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ACOUSTICAL OPTIMAL DESIGN OF (UN)LOADING FACILITIES OF SHOPPING CENTRES NEAR RESIDENCES

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ABSTRACT
Increasing traffic jam problems in the day period in combination with change of opening times of shops has enlarged the demand of supplying stores in the evening and night period. When provisioning activities take place near adjacent dwellings, it can be very disturbing to neighbours. A guideline has been made concerning the acoustical optimal adaptation and/or design of such (un)loading facilities near small and large, existing and projected shopping centers. Based on the relevant acoustical parameters, such as different noise sources with specific sound power levels, distances to dwellings, specific handling devices and geographical configurations, a step by step approach is described by which the owner, designer and local government can assess the (un)loading facility regarding the noise aspect (especially maximum noise levels). Based on this assessment, adequate noise reducing provisions can be selected, related to the exceeding of noise limits. The different kinds of provisions are described. The methodical structure and basic contents of the guideline will be presented in this paper.

1 - INTRODUCTION

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 night. When loading and unloading activities take place near adjacent residences, it can be very disturbing to inhabitants. A guideline has been developed concerning the acoustical optimal design or adaptation of (un)loading facilities near shopping centres. The complete guideline is given in reference [1]. A step by step approach is described, based on the relevant acoustical parameters, such as different activities causing noise with specific sound power levels, distances to residences, specific handling devices and geographical configurations. With this approach the owner, designer and local government can assess the noise levels near residences caused by the activities taking place at the (un)loading facility. Based on this assessment adequate noise reduction measures can be selected, which are described.
The guideline concentrates on peak levels (L_{max}: peak level measured in the position 'fast' of a sound level meter during a certain event). The legislation in the Netherlands is relatively strict in the limits for these peak levels, especially in the evening and the night. Regarding the day there are no limits for the peak levels due to manœuvring and (un)loading activities, only the equivalent noise levels are limited. The limits for the equivalent noise levels in the evening and night are in most cases not exceeded, because the (un)loading activities are less frequent and last shorter than during the day.

2 - ASSESSMENT: STEP BY STEP APPROACH

A step by step approach is used to assess whether noise-limits are exceeded or not. If necessary the approach gives a first impression of the noise reduction measures that have to be taken, and their effect.
Step 1: Assess which (un)loading activities take place and what peak levels can be expected. In table 1 the common peak levels measured at 7.5 m of the relevant activities are shown. These values are based on primary feasibility study [2].

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

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

Step 2: Assess which activities take place in the evening or night.
Step 3: Determine shortest distance of each of these activities to residences.
Step 4: Determine the peak levels at the residences with the following formula:

$$L_{max}\,(\text{residence}) \;= L_{max}\,(7.5\text{m}) - 20\log\;(\text{distance}/7.5)$$

In figure 1 this formula is visualised. This figure shows also the limits regarding L_{max} at the facade of near residences according to legislation of the Netherlands: 65 dB(A) in the evening (19.00 h until 23.00 h) and 60 dB(A) in the night (23.00 h-07.00 h).

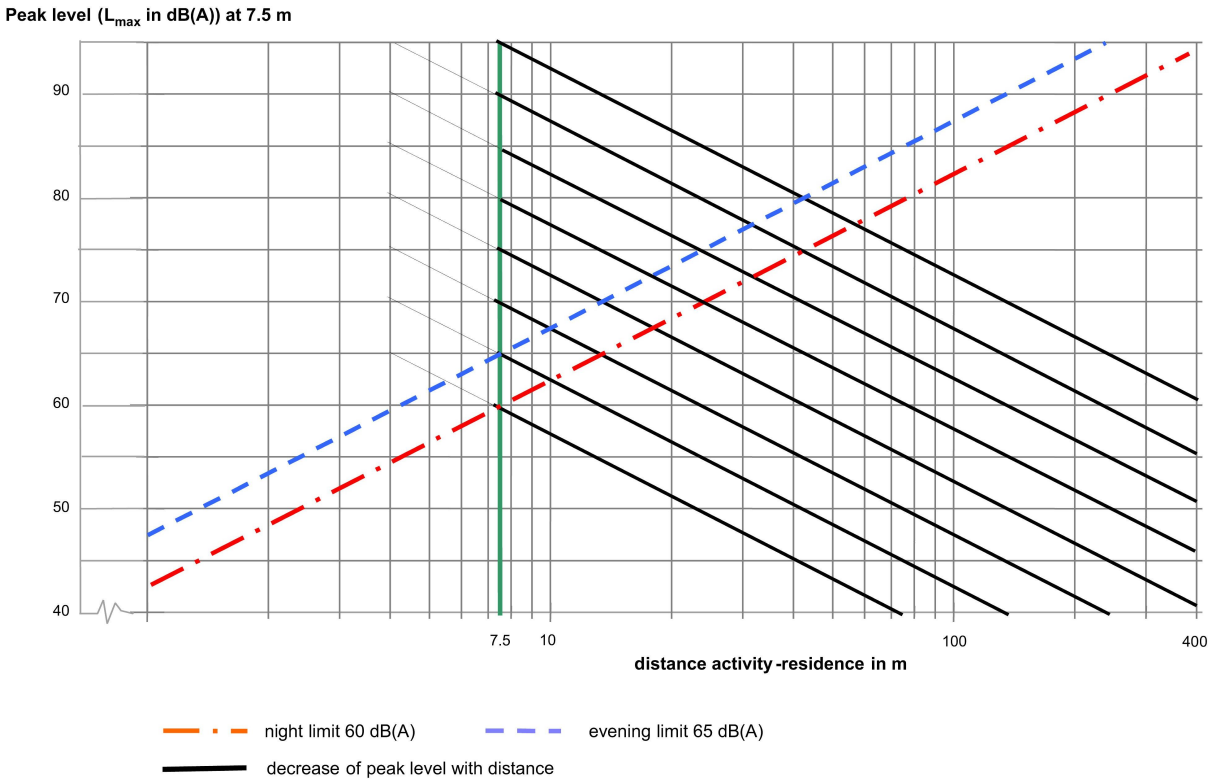

Figure 1: Peak levels varying with distance.

Step 5: Check whether reflections against buildings or other objects are possible. If such reflections can be expected a value of 2 dB(A) as a rough estimate can be added to the noise level determined in step 4.
Step 6: Check per activity whether the limits for the peak levels are exceeded or not.
Step 7: Determine the possible noise reducing measures at the source for those activities that exceed the limits. Calculate the peak level taking into account the effect of the measures.
Step 8: Check whether the peak levels, calculated in step 7, exceed the limits.

Step 9: If after step 8 the limits are still exceeded, measures in the noise path (e.g. noise barriers or surrounding the location with walls and roof) must be considered. In that case the kind of exceeding of the limits is important. In general an additional reduction of 5 to 10 dB(A) is possible by realising noise barriers. If higher reductions are necessary or if reflections make noise barriers ineffective, a completely closed loading facility (with walls and roof) has to be considered seriously. Also increasing the distance between the (un)loading activities and the residences can be effective, although in practice this is only possible in a few situations.
For new situations a similar step by step approach is proposed. In this case in step 3 the necessary minimal distance between the activities and the residences can be calculated by using the formula:

$$\text{Minimal distance} = 7.5 \times 10^{(L_{max}(7.5m) - \text{limit})/20}$$

If this distance is not acceptable new calculations can be made taking into account the several types of noise reducing measures that are feasible.

3 - GENERAL RECOMMENDATIONS

In the guideline some general recommendations are described by which peak levels can be reduced in height and/or amount.

3.1 - Routing

The routing of the vehicle to the unloading location has to be designed in such a way that manœuvring with trucks is limited to the minimal, for which guidelines are given.

3.2 - Lay-out of the location

The dimensions of the (un)loading location have to be large enough to accommodate the maximum amount of vehicles that can be expected simultaneously. If at a certain moment more vehicles have to be accommodated a waiting location at maximum distance to residences has to be available, avoiding unloading activities at locations that are not suited for it, especially near residences.
The pavement of the route from the unloading location to the expedition or the store has to be as smooth as possible. Rough elements or thresholds have to be avoided, especially when containers or pallet-trucks are used.

3.3 - Instruction of employees and drivers of vehicles

In practice it appears that most of the annoyance is caused by behaviour of employees and drivers. These have to be instructed to avoid unnecessary noise, like shouting, smashing doors, loud radio, running engines for long periods.

4 - NOISE REDUCTION MEASURES

4.1 - Relevant parameters

The relevant parameters regarding peak levels at the residences are the sound power level of the unloading activities, the distance between the source and the receiver and the objects that reflect or shield the noise. Besides that, operational parameters like period of time and duration of activities, and specific aspects of the residences like the height and the sound insulation of the facade play an important part. Figure 2 shows an example of a situation and the relevant parameters.

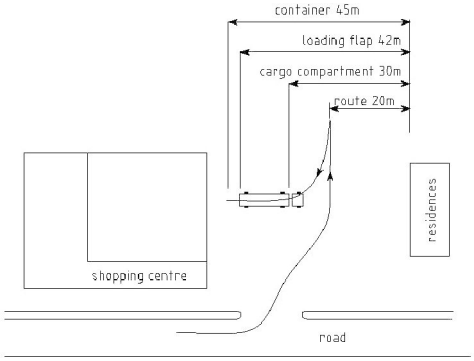

Figure 2: Example of a situation and the relevant parameters.

4.2 - Measures at the source
An extensive research program regarding measures at the source by different parties is still in progress. By the end of 2000 the studies for most of the activities will be ready. As an example table 2 shows the possible noise reducing measures for the hydraulic loading flaps of trucks. The values are based on reference [2] and on the measured data of situations in practice. The guideline gives similar tables for the other activities mentioned in table 1.

Description of measure	Source responsible for highest peak level	L_{max} in dB(A) at 7.5 m
Without measures	Impact of the flap against the road-surface	92
1. Rubber buffers at the contact surface of the flap	Impact of flap against cargo compartment	84
Measure 1 and 2. Rubber buffers at contact surface of flap and cargo compartment	Retracting and folding in the limitation that prevents the containers or pallet-trucks of rolling off the flap	83
Measures 1, 2 and 3. Synthetic or rubber buffer at the limitation	Impact of flap against cargo compartment	70

Table 2: Noise reduction measures for the hydraulic loading flap of trucks.

4.3 - Measures at the road-surface of the unloading location
The roughness of the road surface and the presence of differences in height cause high peak levels, if containers, pallet trucks or lifting trucks are used for unloading of cargo. Therefore it is important that the road surface from the unloading location to the expedition is as smooth as possible. If the road is made of bricks the peak levels can not be reduced adequately. Also when asphalt or concrete is used roughness can occur at holes in the pavement. Regular maintenance is necessary to keep the road surface in good condition.

4.4 - Measures in the noise path
Increasing the distance between the unloading location and the residences can be considered. In some situations noise barriers can be effective. When reflections against objects occur this reduction can be limited locally.
By using loaddocks (or dockshelters) the noise caused by the containers or pallet trucks rolling at the road-surface is reduced effectively. What remains is rolling noise from containers or pallet trucks in the cargo compartment of the truck. Also the threshold between the cargo compartment and the loaddock has to be flat to avoid peak levels.
If the reduction of noise barriers or loaddocks is not sufficient the roofing over of the unloading location can be considered. In new situations this can be realised by a location under the shop level. In this location a floating floor might be necessary, when residences are realised in the same building. Also the sound insulation of the floor between stores and residences has to be sufficient.

4.5 - Operational measures
If measures at the source and other measures cannot provide enough reduction, the activities that exceed the limits have to be carried out during the day. If supplying the shop in the evening or night is necessary more extreme measures can be considered like situating the unloading activities at a non-critical location (e.g. at the border of the city). For the transport of the goods to the shops a system with specially designed electrical vehicles will be necessary.

4.6 - Measures at the facade of the residences
When all measures are considered the final step can be to improve the sound insulation of the facade of the residences. In that case, despite of the high peak levels at the facade, the noise levels inside the residences can be acceptable. In existing situations this measure requires the acceptance of the inhabitants. In new situations this measure can be incorporated in the design.

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