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Acoustic aspects of the development of silent loading and unloading devices

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Abstract

Increasing traffic jam problems during the day in combination with the change of opening times of shops has enlarged the demand of supplying shopping centres during the evening and early morning. Since loading and unloading activities near adjacent residences can be very disturbing to inhabitants rather rigid peak noise limits are applied in The Netherlands.
A research program 'Peak' has been developed by the governmental agency Novem to reduce the sound due to (un)loading trucks near shops. This program aims at measures at the sources, operational measures and measures at the location of (un)loading. Several feasibility studies regarding these aspects have been executed. In this paper the measures that have been examined at the source are presented for a number of devices that are used during loading and unloading of trucks. The devices are the cargo compartment, the hydraulic loading flap, the cooling unit and the containers. The measures that are taken to reduce the sound in different pilot plans will be described. The results of measurements before and after measures were taken are presented.

1. Introduction

The aim of the program 'Peak' is to reduce the peak levels (L_{max}: peak level measured in the position 'fast' of a sound level meter during a certain event) caused by the (un)loading activities to the value of 60 dB(A) or less at 7.5 m. This is based on the limits regarding L_{max} at the facades of residences according to legislation in The Netherlands. In that case the (un)loading activities can take place in most situations during the night. Of course in some situations with residences at larger distances higher peak levels at 7.5 m can be allowed. Only in situations with residences at a shorter distance then 7.5 m a lower value will have to be reached. In table 1 the common peak levels measured at 7.5 m of the relevant activities are shown. These values are based on specific measuring programs and on measurements done in practice [1].
To reduce the peak levels of these activities Novem has started up the program 'Peak'. In this program 10 projects are incorporated. These are:

1. Knowledge transfer, information to the market;
2. Stimulate silent behaviour by publishing a CD-rom and giving courses;
3. Guideline for the acoustical optimal design of (un)loading facilities near residences [1];
4. Silent distribution vehicle < 7.5 tons: whispertruck, presented at truck show RAI 2000;

5. Silent distribution vehicle > 7.5 tons: Distri-unit, silent cooling freighttrailer, silent driving unit;
6. Silent cooling unit on truck;
7. Silent unloading facility (hydraulic crane or lift truck) on truck;
8. Silent rolling containers;
9. Silent shopping cart;
10. Electrical driving gear.

Description	L_{max} at 7.5 m in dB(A)
Manoeuvring of trucks	83
Manoeuvring of vans	76
Cooling units of trucks	78
Excitation of cargo compartment of trucks and vans	80
Hydraulic loading flap of vehicles	92
Rolling containers	85
Pallet truck	93
Shopping cart	77
Lift truck	83
(Un)loading facility on truck	83
Unloading of bulk truck	93

Table 1: Peak levels (L_{max}) at 7.5 m of relevant (un)loading activities

At this moment most of these project are well ahead and the first results of research are available. In this paper the results of a part of project 5 (silent cooling freighttrailer), project 6 (silent transport cooling unit) and project 8 (silent rolling containers) are given.

2. Cargo compartment and hydraulic loading flap

The peak levels during loading and unloading are caused by the following activities:
- riding of the containers or pallet trucks in the cargo compartment and over the flap;
- riding of the containers or pallet trucks over uneven parts (e.g. the rolling stop devices and the transition between cargo floor and loading flap);
- the hydraulic motor of the loading flap;
- bumping of containers or pallets against the cargo compartment;
- closing of the loading flap, doors and curtains.

To reduce the peak levels caused by these activities the following measures are taken:
- The floor of the cargo compartment and the hydraulic loading flap are clad with a special rubber coating. Several rubber compounds were tested and the most promising has been chosen. This rubber compound has high vibration damping characteristics. Also the wear resistance is high and the rolling resistance is low.
- The uneven transition between the hydraulic loading flap and the cargo floor is reduced by using rubber flaps.
- The rolling stop devices are redesigned and provided with rubber buffers (less impact noise).
- The hydraulic motor of the flap is placed in an adequate acoustic enclosure.
- The sides of the cargo compartment are provided with rubber buffers.
- The contact surfaces between doors and cargo compartment are provided with rubber buffers.

- The steel rods and steel curtain wheels are replaced by components made of plastic.

In table 2 the results of measurements of cargo compartments with and without measures are shown. These measurements are carried out according a standardised method [2].

Activity	L_{max} in dB(A)	
	Standard	After measures
Moving hydraulic loading flap	69	55
Riding of container in cargo compartment	62	54
Riding of container over hydraulic loading flap	62	56
Riding of container over transition between floor and flap	65	50
Riding of container over transition between flap and road	71	67
Moving rolling stop devices	80	55
Moving curtain of cargo compartment	79	50
Collision simulation: steel ball against wall	66	53

Table 2: Effect of noise reducing measures for the cargo compartment and hydraulic loading flap.

The results of the measurements indicate that a maximum peak level of 60 dB(A) at 7.5 m can be reached except for one activity. For this activity the measures for the flap are not sufficient, also measures for the container and the road surface have to be taken (silent containers, a flat road surface or a rubber transition profile between the flap and the road).

3. Transport cooling unit

The peak level of 78 dB(A) at 7.5 m is based on standard diesel powered cooling units. It is very difficult to reduce this level to 60 dB(A) because the exhaust and the cooling of the engine require openings to the outside. To reduce the sound through these openings relatively big silencers are required that cannot be placed in the compact space that is generally available for a cooling unit. A low noise alternative is a CO_2-powered unit. This unit was available for use in the USA and Sweden for environmental reasons: less emission of exhaust gasses. The CO_2 is taken from processes in industry (recycled) and is stored in a tank on the trailer. It requires a refuelling station at the expedition centres.
The working of the cooling unit is given in figure 1. It uses compressed CO_2 to cool the cargo compartment. The expanded CO_2 is also used to drive a vapour motor that blows the cold gasses into the cargo compartment.

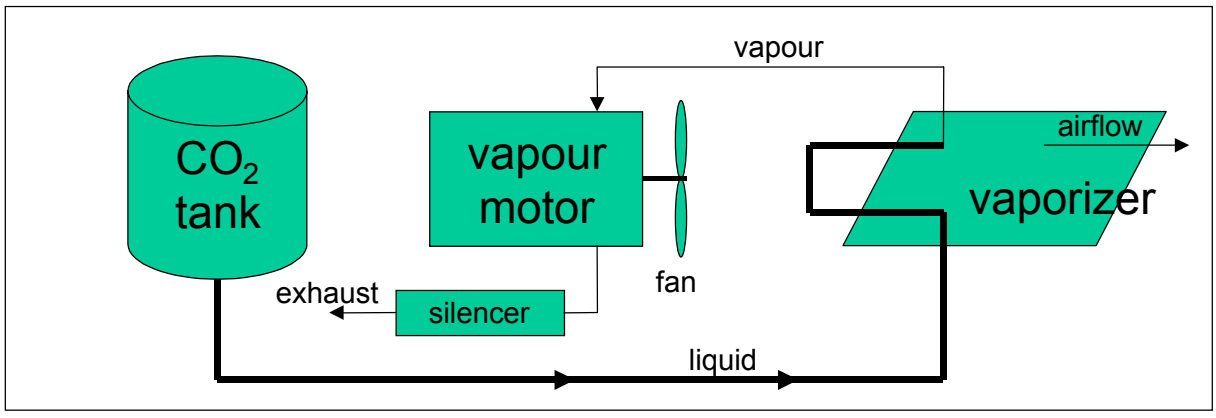

Figure 1: Working scheme of CO_2-powered cooling unit

The original unit caused a peak level at 7.5 m of about 68 dB(A). This was caused mainly by the vapour motor and the connected fan. To reduce this peak level the enclosure of the vapour motor and the fan were acoustically insulated. The exhaust of the motor was provided with a better silencer. This has resulted in a maximum peak level at 7.5 m of 60 dB(A).

4. Containers

There are several types of containers that are used to supply shops. In our research 15 different types were evaluated. The containers were tested on 3 types of road surface: flat concrete, concrete paving stones and concrete paving bricks. Also the load of the containers was varied: empty, silent load (sandbags) and crates with bottles. In table 3 the evaluation of some results of the measurements for 4 types of containers is given.

Situation	Type of container			
	steel wiring bottom		plastic bottom	
	'hard' wheels	'soft' wheels	'hard' wheels	'soft' wheels
Flat concrete surface				
- no load	++	++	+/-	++
- silent load	++	++	+	++
- 8 crates	+	+	-	+
Concrete paving brick surface				
- no load	-	+	--	+
- silent load	+	+	--	++
- 8 crates	-	-	--	--

++ = requirement amply met: L_{max} is less than 55 dB(A) at 7.5 m distance
+ = requirement met (60 dB(A) at 7.5 m distance)
+/- = it may be possible that the requirement is met, but a small exceeding of the requirement can not be excluded
- = requirement exceeded with less than 5 dB(A): L_{max} is less than 65 dB(A) at 7.5 m distance
-- = requirement exceeded with more than 5 dB(A): L_{max} is more than 65 dB(A) at 7.5 m distance

Table 3: Effect of noise reducing measures for the cargo compartment and hydraulic loading flap.

From the results of the research it is concluded that most of the containers on a smooth surface and for all kinds of loads meet the requirement of 60 dB(A) at 7.5 m. On a surface of concrete paving bricks for some loads the requirement can be met. This indicates that for the activities during the night a smooth surface is necessary, unless special measures are taken for the containers. Based on this feasability study propositions for these measures are given. It is now up to the manufacturers to implement these propositions.

Conclusions

From the results of the measurements can be concluded that in many cases sufficient reduction can be reached by taking the appropriate (combination of) measures. An exception has to be made for the manoeuvring of trucks. The economical aspects of the measures have to be discussed. It is expected that on relatively short notice companies who want to (un)load trucks during the evening and night will seriously consider the measures.

References

1. "Preliminary guideline concerning the acoustic optimal design of loading and unloading locations" (in Dutch), CROW report 00-1, February 2000
2. A.M. van Noort, ir. P.P. Kooyman, "Propositions for the assessment methods of peak levels at (un)loading" (in Dutch), TNO-report HAG-RPT-980088, November 1998