Benchmark indicators for industrial noise emission

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Summary
The total noise emission on large industrial areas is caused by many and different types of companies, ranging from small businesses to large (petro)chemical plants or huge container terminals. Controlling the total noise emission of such an industrial area, and the noise levels at nearby residential areas, requires an indicator to assess the noise emission per type of company. An indicator in dB(A)/m2 is used for years now in The Netherlands, also when developing new industrial areas. Although reasonably usable for describing the noise emission, new indicators which incorporate more specific aspects of different types of businesses/activities are needed, especially for giving suitable noise “budgets”. Indicators for different industrial activities such as container terminals, scrap storage / handling,, oil refineries and chemical plants were determined. Indicator aspects such as throughput, specific installation areas, type and number of equipment and power usage were assessed. This resulted in indicators that enables the evaluation of the noise emission of a company or (sub)activity to a given noise ”budget” and BAT (best available techniques) and mutual comparison of companies. Possible noise reducing measures or new future techniques were incorporated into these noise indicators. Noise emission of companies was benchmarked using these noise indicators.

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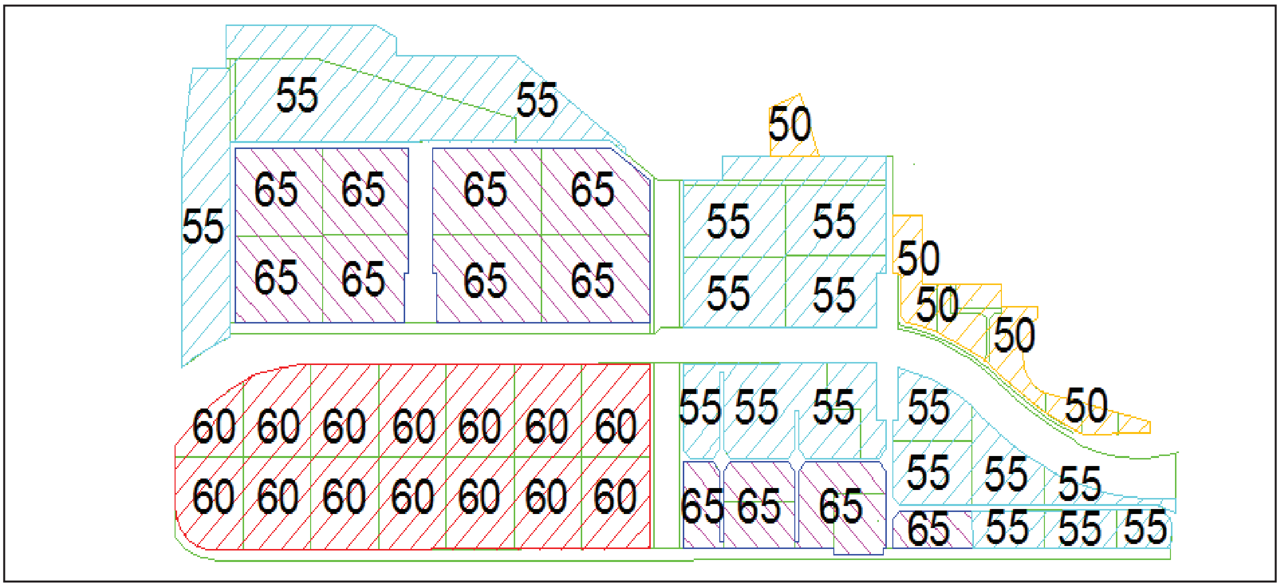

Figure 1. Example of reserved sound power per lot

1. Introduction

In The Netherlands large groups of different companies are clustered on special industrial areas, designed to accommodate companies with a high noise emission such as (petro)chemical plants, container terminals, concrete and asphalt producing facilities et cetera. Controlling the noise emission of such industrial areas and with that controlling the noise levels at nearby residential areas (noise immission) is done using specialized (large) computer models. These computer models consist of many plots with a specified reserved sound power (noise emission) for each plot.

When empty plots on industrial areas are to be used for a new company, or existing companies expand, the total noise emission of the planned activities on the empty plot is assessed to the designated reserved sound power of the plot. In The Netherlands the indicator for this designated reserved sound power is in dB(A)/m^2. Also when developing new industrial areas this indicator in dB(A)/m^2 is used for initial planning purposes and initial acoustical surveys. Figure 1 shows an example of such an industrial area with plots and reserved sound powers.

Although an indicator in dB(A)/m^2 is usable for describing the basic noise emission it does not incorporate company specific factors such as noise efficiency related to throughput, power usage or the specific installation area. To be able to provide a more company or line of companies specific noise emission and control element new indicators are needed. Peutz together with DCMR Milieudienst Rijnmond determined indicators for different industrial activities.

2. Company specific information

To determine possible indicators relevant environmental information about the companies was gathered using recent environmental permit applications, acoustical surveys and energy efficiency surveys. For the study the following types of companies were considered:

- generic chemical plants: these plants produce a wide range of raw and semi-finished products using different thermal en chemical processes. The used raw materials originate from oil refineries or other parties that have pre processed an oil derivative.
- bio based chemicals: these companies produce bio ethanol or bio diesel out of vegetable oils or seeds/grains.
- chemical gasses: these companies produce different types of gasses (such as hydrogen, nitrogen, oxygen) out of natural gas or by compression of air.
- waste water treatment facilities: these companies purify water using large aerated tanks and micro bacteria;

- container terminals: these companies offload and load containers from deep sea vessels onto and from trucks, trains and barges.
- oil refineries: These companies refine crude oil using distillation techniques.
- scrap storage and handling: These companies temporarily transfer and store scrap metals and partly cut of shredder the metals.

The following aspects were assessed for possible indicator usage:
- the total surface area of the company;
- the specific surface area of process installations;
- yearly throughput;
- electrical en thermal energy consumption;
- yearly usage of primary energy (calculated standardized energy usage from use of electricity, natural gas and steam);
- number of cranes;
- length of quay.

For the bio based chemicals two companies with different processes (production of bio ethanol and bio diesel) have been assessed. For these companies it is not logical to determine a mean value of the sound power in dB(A)/tons using only two companies who are also quite different in production process. Therefore for the bio based chemicals two indicators have been suggested

For the container terminals a separation has been made in large modern terminals that utilize automated guided vehicles (AGV's) and terminals smaller more classic terminals without AGV's (using straddle carriers).

For the waste water treatment facilities a separation has been made in facilities that utilize either cone aerators or fine bubble aeration.

For the scrap storage and handling companies a separation has been made in companies that merely transfer and store scrap and companies that process scrap (cutting/shreddering).

3. Indicator assessment

3.1 Throughput

Using the yearly throughput as possible indicator table I shows the relevant information used for the evaluation.

Table I. Sound powers per tons of yearly throughput

Company	L_W in dB(A)/tons (average values)
Generic chemicals	61
Bio based chemicals	
- bio ethanol	50
- bio diesel	57
Chemical gasses	59
Waste water purification	
- cone aeration	54*
- fine bubble aeration	49*
Container terminals	
- with AGV's	64^{Δ}
- without AGV's	62^{Δ}
Oil refineries	60
Scrap storage and handling	
- shipment and storage	58
- processing	60

* Sound power in dB(A)/purification unit (VC)

$^{\Delta}$ Sound power in dB(A)/TEU

AGV = automated guided vehicle for transporting containers from quay to stack

3.2 Surface area

In practice large parts of the surface area of these types of companies are not occupied by installations, but are empty spaces, offices, workshops or storage facilities. These parts are not relevant for the noise emission to the environment. Therefore as a noise indicator it seems logical to only consider the surface area of relevant noise emitting installations (installation area (ia), in m^2_{ia}). Table II shows the calculated sound power in dB(A)/m^2_{ia} and the sound power in dB(A)/m^2_{ta} (total company surface area). For the waste water purification companies the surface area of the 'installations' is the total aeration area (surface area with oxygen mixing).

Table II. Sound powers per m^2 (average values)

Company	L_W in dB(A)/m^2_{ta}	L_W in dB(A)/m^2_{ia}
Generic chemicals	64	71
Bio based chemicals		
- bio ethanol	64	74
- bio diesel	58	65
Chemical gasses	64	71
Waste water purification	69	72
- cone aeration	60	73
- fine bubble aeration	53	65
Container terminals	67	-
Oil refineries	68	77
Scrap storage and handling		
- shipment and storage	66	-
- processing	67	-

3.3 Alternative indicators

In the survey the company specifics thermal and electricity usage were also assessed, but found not usable because of too little available data. Also when assessing new companies on empty plots these figures are in general not yet available.

Developing an indicator using the length of quays gives information about the acoustical use of the quay, however has no efficiency judgement. With equal yearly throughput a company with a larger quay length could with the current way of noise budgeting in The Netherlands get a larger noise budget.

Therefore these other aforementioned company specifics are not assessed as a viable indicator for developing a benchmark value.

4. Acoustical efficiency rating

The ability of an industrial plant (part of a company) in producing a volume of products within a certain area is an indicator of compactness of the plant. When using an indicator which includes both the yearly throughput and the installation area a high value of that indicator can mean a high number of compactness and therefore more internal noise deflection and diffraction. This leads to a higher specific noise emission compared to similar plants with a lower indicator value. Therefore a single rating with indicators throughput versus installation area seems very helpful when assessing (benchmarking) the sound power of new companies or expansion of existing companies.

Using the indicators dB(A)/m^2_{ia} and dB(A)/tons a single value acoustical efficiency rating was developed for the generic chemical companies and the waste water purification facilities. Each of the separate indicators were assumed to determine 50% the total noise emission of the company, or both indicators have equal shares in the total noise emission.

The single value acoustical efficiency rating is determined using formula 1 for the generic chemicals and formula 2 for the water purification facilities.

$$L_{W;ek} = 10 \cdot \log\left(\frac{1}{2}10^{\frac{(10 \cdot \log(A_{IA})+71)}{10}} + \frac{1}{2}10^{\frac{(10 \cdot \log(D)+61)}{10}}\right) \quad (1)$$

$$L_{W;ek} = 10 \cdot \log\left(\frac{1}{2}10^{\frac{(10 \cdot \log(A_{IA})+65)}{10}} + \frac{1}{2}10^{\frac{(10 \cdot \log(VC)+49)}{10}}\right) \quad (2)$$

Table III shows a comparison of the calculated single value acoustical efficiency rating of each company. Using the calculated $L_{W;ek}$ and the given total sound power a normalized efficiency rating (E-rating) can be determined. An E-rating of less than 1 means a less efficient process. An E-rating of more than 1 can be judged as BAT, with the remark that the assessed companies and used processes are not equal (also different products manufactured) and therefore the calculated $L_{W;ek}$ and E-rating are indicative. The E-rating is determined by formula 3 and can be used as a benchmark when comparing the noise emission of companies.

$$E = 10^{\frac{(L_{W;ek} - L_W)}{10}} \quad (3)$$

The determined E-ratings are also presented in table III.

Table III. $L_{W;ek}$ and E-ratings

Company	L_w in dB(A)	A in m^2_{ia}	D* in ktons per year	$L_{w;ek}$ in dB(A)	E [-]
Generic chemicals					
1	125.2	214,559	3,355	125.4	1.1
2	127.2	112,207	2,022	123.0	0.4
3	121.9	78,432	975	120.5	0.7
4	119.7	135,000	745	121.2	1.4
5	114.7	27,309	450	116.6	1.6
6	118.4	26,894	200	114.7	0.4
Waste water purification					
1	103,1	1,400	86,000	98	0,3
2	106,0	4,360	154,000	101	0,3
3	99,9	4,487	135,000	101	1,3
4	97,4	3,127	77,000	99	1,5
5	97,1	1,128	105,000	98	1,2
6	104,8	708	44,800	95	0,1
7	110,9	4,841	430,000	104	11,6
8	96,9	3,845	84,000	100	1,9
9	118,3	1,500	307,655	102	0,02

* For the waste water purification facilities D is the total purification capacity (VC in formula 2).

5. Future noise emission indicators

A second part of the survey was to investigate possible future developments in which an effect of noise reduction and therefore lower indicator values are to be expected. For the assessed companies the following effects and noise reductions can be used.

Oil refineries, generic chemicals, bio based chemicals and chemical gasses
Most installations are relatively old and will be used for long periods. Production will probably only be raised by debottlenecking current installations. These limited alterations will not cause a significant reduction of the total sound power of the installations, but will cause a slight reduction of the indicator in dB(A)/tons. Also most equipment will, after the terms of technical depreciation, be replaced by more silent versions. This will cause a slight reduction of total sound power and the indicator value. On the other hand because of new (EU) regulations more downstream (gas or water) purification installations could be necessary, raising the total sound power and indicator values.

The net expected future noise reduction and indicator value reduction is estimated at 0 dB(A).

Container terminals
The expected future changes on container terminals, leading to a noise reduction are:
- better insulation of quay cranes;
- increased use of electric transportation vehicles (AGV's);
- replacement of the tug masters and MTS diesel engines by low noise vehicles, i.e. with CNG engines;
- use of new low noise straddle carriers with i.e. CNG engines.

The total net noise reduction and reduction of the indicator value is estimated at 2 dB(A).

Waste water purification
Necessary noise reducing measures are often directly related to the distance to nearby residential areas (or separate dwellings) and the necessity for odour reducing measures (which can also have an acoustical effect). A lot of measures such as placing engines and pumps inside buildings or enclosures and closing open aeration areas are already standard procedure. New installations or overhauls of existing installations will no longer use point aeration techniques, but will use bubble aeration techniques. For waste water purification plants where the aforementioned measures are not yet applied a noise reduction and indicator value reduction of 5-10 dB(A) is estimated.

Scrap storage and handling
Because of the relatively long use of equipment a significant direct effect in noise reduction and indicator value is not to be expected. Possible noise reducing measures and effects within 10 years are:
- better noise and vibration insulation of engines and hydraulic units with metal pinchers;
- new developments in engines and possible use of electric mobile cranes;
- use of electric harbour/quay cranes.

The total net noise and indicator value reduction is estimated at 0 to 1 dB(A).

6. Conclusions

This paper based on a survey done by Peutz describes a method in developing new noise indicators with specific activities taken into account. The presented indicators and ratings can be used when assessing new companies, expansion of companies, or when planning new industrial areas. The paper also describes a method for developing a single value efficiency rating and an normalized rating (E-rating) for an easy comparison of companies to acoustical performance in relation to throughput and used installation area. For generic chemical companies and water purification facilities the following formulas can be used.

Generic chemical companies:

$$L_{W;ek} = 10 \cdot \log\left(\frac{1}{2}10^{\frac{(10\cdot\log(A_{IA})+71)}{10}} + \frac{1}{2}10^{\frac{(10\cdot\log(D)+61)}{10}}\right) \quad (4)$$

Water purification facilities:

$$L_{W;ek} = 10 \cdot \log\left(\frac{1}{2}10^{\frac{(10\cdot\log(A_{IA})+65)}{10}} + \frac{1}{2}10^{\frac{(10\cdot\log(VC)+49)}{10}}\right) \quad (5)$$

As a quick benchmark a normalized E-rating value can be used, determined by formula 6.

$$E = 10^{\frac{(L_{W;ek} - L_W)}{10}} \quad (6)$$

This method can be used to develop these formulas for other types of companies. Also the indicators presented in table I and II can be used to benchmark the noise emission of companies to a company specific.

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