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Evaluation of Directive 2000/14/EC on Outdoor Machinery Noise

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The European Directive 2000/14/EC sets a requirement for noise labelling for the sound power level of 57 types of outdoor equipment, and sound power limits for 22 of these. In the NOMEVAL project the Directive and its amendment 2005/88/EC were evaluated, resulting in recommendations for an update of the equipment list, the noise limits and the test codes. A European database of noise emission data was assessed, and environmental bodies and industry were consulted. The recommendations were also based on environmental, technical and economic impact assessments. A new environmental indicator was applied to rank the impact of the different equipment types. It was found that many types currently without noise limits have a higher impact than those with noise limits. Some new types of equipment have been identified including snowmobiles, mobile waste breakers and and screens, motorised brooms, handheld cut-off saws and power pruners. The technical impact assessment was based on current technology and trends and the feasibility of new of stricter limits. The economic impact assessment was based on estimated societal benefits versus the estimated additional cost to the consumer or purchaser. Finally, a number of instruments for further reduction of outdoor equipment noise were proposed.

1 Introduction

European Directive 2000/14/EC [1] requires noise marking for 57 types of equipment used outdoors, and sets noise limits for 22 of these. It brings together a number of previous separate Directives covering noise emission from some types of machinery such as lawnmowers, compressors and construction equipment, adding several new ones, such as cooling equipment on vehicles, glass recycling containers and piling equipment. All equipment listed in the 2000/14/EC Directive must be marked with a guaranteed sound power level, which is based on a measurement performed according to the methods specified by the Directive. Equipment types subject to noise marking only are known as 'Article 13' equipment, whereas equipment types also subject to noise limits are known as 'Article 12' equipment. These so-called stage I limits are for the guaranteed noise level, which is higher than the measured level to take measurement uncertainties and production spread into account. Both measured and guaranteed levels are registered and should be submitted to the Commission in a Declaration of Conformity (DoC). Since Directive 2000/14/EC came into force in January 2002, the Commission has collected DoCs and assembled thousands of measured and guaranteed noise levels in a database which has been made available on the Internet. Directive 2005/88/EC [2] is an amendment to 2000/14, adapting the stage II limits for Article 12 equipment, some of which are becoming only indicative.

The European Commission assigned a study contract to a consortium led by TNO, with partners TÜV-Nord (Germany), LNE (France) and VCA (UK). The study objective [3] was to evaluate the experience in the implementation and administration of Directive 2000/14/EC (NOMEVAL project). The study reviews the current noise limits (stage I, stage II and indicative limits) and the equipment list, taking into account available collected noise data, test codes, technological development, available position papers and relevant documents, consultations with various stakeholders, and environmental, economic and technical impact analyses. The stakeholders include industry and industry associations, notified bodies, purchasers and users of equipment, affected citizens, cities and communities, environmental organisations, and national and local authorities.

Some examples of outdoor machinery in situations causing considerable noise at the nearby dwellings are shown in figures 1.1-1.4. Examples of limit values for Article 12 equipment are listed in table 1.

Figure 1a: Construction machinery in an inner city area with nearby newly developed apartments

Figure 1b: Excavator working in a narrow residential street

Figure 1c: Lawnmower in urban area

Figure 1d: Compressor in inner urban area

Table 1: Examples of A-weighted sound power limits for Article 12 equipment as in Directive 2005/88/EC, see [2]

	Stage I from 3/1/2002	Stage II from 3/1/2006
Compaction machines (vibrating rollers,vibratory plates,vibratory rammers)	P≤8 kW : 108 8<P≤70 kW: 109 P>70 kW: 89+ 11 lg P	105 106 86+11 lg P
Wheeled dozers/ loaders/excavator-loaders, dumpers, graders, landfill compactors, …	P≤55 kW: 104 P>55kW: 85+11 lg P	101 82 + 11 lg P

2 Machinery noise database

A European machinery noise database is available online (see www.ec.europa.eu/enterprise/mechan_equipment) which contains thousands of DoC data provided by manufacturers of outdoor machinery. This data includes measured and guaranteed sound power levels together with the relevant technical parameter such as mechanical or electrical power, cutting width or mass. This database was reviewed to examine to what extent new limits could be proposed based on statistical analysis of the data. This resulted in an indication for some equipment types with many data points, but for a substantial number of equipment types, data was incomplete. This was due to non-submission or input errors. This is currently resolved by a new online data registration tool provided by the Commission. It was also noted that especially Article 12 equipment (with noise limits) had more numerous data than Article 13 equipment types (only labelling). Although some indications were obtained from the database, also other analyses were clearly required to review the noise limits.

3 Consultation

A consultation was conducted using a questionnaire and interviews with manufacturers, industry associations, NGOs and authorities including ministries, municipalities and notified bodies. This covered the key issues in relation to the directive, such as understanding and impact of the directive, test codes, environmental impact, technical aspects and economic impact. In general, the directive is known to many but considered rather complex and in some cases an administrative burden for industry. Especially the concept of guaranteed noise levels was identified as a difficulty, as there is no fixed procedure to determine the guaranteed sound power level from the measured level. It was also frequently noted that there is a lack of market surveillance; this can lead to unfair competition between compliant and non-compliant companies. The concept of sound power labelling was also considered as viable for improvement, as there is often confusion with sound pressure levels. Another issue are the categories and definitions of equipment types in the directive.

On the environmental side, a number of machine types were identified as a common source of complaints, such as handheld concrete breakers, piling equipment, leaf blowers, chain saws, compaction machines, circular saw benches, excavator-loaders, hydraulic hammers, lawnmowers and others. On the technical side, some manufacturers indicate that further noise reduction is limited by other constraints such as performance, weight or volume.
Suggestions were made for new equipment types and introduction or tightening of limits, in particular for several equipment types currently without limits, such as leaf blowers, chainsaws and hydraulic hammers.

4 Environmental impact assessment

The environmental impact is a basis on which to examine the need for noise limits. For outdoor machinery this is not easy to assess, as it is mobile, operates temporarily in different locations and has highly variable characteristics. This makes it more complex to deal with than road, railway or industrial noise. This issue was dealt with by defining a single number 'Environmental Impact Indicator' EI, which includes all the parameters which determine the overall impact per machine type.

$$EI_{\text{equip}} = 10\lg \sum_{i=1}^{10} \mathrm{N}_{\text{equip,situ}} \mathrm{D}_{\text{equip,situ},i} 10^{L_i/10} \qquad (1)$$

where $N_{equip,situ}$ = number of equipment in use in specific situation; L_i sound level class i (5 dB classes); $D_{equip,\ situ,i}$ =distribution of inhabitants over sound level class i for each equipment and in each situation, normalized to the total number of inhabitants considered. L_i is defined by a rated sound power level $L_{WA,rated,yeareq}$:

$$\begin{aligned} L_{\text{WA,rated,yeareq}} &= L_{\text{WA,guaranteed}} + \\ &C_{\text{evening/night}} + C_{\text{tonal/imp}} + C_{\text{intermittent}} + \\ &C_{\text{opcon}} + 10\lg\left(\frac{n_{months} n_{days} t_{dayuse}}{364 \cdot 24 \cdot 60}\right) \end{aligned} \qquad (2)$$

with $L_{WA,guaranteed}$ (Average) Guaranteed sound power level;

$C_{evening/night}$=adjustment for evening/night use (0 or 5 dB)

$C_{tonal/imp}$ =adjustment for tonal and/or impulsive sound character (0 or 5 dB)

$C_{intermittent}$ =adjustment for sound character due to intermittent use (0, 3 or 6 dB);

C_{opcon} =adjustment for difference in operating condition between normal use and testing conditions (0 or 3 dB); n_{months} =number of months per year in use; n_{days} =number of days per month in use; t_{dayuse} =minutes per day in use.

The distribution function $D_{equip,situ,i}$ was determined from noise mapping calculations for different types of area, such as inner city, dense suburban, normal suburban and rural areas. This was done as differences can be expected between the numbers of people affected and the noise levels, depending on the situation and surroundings of the source. For example, a machine operating in an urban street with facades on both sides may produce more disturbed residents than in a less densely populated suburban area. This approach using the EI indicator resulted in a practical means of comparing all the equipment types, taking into account average sound power level, numbers of equipment in the EU, usage time, sound content, typical type of area of usage and operating condition. The resulting EI is a single figure quantity in dB(A) similar to an adjusted L_{eq} over a year. A ranking based on the EI results in a completely different priority order to a ranking based only on sound power levels of to the various equipment types. Notably, the EI ranking seemed to correlate well with some of the consultation results. In figure 2 the EI is set out for each equipment type. Although it is an approximate quantity due to uncertainties in the inputs, due to the large dynamic range it is quite suitable for comparison purposes. A value of more than 57 dB(A) is considered high and is indicated in orange or red in figure 2. From this analysis it was concluded that many Article 12 equipment types (those with limits) do not all have a high environmental impact, such as tower cranes and landfill compactors, in contrast to many Article 13 types.

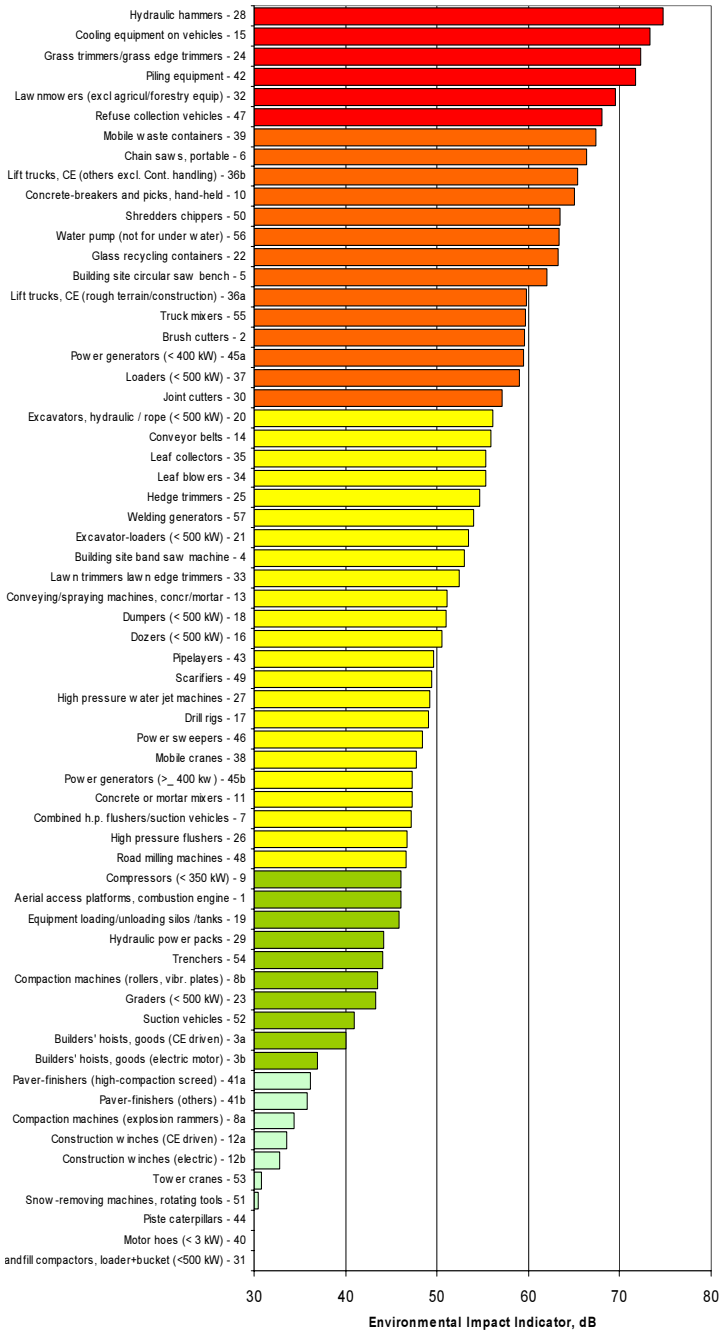

Figure 2: Environmental impact indicator for all equipment types in the 2000/14 directive.

5 Test codes

Test codes have to provide comparable results with minimum uncertainty. In particular, the operating conditions including test cycle need to be representative but also reproducible. The uncertainty factor K is defined as the difference between the measured value L_{guar} and the guaranteed value L_{meas}:

$$L_{guar} = L_{meas} + \mathrm{K} \qquad (3)$$

It is determined by the manufacturer or the testing body and it is affected by, amongst others: reproducibility of the loading and operating conditions; margin chosen by the manufacturer; spread in production; influence of the environmental correction (K_{2A}); the sound radiation due to the process or work piece; multiple sources and/or complex work cycle; temperature range.

The relation between the measured sound power level (or guaranteed level) and the level occurring under real field conditions is not always straightforward. It may not always be easy to recreate 'realistic' conditions, and reproducibility may be too low due to a large spread in the noise levels under these conditions. The directive originally applied 2 principles for the operating conditions: 1) operation at high idle and 2) minimising process noise. This obliges the manufacturer to reduce machine noise. But in some cases in practice, process noise may still be dominant. The study gives a large number of proposed improvements for the test codes, where possible adhering to CEN or international standards. Test codes still need to be developed for new equipment types.

6 Technical impact assessment

A technical impact assessment was performed to examine the possibilities and impact of changing or introducing noise limits. For some equipment types it was clear that even though the environmental impact is quite high, there are several constraints in reducing noise levels further. Examples are handheld equipment with compact combustion engines such as chainsaws, leaf blowers, grass trimmers, stone saws and brush cutters, lawnmowers and all percussive tools including piling equipment, concrete breakers and hydraulic hammers. For these and some other types further effort is required to bring down noise levels. An overview of all relevant noise sources for each equipment type was made, together with a list of noise control measures for frequently used components. Some of the main sources and components are discussed here.

Internal combustion (IC) engines are a noise source found in many equipment types, mostly 2 or 4 stroke petrol engines and diesel 4 stroke engines. Especially handheld compact engines are hard to tackle, but need addressing particularly because of the high noise levels at high engine speeds. For construction machines, engine management, improved enclosures, damping, inlet/exhaust silencers, lower mechanical noise are all possible solutions for further noise reduction. One particular design conflict is the demand for lower exhaust emissions, which leads to higher heat rejection from IC engines, and in turn more noise from cooling fans. For those equipment types which are mounted on a carrier vehicle such as sweepers, suction vehicles, concrete mixer trucks and others, quieter truck engines would help bring down noise levels as they are often also used as the power source for the equipment.

Fans and cooling noise are a second common noise source, which can be improved by better aerodynamic design, electronic control and flow orientation. Impact noise can to a certain extent be reduced by damping and shielding measures and optimisation of the impact process. Noise from steel tracked machines is technically still difficult to resolve. Noise from hydraulics systems is technically possible to reduce further by means of resonance or branch dampers and optimised pumps and valves. For transmission and gear noise, the choice of gear type, gear quality and assembly precision are potential solutions. Blade noise as

produced by lawnmowers should be possible to reduce further if aerodynamic optimisation is applied.

Despite the many design constraints that have to be dealt with, including cost and other European regulations on safety, exhaust emissions and materials usage, the introduction of a first step noise limit seems reasonable for equipment types with high environmental impact. For the future there are some clear trends towards more electrically and hybrid powered equipment.

7 Economic impact assessment

The aim of the directive is to harmonise the laws of the Member States relating to noise emission standards, conformity assessment procedures, marking, technical documentation and collection of data concerning the noise emission in the environment of equipment for use outdoors. It is meant to contribute to the smooth functioning of the internal market, while protecting human health and well-being. The directive is justified by the fact that without it, member states would be free to enforce their own regulations, which would lead to a multiple of the current costs for industry.

If market surveillance is applied, both citizens and industry benefit, as the noise reduction is achieved and there is no competitive advantage for non-compliant companies or loss of market share for compliant companies. Market surveillance is essential for the proper functioning of the directive and to avoid unfair competition. The current environmental situation will improve if the directive is periodically reviewed, and where necessary and possible, limits are tightened. The growth in the market is such that the numbers of equipment are increasing, new equipment types are appearing and population density is increasing. The user is not directly confronted with the effects or costs of noise disturbance, in the way the affected people in the vicinity are. European regulation is therefore an appropriate means of protecting the population. Local regulations, if present, tend to vary significantly and do not always offer the appropriate protection, especially if not properly enforced. An alternative option is state incentives, such as tax benefits for quieter equipment, to encourage manufacturers to put quieter equipment on the market.

The total market for outdoor equipment is tens of billions of Euros in the EU annually, in recent years with growth in the construction sector, the municipal service sector, the materials handling sector, the transport sector and the horticultural sector. Many relatively new types of machinery have appeared on the market such as compact excavators, telescopic handlers, power pruners, handheld stonesaws, home pressure cleaners and others. A significant number of products is imported from the far East at low prices.

The economic impact assessment in the study is based on benefits and costs at societal level due to traffic noise (similar to [4]) and costs for industry and its customers. The costs to society of outdoor equipment noise can be linked to the environmental impact indicator as shown in figure 3.

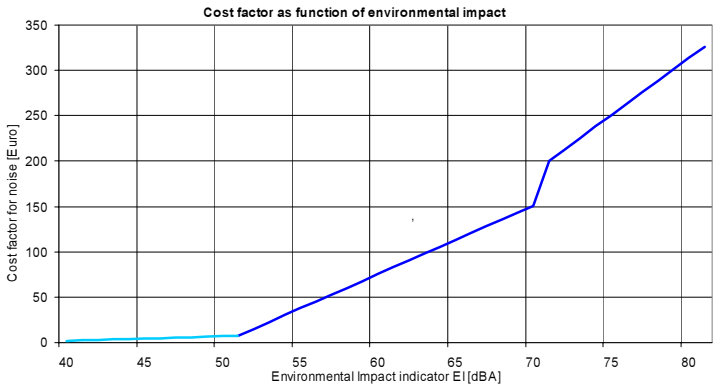

Figure 3: Cost factor for noise exposure (2002, € per year per person exposed) for EU25 unweighted average (including the extrapolated costs below 51 dB), in relation to the environmental indicator.

Estimates were made for the costs to industry and the market incurred to comply with tighter noise limits, which were found to be significantly lower than the benefits of noise reductions of around 2-3 dB for equipment with medium to high environmental impact. This supports the conclusion that it is economically beneficial to tighten or introduce noise limits for these types. It was calculated that the overall benefits to EU citizens in the first year would be around € 9,52 per person whereas the cost to industry and the market would be around € 0,82 per person. This cost would be reflected in the market price of equipment.

8 Proposals for the directive

The equipment list revisions were proposed as described below, based on all of the analyses and using a decision diagram (see report [3]). Based on the environmental, economic and technical impact, 12 high and medium priority types for Article 12 limit changes were identified. For the remaining Article 12 types, limit changes are expected to have much less impact. For Article 13 equipment, a group of 16 equipment types was identified that clearly would be worth moving to Article 12. For potentially new equipment types, 11 out of 22 were shown to be potential candidates for addition to the Article 13 list, based on the expected environmental impact. Limit changes of 3 dB or moving equipment from article 13 to 12, is most effective for those types with a high environmental impact, as it affects most people.

New or modified limits were proposed for most of the equipment to be added or to remain in Article 12, with a stage after 5 years and another after 8 years. A detailed list is given in the report [3]. Limit proposals are generally 2-3 dB tighter than current ones.

The following equipment types were proposed as new in Article 12: mobile waste breakers and screens (after 5 years), mobile cranes for harbours and terminals (bridge/gantry cranes), motorised brooms (road sweepers without aspirators), airconditioning and ventilation equipment and heat pumps (after 5 years) and telescopic pruners (after 5 years).

It was proposed to move from Article 13 to Article 12: aerial access platforms CE powered, brush cutters, building site circular saw benches, high pressure flusher and suction vehicles, (separate or combined), cooling equipment on vehicles, portable chain saws, drill rigs, glass recycling containers, grass trimmers/grass edge trimmers, CE powered hedge trimmers, high pressure water jet machines (upto 3 kW, electric), hydraulic hammers, joint cutters, leaf blowers, leaf collectors, mobile waste containers, piling equipment (vibratory), power generators (>_ 400 kW), power sweepers, refuse collection vehicles, road milling machines, CE powered scarifiers, shredders/chippers, truck mixers and water pump units. Completely new types proposed for Article 12 were snowmobiles (after 5 years) , handheld stone cut-off saws (after 5 years), mobile waste breakers and screens (after 8 years) and airconditioning and ventilation equipment and heat pumps (after 8 years). A number of types were proposed to be removed from the directive: builders' hoists for the transport of goods (electric motor), building site band saw machines, compaction machines (explosion rammers), handheld concrete breakers and picks (<3 kg), construction winches (all), conveyor belts, landfill compactors (loader-type with bucket, < 500 kW), motor hoes (<3 kW), pipelayers, piste caterpillars and trenchers.

9 Instruments for noise reduction

An integral range of instruments for noise reduction of outdoor equipment was set out. These include technical, financial, regulatory, political and communication instruments. Key examples are the improvement of market surveillance, clearer noise marking, financial incentives for quieter equipment, improved information to industry and to the public, better assessment of environmental impact including complaints, R&D on quieter equipment, automated data collection and improved DoC, and many others. Some potential technical R&D topics are: quieter IC engines and carrier vehicles; alternative power sources such as improved power accumulators (batteries) to replace some types of IC engines; alternative quieter working processes for cutting and hammering; better indicators for annoyance and environmental impact; improved measurement methods and procedures to determine uncertainty. In the report, data sheets are provided for each equipment type giving details on each of the assessments (environmental, technical and economic) and proposals for limits where applicable.

10 Conclusions and recommendations

The following overall conclusions could be drawn from the study. The European database is a useful tool, but it could not be the only basis for limit proposals as more and better data is required. This is now better facilitated by new online database tools provided by the Commission. From the consultations it was found that there is common agreement on the need for market surveillance, a better marking system and further technical progress. The new environmental impact indicator gives a means of setting priorities for list and limit changes; much Article 13 equipment has a relatively high impact. For many equipment types tighter limits or new limits are feasible; a few have technical hurdles to overcome (compact and impacting equipment). Economic societal benefits far outweigh costs to industry or customers for equipment with high environmental impact.

4 new equipment types were proposed for Article 13; 27 types were proposed to be moved from Article 13 to 12, some combined; 1 new type was proposed for Article 12 (snowmobiles). Stage II limits are generally feasible with some exceptions for equipment with indicative limits. 11 equipment types were proposed for removal from the directive. A set of instruments including technical R&D topics was proposed, including better market surveillance, development of better environmental metrics, uncertainty procedures, measurement methods, quieter processes, quieter engines and carrier vehicles.

Key recommendations are: application of market surveillance; focus on equipment with high environmental impact; use of ISO or EN standards where possible; improvement of the noise label; stimulation of the market for low noise products; balancing of noise reduction with requirements for gas emission, public health and costs; combination of similar equipment types into groups; improvement of non-standard test codes in cooperation with industry and notified bodies; reduction of noise limits for lawnmowers with an improved formula, and further research; incentives for engine and truck manufacturers to offer quieter engines and carrier vehicles.

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References

[1] Directive 2000/14/EC of the European Parliament and the Council of 8 May 2000 on the approximation of the laws of the Member States to noise emission in the environment by equipment for use outdoors.

[2] Directive 2005/88/EC of the European Parliament and the Council of 14 December 2005 amending Directive 2000/14/EC.

[3] M. Dittrich, F. de Roo, E. Gerretsen, A. Burgess, H.J. Beckmann, G. Spellerberg, P. Cellard, A. Bowker, "Study on the experience in the implementation and administration of Directive 2000/14/EC relating to the noise emission in the environment by equipment for use outdoors - Final Report", TNO Report MON-RPT-033-DTS-2007-03482, 12 December 2007 (see www.ec.europa.eu/enterprise/mechan_equipment).

[4] "Valuation of Noise. Position paper of the Working group on health and socio-economic aspects", European Commission, Brussels, 2003.