patterns of winter tyres have a higher void ratio (ratio of open space in the tyre footprint) and significantly more sipes (small grooves). Additionally, the initial tread depth typically is a little bit larger for winter tyres. An attribute that contributes to the higher void ratio of winter tyres is the higher number of blocks (separated by lateral grooves) around the tyre circumference. The higher void ratio and larger tread depth increase the tyre's ability to channel water and snow away from the footprint. Sipes increase the traction edges of the tyre to improve the grip of the tyre on wet, icy or snow-covered surfaces. The higher void ratio and sipes also significantly decrease the stiffness of the tread resulting in some decrease of steering performance on dry roads, which is however generally not noticed by regular drivers.

[1] Fine cuts in the tread pattern

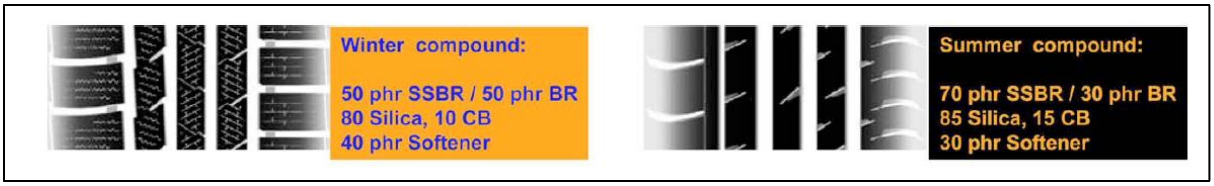

Figure 1: Comparison of typical winter and summer tyre [1].

Moreover, the different tread patterns also affect tyre-road noise. The traditional experience is that winter tyres have higher noise levels, particularly in the rain. However, measurements of noise levels on smooth asphalt do not confirm this.

The second and probably the most important, but not visible, difference between summer and winter tyres is the rubber compound. Rubber is a polymer, which means that it can have two solid states: it can be glassy (like hard plastics, e.g. water bottles) at low temperatures or rubbery (like flexible plastics, e.g. rubber balls or tyres) at high temperatures. The glass transition temperature (Tg) is the temperature at which a polymer switches between the glassy state and the rubbery state. Additionally, rubber belongs to the visco-elastic materials, meaning that after deformation the material reverts to its original shape, but with a certain delay (hysteresis). This delay is accompanied by a loss of energy. Close to the glass transition temperature the hysteresis is at its maximum. In this maximum hysteresis zone, rubber to road grip is also maximal. In Figure 2 typical curves are shown for energy loss (denoted as tan(δ)) and modulus (stiffness) versus temperature. The left figure shows the glass and rubbery states, the zone of maximum hysteresis and the glass transition temperature. Note that the energy loss or tan(δ) curve exhibits a maximum. Further, note that the modulus (stiffness) decreases with temperature. The right figure shows test results of a winter and summer rubber compound. It is clearly seen that the winter compound has a lower glass transition temperature than the summer compound, leading to maximum grip in a lower temperature range. It is important to note that compound tests are typically done at varying temperatures (measurement points) and at a fixed excitation frequency of for example 10 Hz. The excitation frequencies from the tyre road contact are much higher and for this reason the temperature scale is very different from normal ambient temperatures. In practice the glass transition temperature can be engineered in a range of about -60°C to 0°C at 10 Hz.

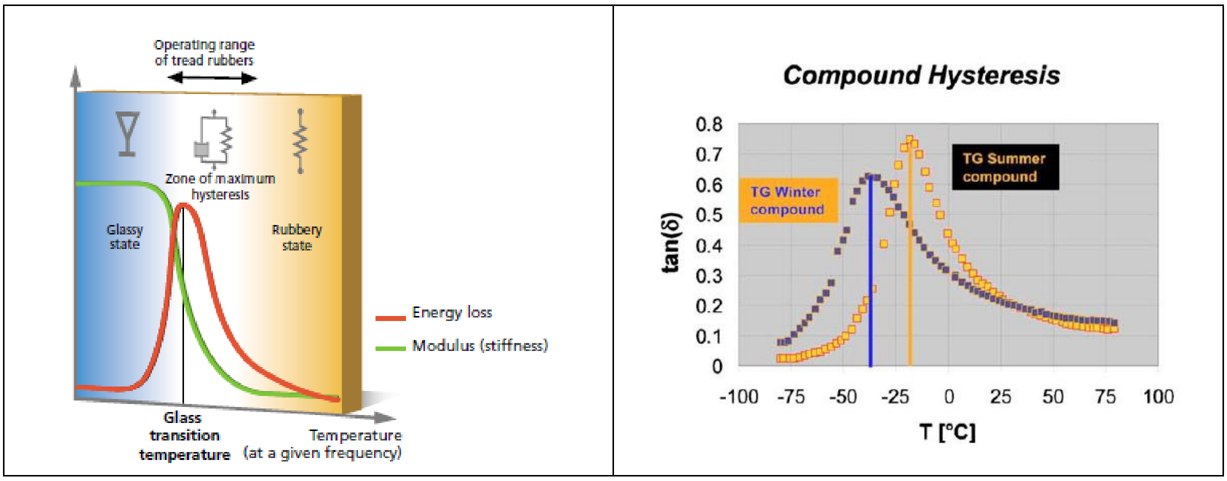

Figure 2: Left graph showing energy loss (tan(δ)) [2] and right graph shows modulus of tread rubber compounds [1].

In Figure 3 an attempt is made to indicate the stress frequencies of the compound in the energy loss graph for ABS braking on a wet road. Regions 1 and 2 are relevant for gripping the road; region 3 is relevant for rolling resistance. Note that rolling resistance and grip work at very different frequencies, thus temperatures in the test. For low rolling resistance, energy loss must be minimised. Consequently, the compound must be engineered to have low energy loss at high temperatures. Going back to Figure 2 (right), it is observed that for high temperatures (say above 25 °C) the differences in energy loss are relatively small compared to the change of the graph around the glass transition temperature, meaning that rolling resistance is only slightly affected by the choice of compound.

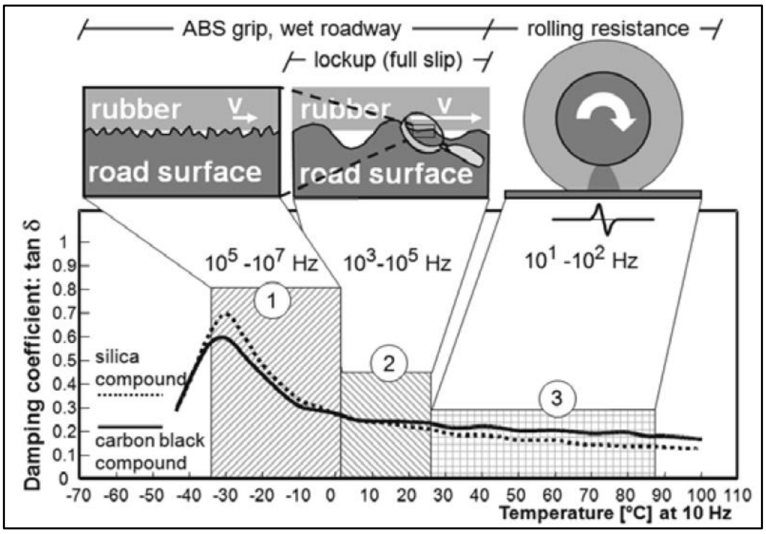

Figure 3: Energy loss versus temperature curve showing the excitation frequencies experienced by a tyre [3].

Another aspect is tyre tread wear. Wear of rubber is minimal close to the point where the friction is maximal, i.e. in the viscoelastic region. This is illustrated in Figure 4. At low temperatures wear increases, but also at high temperatures. Due to the link with friction, tyres wear less in those conditions where grip is maximal, i.e. winter tyres wear more at very high temperatures and summer tyres more at very low temperatures and wear is minimal in those conditions for which the tyres are targeted.

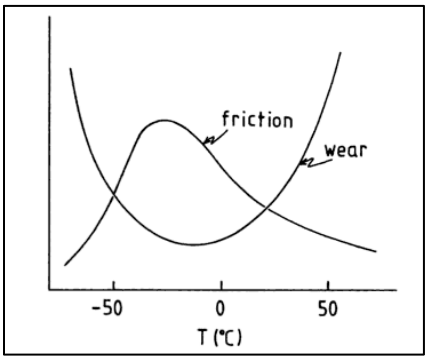

Figure 4: Relation of friction and wear versus temperature of a rubber compound [4].

Traction force versus longitudinal slip curves are shown for a snow surface in Figure 5. It is clearly seen that the combination of a winter tyre tread and winter compound gives the best snow traction (highest and constant traction force).

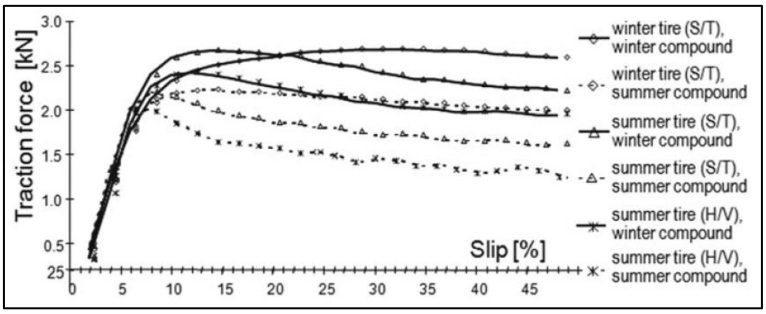

Figure 5: Curves showing the effects of tyre type and rubber compound on the coefficient of friction (snowy surface) [3].

Finally, as example, some test results of Touring Club Schweiz are shown in Figure 6. They compared the performance of summer, winter and all season tyres for different conditions. Note that the low temperature for dry and wet are still above the optimal range for winter tyres. The all season tyres seem to be a compromise between summer and winter tyres, at the cost of higher rolling resistance. The figure clearly shows the different performance of the tyre types: summer tyres perform best in dry and wet conditions for higher temperatures, winter tyres are superior in snow and have good wet performance at low temperatures. Further note that additional tyre wear is similar for summer tyres in low temperatures and winter tyres in high temperatures respectively. Finally, note the small difference in fuel consumption for summer and winter tyres.

Vergleichstabelle

Testkriterien	Testbedingungen	Sommerreifen 	Winterreifen 	Ganzjahresreifen 
1. Bremsweg trocken	100 – 0 km/h ca. 10°C	38 m	51 m (+ 13 m) Rg: 50 km/h*	49 m (+ 11 m) Rg: 48 km/h*
2. Bremsweg trocken	100 – 0 km/h ca. 20 – 25°C	38 m	56 m (+ 18 m) Rg: 57 km/h*	52 m (+ 14 m) Rg: 52 km/h*
3. Bremsweg nass	80 – 0 km/h ca. 10°C	43 m (+ 3 m) Rg: 21 km/h*	40 m	44 m (+ 4 m) Rg: 24 km/h*
4. Bremsweg nass	80 – 0 km/h ca. 20 – 25°C	40 m	45 m (+ 5 m) Rg: 27 km/h*	47 m (+ 7 m) Rg: 31 km/h*
5. Bremsweg Schnee	40 – 0 km/h	61 m (+ 32 m) Rg: 29 km/h*	29 m	42 m (+ 13 m) Rg: 22 km/h*
6. Treibstoffverbrauch	l/100 km	7.5	7.6 (+ 0.1 l)	7.9 (+ 0.4 l)
7. Verschleiss	ca. 10°C	105% (+ 5%)	100%	115% (+ 15%)
8. Verschleiss	ca. 20 – 25°C	100%	115% (+ 15%)	110% (+ 10%)

* Restgeschwindigkeit, wenn das Fahrzeug mit dem kürzesten Bremsweg still steht

Figure 6: Example of test results of different tyre types [5] .

2.2 Tread wear and aging

As mentioned above, the tread pattern channels water away from the contact patch. Moreover, the profile of winter tyres also provides better grip performance on snow and ice. It is obvious that with increasing tread wear the grip performance of the tyre on wet and winter surfaces decreases. Figure 7 shows the average increase in stopping distance from 80 km/h versus tread depth from studies conducted by MIRA in 2003 and 2004 on 4 different vehicle types [7]. It is observed that below 3.5 mm of tread depth, the stopping distance increases rapidly. Further, it is seen that the stopping distance increases in a range of 30 % to 65 % at the legal limit of 1.6 mm.

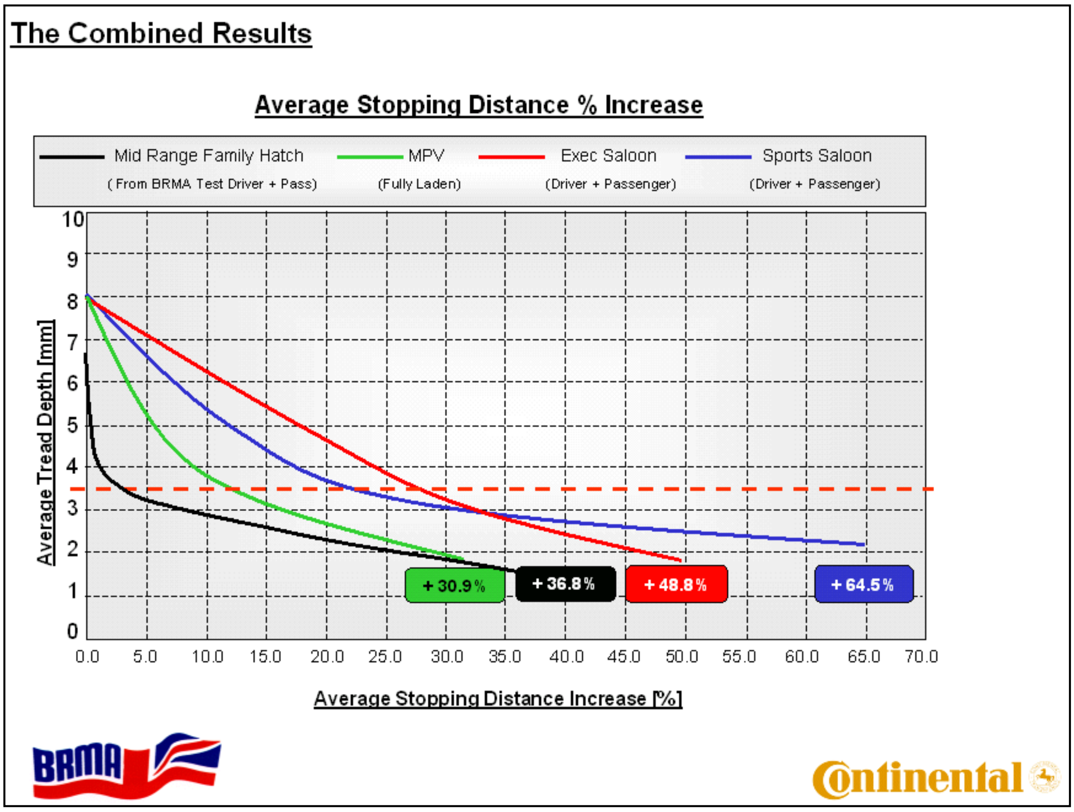

Figure 7: Percentage change in stopping distance versus tread depth [6].

The Technical Testing and Service division (TVS) of the MVI Group conducted a winter tyre tread depth study commissioned by Continental [7]. The results of this study are summarised in Figure 8. It is observed that the braking performance on snow and wet below 4 mm tread depth decreases more than proportional.

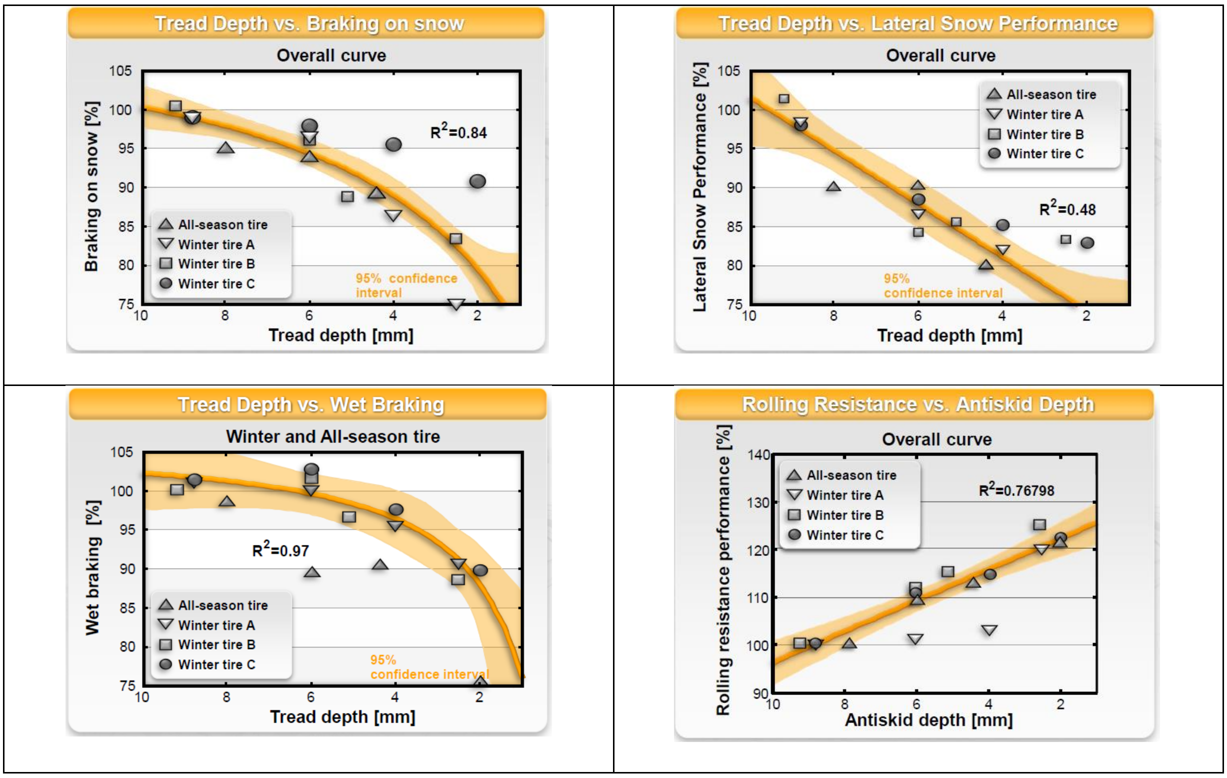

Figure 8: Results of winter tyre tread depth study [7].

Finally, also the risk of aquaplaning increases with decreasing tread depth; the speed at which aquaplaning can occur drops significantly as is shown in Figure 9.

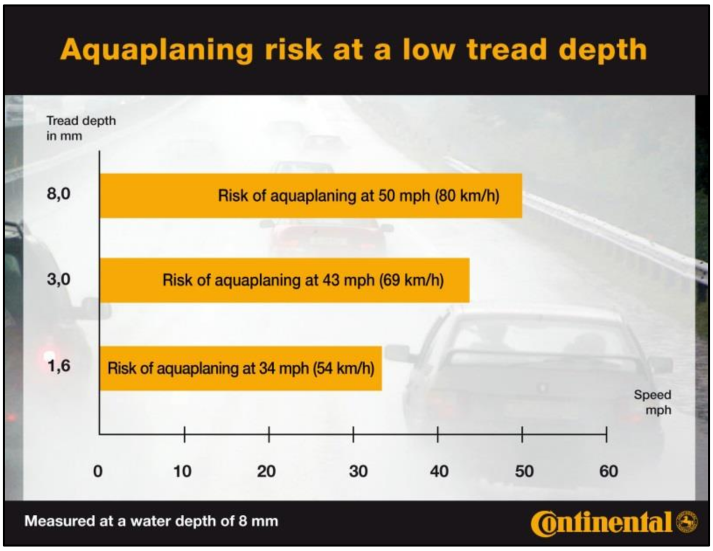

Figure 9: Risk of aquaplaning at different tread depth.

Besides tread wear, tyres degrade naturally through exposure to heat, sunlight (Ultraviolet/UV) and rain. The rubber parts become less elastic, the steel webbing inside the tyre corrodes and the rubber mixture of which the tread is formed hardens. The amount of damage depends on the exposure and the severity of the weather. Generally tyres wear out before failure due to aging occurs. However, for vehicles or trailers that are only used occasionally (e.g. recreational vehicles) aging could be an issue. Since climate and exposure to sunlight affect aging, no date can be given at which a tyre expires. Recommendations for changing tyres range from 4 to 10 years. Aging may be observed by cracks on the tyre surface. However, according to NHTSA, tyres are primarily degrading from the inside-out, due to permeation and reaction of the pressurised oxygen within the tyre structure, with rates proportional to temperature. Cracking can eventually cause the steel belts in the tyre to separate from the rest of the tyre.

2.3 Inflation pressure

Almost all tyre properties are influenced by inflation pressure, e.g. the vertical stiffness, the handling performance, ride comfort, rolling resistance, speed at which aquaplaning occurs, etc. With the correct inflation pressure, the vehicle and the tyres will achieve their optimum performance. In addition to tyre safety, this means the tyres will wear less and improve vehicle fuel consumption as result of a lower rolling resistance. Extreme under-inflation of a tyre leads to large deflections and causes excessive heat build-up and internal structural damage that may lead to tyre failure, even at a later date. Tyre Pressure Monitoring Systems (TMPS) warn the driver for incorrect inflation pressure, avoiding accidents due to tyre failure.The TPMS can be categorized as direct systems which are additional devices for measureing the tyre pressure and as indirect systems that compare rotation speeds of individual wheels on a vehicle, which is explained in more detail on the website Tirerack.com [8].

Additionally these systems significantly contribute to the reduction of fuel consumption. Michelin categorises under-inflation for passenger car tyres as indicated in Table 1 below [9].

Table 1: Overview of categories for under-inflation of tyres

Type	Under-inflation
Correct or acceptable pressure	Below 0.3 bar
Moderate under-inflation	Between 0.3 and 0.5 bar
Dangerous under-inflation	Between 0.5 and 1.0 bar
Very dangerous under-inflation	Over 1.0 bar

This does not mean that small under-inflation is not important. As shown in Figure 10, 0.3 bar under-inflation for a passenger car tyre results in a rolling resistance increase of about 6 %. This would lead to about 1 % additional fuel consumption.

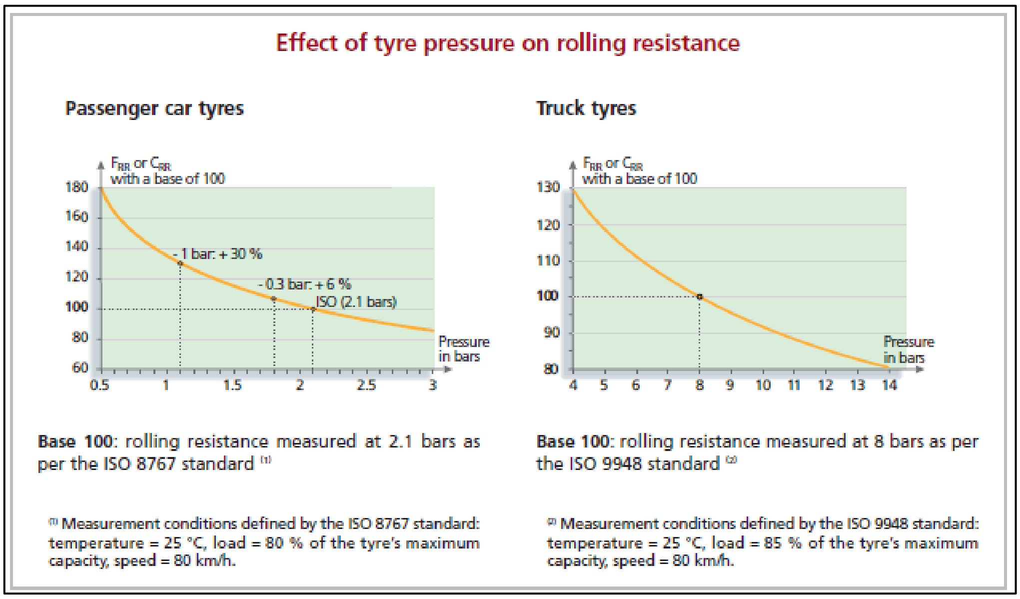

Figure 10: Effect of tyre inflation pressure on rolling resistance [8].

2.4 References

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[2] Michelin, "The tyre, Grip", Société de Technologie Michelin, 2001.

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[4] B.N.J. Persson, "Sliding Friction: Physical Principles and Applications", 2nd edition, Springer, 2000.

[5] Touring Club Schweiz, "Leistungs- und Kostenvergleich Sommer-, Winter- und Ganzjahresreifen", 2009.

[6] R. D. Sanders, "Tyre Tread Depth and its influence on wet weather performance", Continental.

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[8] Michelin, "The tyre, Rolling resistance and fuel savings", Société de Technologie Michelin, 2003.

3 Tyre impact on road safety

The study on tyre impact on road safety considers two main influences of tyres:

- Tyre grip
  Tyre grip is defined as the maximum horizontal force that can be transmitted between tyre and road surface. A higher level of grip allows the driver to better avoid accidents, or reduce the chance of losing control over the vehicle.

- Tyre blow out
  Tyre blow out can pose a direct threat as a vehicle may lose stability, or surrounding persons may be injured by the debris of the tyre. Indirectly, debris on the road may damage other vehicles, or the vehicle with the tyre blow out cannot be stopped at a safe place next to the road.

Table 2 shows the qualitative relation with tyre aspects under investigation

Table 2: Indication of tyre safety aspects (X indicates influence)

	Tyre grip	Tyre blow out
Summer tyre / winter tyre	XXXXX	
Tread depth	XXXXX	X
Inflation pressure	XXX	XXXXX
Tyre age	X	XXXXX

Each of the safety influences is elaborated in the next sections.

3.1 Tyre grip

An increase in tyre grip improves the steering and braking potential of vehicles. This means that vehicles can better avoid accidents, and are better able to reduce the speed before a collision, leading to a lower impact speed. A lower impact speed reduces the risk of injury or fatality, as shown in Figure 11 for car occupants [2] and in Figure 12 for pedestrians respectively [3]. Additionally with increased tyre grip the risk of directional vehicle instability during steering and braking manoeuvres is reduced, leading to further reduction of accidents[2].

[2] Rollover instability can occur under high grip conditions but that is considered to be a minor effect

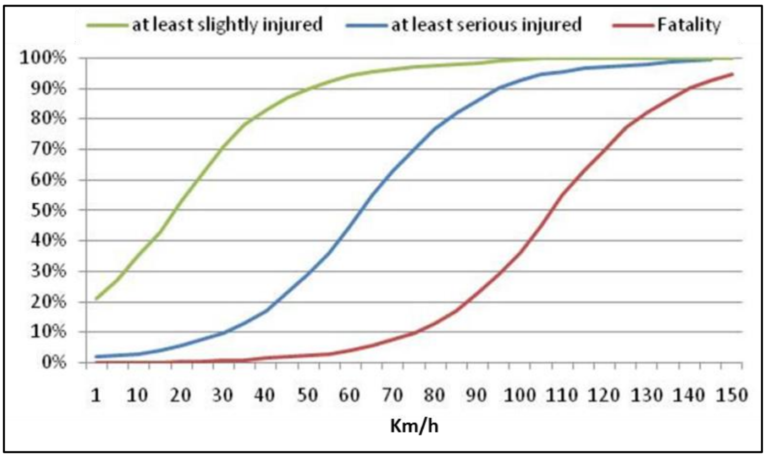

Figure 11: Injury risk of passenger car occupants depending on impact speed [2]

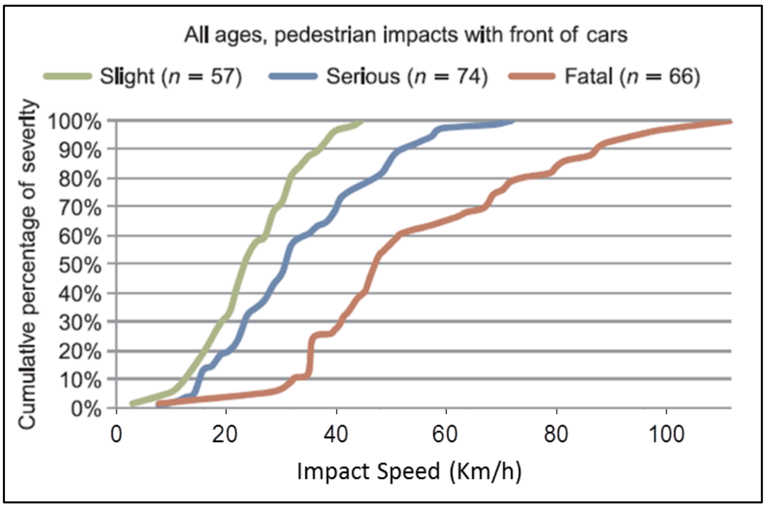

Figure 12: Injury risk of passenger pedestrians depending on impact speed [3]

An analysis has been done on the impact of grip level using accident statistics in The Netherlands. Figure 13 shows the potential reduction of traffic fatalities and injuries when a 10% increase in tyre grip is assumed. The reduced number of traffic fatalities is about 3-4% of the total number in The Netherlands, which is significant.

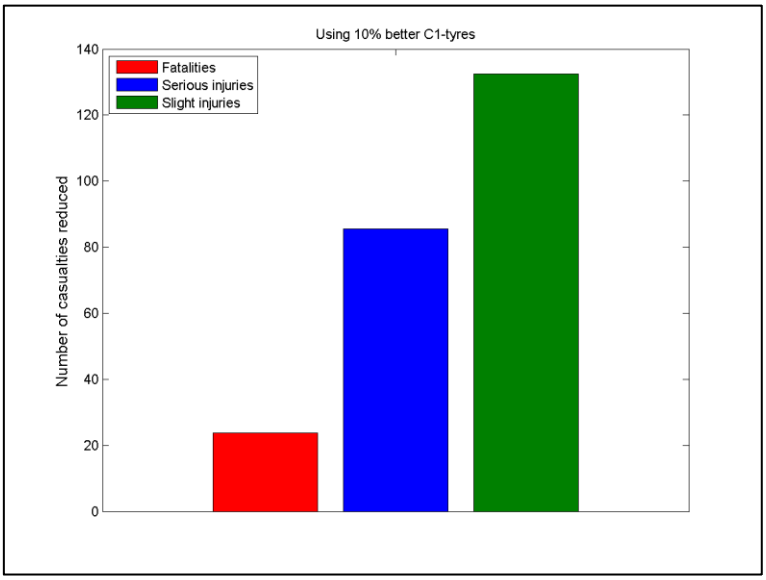

Figure 13: Potential reduction in casualties with 10% improved grip level using accident statistics from The Netherlands

3.2 Tyre blow out

A study on French accident data over the period 1996-2002 [4] mentions that in 6.7% of the vehicle crashes the vehicle has a blown tyre. Tyre blow out mostly results in a crash for vehicles with only four wheels as the vehicle stability is directly affected. Vehicles with more tyres have a higher intrinsic stability, but typically have larger tyres that result in more dangerous debris on the road.

Apart from damage by (sharp) objects, tyre blow out occurs typically due to overheating of the tyre. Heat is generated by deflection of the tyre, and lower inflation pressure results in larger deflections and thus an increased risk of tyre failure. Tyre Pressure Monitoring Systems will reduce the number of under inflated tyres, and therefore reduce the number of tyre blow out events.

Secondly tyre ageing can be a significant factor due to reduced heat resistance of the tyre, and also the resistance to impact with obstacles is reduced, as explained most clearly on the website of Bridgestone [5] .

There are three main mechanisms of tyre ageing. The first involves rubber becoming more brittle. Sulphur is used to link rubber molecules together during vulcanisation with the application of heat and pressure, giving the rubber its useful elastic properties and strength. As the tyre absorbs energy in the form of light, heat or movement the tyre continues to vulcanise. This ongoing vulcanisation causes the rubber to become stiffer and more brittle.

The second mechanism of tyre ageing is oxidation involving oxygen and ozone from the air compromising the strength and elasticity of the rubber and the integrity of the rubber to steel bond. Basically heat and oxygen cause cross linking between polymer chains (causing the rubber to harden) and scission of polymer chains (leading to reduced elasticity).

Thirdly, breakdown of the rubber to steel-belt bond will occur due to water permeating through a tyre and bonding with the brass plate coating on steel belts. This causes the steel to rubber bond to weaken leading to reduced tyre strength and reduced heat resistance. If compressed air used for inflation is not completely dry, tyre strength will be affected over time. Even unused tyres will become more brittle, weaker and less elastic with exposure to water, air, heat and sunlight.

4 Tyre use legislation and recommendations

This section contains a summary of tyre use legislation and recommendations for tread depth and use of winter tyres. There is no specific regulation for tyre pressure; however Tyre Pressure Monitoring Systems (TPMS) will be mandatory on all passenger cars sold in Europe after November 1st 2014. Adequate functioning of TPMS may become part of Annual Vehicle Inspections. On tyre age no legislation exists, however the recommended replacement age for winter tyres is 4 years, and some tyre manufacturers provide a 5 year warranty. Visible tyre age effects (cracks) may be part of Annual Vehicle Inspection, leading to a recommendation to change tyres.

4.1 Tread depth

A selection of tread depth legislation and recommendations as obtained from questionnaire replies is presented in this section. The results are indicative of the variety of legislation and recommendation of tread depth for summer tyres and winter tyres respectively. Moreover, some questionnaires returned are inconsistent for the same countries, but nonetheless the results are indicative of the variety that exists between countries. Table 3 shows the results for passenger car tyres.

Table 3: Tyre tread depth legislation/recommendation for passenger car tyres

Country	Summer tyre Legal/recomm	Winter tyre Legal/recomm
Croatia	1.6/-	1.6/-
Denmark	1.6/2.5	1.6/2.5
Finland	1.6/4.0	3.0/5.0
Germany	1.6/3.0	1.6/4.0
Greece	1.6/-	1.6/-
Ireland	1.6/3.0	1.6/-
Italy	1.6/-	1.6/-
Netherlands	1.6/2.5	1.6/2.5
Poland	1.6/-	1.6/-
Spain	1.6/-	1.6/-
Sweden	1.6/3.0	3.0/-

As can be seen in Table 3 the recommended tyre tread depth for summer tyres is around 3 mm. Some countries have different tyre tread depth regulation for winter tyres; these are mainly countries with a high occurrence of winter conditions. The recommended tread depth by the tyre industry for winter tyres is 4 mm, which is often referred to in the questionnaire answers.

The tyre tread depth regulation for trucks and busses typically is different from passenger car tyre regulation. Table 4 shows some indications obtained from the questionnaire for trucks. Some countries apply the same tyre tread depth regulation for trucks as for passenger cars. It seems that for summer tyres of trucks the recommended value of 3 mm is most common. For winter tyres the recommended tread depth for trucks is mostly 5 mm (when mentioned).

Table 4: Tyre tread depth regulation for trucks

Country	Summer Legal/recomm	Winter Legal/recomm
Croatia	1.6/-	1.6/-
Denmark	1.0/-	1.0/5.0
Finland	1.6/3.0	1.6/5.0
Germany	1.6/3.0	1.6/4.0
Ireland	1.6/3.0	1.6/3.0
Italy	1.6/-	1.6/-
Netherlands	1.6/-	1.6/-
Sweden	1.6/-	5.0/-

Based on the results from the questionnaire the following can be summarized about tread depth:

- A recommended tread depth for summer tyres of 3 mm is most common
- A recommended tread depth for winter tyres of 4 mm is most common for passenger car tyres and 5 mm for trucks
- Several countries apply the same tread depth regulation for passenger car and truck tyres.

4.2 Winter tyres

The legislation on winter tyres has been reviewed for five vehicle categories ranging from passenger cars to full size trucks. A distinction is made between three types of legislative positions on the use of winter tyres, snow tyres or winter equipment. The types are:

- no legislation
- conditional legislation (weather conditions, road conditions or local traffic signs)
- Fixed Period legislation (few months between 1 November and 30 April).

An overview of the countries and the types of legislation is shown in Table 5.

Table 5: Overview of legislation on winter tyres, snow tyres or winter equipment in different countries

No legislation	Depending on weather, road conditions or traffic signs	Fixed period
Belgium, Bulgaria, Cyprus, Denmark, Greece, Hungary, Ireland, Malta, Netherlands, Poland, Portugal, Spain, United Kingdom	Czech republic (*), France. Germany, Italy(*), Luxembourg, Romania(*), Slovenia(*), Switzerland (*) within a period	Austria (**), Croatia, Estonia, Finland, Latvia, Lithuania, Slovakia (**), Sweden, Norway (**) (**) not all vehicle categories

As can be seen in Table 5, mainly the countries with a high occurrence of winter conditions have regulation on winter tyres.

Based on the contents above, the following can be summarized about regulation on winter tyres:

- Some countries with winter conditions do not have regulation on winter tyres
- Winter tyre regulation is not consistent for different vehicle types in some countries
- Some countries use conditional regulation for a specified period in the year only.

5 Weather and accidents

5.1 Conditions related to winter tyres

There is a large variety of weather conditions in Europe, ranging from Sub-tropical climate in the South to Sub-arctic climate in the North, a Marine climate in the West and Continental climate in the East. As an example to show which countries have a high occurrence of winter conditions Figure 14 indicates probability of freezing temperatures during the winter season in different regions.

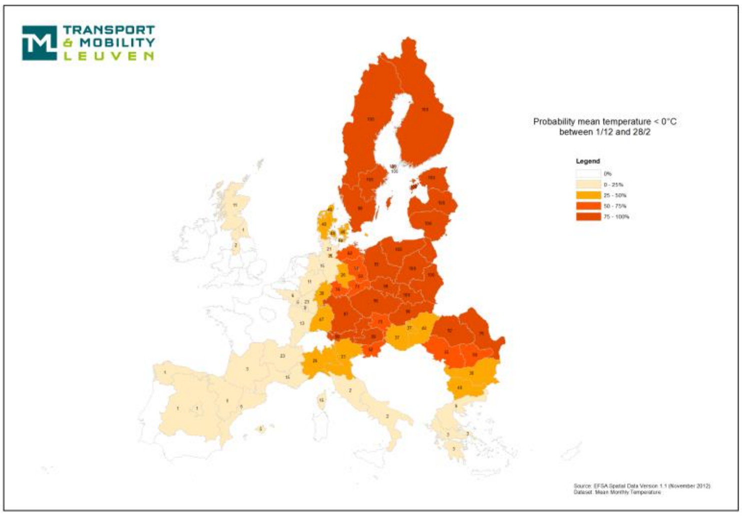

Figure 14: Distribution of freezing temperature probability over Europe during the winter period

As can be seen mostly North and East Europe have low temperatures during the winter season, however also outside the coloured regions low temperatures and winter conditions can occur, although that is more incidental. The temperature range for use of winter tyres is generally advocated to be below +7 °C, and Figure 15 shows the probability distribution of a maximum temperature of less than +7 °C during the winter period.

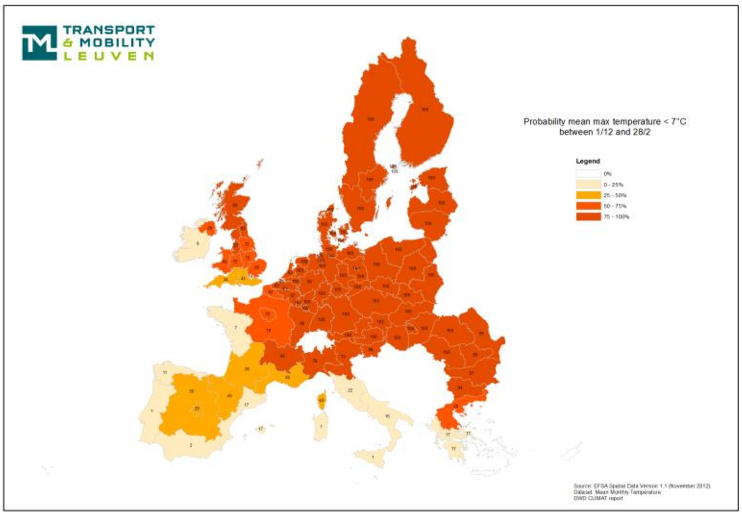

Figure 15: Distribution of low temperature (max temperature below +7 °C) probability over Europe during the winter period

From Figure 15 it can be seen that in most European countries temperatures can occur that suit winter tyres better than summer tyres.

To summarize the results in this section:

- North and East Europe have a high probability of long duration winter conditions, other parts of Europe have more incidental winter conditions
- Assuming a +7 °C threshold for winter tyres it seems that in the winter season in most European countries conditions can occur that suit winter tyres better than summer tyres.

5.2 Accidents under wintery conditions

The main information source for the current analysis is the CARE database, migrated to CaDAS (Common Accident Data Set) [6]. The data is made available by DG MOVE and currently covers the time period from 2000 up to 2012.

As an example of the information available, Figure 16 shows an overview of traffic fatalities in road accidents under wintery conditions. Note that the vertical scaling in the graphs is different.

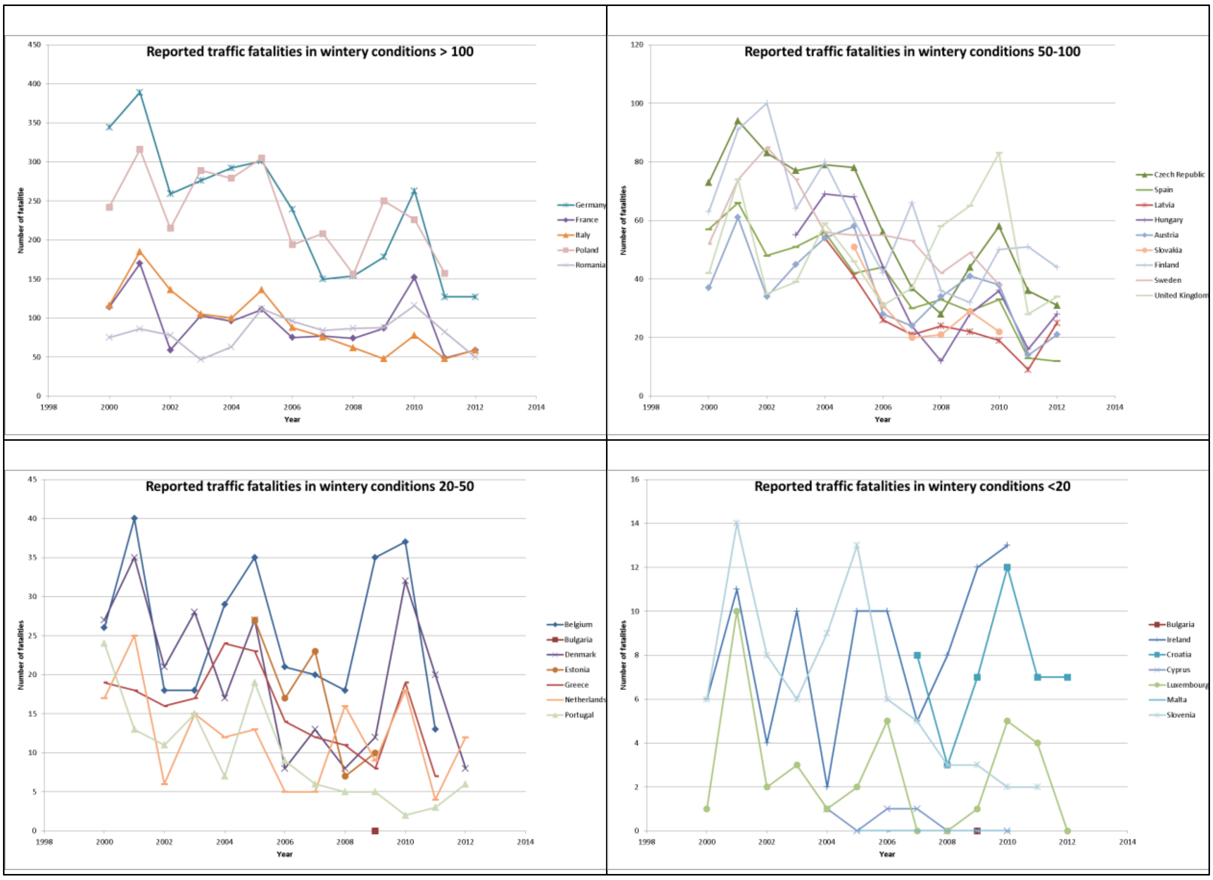

Figure 16: Overview of reported traffic fatalities in wintery conditions

The top graphs in Figure 16 show results of countries with a large number of reported traffic fatalities under wintery conditions. As can be seen there is a general trend of a reduced number of traffic fatalities starting around 2005, which is roughly the time of introducing regulation for using winter tyres in Germany and several other countries. Another observation is that there is an increase for more countries simultaneously around 2010, which is probably related to the general weather conditions in that specific winter season. The results for countries with a low number of reported traffic fatalities do not seem to be statistically relevant, and may be related to the incidental occurrence of wintery conditions.

Summary

- Results suggest less fatalities since winter tyre regulation was introduced
- Large variations in the number of fatalities seem to occur due to varying duration of winter conditions.

6 Summary of tyre safety aspects

The previous chapters have provided an overview of influences of tyre type, tyre tread depth, inflation pressure and tyre ageing on road safety. Specifically for winter tyres the climatic conditions in Europe and accident data is presented. The following can be summarized from the previous chapters:

- Grip
    - A use case study shows that an increase in grip level of 10% potentially leads to a 3-4% reduction of traffic fatalities.
- Tread depth
    - Tyre safety performance on wet and snow roads is better with more tread depth
    - There is a variety of regulation on minimum tread depth requirements for winter tyres. Some countries have a uniform regulation for all vehicle categories, others distinguish between vehicle categories
    - The recommended tread depth for summer tyres is around 3 mm and for winter tyres around 4 mm for passenger cars and 5 mm for Trucks.
- Winter tyre
    - Winter tyres are engineered for better grip in a lower temperature range than summer tyres, and the tread design is optimized for traction on winter surface conditions
    - Winter tyre regulation exists mainly for countries with winter conditions for a longer period, a small share of countries with incidental winter conditions have winter tyre regulation
    - Winter tyre use typically is regulated for a fixed period, depending on conditions, or conditions within a fixed period. The regulation in a country may be different for vehicle categories
    - Accident statistics suggest a reduction in traffic fatalities during winter conditions since the introduction of winter tyres.
- Inflation pressure
    - Low inflation pressure increases tyre temperature which can cause tyre blow out. Tyre Pressure Monitoring Systems will reduce occurrence of this type of tyre blow out.
    - Incorrect inflation pressure affects the grip level of tyres.
- Tyre ageing
    - Ageing reduces the heat resistance of tyres, which increases the risk of tyre blow out
    - The mechanical properties deteriorate over time, which makes the tyre also less resistant to impacts with obstacles, and also the grip level is affected.
    - No regulation exist for tyre age, the recommended replacement age for winter tyres is 4 years because of the reduced grip level.

7 Possible actions

This section lists from a technical perspective some possible topics for improvement of tyre-safety related aspects and proposes some concrete questions to guide the discussion.

7.1 Harmonised tread depth requirements

Although a minimum tread depth of 1.6 mm applies across the EU, a variety of additional tread depth requirements exist for passenger car winter tyres and truck tyres in general. When travelling between countries it may be unclear which tread depth requirements apply.

In the absence of legal requirements, a common recommended tread depth for all Member States could contribute to improve safety.

Questions for the discussion:

A. Is the current minimum tread depth requirement (1.6) adequate?

B. Should there be a common EU minimum legal tread depth for heavy goods vehicles?

C. Should the EU set different minimum legal tread depths for summer tyres and winter tyres respectively?

D. In the absence of legal requirements, should there be a common recommended minimum tread depth?

    a. Passenger car tyres

    b. Truck tyres

    c. Winter tyres

E. Should the recommended minimum tread depth become in the future the minimum legal tread depth?

F. What are the costs of tread depth requirements in terms of tyre duration?

7.2 Definition of 'winter tyres'

Currently winter tyres are generally understood as 'snow tyres' and 'snow tyres for severe snow conditions' defined as follows,

- 'Snow tyres'
  - Marked "M+S" (or M.S. or M&S)
  - Supplier needs to prove that a different tread pattern, compound or structure is present that is designed for better performance in snow conditions
  - Since 2012 need to fulfil measurement criteria, but no approval marking on tyre.
- 'Snow tyres for severe snow conditions'
  - Marked with the "Alpine symbol" 
  - Needs to perform a regulated test (UNECE regulation No. 117-02).

Questions for discussion:

A. Is a new definition of 'winter tyres' needed or the current M+S and Alpine categories suffice?

B. Should tyres other than M+S and Alpine tyres be allowed in the category 'winter tyres'?

C. Should a type-approval testing protocol for all tyres to qualify as winter tyres be established?

D. Should another type of test protocol be introduced for winter tyres next to the Alpine symbol tyre testing protocol

E. What is understood by an 'all-season' tyre?

F. Is the 'all-season' tyre qualification adequate for consumers?

7.3 Standardized testing for winter performance

Tyre labelling exists for wet grip performance of tyres. The current test procedure for wet grip labelling (Regulation (EC) No 1222/2009) requires a surface temperature of around 20 °C. Also winter tyres are also subjected to the test at 20 °C, and as they are optimized for temperatures below +7 °C range the wet grip performance label is inferior to summer tyres. Standardized testing for winter conditions can be used to extend tyre labelling, and may also be considered for type approval testing of winter tyres.

Questions for discussion:

A. How can tyre performance be properly characterised in relation to the temperatures of use?

B. Should the current labelling scheme be extended for consumers to identify suitable tyres for winter conditions?

C. Should summer tyres be labelled for winter performance?

D. Should labelling tests only be executed by tyre suppliers, or should independent parties execute these tests?

E. Should performance based testing be the basis for type-approval?

F. Should testing be vehicle based, or tyre based?

7.4 Regulations on the use of 'winter tyres'

A wide variety of regulations exist concerning the use of 'winter tyres'. It may not be clear to travellers what rules apply in the country they visit or under which weather conditions they are require to fit 'winter tyres'.

Questions for discussion:

A. Are the different regulation on the use of 'winter tyres' which apply in various Member States a problem for international traffic?

B. Should winter tyre regulation be harmonized between member states? Would such a harmonisation be feasible?

C. Would the harmonization of the winter tyre definition a prerequisite for harmonisation of the winter tyre regulation?

D. How can road users be better informed about winter tyre regulation in other countries, and when to change from summer to winter tyres and vice versa?

E. Should the use of winter tyre be prohibited in summer conditions?

F. What are the costs of 'winter tyres' for consumers?

7.5 Tyre Pressure Monitoring System safety standard

The Tyre Pressure Monitoring Systems provides a warning for low inflation pressure, and consumers that rely on the system will inspect their tyres less often. This makes TPMS a safety system which should be evaluated on its functional safety, and for instance provide a clear indication when it is not functioning, or limit the amount of human intervention on its functioning.

Questions for discussion:

A. How can we support road users to keep their tyre pressure at an adequate level?

B. Are the current TPMS performance requirements satisfactory? Should they be revised?

C. Should TPMS be considered a safety device instead of a warning device, including functional safety requirements?

D. Battery operated systems (Direct TMPS) have a life span of 3-7 years, and malfunction due to damage. When to decide on replacement? What about changing to wheels with winter tyres?

E. Indirect TMPS can in some circumstances lead to under inflation of all tyres, how can this be prevented?

7.6 Tyre ageing

Tyre ageing is for a large part the result of exposure to environmental conditions such as sunlight and high temperatures. An indication of the tyre ageing effects could allow consumers to monitor their tyres, and prevent having too old tyres mounted on the vehicle.

Questions for discussion:

A. To what extent does aging affect tyre safety performance?

B. How can ageing of tyres be quantified?

C. What indicator can be used for ageing as a result of exposure?

D. Should a time limit on tyre age be introduced, or should it be based on exposure to the environment?

E. What advice should we give road users regarding tyre age?

F. Should the consumers be informed about tyre aging performance?

G. How could this information be provided?

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