Appendix 4

NOISE REDUCTION POTENTIAL:
THE NORDIC SITUATION AND FUTURE DEVELOPMENT

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SINTEF
Trondheim, February 2007

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MEMO

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Content

1 Introduction

This memo is divided into two parts. The first part gives a summary of the situation in Norway concerning the use of studded tyres and its potential effect on the road surfaces and typical road surfaces used. The second part describes possible future developments regarding the effect of reduced noise emission levels of vehicles, including both engine and tyres.

2 Road surfaces and studded tyres - the situation in Norway

2.1 The use of studded tyres

Due to the very different climate areas in Norway, the use of studded tyres can vary much between regions in the northern and in the southern part.

Generally, we can divide the use of studded tyres into 3 categories/regions:

1. Cities that have a studded tyre taxation system
2. The northern region, with typical long winter season
3. The southern region with a shorter winter season

The winter season, with allowance to use studded tyres in Norway, normally starts 1st of November and ends the 1st Sunday after Easter. The length is then depending on the time of the Easter period. The exception is the 3 most northern counties (see 2.1.2), where the season starts 1st of October.

Despite the "formal" start and end of the period of allowance of studded tyres, it is of course no restrictions in using the winter tyres when the conditions are difficult (snow, ice) outside the formal period.
As an example, in the recent years in Trondheim, we have had snow/ice for a few days in the period 15-30th of October, i.e. before the formal start of the studded tyre allowance period. Most people then change to winter tyres, and thus extend the period of using studded tyres. Afterwards, typically there can be no snow or ice for several weeks, as in this winter. The first snow came 27th of Oct. 2006, then it disappeared after a few days, and the winter conditions did not arrive again until mid January 2007.

2.1.1 Cities with studded tyre taxation

In Oslo, Bergen and Trondheim, a tax has been introduced for those who use their vehicles within the city/commune. The taxation system is such that you can choose 3 possible payment options: daily, monthly or season.
Table 2.1 shows the taxation system for the different options and categories of vehicles.

Table 2.1 Studded tyre tax system. Values in NOK

Period	Light vehicles	Heavy vehicles
Daily	30	60
Monthly	400	800
Season	1200	2400

The daily fee can be paid either at an automat (gives you a ticket to show through the windscreen), equivalent to parking automats or by mobile phone.
The monthly or seasonal payment is verified by an oblate.

The penalty for not paying the tax is currently NOK 750, but there is a discussion to increase this fee. The reason is rather few controls. The tax payment is normally controlled by the same personnel that check parking tickets or by a few roadside checks by the police during the season. More frequent controls are discussed; as the statistics show that quite a high percentage (20-30 %) of vehicles do not pay the tax.

In addition to the tax, there is an additional incentive to encourage the use of non-studded tyres: If you change your studded tyres with non-studded before the 1st of December, you will get NOK 800 refund (totally, for 4 tyres) from the city.

The goal of the city authorities is to reduce the dust problem and the wear of the road surfaces. It was assumed that if 80 % of the vehicles had non-studded tyres, it would be possible to reach an improved air quality. As a consequence of this, it was a political decision to remove the taxation of studded tyres when the goal of 80 % was reached.
When the taxation system was first introduced in Oslo, the goal of 80 % was reached after a few years. However, statistics the following winter season showed an unwanted ***increase*** in the use of studded tyres, and the tax was introduced again in 2005.

The latest figures show that in Oslo, the amount of non-studded tyres is approx. 85 %. In Bergen and Trondheim, approximately 65-70 % of the fleet have non-studded tyres.
The statistics is based on manual counting on parking places, gas stations etc.

In Bergen there is available figures that show that there are 37 000 vehicles (approx. 30 % of the total fleet) with studded tyres running on roads that are free of ice/snow for 95 % of the winter season.

2.1.2 Studded tyres in the northern regions

In the 3 most northern counties (Nordland, Troms and Finmark) the winter climate is more stable, and the use of studded tyres is most widespread. There is no statistics available, but it is assumed that approx. 80 % of the cars have studded tyres. The winter season is also longer, with an allowance to use studded tyres already from 1st of October. The end of the season is the same as for the southern parts, i.e. depending on the Easter period.

2.1.3 Studded tyres in the southern regions

If we disregard the south/west region (around the city of Stavanger), some statistics indicate about 50/50 share of studded/non-studded tyres. In some cities without tax, there may be higher percentage non-studded tyres than 50 %, due to more frequent winter maintenance of the road (salt/sand).
In the south/west region, there is very few days with winter conditions and most people here drive with either all-year type of tyres or non-studded friction tyres.

A more detailed counting on some of the roads in the southern region outside Oslo is planned during the winter 2006/2007, using the SINTEF-trailer.

2.2 General information

The increasing use of non-studded tyres in Norway is depending on several factors.

- The media focus on the good performance and safety of modern non-studded friction tyres has been high.

- The comfort of driving on non-studded tyres (reduced interior noise)
- The flexibility to choose when to change tyres on the beginning and end of the winter season
- The tax in the 3 cities, including the economic incentive for replacing studded tyres.

In addition, statistics from the insurance companies on a large number of accidents, show that vehicles with non-studded tyres are more seldom involved in severe accidents than those with studded.

The evaluation of the effect on improved air quality in the cities with taxing is outside the scope of this work.

In a project for the Directorate of Public Roads some years ago, SINTEF did develop an acoustical detection system to be mounted in a small trailer. 3 such trailers were finalised and distributed to local road authorities in the 3 cities. The use of these trailers has been limited, but in Trondheim we used the trailer and counted more than 50 000 vehicles in the season 2003/2004. The agreement with manual counting is very high. The use of a trailer for such statistics is very flexible, efficient and much cheaper than manual counting. The limitation is that acoustical detection is dependent on dry road surfaces. Figure 2.1 and 2.2 show a drawing/picture of such a trailer. The microphone for detection of tyre type is flush mounted on the side wall facing the traffic.

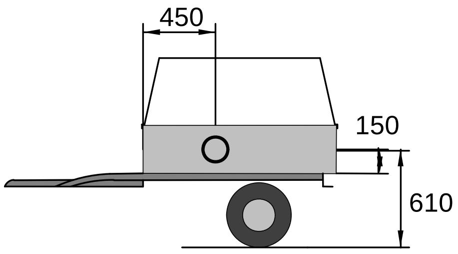

Figure 2.1 Trailer for acoustic detection of studded/non-studded tyres. Dimensions in mm.

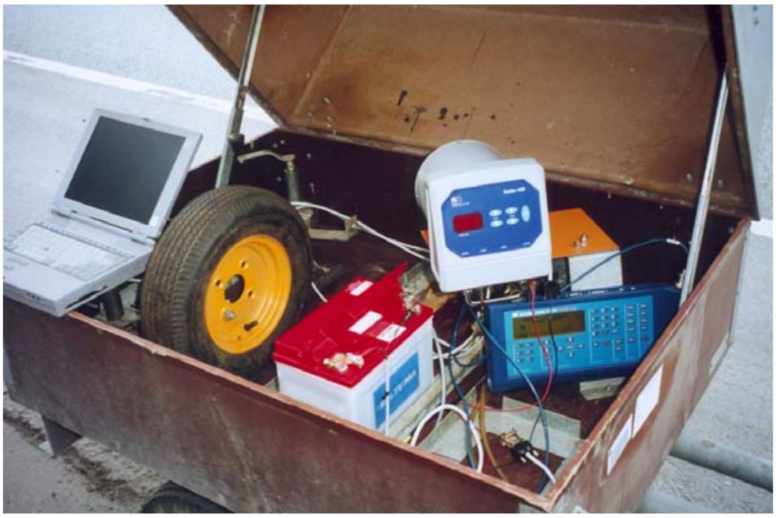

Figure 2.2 Picture of trailer equipment

2.3 Noise from studded tyres

Figure 2.3 shows measurements of pass-by levels (L_{Amax} at 7.5 m, 1.2 m height) of passenger cars in a speed range of 30-90 km/h. On average, the pass-by levels from cars with studded tyres is in the range of 3-5 dB(A) higher than cars with non-studded friction winter tyres.

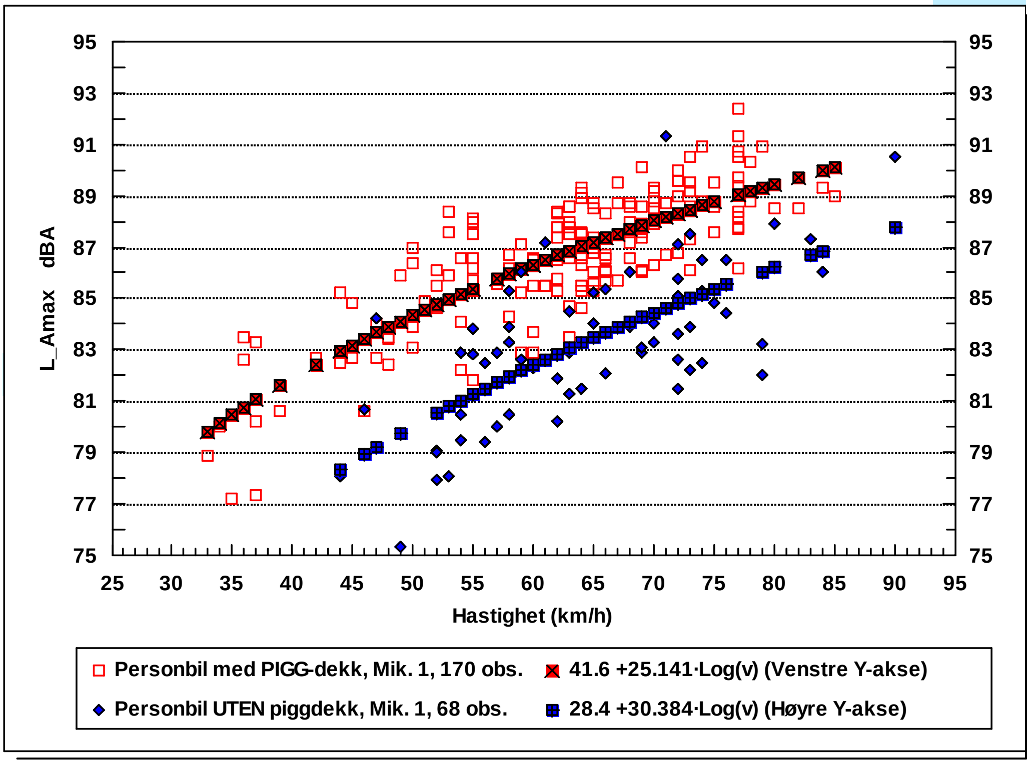

Figure 2.3 L_{Amax} *-levels for passenger cars with and without studded tyres.*

In figure 2.4 the average 1/3rd octave band frequency spectra for studded and non-studded tyres are shown.
The upper curve is the average linear spectra for measurement of 149 light vehicles with studded tyres and the lower curve is the average of 64 light vehicles with non-studded tyres.

Beside a general higher noise level for studded tyre, it is above 4 kHz the main difference is. For non-studded tyres, the level falls continuously with increasing frequency, while the spectrum for the studded tyre flattens out.
This difference in the upper frequency range is used in the acoustical detection system developed for the SINTEF-trailer.

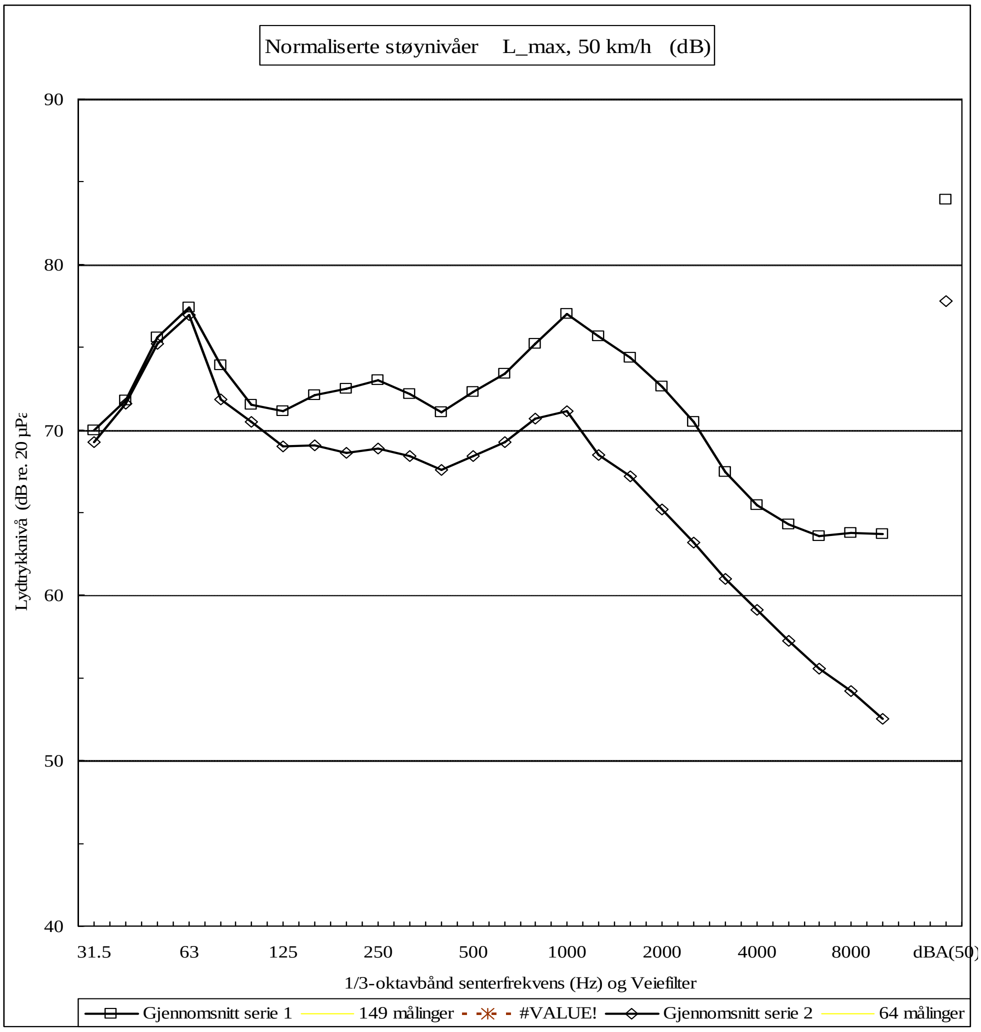

Figure 2.4 1/3rd octave band spectra for light vehicles with studded and non-studded tyres.

The differences in the general level and in the spectra have also been taken into account in the Nord2000 and Harmonoise work. A correction factor is given on the form of a + b·lg(v), where v is speed in km/h. For each 1/3rd Octave band level from 25 to 10 kHz, new coefficients of a and b for studded tyres has been derived.[1]

2.4 Studded tyres and its noise related effects on road surfaces

The use of studded tyres increases the wear of the road surfaces used in Norway.
It is also clear that they have a significant influence on the texture of the road surface, and thus the noise generated by the tyre/road interaction.
Typically a newly laid surface has a “negative” texture until the first winter season. After being exposed to studded tyres, the texture profiles typically have a “positive” shape, i.e. a shape showing the stones as peaks in the profiles. Such profiles are normally generating a higher tyre/road noise level, than a negative texture, that can reduce air pumping noise.

The Directorate of Public Roads in Norway is presently conducting a large project (12 mill NOK) called “Environmental friendly roads”. Within this project SINTEF has done CPX-measurements on a wide range of typically used road surfaces in Norway.

The age of the different road surfaces varied from approx. 4-5 weeks after construction, to about 15 years.
This enabled us to compare road surfaces ***not*** exposed to studded tyres, with surfaces exposed to one or more winter seasons.
The results of this comparison are shown in figure 2.5 (50 km/h) and figure 2.6 (80 km/h).

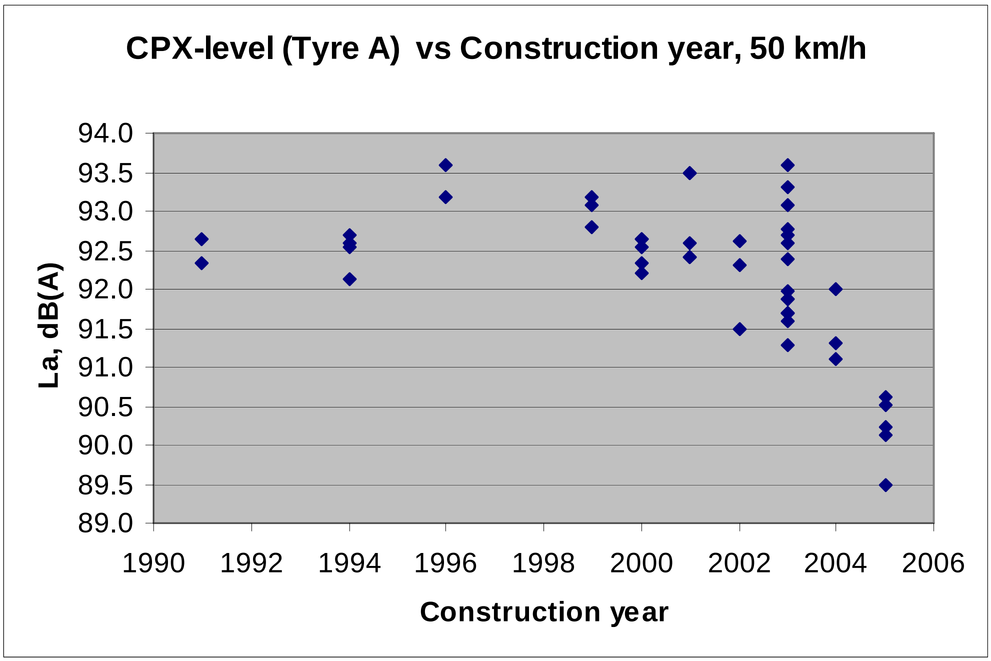

Figure 2.5 CPX-measurements (Tyre A) at 50 km/h on different dense road surfaces in Norway as a function of construction year

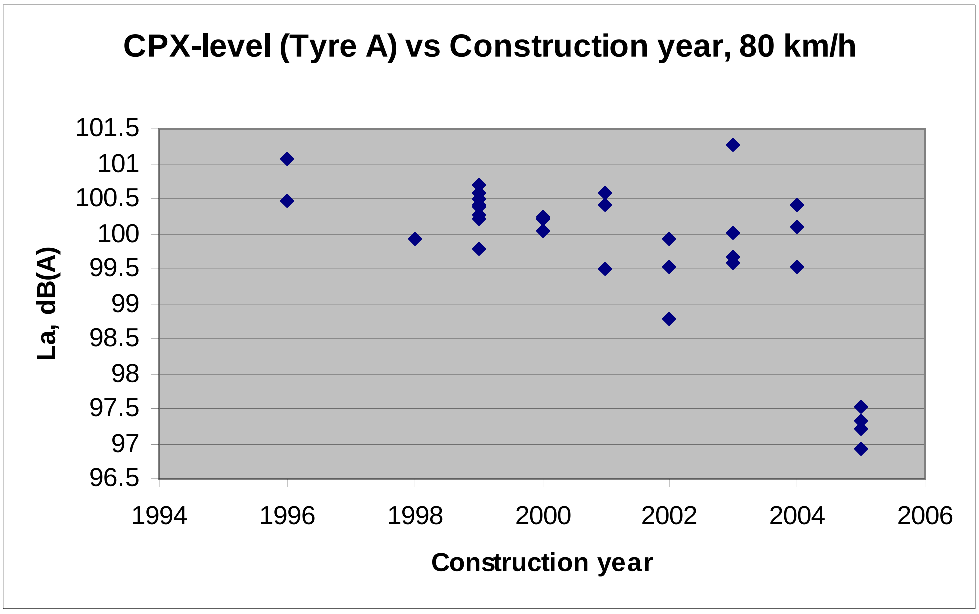

Figure 2.6 CPX-measurements (Tyre A) at 80 km/h on different dense road surfaces in Norway as a function of construction year

The measurements were done in 2005, and both figures show clearly that those surfaces ***not*** exposed to a winter season and studded tyres give a significant lower noise level than the others. The difference is in the order of 2-3 dB(A). This is not consistent with countries ***not*** using studded tyres, e.g. Denmark. Monitoring of road surfaces in Denmark shows very little changes after the first year; even some reduction has been found.[2]

A difference in the same range has been observed during one measurement on a SMA11 surface using the CPX-trailer. The noise was measured both in the wheel track and on the road shoulder (outside the white line), where the road surface was more or less identical to a new surface.

In addition to noise levels, we are also conducting texture measurements. This is important, to be able to study the effect of winter/studded tyres on the roads.

An example of the development in texture level on a SMA11 thin layer road surface is shown in Figure 2.7. Increased texture is clearly seen in the wheel tracks after 14 months compared to a relatively new-laid surface. After 14 months there is still a difference in texture level in wheel tracks and between wheel tracks.

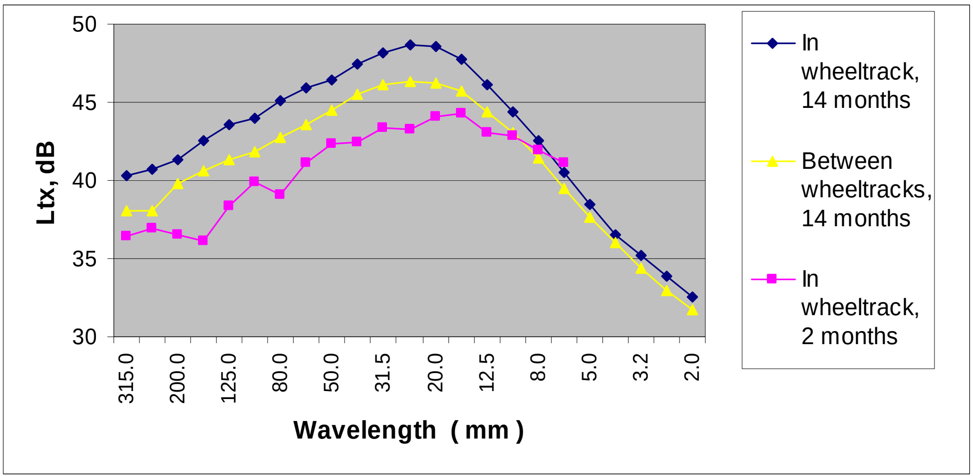

Figure 2.7 Texture spectra on a SMA11 thin layer surface before and after exposed to studded tyres.

Since the percentage of vehicles with studded tyres differ quite much in the different regions/cities in Norway, it would be interesting to investigate if a small percentage (5-15 %?) of studded tyres has the same effect on the texture as 50-80 %. So far, this has not been looked into, but it may be possible to do so within the last part of the project on Environmental friendly roads.

The influence of the percentage of studded tyres on different categories of low noise road surfaces (porous, thin layers) is an important subject to clarify. It is necessary to be able to predict a possible acoustical lifetime of a road surfaces and the need/effectiveness of cleaning process.

3 Typical road surfaces in Norway

3.1 Road statistics

The choice of road surfaces in Norway depends on a wide range of factors; regional/climatic differences, traffic volume, posted speed, durability, safety requirements, costs, etc.

In general, only dense types of surfaces have been used, such as asphalt concrete, stone mastic, cement concrete, etc.

Previously, due to durability and safety requirements, the use of rather large maximum chipping size (16-22 mm) was used, especially on roads with high traffic volume and speed.

In the recent years, however, a chipping size of 11 mm is becoming more and more in use, as it has been shown by experience that these surfaces can be durable and safe within the requirements given.

Statistics for the most frequent used surface material are only available for the road network for European Roads (Ev), national highways (Rv) and county roads (Fv). For roads owned by the local commune, no statistics are available.

Table 3.1 shows the most common used road surfaces for the 3 categories of roads.
The first 3 types of surfaces are all dense asphalt concrete (AC) surfaces.
(Ab = asfaltbetong, Agb = asfaltgrusbetong, Ma = mykasfalt)

The 4 types given in the table represent more than 83 % of the total km of road network in Norway for road categories Ev, Rv and Fv and 11-16 mm represents nearly 80 % of the chipping sizes used.

Table 3.1. The most common surfaces in Norway (2004)

Surface type	**% of total km**	**Most important types**	**% of surface type**
Ab (AC)	13.0	Ab11 Ab16 Ab16t	4.6 4.7 2.8
Agb (AC)	33.2	Agb11 Agb16	15.2 16.0
Ma (AC)	23.7	Ma11 Ma16	6.9 15.4
SMA	13.4	SMA11 SMA16	6.3 6.9
Sum	83.3		78.8

The expected lifetime of different road surfaces is dependent on type of mass used, the traffic load, climatic and local conditions.

Table 3.2 shows the expected lifetime for different types of mass (all dense surfaces), depending on the traffic load (ADT), as defined by the Public Roads Administration.

Table 3.2 Expected lifetime of road surfaces in Norway (“Handbook 018”)

Numbers in parenthesis are normal deviations from expected years.

Surface type	Normalised lifetime expectance of different road surface types						
	ADT						
	< 300	300-1500	1500-3000	3000-5000	5000-10000	10000-15000	> 15000
SMA					9 (8-10)	7 (6-8)	6 (5-7)
AC (Ab)			13 (12-14)	11 (10-12)	8 (7-9)	6 (5-7)	5 (4-6)
AC (Agb)		13 (12-14)	12 (11-13)				
AC (MA++)	14 (12- 16)	12 (10-14)	10 (9-11)				

As can be seen from the table, for roads with high traffic volume (> 15 000 ADT) it is normal to have a lifetime of 4-7 years, depending on local conditions. This is mainly to do with the winter conditions and use of studded tyres.

It has not yet been investigated if the reduced percentage of studded tyres in some cities, like Oslo, has increased the lifetime of dense SMA-surfaces (most frequently used surface in this area).

3.2 Road surfaces and noise levels

The classification of the influence of the road surface to the general traffic noise level can be measured according to 2 different standards; the Statistical Pass-by Method (SPB, ISO 11819-1) and the CPX-method (ISO/DP 11819-2). Presently, it is the CPX-method that has been used to measure the different road surfaces in Norway, but in 2007, measurements according to the SPB-standard are also planned.

As show in 2.4, SINTEF has conducted noise measurements on a wide range of Norwegian road surfaces, using the CPX-trailer of the Norwegian Directorate of Public Roads. Due to limited access to all the reference tyres in the CPX-method, measurements have mostly been done with the so called Tyre A (Avon Cooper ZV-1). The reference tyres for the CPX-method are currently under revision, and some new candidate tyres for replacing Tyre A and Tyre D have been measured in Norway/Trondheim this autumn.

Due to limitations in the project, we have only been able to measure noise on road surfaces in two regions:
Trøndelag, including Trondheim
Østlandet, including Oslo

Even if there can be some climatic differences between these regions, we do not see much difference in the noise “behaviour” of the most frequent used surfaces here. Outside the cities of Trondheim and Oslo, the amount of studded tyres is quite similar (approx 50/50 share).

Ideally, we would have liked to include road surfaces in the northern region, where most cars are running with studded tyres, and the south/west part, where few are using such tyres.

3.2.1 Dense surfaces

In figures 2.5 and 2.6 (page 7), we have shown the CPX-levels for Tyre A on a wide range of road surfaces. If we exclude the measurements on road surfaces not exposed to studded tyres (construction year 2005), it seems that we have a variation of about 2-2.5 dB(A) in the levels.

If this variation is representative for the variation in the general traffic noise levels (Leq/Lden), this needs to be verified through additional CPX-measurements with tyres representative of heavy duty vehicles and with SPB-measurements.

In figures 3.1 and 3.2, we have looked in more detailed on the results for SMA-types of road surfaces, where we have separated results depending on maximum chipping size. The age of the road surfaces varies from 1991 to 2005.

In figure 3.1, there is one SMA11-surface from 2005, with a level below 90 dB(A) and this surface was not yet exposed to a winter season.

Both figures indicate a lower level for SMA8, which could be expected. However, for larger chipping sizes, there seems to be no clear relationship.

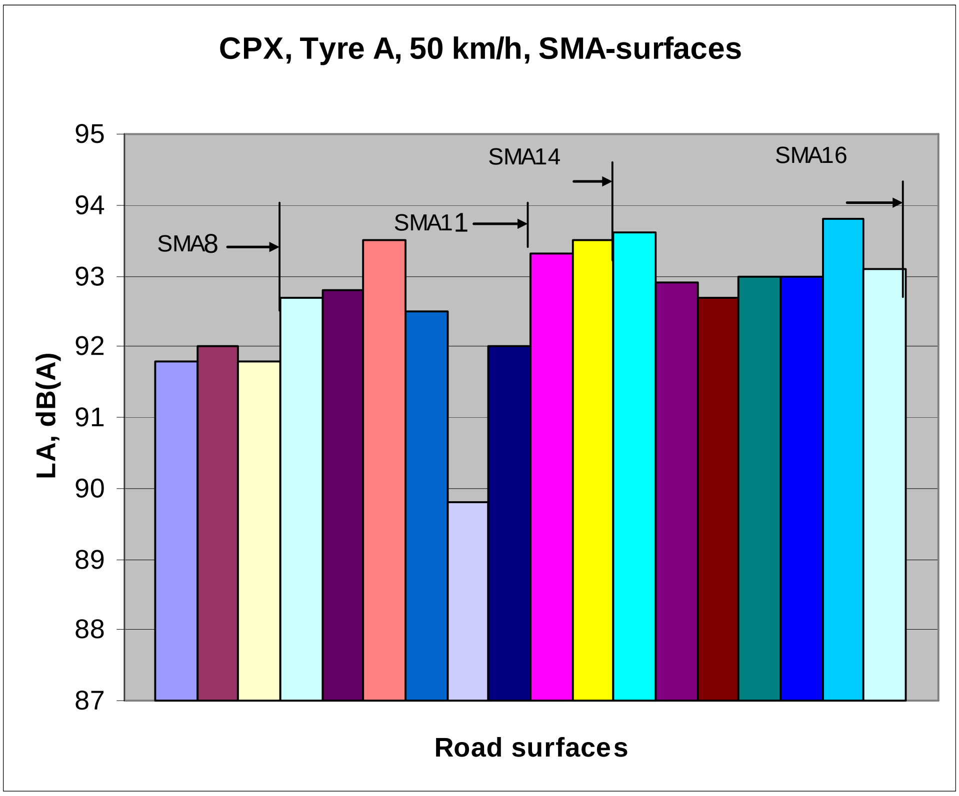

Figure 3.1 CPX-levels for Tyre A on SMA-surfaces, 50 km/h.

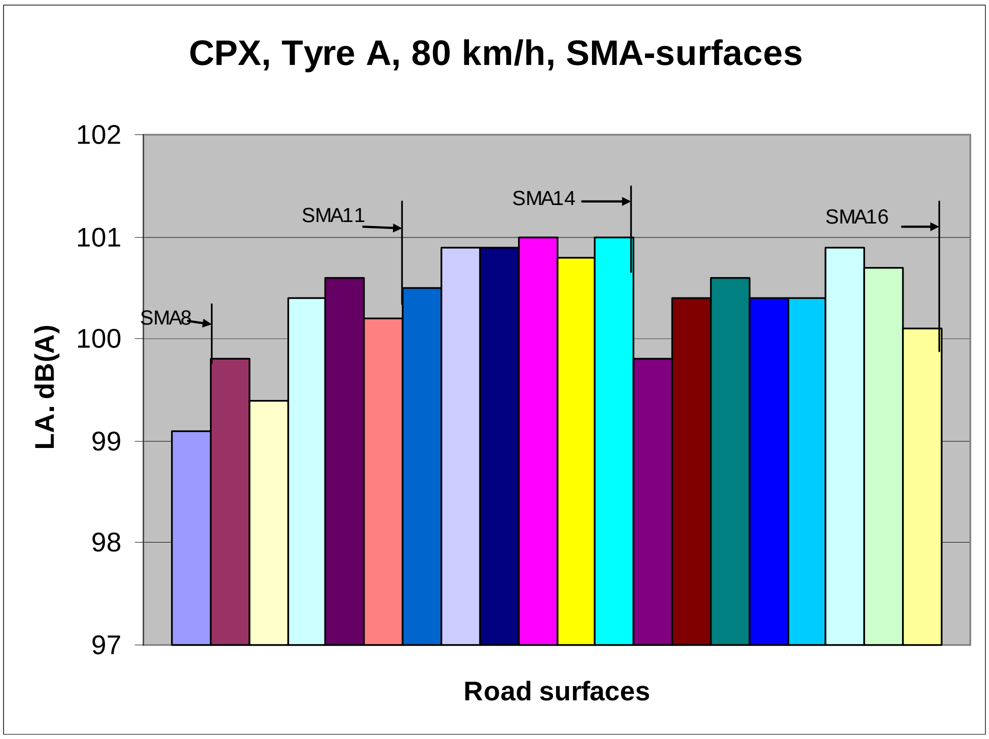

Figure 3.2 CPX-levels for Tyre A on SMA-surfaces, 80 km/h.

3.2.2 Thin and porous layers

Within the Road Directorate project a number of test surfaces have been constructed in 2005/2006, both in the Oslo and Trondheim region. The test program includes both thin layers and some porous road surfaces.

3.2.2.1 Thin layers

In 2005, a number of thin layers with maximum chipping sizes ranging from 6 to 11 mm were constructed.
These surfaces have been measured (CPX) both in 2005 and 2006. The analysis of results is still to be finalised. Some results are available and figure 3.3 shows the results from measurements on Rv. 715 at Trolla, outside Trondheim.

On this road, 6 different thin layers with maximum chipping size from 6 to 11 mm were constructed. In addition a traditional SMA11 was laid down at the same time (second surface to the far right of the figure). This surface, together with an older AC16 surface (far right) is considered as reference surfaces at this location. The figure compares measurements taken some 4-5 weeks after construction (first column) and measurements taken after the first winter season (second column). At this road section the percentage studded tyres have been counted to be in the range 55-60 %.

The results indicate that the AC-types of surfaces with small chipping size (6-8 mm) are more influenced by the winter season and studded tyres than the SMA-surfaces. Again, we can see an increase in noise levels after the first winter season in the range of 2-3 dB(A), with the exception of the AC6-surface (increase of 5 dB(A)).

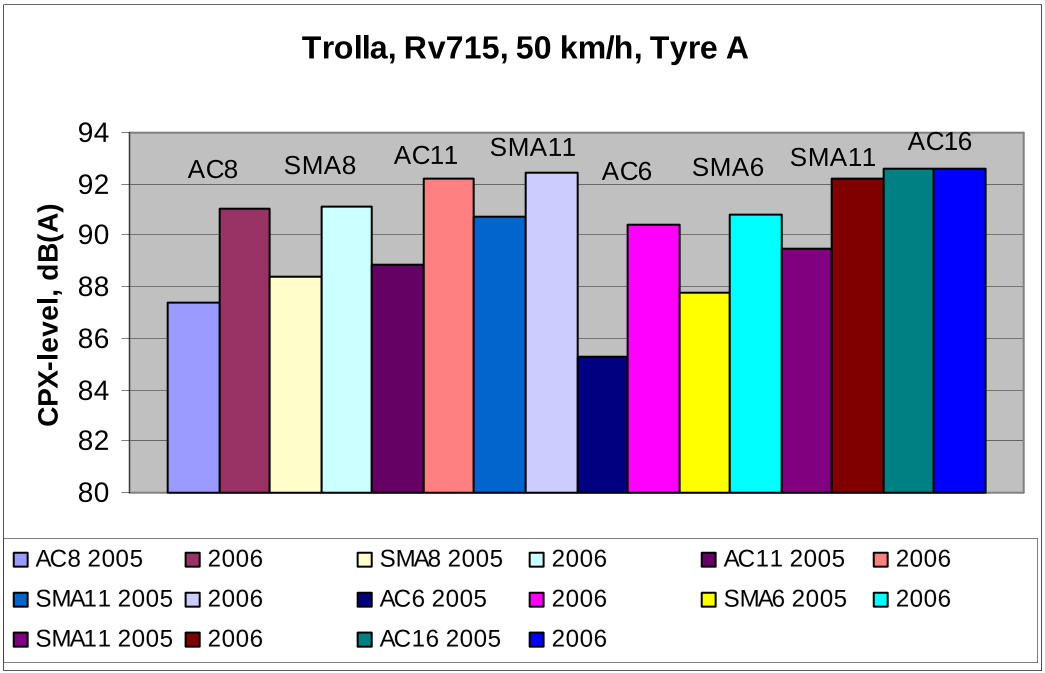

Figure 3.3 CPX-measurements (Tyre A) on thin layers, Rv715, 2005 and 2006.

In figure 3.4 we have similar results from a test section on E6 Stange (approx 120 km north of Oslo). In addition to 3 thin layers, a single layer porous surface, Da11, was constructed in 2005. Measurements with tyre A have been carried out about 5 weeks after construction and then repeated the next year, after one winter season. The reference is a SMA14 surface, constructed in 1999.

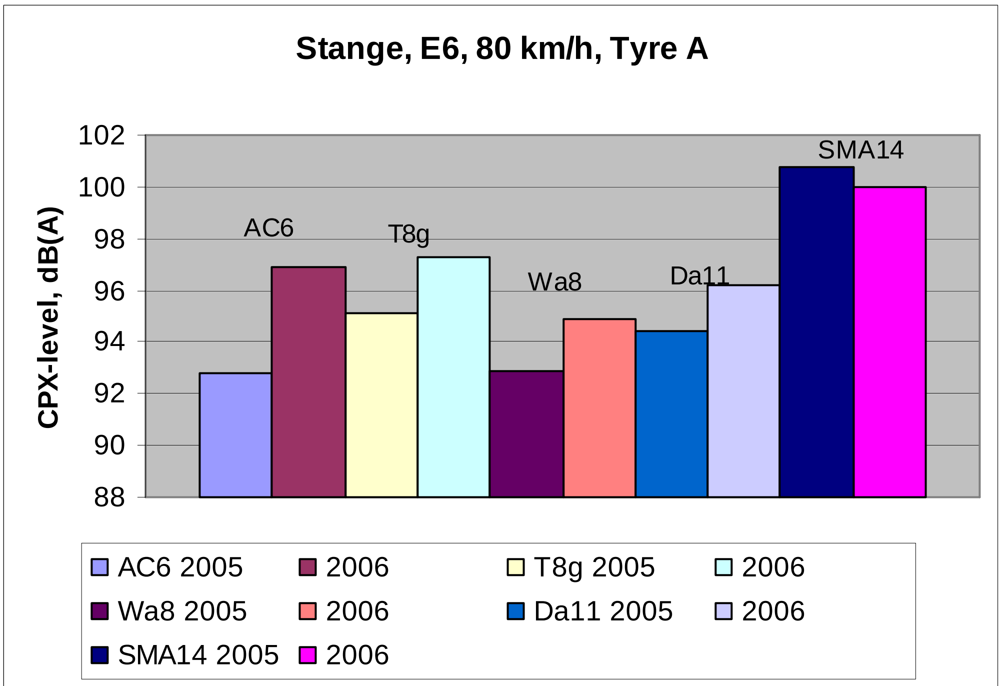

Figure 3.4 Test surfaces at E6 Stange, measured with Tyre A in 2005 and 2006.

Again the results show that the AC6 has the highest increase in noise levels after one winter season.

3.2.2.2 Porous surfaces

In 2006, a test section consisting of 3 different types of double layer porous asphalt was constructed by 3 different companies; NCC Roads, Kolo-Veidekke and Lemminkainen:

NCC Roads: DaFib8/16
Kolo-V: ViaQ11/ 16
Lemminkainen: Wa8/Da16

In addition, Lemminkainen constructed a single layer Da11 as a reference. Another reference, SMA11, was also laid down at the same location and time.

The test area is located at Bjørkelangen, Rv170, south east of Oslo. The road is a dual lane rural road with a posted speed of 80 km/h.

Each test section is approx. 450 m long.

Initial measurements with tyre A have been performed and the results are given in figure 3.5.

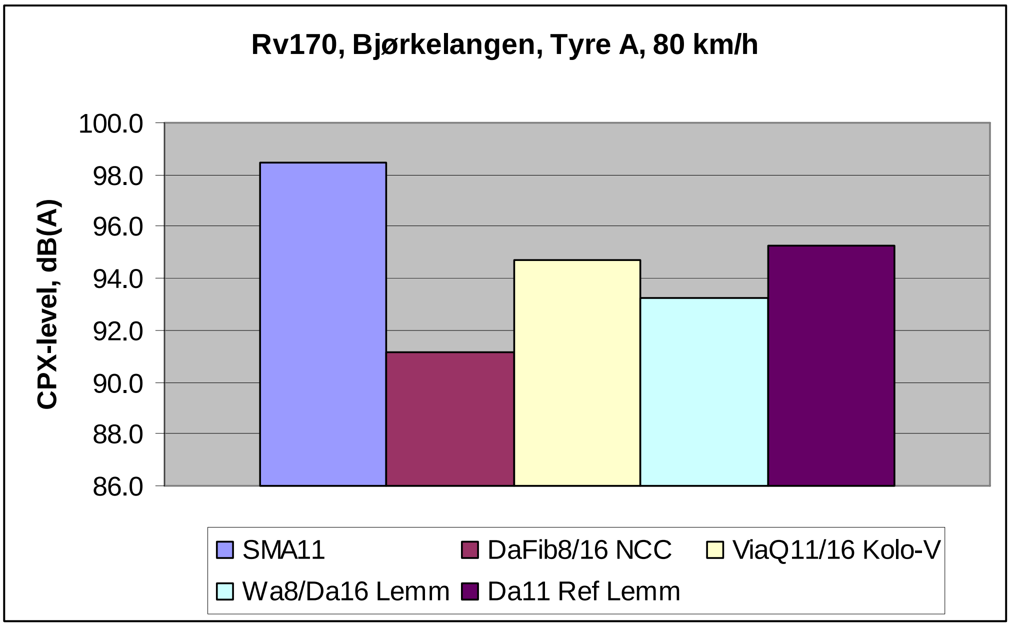

Figure 3.5 CPX-measurements (Tyre A) different porous asphalt test sections at Rv170, Bjørkelangen.

The measurements show that the NCC double layer porous surface is approx. 7 dB(A) more silent than the reference surface SMA11. The other surfaces are in the range of 3-5 dB(A) quieter with tyre A.

All these surfaces have also been measured with some new candidate reference tyres (CPX-method) and will be published at a later stage.

3.2.3 Comparison with ISO-surfaces

Both type approval of noise emitted by vehicles (ISO 362) and noise emitted by tyres (2001/43/EC) are performed on an ISO-surface (ISO 10844).

SINTEF, together with M+P in the Netherlands, have measured tyres according to the type approval method (2001/43/EC), to investigate the ranking of passenger car tyres on different road surfaces, including ISO-surface[3].

A total of 20 tyres were measured in 2004 on 2 surfaces on a test track in the Netherlands; double layer porous asphalt (2LPA) and an ISO-surface. Tyre dimensions from 175 to 205 mm (widths).

In addition the same tyres were measured on 2 trafficked road surfaces in Norway on Rv.2 near Kongsvinger:

- SMA11 surface, approx. 8 months old and exposed to one winter season
- SMA14-surface, exposed to 5 winter seasons.

Table 3.3 and Figure 3.6 and shows the results for all 4 road surfaces.

Table 3.3 20 passenger car tyres.
Mean value of noise levels at 80 km/h on 4 road surfaces

ISO 10844 dB(A)	2LPA dB(A)	SMA11 dB(A)	SMA14 dB(A)
72.3	67.7	79.6	80.3

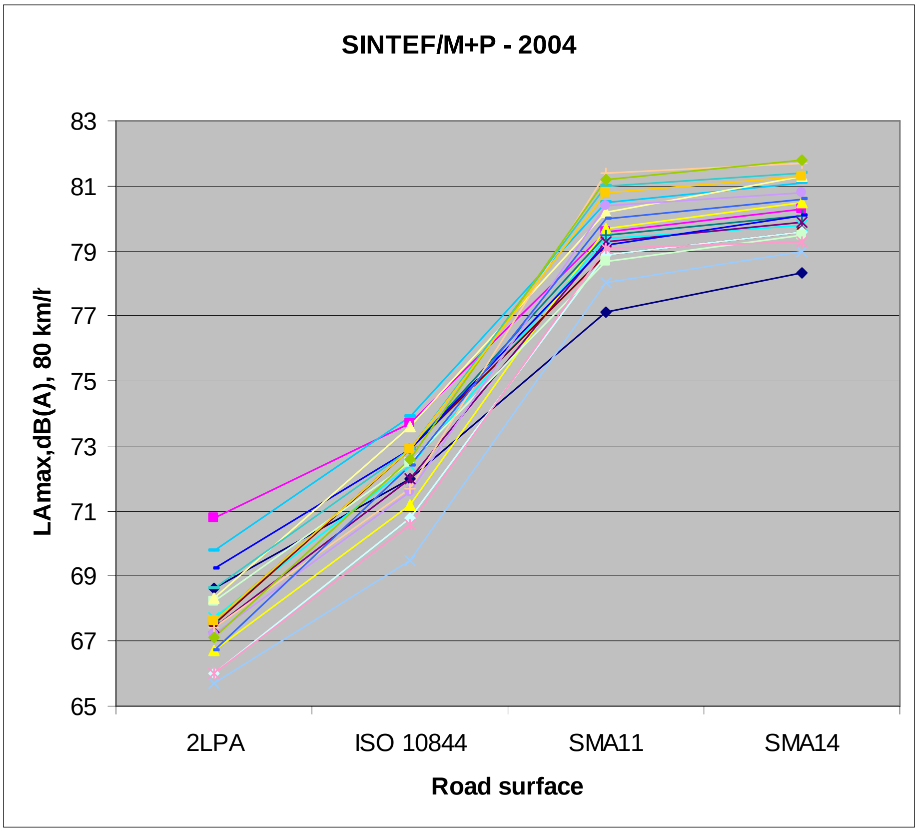

Figure 3.6 Noise from 20 passenger car tyres on 4 different road surfaces.

Compared to the ISO-surface, the noise levels on the SMA-surfaces are on average **7-8 dB(A)** higher. This difference was surprisingly high, taking into account that all three are dense surfaces with, presumably, no absorption. The noise levels on the ISO-surface have been compared to similar tests on other ISO-test tracks and the results on the Dutch test track seems to be reasonable average. The results on the SMA-surfaces has been compared (by CPX-measurements) to other similar SMA-surfaces in Norway, and they are very comparable.

The reason for the large noise differences between the SMA-surfaces in Norway and the ISO-surface is mainly due to the rather unfavourable texture on the SMA, partly caused by the use of studded tyres.

The ranking of the tyres are on a general level was quite similar on the 4 road surfaces, even if there are some tyres that behave differently.

However, further investigations are needed to verify if the ISO-surface as it is today is the only surface to be used for type approval purposes, or if additional and rougher surfaces are needed during type approval.

4 Future developments

In this memo, only a brief summary of the regulatory situation for tyres and vehicles will be given. The main focus will be on calculations made for different scenarios, to elaborate the effects of source related measures.

4.1 Tyre noise regulation

The noise from tyres is regulated by the EU-directive 2001/43/EC and the UN/ECE Reg.117.

The directive has listed some future reduction of the limit, but they are linked to safety issues and thus cannot be foreseen to be effective in a long time yet.

However, the European Commission has conducted a study on all aspects of the possibility of reduced permissible noise limits. This study has been reported into two documents:
Report: http://ec-europa-eu/enterprise/automotive/projects/report_tyre_road_noise1.pdf
Annexes: http://ec-europa-eu/enterprise/automotive/projects/report_tyre_road_noise2.pdf

These reports show that already more than 50 % of the passenger car tyres have a noise level more than 3 dB(A) below the limit. Some tyres are even 7-8 dB(A) below.

Since liberal limits were set from the introduction of the directive, it has had no real effect on the general noise levels from the road traffic.

The reports conclude that it is possible to reduce the passenger car tyre limits with 2.5 to 5.5 dB(A) and commercial tyres with 5.5 to 6.5 dB(A), without compromising safety issues.

Two steps for tightening of the limits are proposed: 2008 and 2012.

The overall environmental benefit is estimated to be a reduction of traffic noise levels in the range of 2-3 dB(A).

It is of most importance that a strong international pressure is put on both EU and UN/ECE to follow the proposals of this report.

The introduction of noise labelling of tyres should also be considered within UN/ECE, as this can be necessary in order to be able to introduce economic incentives on a national basis for the use of low noise tyres.

4.2 Vehicle noise emission regulation

Current regulation for the limitation of noise emitted by vehicles, ECE Reg.51, was amended in 1996/97 with new limits for light and heavy vehicles. For 10 years now, the limits have been unchanged. In addition, the test method (ISO 362) was not well correlated with normal driving pattern in urban traffic. Since then, ISO has been working revising the test method, which in principle has been adopted as the new test method in ECE Reg.51. The test method increases the influence of the tyres, which is consistent with real traffic situations.
However, there is yet no agreement on new limits set according to the new test method. The discussion about new limits is presently taking place within UN/ECE WP.29 and EU.

At the November 2006 meeting of WP.29, it was decided to adopt a proposal from EU, to have a two year transition period, where all vehicles shall be tested according to both the new and old test method. On basis of these measurements, new limits will be set.

This decision will inevitable mean a further delay in the process of introducing more stringent noise levels for motor vehicles. In my opinion, no real tightening if the noise limits can be expected before 2014-2015. Then, we have had nearly 20 years without any real progress concerning more stringent noise emission limits for motor vehicles.

4.3 Calculations and scenarios

4.3.1 Background

In Norway, in 2000, the Parliament did set a national environmental noise target; the noise annoyance, SPI (national noise annoyance index), shall be reduced by 25 % in 2010, compared to the reference year 1999. Road traffic noise is the main contributor to the SPI-number (80 %).

Last year, an evaluation was performed, to see the progress in different areas (road traffic, aircraft, rail, industry, etc). It was then clear that, except road traffic noise, all other sources had reduced their SPI-values compared to 1999, but SPI from road traffic had increased, mainly due to increased traffic volume.

The 2010-goal is presently under revision and 2020 is becoming a more likely target year for achieving a reduction of SPI.

As part of the evaluation, SINTEF was engaged to make calculations for different scenarios.
The aim was to be able to predict the effect of different noise reduction measures at source.

4.3.2 The calculation method

To be able to calculate the different scenarios, the **Tra**ffic **N**ois**e** **Ca**lculation **M**odel, TraNECam, was used. This model was developed by Heinz Steven, RWTÜV, for the German Ministry of

Environment. The model has since been further developed within the European project ROTRANOMO.

In contrast to traditional noise calculation models, TraNECam allows you to calculate the influence of separate noise sources, such as engine noise, tyres and road surfaces. It can also take into account different traffic management system influencing the driving pattern (stop and go-traffic, acceleration rates, detailed traffic compositions, etc).
The model allows you to make different scenarios, calculating the effect up to 2020.

To be suitable for our purpose, TraNECam was modified with data for the Norwegian vehicle fleet (fleet age structure, replacement rates, etc), as this is somewhat different from the average European fleet.
Based on measurement results, rolling noise levels on typical dense Norwegian roads, were put in the model, as reference road surface. This enables us to calculate the effect of different noise reducing pavements available in the model.

Since the model is more complex than the Nordic Traffic Noise Calculation Method (NBV96), a test was performed to choose parameters in TraNECam, to establish a reasonable agreement between the two models, using simple calculation cases[4].

4.3.3 Test cases and scenarios

Reducing the sources (engine, tyres) will have different effect for different traffic composition and speeds. As test cases, the following were chosen:

1. ADT = 10 000
   HDV = 10 %
   Posted speed = 50 km/h
2. ADT = 20 000
   HDV= 15 %
   Posted speed = 80 km/h

The following scenarios were chosen:

1. Basic trend-scenario:
The current trend continues, without any further reduction of engine or tyre noise.

2. GRB/Germany-scenario:
- Based on a German proposal to UN/ECE GRB on new limits for vehicles and a new measuring method

Table 4.1 shows the estimated source reduction in dB(A) for light and heavy vehicles and the year of introduction, as a calculated effect of the German proposal for new limits and measuring method. A typical Norwegian dense asphalt concrete road surface is used as reference surface in the calculations.

Table 4.1 The GRB/Germany-scenario. Reductions in dB(A).

	Light vehicles		Heavy vehicles	
Year	**Engine noise**	**Tyre noise**	**Engine noise**	**Tyre noise**
2011	-1.5	- 1.5	-1.8	-0.9
2015	-0.75	- 0.75	- 0.9	-0.5
Total	- 2.25	-2.25	-2.7	-1.4

3. Low ambition scenario:

Table 4.2 show the expected source reduction in dB(A) (same reduction for both light and heavy vehicles).

Table 4.2 Low ambition scenario

Year	Engine noise	Tyre noise
2011	-1	-1
2015	-1	-1
Total	-2	-2

4. High ambition scenario:

Table 4.3 show the high ambition scenario.

Table 4.2 High ambition scenario

Year	Engine noise	Tyre noise
2008	-1	
2011	-1	-2
2015	-1	-2
Total	-3	-4

5. Very high ambition scenario:
This scenario was chosen, not to be realistic, but to see the effect of a very high source reduction, where the main focus is on further reduction on engine noise (- 6 dB(A)).

Table 4.3 High ambition scenario

Year	Engine noise	Tyre noise
2008	-2	
2011	-2	-2
2015	-2	-2
Total	-6	-4

4.4 Results of predictions

The effect of the different source reductions was calculated as reduction of Leq-levels (L_{tot}) at 10 m from a centreline of the road. Separate results are available also for engine/propulsion noise (L_{prop}) and tyre/rolling noise (L_{roll}), but are only briefly presented here.

The results are summarised in table 4.4 for test case 1 and in table 4.5 for test case 2.

For the ***Basic trend*** scenario, the reference year is 1999. For all the other scenarios, changes in the levels are calculated in the years 2015 and 2020, assuming no effect in 2010.

Test case 1: 10000 ADT, 10 % HDV, 50 km/h

The results are given in table 4.4.

Table 4.4 Calculated reductions of Leq-levelsin in dB(A). Reference year 1999.

Year	Basic	GRB/G	LOW	HIGH	VERY HIGH
2010	- 0.9	-	-	-	-
2015	-0.9	-0.1	-0.5	-0.8	-1.1
2020	-0.9	- 0.8	-1.3	-2.2	-2.8

The table shows that for the basic trend, a reduction of 0.9 dB(A) is predicted in 2010, but no further reduction are expected (due to a small increase in rolling noise levels).
For all the other scenarios, the reductions are in ***addition*** to what the basic trend indicates. Example: compared to 1999, the basic trend gives a reduction of – 0.9 dB(A) in 2020. The GRB/German scenario gives an additional – 0.8 dB(A) in 2020, thus a total of - 1.7 dB(A) compared to a reference year of 1999.

Figure 4.1 shows a graphical presentation of the effect of the “Very high ambition”-scenario, including the calculated changes in the engine noise and tyre noise levels.

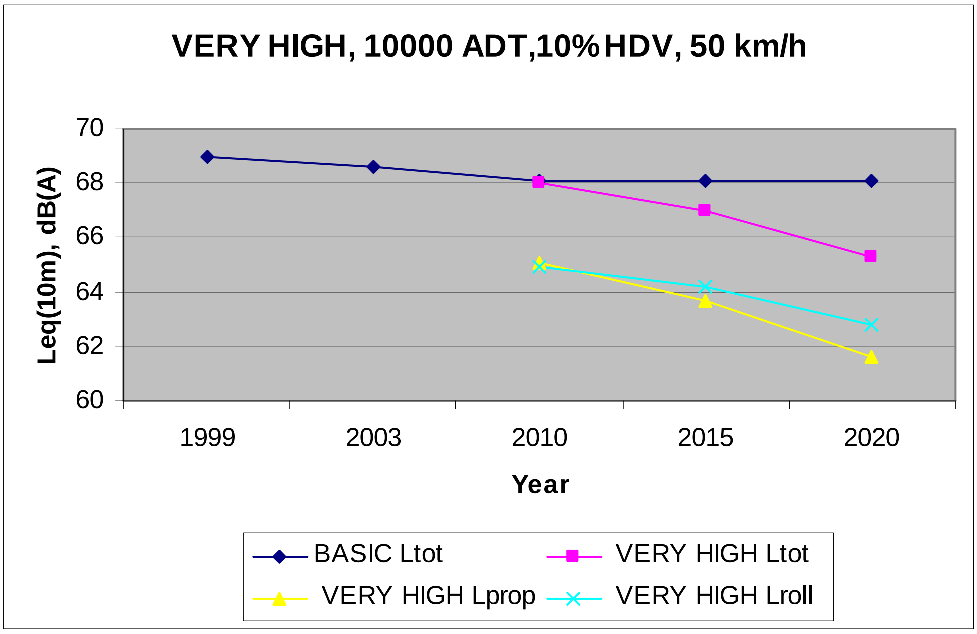

Figure 4.1 Test case 1. “Very high ambition” scenario, compared with the” Basic trend”-scenario

Test case 2: 20000 ADT, 15 % HDV, 80 km/h

The results are given in table 4.5.

Table 4.5 Test case 2 .Calculated reductions of Leq-levels in dB(A). Reference year 1999.

Year	Basic	GRB/G	LOW	HIGH	VERY HIGH
2010	- 0.3	-	-	-	-
2015	-0.3	0	-0.4	-0.8	-0.8
2020	-0.3	- 0.6	-1.2	-2.1	-2.4

In figure 4.2 we show a graphical presentation of the "Very high ambition"-scenario for test case 2.

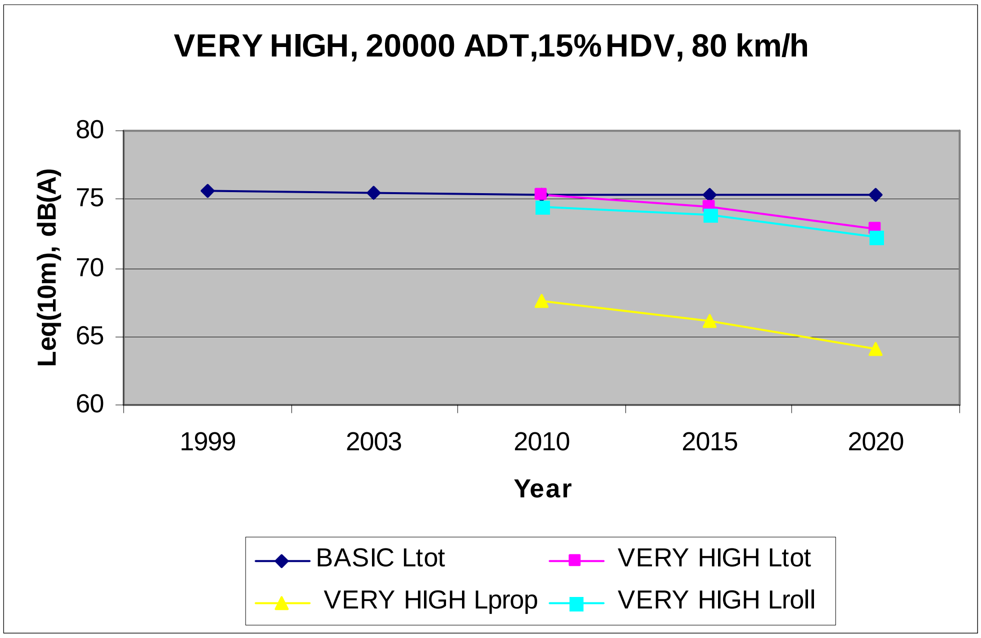

Figure 4.2 Test case 2. "Very high ambition" scenario, compared with the" Basic trend"-scenario

It is interesting to see that a 10 dB(A) source reduction for both test cases ("Very high ambition") only gives an effect of in the order of 2.5-3 dB(A) on the Leq-levels in 2020. The main reason for this is of course that it takes a long time to replace older vehicles in the fleet (the average age of passenger cars in Norway is almost 11 years).

4.5 SPI-calculations

The Statistics of Norway has been calculating the effect of some of the above scenarios on the noise annoyance index in Norway (SPI)[5]. In the calculations, the reduction of tyre and engine noise has been separated somewhat.

In addition to the above mentioned scenarios, a few other options were introduced:

1. The effect of introducing road surfaces that are on the average -1.5 dB(A) more quiet than the normal used surfaces in Norway and low and a high replacement rate of existing road surfaces
2. A slow and a very high replacement rates for low noise tyres
3. A general speed reduction on a selection of roads

The results are given in table 4.6. The %-changes are relative to Basic 1999.

Table 4.6 SPI- calculations for different scenarios

Scenario	1999	2010	2020	2020 %
Basic trend	429 626	492 338	563 809	+ 31
Basic with speed reduction		489 635	560 896	+ 31
High amb. tyres (2012), incl. speed reduction		478 509		
Basic, with low ambition road surfaces			542 888	+ 26
Basic, with high ambition road surfaces			535 315	+ 25
High amb. tyres (-4 dB) (slow replacement rate)			460 063	+ 7
High amb. tyres (very high replacement rate)			407 992	- 5
High amb. tyres (very high replacement rate) high ambition repl. rate of road surfaces)			388 344	- 10
Low amb. engine (-2 dB), low amb. tyres (-2 dB) (slow repl. rate tyres)			463 972	+ 8
Very high amb. engine (-6 dB), high amb. tyres (- 4 dB) (slow repl. rate)			364 054	- 15
Very high amb. engine, high amb. tyres (very high repl. rate)			328 973	- 23
Very high amb. engine, high amb. tyres (very high repl. rate), speed reduction, high amb. road surface			297 652	- 31

The calculations are based on a dynamic model that takes into account an ***increase*** in the traffic, and in demographic parameters (increasing number of people living in densely populated areas).

The table shows that if nothing is done towards reducing the traffic noise, we will have an ***increase*** in the noise problems: SPI increase of + 31 % in 2020 compared to 1999, instead of the national goal of – 25 % within 2010.

A substantial reduction of the sources is needed, together with the introduction of low noise road surfaces, if the political goal of - 25 % reduction shall be achieved, even in 2020.

5 References

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