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NOISE REDUCTION ON TANKERS AND REFRIGERATED DELIVERY VEHICLES

F. MOSCHEL

FIGE GmbH Forschungsinstitut Geräusche und Erschütterungen, Technologiepark, Kaiserstrasse 100, D-5120 Herzogenrath, F.R.G.

Resumé: Programme de recherches "définition des critères de véhicules utilitaires peu bruyants à agrégats supplémentaires bruyants" de l'Office Fédérale de l'Environnement à Berlin, mesures de réduction du bruit, véhicule-citerne, véhicule à réfrigération, réduction du niveau acoustique de plus de 10 dB(A).

Abstract: Noise reduction measures on fuel oil tankers and refrigerated lorries used in local distribution networks were investigated as part of the German Federal Environment Agency (Umweltbundesamt, UBA) research programme for the "Definition of Criteria for Low-Noise Utility Vehicles with Noise-Relevant Ancillary Units". Reductions of more than 10 dB(A) were achieved.

1 — Reduction of Chassis Noise

A Type 2222 C 3-axle, 22t vehicle adapted to meet the "low-noise" criterion as specified in § 49 of the Traffic Regulation Order(1) (StVZO) was selected as the basic vehicle. Modifications were as follows:

- reduction of the rated engine speed from 2,300 rpm on the original engine to 1,800 rpm, with only slightly reduced rated power; this modification reduces noise by 3 dB(A) as compared to the original version;
- modified combustion cycle;
- sound encapsulation below the engine and gearbox and at the rear of the cab;
- wheel housings to prevent sound escaping from the sides of the wheels;
- acoustically improved exhaust system;
- sound insulation on all air-brake pressure release valves.

2 — Noise Reduction Concept for Ancillary Units

The following procedure was selected for development work on reducing ancillary unit noise:

- Existing commercial units already embodying noise reduction features were selected as the point of departure for the investigations.
- A sound source analysis establishing the relevant sound sources, their characteristics and their contribution to the overall noise emission of the unit was carried out.
- Noise emission was determined as a function of operating parameters or design features, e.g. noise reduction as a result of reduced fan speeds achieved by using larger fans.
- Alternative operating principles (e.g. compressors) were investigated.
- Individual components producing the least possible noise while remaining economically viable were selected and used.
- As a final resort, sound insulating capsules and hoods were used to reduce noise.

In planning the noise reduction measures, particular attention was paid to preventing indirect sound propagation, in order to avoid undesirable resonances through structure-borne sound transmission.

(1) Straßenverkehrszulassungsordnung
3 - FUEL OIL TANKER

At a distance of 1 m from the pumping position, conventional tankers produce a noise level of approximately 85 dB(A) during the pumping process, constituting a considerable potential noise load and annoyance for residents and passers-by. The objective of the research project was therefore to reduce noise emission from a conventional 18 000 l tanker to a point at which not only a measured difference but a clear subjective difference was experienced. There was to be a reduction in both pumping and driving noise. The entire vehicle was subsequently to be classified as "low-noise". Criteria and noise limits for this classification are laid down in the StVZO.

The vehicle was to have two separate pumping assemblies with hydraulic pumping plant. As compared to direct pump drives, hydraulic drives represent an additional sound source; on the other hand, they allow the noise reduction modifications to be applied on articulated lorries.

It was evident from preliminary investigations that the vehicle engine and the pump assemblies were responsible for equal shares of the total noise emission. Consequently, modifications were needed to reduce noise from both these sources.

Pump noise reduction: Vane cell pumps are generally used in tanker construction, owing to their considerable advantages of size, weight, priming characteristics and cost as compared to other - lower-noise - types of pump (e.g. centrifugal pumps). Preliminary tests were carried out to establish the optimum pump in terms of noise and power criteria. Pump size, operating speed and the shape and material of the vanes were varied. As a result of the tests, the speed of the fuel oil pump was reduced from 1 200 rpm to 700-800 rpm. A larger fuel oil pump was installed to maintain the same pumping volumes.

Additional modifications prevent sound propagation to other parts of the vehicle. The pump assembly was insulated to prevent transmission of structure-borne sound and encapsulated in a separate pumping assembly enclosure. All connections between the pump assemblies and the delivery pipes were structure-borne-sound insulated (Fig. 1).

Other vehicle modifications:
- Use of a low-noise chassis: 3-5 dB(A)
- Reduction of pump drive speed: 2 dB(A)
- Quieter internal gear pump and reduced hydraulic pump speed: 10 dB(A)

Pump noise was reduced by 11 dB(A). Owing to the considerably greater reduction of the pump noise component, the engine becomes the clearly predominant sound source, and is subjectively perceived as such. At present, therefore, further reduction of pump noise is unhelpful, as it cannot contribute to additional reduction in total vehicle noise during the pumping process (Fig. 2).

4 - REFRIGERATED DELIVERY VEHICLE

Unlike many other types of vehicle, refrigerated vehicles may continue to constitute an annoying sound source even when they are stationary and the engine is not running. The refrigeration unit is normally pre-cooled or kept at a lower temperature overnight, while deliveries are also sometimes made at night or in the early hours of the morning. Considerably higher noise levels are encountered where the refrigeration plant is powered by a generator or a separate engine while being driven. During deliveries, these are supplemented by loading and unloading noises which have an annoying effect due to their predominantly tonal sound components. Noise reduction measures therefore need to centre on the vehicle engine or alternatively on the separate engine, followed by the refrigeration plant and the loading platform.

Reduction of loading noise: Investigations into the reduction of loading noise from rolling containers on different types of surface indicated that the influence of the bodywork floor on rolling noise emission is very much greater than that of the type and material of the rolling container or of the bodywork itself.

Greater noise reductions are achieved with floors constructed of screen-printed plates and sandwich plates.
Noise reduction modifications to the loading platform: The loading platform was constructed in plastic as a sandwich structure. The cavity is filled with a rigid expanded polyurethane largely free of thermal bridges, which as a side-effect reduced rolling noises on the loading platform by 26 dB(A) as compared to conventional platforms.

The platform raising noise was reduced by 8 dB(A) as compared to conventional plant by fitting a slower-speed hydraulic drive unit with enlarged working volume, which was also sound-insulated and structure-borne-sound insulated in the axle tube. The speed reduction eliminated the subjectively irritating frequency components (Fig. 3).

Platform locating noises were reduced by 11 dB(A) through the use of a complex proportional control system with continuous deceleration to decrease the raising and lowering speed shortly before the stop position. In the series production model, this was replaced by a more economic two-step control.

Noise reduction modifications to the refrigeration plant: Noise reduction modifications were carried out on a refrigeration unit which had already been identified as the most suitable for further noise reduction measures in the preliminary tests.

A sound source analysis was followed by investigation of numerous fans and compressors of different makes, designs and power unit types. Tests were conducted in an acoustic test room on a fan test stand and in the case of the compressors on a test stand for refrigerating capacity.

The use of larger fans at lower refrigerating compressor speeds, coupled with a two-speed circuit with a pole-changing motor and an additional sound absorber, enabled the refrigerating plant to attain a noise level of 43 dB(A) at a distance of 7 m at the lower nighttime speed of 575 rpm. The reduction as compared to conventional plant is 24 dB(A). At the standard speed of 1 150 rpm, equivalent to a refrigeration capacity only marginally less than that of the original model, the highest noise level was no more than 53 dB(A) (Fig. 3).

Noise reduction modifications to the diesel generator: The most complex task was the reduction of the noise level of the diesel generator set used to power the refrigeration plant. Even modern diesel-powered refrigeration equipment averaged values of 75 dB(A). A 12 dB(A) reduction was required to achieve the desired objective of 63 dB(A).

In devising a reduction concept, special attention needed to be paid to the space available in the vehicle. Owing to the enclosed refrigerated unit, the assembly had to be mounted at the side under the chassis.

The required generator set was to be designed for a power output of 7/10 kVA. Small industrial diesels with a cylinder capacity of roughly 1 000 ccm are capable of achieving this power. These engines are more compact than pre-encapsulated engines with close-mounted engine capsules, which would also have required a second capsule with ensuing maintenance problems.

The optimum solution proved to be a 3-cylinder precombustion chamber diesel engine with a capacity of 952 ccm and a rated power of 14.7 kW at 3 000 rpm, which also provided adequate power reserves for any speed reduction which might prove necessary.

To save weight on encapsulation, sandwich materials with elastic interlayers were tested for their sound absorption properties alongside such alternative materials as aluminium, steel and glass-fibre reinforced plastic. Depending on local requirements, the encapsulation therefore consists of stainless steel, aluminium and plastic linings with absorptive material bonded to the interior surface.

Structure-borne sound insulation of the drive unit from the main frame was achieved by using elastic engine mountings with metal-rubber elements specially matched to the engine characteristics and the envisaged engine speeds. In the prototypes, link elements were also used to insulate the main frame from the outer frame.

On completion of the prototype, admission and exhaust sound absorbers still had to be optimized for the
systems to reduce are encountered in this speed range, a system with two reflective sound dampers was selected from several combinations of commercial absorptive and reflective sound dampers. The standard air filters were incapable of meeting the acoustic criteria required in this case. An additional absorber producing the necessary effect was therefore designed.

The modified generator set attained a maximum noise level of 60 dB(A) at a distance of 7 m at its higher speed, i.e. some 16 dB(A) below the level for conventional diesel-powered vehicle refrigeration plant (Fig. 3).

<table>
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<tr>
<th>Table 2. Geräuschpegel des Pumpaggregates in 7 m Abstand vom Armaturenshrank bei Fremdantrieb durch eine Hydraulikanlage für verschiedene Minderungsstufen. Tankaufbau mit Armaturenshrank ohne Trägerfahrzeug – fremd angetrieben, Förderleistung ca. 550 l/min gegen 3 bar</th>
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Alle Pegel gemessen in 7 m Abstand vom Armaturenshrank

Fig. 1

max. Geräuschpegel in 7 m

Fig. 2

Fig. 3

Prinzip Schalldämpfer