TØI report 806/2005
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Oslo 2005, 48 pages, Norwegian language

Summary:

A Nordic perspective on noise reduction at the source

This report serves a dual purpose – the first is to summarize research on noise reduction at the source, including low noise road surfaces, tyres with improved noise emitting properties, and reductions in engine and power train emissions. The second is to assess the maturity of the research, identify areas where promising results need to be corroborated, and where new research initiatives are warranted. The project is commissioned by the Nordic Council of Ministers.

Significant noise reductions at the source ten years away

In areas where Nordic researchers could reach consensus on noise reduction and mitigation measures and their expected effects, the idea was to provide the Nordic authorities with clear advice on which measures could be deployed with a reasonable probability of success.

However, with the exception of Denmark, Nordic research activities feature few longitudinal studies and lack maturity. For Norway, Sweden and Finland not having a continental climate, research results on low noise road test surfaces need to be adapted to, and validated under several years of Nordic winter conditions. We therefore assess that it will take at least ten years before industry and the authorities in Norway, Sweden, and Finland have developed low noise surfaces suitable for our Nordic winters and can start deploying them.

The types of tyres that have the best noise emitting characteristics depend on road surface type. This may imply that European standardisation is not only a question of stricter limits, but also of necessary regional (Nordic) adaptations.

Table S.1: At-source noise reduction in dB(A). Possible effects and barriers.

	Vehicle		Speed reduction	Road surfaces	
	Engine	**Tyres**		**Thin/Dense**	**Porous**
Noise reduction : Existing technology/ knowledge based on:					
- 5 year perspective	1-2	1-2	1-3	1-3	2-4
- 10 to 15 years perspective	2-4	2-4	-	3-5	6-8
Durability:	15-20 years	3-5 years	-	7-15 years	3-10 years
Economy:					
- costs (investment, maintenance)	Medium	Medium	Low	Medium	High
- who pays	Consumer	Consumer	Road owner/ consumer	Road owner	Road owner
- socio-economic	+	++	++	+++	+++
Feasibility:					
- politically	Time consuming	Time consuming	-	+	?
- producers	Possible	Possible		Possible	Possible

Source: TØI report 806/2005

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That research into the durability of new types of road surfaces, and adaptation of low noise tyres to Nordic conditions will take time, does not mean that noise reduction is not needed. Neither does it mean that we lack solutions that show considerable promise of being able to provide significant noise reductions.

Lowering the speed on important ring roads, and main roads going through densely populated areas could provide a stopgap cost efficient intermediary measure to reduce noise emissions at the source.

Noise from road transport a persistent problem for Europe

80 million Europeans are exposed to unacceptable noise levels. Road transport is one of the major sources of the noise, and about 70 percent of the noise annoyance in Nordic countries is attributed to road traffic.

While regulations of air pollution emissions have led to improved air quality, regulations have not had the same positive effect. This is due to the increased level of transport, heavier vehicles with more engine power, certification test not comparable enough to real traffic situations, and insufficiently strict noise regulations.

Europe and the Nordic countries all have ambitious targets when it comes to noise reduction. To reach the targets, at-source noise reduction will be necessary.

Noise reduction at-the-source

Research on noise reduction at the source has increased lately, but not all results are transferable. Nordic climatic conditions, with the use of studded tyres require a somewhat different approach than in the rest of Europe. Therefore, a common Nordic approach to the problem is desirable.

We are in this study looking at the possible effects of the following at-source measures:

- Noise reduction due to speed reductions
- Low noise road surfaces
- Reducing noise from vehicles
- Reducing noise from tyres

The literature review undertaken as part of this report is based on newer European studies. It provides an overview of what is known about the different types of noise abatement efforts. It focuses on the potential for noise abatement measures at-the-source, achieving noise reductions in real traffic and real operating conditions, life time cycle, costs and modifying factors of the measures.

A 10 dB(A) noise reduction may be possible by combining measures

By combining different measures a noise reduction of about 10 dB(A) may be possible in a 10-15 years perspective, se table S.1. If noise reduction of this size is demanded, cooperation between the Nordic countries on developing and testing of different surface types is necessary.

Research show that Nordic winter conditions demand somewhat different types of low noise surfaces, than southern parts of Europe. Different types of porous surfaces need further testing under Nordic conditions before they can be used on a more full-scale basis (arterial-roads near urban/residential areas, on roads with speed level above 50 km/h). Use of low noise dense surface types, are less problematic and can be implemented as of today. To optimize the noise reduction from surface/tyre, surface types and tyre types adequate for Nordic conditions need to be matches as good as possible.

Using speed reductions as a noise reducing measure is a measure with instant impact both on noise and air quality, and it is cheap to implement. But it may be politically hard to get acceptance fore this type of measure. If given priority, it is important to use the measure on roads with high speed levels in areas with high density of residents or high numbers of pedestrians/cyclist**.** This to reduce the negative response from the public.

At-source noise reduction

The limits imposed through the EU tyre directive need to be made stricter if new technology is to be promoted. Financial advantages or reduced taxes on certain vehicle and tyre types could be implemented. This will probably have a limited effect on noise reduction unless a majority of the cars are induced to actually change tyre types.

Use of low noise surfaces has the greatest potential effect on noise, se table S.1. It is a measure for urban areas, and for major high speed roads close to residential areas. With today's knowledge, thin surfaces are probably the best alternative to pursue for the Nordic authorities. These surfaces have a somewhat longer durability, are cheaper, have better friction, and are easier to maintain than porous surfaces. But the noise reduction possibility is also somewhat limited, about 2-4 dB(A) is feasible. Compared to conventional surface types in Europe, Nordic surface types emit more noise. It is therefore

possible that the effect of thin surfaces can be higher in the Nordic countries.

To reduce the noise level further, use of porous/or poroelastic surfaces may be necessary. Further testing needs to take place before these surfaces can be employed on Nordic roads. But it is possible, with current knowledge to lay these kinds of surface on high speed road stretches close to residential areas. The investments and maintenance costs are higher, and the lifespan is shorter than conventional surfaces and thin surfaces. For road owners to choose a more expensive and more difficult surface to lay and maintain, governmental demand for this kind of noise reducing measures is necessary.

Measures with long and short impact time

When it comes to possible noise reductions with existing technology (5 year perspective), the potential effects are based on:

- Low-noise zone (restricted access for heavy vehicles), new vehicles or encapsulation of engines.
- Financial advantages for persons buying tyres scoring high on environmental qualities. Information.
- Reducing speed from 80/90 to 60/70 km/h on major arterial road near residential areas.
- Use of thin surface, and better conventional road surfaces.

Possible long time effects (10-15 year perspective) are based on:

- A major part of the vehicle fleet is replaced with new-technology vehicles.
- Improved tyre technology in production. Financial advantages for persons buying tyres scoring high on environmental qualities.
- Use of twin layer-porous or poroelastic surface on high speed arterial roads/urban roads near residential or recreational areas.

Conventional road surfaces must be given priority

The noise properties of road surfaces that are currently employed in Norway, Finland and Sweden have not been an issue in road surface laying contracts, and the road surface layers have unknown noise emission properties.

Limited testing in Norway suggests that the focus on durability, safety and good winter properties may have led to the production of dense road surfaces that produce 2-4 dB(A) more than the normal dense asphalt types that are in regular use in Europe. If the standard Nordic dense asphalt surfaces are equally inferior with respect to noise emissions (compared to what is common in the Netherlands and Denmark), priority should be to investigate why the differences between conventional road surfaces laid in Finland, Sweden and Norway and the rest of Europe are so large.

Potential noise reduction from low noise road surfaces

Unlike vehicle and tyre noise, there are no EU regulations for surface type. Choosing which type of road surface to use is up to the road owner.

Low noise road surfaces can be divided into three types:

- Thin/dense surfaces
- Porous surfaces
- Poroelastic surfaces

Tyre-road noise reductions are dependent on a match between road surface and tyre properties.

Thin surfaces are being tested out in several countries, including the Nordic. A noise reduction of 2-4 dB(A) is commonly achieved on the different test sections. The advantages of thin surfaces are mainly due to durability and costs.

Noise reduction of 4-6 dB(A) are achieved on tests in real traffic situation, with 2-layer porous asphalt. The problem with porous surface today, and especially in the Nordic countries, are clogging and freezing of ice in the drainage systems. Poor friction and adhesion problems are other problems with today's porous surfaces. The surface type is usually used on high speed roads, where the high speed seems to prevent some of the clogging. High pressure water spraying and sucking can reduce the clogging somewhat, and the cleaning technique for these kinds of surfaces is improving.

According to producers, noise reduction of 8-10 dB(A) will be possible when the technology has improved further. At present this type of surface is expensive (costs at least 50 percent more than conventional surfaces), and has a short life-span, but even with this taken into consideration, these kinds of

surfaces are usually cost-effective (if used on high speed roads in areas highly populated).

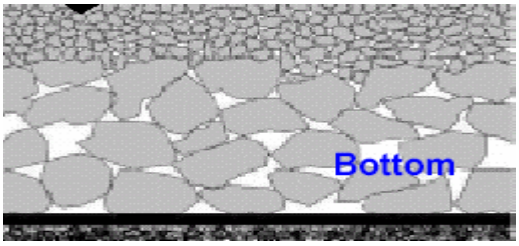

Figure S.1: Twin layer porous asphalt. Source: Berengier and Licitra 2003.

Poroelastic surfaces have an even higher possible noise reducing effect than porous surfaces. Noise reduction of 6-12 dB(A) are measured on new surfaces. The elasticity in the surface is based on rubber granules, sometimes made out of old tyres. Problems with adhesion, poor friction, and short life span are prominent at present, but these types of surface are improving.

Low noise surfaces under Nordic winter conditions

Norway, Sweden and Finland experience more adverse winter conditions than Denmark and use studded tyres during winter time. It is not reasonable to expect that improved conventional or brand new types of low noise surfaces can be deployed within a reasonable time frame.

Before deployment it is necessary to lay test-surfaces along stretches of roads that are typical for the application area (high speed roads in urban conditions) and to ascertain:

- The noise-emitting properties of the road surfaces that are in use, and the importance of surface texture for noise production.
- The interactions between Nordic road surfaces and tyre-thread patterns.
- The durability and maintainability of road surfaces under Nordic winter conditions.

An important task is to find out how to construct roads with drainage systems that works in freeze-melt conditions with partial ice-formation, and that can survive winter maintenance activities. Even with extra research effort, these types of surfaces are not expected to be deployable within a 10-year time frame. Denmark, having a more continental climate and having undertaken long time durability testing of some road surfaces, is already in the position to deploy low noise surfaces where this proves to be cost efficient.

Engine noise reduction

Even if there is a potential for further noise reduction from the engines, this is not likely to come through regulations, due to the fact that new vehicles already fulfil the EU requirements. While the potential for power train emission reductions is there, consumers are unwilling to pay for less noisy vehicles.

Noise reduction from tyres

When developing new tyres, safety, price and environmental properties such as noise are factors that need to be considered. Improving the quality on one of these factors does not necessarily mean that the tyre fares worse on others. However, some of the tyres most promising in respect to noise have inferior friction when the road surface is wet. With further development, it is expected that the properties with respect to friction under wet conditions will improve.

Factors influencing noise from tyres are:

- Tyre width
- Hardness of tyre
- Tread patterns
- Groove depth
- Road surface

The difference between the noisiest and least noisy tyres on today's market can be as 4-5 dB(A). The EU tyre directive is so moderate that all tyres produced today fulfil the requirements and will do so until at least 2011. The directive provides no incentive to tyre producers to improve the noise quality of the tyres.

An optimal combination of tyre and road surface properties is necessary. When different tyres are tested on different road surfaces, up to 9 dB(A) difference in noise levels are measured. For Nordic authorities, it is important to determine which tyre and surface type that is most efficient for Nordic conditions, and ensure that imposed EC-standards are not only appropriate for continental road surfaces, but also Nordic types with rougher surface texture.

To promote the use of low noise tyres, different financial incentives might be considered.

Noise reduction from speed reductions

The most promising measure to achieve at-the-source noise reduction in the short term is environmentally motivated speed reduction. Noise emitted from vehicles increases with their speed. It is mainly tyre-

road surface noise that is reduced. Apart from reducing noise, speed reduction will:

- Improve traffic safety
- Reduce amount of combustion particles (down to a certain speed level)
- Reduce road surface wear, and particle emission
- Reduced resuspension

When reducing the actual speed by 10 km/h, a noise reduction of about 2-3 dB(A) can be achieved. Reducing speed limits alone is not enough, because driver compliance with the new levels is low. Different types of traffic enforcement are therefore necessary. The political acceptance for the measure is often low. 2/3 of the respondents in a local survey in Oslo stated that they were positive to reduced speed level, if this meant that the air quality improved. It might thus be possible to gain local acceptance for this measure, provided there is a noise problem. The advantage of this measure is that it is efficient from the first day of implementation, and cheap compared to other measures.

Nordic low-noise-surface research should be coordinated

Research activities need to be coordinated between the Nordic countries, to make optimum use of the scarce resources that are allocated to this research area. The laying of test surfaces and establishing multi year measurement and monitoring programs is costly, and funds need to be allocated in a more efficient way.

Here the extensive knowledge from researchers in Denmark and Netherlands should be utilised by enlisting their researchers into sustained efforts of adapting the surfaces to Nordic conditions. In other words, their general competence on such surfaces should be utilised in cooperative sustained efforts together with experts on Nordic winter conditions in order to solve the winter condition and maintenance problems.

Purchasing competence and Nordic standard road surfaces needed

To promote use of low noise surfaces, contractors should ideally be presented with performance contracts. For example, the contract can include a part where the contractor is paid per reduction in the number of annoyed persons and the pay is reduced if the noise emission properties deteriorates over time.

If possible the Nordic countries should specify one or a few common Nordic standard surfaces. This could act as a baseline for further testing, designing common quality contracts for contractors, and help to promote production of surface types adapted to Nordic climatic conditions, winter maintenance and vehicle fleet (tyre types etc.).