

Report I.2007.1070.00.R002

Acoustic Investigation Ceres

Status: FINAL

Adviseurs voor bouw, industrie, verkeer, milieu en software

lid

info@dgm.nl
www.dgm.nl

Van Pallandtstraat 9-11, Postbus 153
NL-6800 AD Arnhem
T +31 (0)26 351 21 41
F +31 (0)26 443 58 36

Eisenhowerlaan 112, Postbus 82223
NL-2508 EE Den Haag
T +31 (0)70 350 39 99
F +31 (0)70 358 47 52

Morra 2, Postbus 671
NL-9200 AR Drachten
T +31 (0)512 52 23 24
F +31 (0)512 52 25 19

Geerweg 11, Postbus 640
NL-6130 AP Sittard
T +31 (0)46 411 39 30
F +31 (0)46 411 39 31



Order Data

| | | |
|---|--|---------------|
| Report No.: | I.2007.1070.00.R002 | |
| Place and Date: | The Hague, 10 th February 2010 | |
| Version: | 003 | Status: FINAL |
| Client: | Port of Amsterdam P.O. Box 19406 1000 GK AMSTERDAM | |
| Contact: | Mr. A. J. G. van Breemen | |
| Telephone: | + 31 (0)20 523 45 00 | |
| Fax: | + 31 (0)20 620 98 21 | |
| E-mail: | ton.van.breemen@portofamsterdam.nl | |
| Executed by: | DGMR Industrie, Verkeer en Milieu B.V. | |
| Information: | M.A.W. Jansen | |
| E-mail: | mja@dgmr.nl | |
| Telephone: | +31 (0)70 350 39 99 | |
| Fax: | +31 (0)70 358 47 52 | |
| Author(s): | M.A.W. Jansen ir. J. Witte / R.L.Q. Maas | |
| Final Responsibility: Under consignment: | J.F. Cleij ir. J. Witte | |
| Secretary: | LGU/MEL | |

| CONTENTS | PAGE |
|--|-------------|
| 1. INTRODUCTION..... | 4 |
| 2. IMMISION MEASUREMENTS | 5 |
| 2.1 Introduction | 5 |
| 2.2 Measurement results..... | 5 |
| 3. EMISSION MEASUREMENTS..... | 7 |
| 3.1 Introduction | 7 |
| 3.2 NYK Lyra | 7 |
| 3.3 NYK Pegasus | 8 |
| 4. TRANSMISSION | 9 |
| 4.1 Introduction | 9 |
| 4.2 Measurements on the ships (see chapter 3) | 9 |
| 4.3 Calculations..... | 9 |
| 4.4 Calculations compared with the measurements..... | 10 |
| 5. SOUND PRESSURE LEVELS NEAR WESTZAAN | 11 |
| 5.1..... | 11 |
| 6. CALCULATIONS OF SOUND POWER LEVELS OF THE SHIPS | 11 |
| 7. NOISE MITIGATING MEASURES | 12 |
| 7.1 The chimney of the exhaust and ventilation systems of the auxiliary engine | 12 |
| 7.2 The ventilation system for the cargo space..... | 12 |
| 7.3 Examples reductions | 13 |
| 7.4..... | 13 |
| 8. SOUND PRESSURE LEVELS AT VELDWEG | 14 |
| 8.1 the Lyra | 14 |
| 8.2 the Pegasus..... | 14 |
| 9. CONCLUSIONS..... | 15 |

Figure 1: location

1. Introduction

On behalf of the Port of Amsterdam, DGMR Industrie, Verkeer en Milieu B.V. has performed an acoustic investigation in the surroundings of Ceres Paragon Terminal on the industrial estate Westpoort in Amsterdam. Inhabitants of Westzaan and Zaandam have indicated that noise annoyance is experienced and as most likely cause the ships in the port of the Ceres Paragon Terminal have been indicated. The ships are moored at the dock of the Ceres Paragon Terminal. On the various ships a number of sound sources were found. These sources are well audible at the north side of the North Sea Channel.

Measurements are performed in the surroundings of the ships. In this report the results of the measurements and calculations are described. Furthermore noise mitigating measures and their effects are investigated.

Measurements were carried out in the months March, April, May and June 2007. The measurements have been made on the dike of the North Sea Channel (P1-13) and on the Ruigoordweg near Ceres Paragon Terminal.

Also emission measurements were carried out on board of two ships, the NYK Lyra and the NYK Pegasus, both moored at the dock of the Ceres Paragon Terminal.

In the past, DGMR has performed extensive investigations to the sound production of ships when they are in the harbour. These investigations are described in DGMR-report W.93.530.D of 6th February 1995 and W.97.0799.C of January 2003. From these previous investigations it appeared that for the largest category of ships (to which also the NYK Lyra and the NYK Pegasus belong to) an average sound power level is found of 110 dB(A).

2. Immision measurements

2.1 Introduction

As stated before, measurements were carried out in the months of March, April, May and June 2007. The measurements have been done on the bank of the North Sea Channel (P1-13), the Veldweg in Westzaan and on the Ruigoordweg near Ceres Paragon Terminal.

Table 1
Measurements

| date | d/e/n | ship | location |
|------------|---------|-----------------------|-------------|
| 9 March* | evening | OOL Shenzhen | P1-13 |
| 12 March | night | NYK California Luna | P1-13 |
| 23 March* | day | HLC Francisco Express | P1-13 |
| 26 March | day | NYK Pegasus | P1-13 |
| 30 March** | day | HLC Bangkok Express | Ruigoordweg |
| 25 April | day | NYK Lyra | P1-13 |
| 20 June | evening | NYK Lyra | P1-13 |
| 20 June | evening | NYK Lyra | Veldweg |

*Considering the influences of high wind speed, the data of various measurements should be interpreted with caution.

**The measurements on location "Ruigoordweg" did not meet the optimal meteoconditions. Therefore these results are not used in this investigation.

2.2 Measurement results

In the surroundings of the Ceres Paragon Terminal the measurements are carried out. These measurements are performed with a sound level meter B&K 2260 which is calibrated before the measurements. The measurements are performed on the following locations:

- location P1-13: on the bank on the other side of the North Sea Channel (P1-13), on a distance of approximately 500 m from the ship. The measurement height is 5 m above the bank;
- location Veldweg in Westzaan on approximately 1,2 km distance from the ship.

All the measurement heights are 5 m. Locations of the measurement points are given in figure 1. The measurements are performed with a standard windshield (diameter approximately 10 cm) mounted on the microphone. On 9, 23, and 30 March the wind reached an average speed of approximately 50 km/h. The results are shown in table 2.

Table 2
Measurement results location P1-13 and Veldweg
in dB(A) per octave band [Hz]

| date | type | 31 | 63 | 125 | 250 | 500 | 1k | 2k | total |
|------------------------|-------------|-----------|-----------|------------|------------|------------|-----------|-----------|--------------|
| 9 March 2007* | L95 | 38.5 | 46.6 | 50.2 | 50.7 | 52.3 | 50.5 | 45.3 | 57.7 |
| 12 March 2007 | L95 | 36.1 | 37.4 | 40.3 | 43.5 | 44.9 | 42.1 | 35.5 | 50.6 |
| 23 March 2007* | L95 | 31.7 | 39.9 | 43.6 | 45.0 | 46.1 | 45.6 | 40.2 | 52.8 |
| 26 March 2007 | L95 | 33.6 | 40.8 | 47.2 | 49.8 | 51.3 | 48.7 | 41.7 | 56.7 |
| 25 April 2007 | L95 | 29.4 | 37.5 | 41.2 | 46.5 | 49.0 | 46.2 | 41.0 | 53.0 |
| 20 June 2007 | L95 | 26.4 | 37.9 | 42.3 | 49.0 | 51.1 | 48.0 | 43.3 | 56.2 |
| 20 June 2007 (Veldweg) | L95 | 22.1 | 25.6 | 22.0 | 37.7 | 34.8 | 33.4 | 27.9 | 41.4 |

In table 2 the octave bands of 4 kHz and 8 kHz are not shown because these are not relevant: the contribution to the total level is very small and arises moreover mainly as a consequence of wind rustling.

Since the ships produce a very constant noise, there has been made use of the so-called L_{A95} . That is the sound level which is exceeded 95% of the measuring time. By using the L_{A95} , the influence of the wind remains to a minimum, thus giving a better judgment of the sources that produce the continuous noise.

*Considering the influences of high wind speed, the data of various measurements should be interpreted with caution.

3. Emission measurements

3.1 Introduction

Emission measurements have been carried out on board of the NYK Lyra and the NYK Pegasus, in the dock of the Ceres Paragon Terminal. The ships are navigated forward into the dock. The backs of the ships are facing east. A number of sound sources were found which are well audible at the north side of the north sea channel. Measurements were carried out on the NYK Lyra on 25 April 2007 and on the NYK Pegasus on 29 May 2007. On board measurements were carried out on the normative noise sources. These sources are:

- the chimney of the exhaust and ventilation systems of the auxiliary engine at the back of the pilothouse of the ship;
- the ventilation system of the engine room at the back of the pilothouse of the ship.

3.2 NYK Lyra

3.2.1 Air vents

The air intake/outlet vents were found at the back of the pilothouse of the ship on a height of approximately 30 m above the water line.

In total there are six air vents with a total surface of 35 m². The total sound power level is determined at 114 dB (A), the spectrum is given in table 3.

Table 3
Total sound power level of the air vents in dB(A)

| octave band [Hz] | 31 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | total |
|------------------|----|----|-----|-----|-----|-----|-----|----|----|-------|
| [dB(A)] | 81 | 95 | 103 | 106 | 109 | 107 | 104 | 95 | 87 | 114 |

3.2.2 Chimneys of the exhaust system

The chimneys of the motors were found at the top of pilot house of the ship on a height of approximately 45 m above the water line. In total there are seven chimneys present, six have a diameter of approximately 0.5 m for the power generator, and one chimney with a diameter of approximately 3 m is for the main engine. When the ship lies in the dock of the harbour one of the smaller chimneys is in use for the power management on the ship. This chimney is measured as a concentrated source. The sound power level of the chimney is determined at 110 dB(A), the spectrum is given in table 4.

Table 4
Total sound power level of the chimney in dB(A)

| octave band [Hz] | 31 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | total |
|------------------|----|----|-----|-----|-----|-----|----|----|----|-------|
| [dB(A)] | 64 | 77 | 99 | 105 | 106 | 103 | 99 | 92 | 82 | 110 |

3.2.3 Total sound power level of the Lyra

In table 5 the total sound power level of the emission measurements is given.

Table 5
Total sound power level of the NYK Lyra in dB(A)

| octave band [Hz] | 31 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | total |
|------------------|----|----|-----|-----|-----|-----|-----|----|----|------------|
| SPL measured | 81 | 95 | 104 | 109 | 111 | 108 | 105 | | | 115 |

3.3 NYK Pegasus

3.3.1 Air vents

The air intake/outlet vents were found at the back of the pilothouse of the ship on a height of approximately 30 m above the water line. There are twelve air vents with a total surface of 48 m². The total sound power level is determined at 120 dB (A), the spectrum is given in table 6.

Table 6
Total sound power level of the air vents in dB(A)

| octave band [Hz] | 31 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | total |
|------------------|----|----|-----|-----|-----|-----|-----|-----|----|------------|
| [dB(A)] | 79 | 91 | 109 | 113 | 115 | 114 | 108 | 100 | 88 | 120 |

3.3.2 Chimneys of the exhaust system

The chimneys of the motors were found at the top of the pilot house of the ship on a height of approximately 45 m above the water line. In total there are seven chimneys present, six have a diameter of approximately 0.5 m for the power generator, and one chimney with a diameter of approximately 3 m for the main engine. When the ship lies in the dock of the harbour one of the smaller chimneys is in use for the power management on the ship. This chimney is measured as a concentrated source. The sound power level of the chimney is determined at 110 dB(A), the spectrum is given in table 7.

Table 7
Total sound power level of the chimney in dB(A)

| octave band [Hz] | 31 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | total |
|------------------|----|----|-----|-----|-----|----|----|----|----|------------|
| [dB(A)] | 89 | 94 | 100 | 100 | 102 | 91 | 84 | 73 | -- | 106 |

3.3.3 Total sound power level of the NYK Pegasus

In table 8 the total sound power level of the emission measurements is given.

Table 8
The total sound power level of the NYK Pegasus in dB(A)

| octave band [Hz] | 31 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | total |
|------------------|----|----|-----|-----|-----|-----|-----|----|----|------------|
| SPL measured | 89 | 96 | 110 | 113 | 115 | 114 | 108 | | | 120 |

4. Transmission

4.1 Introduction

Measurements were carried out with a B&K class 1 sound level meter. The tolerances of the measurement are within the values stated in section 2.5.1 of the Dutch "Handleiding Meten en Rekenen Industrielawaai" (Manual for measuring and calculations industrial noise).

4.2 Measurements on the ships (see chapter 3)

The ships are navigated forward into the dock. The backs of the ships are facing east. A number of sound sources were found which are well audible at the north side of the North Sea Channel.



Figure 2: view from location P1-13

In the figure it becomes clear that the screening effect of the container stacks on the air vents is minor.

4.3 Calculations

Calculations were carried out with Geonoise 5.31 and zone control model of BMD (City of Amsterdam) and Havenbedrijf Amsterdam (Port of Amsterdam). For each ship two calculations were carried out.

1. with screening effect container stack,
2. without screening effect container stack.

4.4 Calculations compared with the measurements

In table 9 the results of the calculations are compared with the measurements at location P1-13.

Table 9
Calculations compared with the measurement

| | | Lyra | Pegasus |
|--|------------------------------------|-------------|----------------|
| Sound Power Level (table 5 & 8) | dB(A), ref. 10^{-12} W | 115 | 120 |
| results Geonoise with screening effect at P1-13 | dB(A), ref. 20×10^{-6} Pa | 47.2 | 49.3 |
| results Geonoise without screening effect at P1-13 | dB(A), ref. 20×10^{-6} Pa | 49.5 | 53.7 |
| measurement results (table 8) | dB(A), ref. 20×10^{-6} Pa | 53 | 56.7 |
| difference between calculations and measurements | dB | 3-6 | 3-7 |

Because of the minor screening effect a difference of 3 dB needs to be explained:

- measurement tolerance up to 1 dB;
- tolerance quantities up to 1 dB;
- calculation model up to 2 dB;
- remaining sound sources Ceres Terminal/ship up to 2 dB.

Therefore the conclusion is that the results of the measurements meet the values stated in the Dutch "Handleiding meten en rekenen Industrielawaai".

5. Sound pressure levels near Westzaan

Calculations have been carried out for the sound pressure levels near the houses at the Veldweg (Westzaan). Table 10 shows the actual sound pressure levels for the Lyra and the Pegasus.

Table 10
Sound pressure levels NYK Lyra and Pegasus near the Veldweg (dB(A), inclusive Cm)

| | 1/1 octave band frequencies in Hz | | | | | | | total dB(A) |
|-------------|-----------------------------------|----|-----|-----|-----|----|----|----------------|
| | 31 | 63 | 125 | 250 | 500 | 1k | 2k | |
| NYK Lyra | 11 | 25 | 24 | 30 | 32 | 27 | 19 | 36 |
| NYK Pegasus | 18 | 24 | 29 | 35 | 37 | 33 | 22 | 40 |

In the situation that these ships are also present in the night period (23.00h – 07.00h), a penalty of 10 dB must be applied. The total level caused by the ship is 50 dB(A) 'etmaalwaarde' (the Dutch twenty-four hours level).

6. Calculations of sound power levels of the ships

Table 11 shows the actual sound power levels (SPW) for the ships (vessels), calculated based on the measurements given in table 1 and 2.

Table 11
SPW's of the different ships

| ship | SPW in dB(A) |
|-------------------------|--------------|
| OOL Shenzen * | 120 |
| NYK California Luna | 113 |
| HLC Fransisco Express * | 115 |
| NYK Pegasus | 120 |
| NYK Lyra | 115 |

7. Noise mitigating measures

Leading for the prognoses is the situation during (off)loading of the ship, when two types of noise sources are active. These sources are:

- the chimney of the exhaust and ventilation systems of the auxiliary engine at the back of the pilothouse of the ship;
- the ventilation system of the engine room at the back of the pilothouse of the ship.

7.1 The chimney of the exhaust and ventilation systems of the auxiliary engine

From the outside it is not possible to see whether there are any existing exhaust system dampers already present. A resonance part is included in these dampers. Looking to the available space and a practical execution, one of the possibilities is placing mufflers in the existing exhaust system.

If they are already present, extra or different mufflers should be placed. Suggested is the QAN muffler from G&H (or equivalent).

7.1.1 Mufflers in the existing exhaust system

If possible the new or extra silencers should have a resonance part that is tuned to the frequency bands that are normative. Based on the sound power levels the exact frequencies may slightly vary for each ship individually. That is why each ship will require its own tuning.

7.1.2 Complications of adjusting the muffler system

Space must be found for placing the extra mufflers. For placing the extra noise mufflers on top of the chimney construction the possibilities are limited. Moreover both shipbuilders and users will find this extremely undesirable, amongst others because of the extra wind load. Therefore all the adjustments should preferably be made inside the ship, although space is limited and practical execution is not simple. Possibly plating in the side of the hull must be removed which has to be welded back later. Suggested reductions are given in table 12.

7.2 The ventilation system for the cargo space

Looking to the available space and a practical execution, there are two possibilities:

- low noise fans;
- extra noise reduction between fans and the air holes on the top deck.

7.2.1 Low noise fans

It is possible to replace the existing fans for new extra low noise fans. A reduction of 12 dB is suggested. For details and values it is necessary to consult a manufacturer of these extra low noise fans.

7.2.2 Extra noise muffler

Between the fans and the air holes on the top deck there is enough space for an extra noise silencer. In practice it can be realised by an absorptive parallel baffle or an acoustical silenced louvre. Both ways can bring reductions. In table 12 the suggested reductions are given.

7.3 Examples reductions

In the following table 11 a reduction of 12 dB is suggested, as an example, on the ventilation system (length of silencer 500 mm) and on the exhaust system.

Table 12

Example of noise reduction mufflers in the NYK Lyra and NYK Pegasus

| | 1/1 octave band frequencies in Hz | | | | | | |
|---|-----------------------------------|----|-----|-----|-----|----|----|
| | 31 | 63 | 125 | 250 | 500 | 1k | 2k |
| QAN muffler in the exhaust (G+H) | - | 12 | 30 | 50 | 50 | 50 | 50 |
| coulisse mufflers in the ventilation system | - | 4 | 9 | 10 | 12 | 20 | 26 |

8. Sound pressure levels at Veldweg

The calculated sound pressure levels at Veldweg (inhabitants of Westzaan) with and without measures for the NYK Lyra and the NYK Pegasus are reproduced in the tables 13 and 14.

Table 13
NYK Lyra, effects of noise mitigating measures inclusive Cm
Sound pressure levels at Veldweg in dB(A)

| the Lyra | 1/1 octave band frequencies in Hz | | | | | | | total dB(A) |
|-------------------------------|-----------------------------------|----|-----|-----|-----|----|----|-------------|
| | 31 | 63 | 125 | 250 | 500 | 1k | 2k | |
| no treatment | 11 | 25 | 24 | 30 | 32 | 27 | 19 | 36 |
| with reduction in ventilation | 11 | 21 | 19 | 27 | 28 | 22 | 12 | 32 |
| with reduction in exhaust | 11 | 24 | 23 | 28 | 30 | 26 | 18 | 34 |
| with both reductions | 11 | 20 | 14 | 18 | 18 | 6 | - | 24 |

Table 14
NYK Pegasus, effects of noise mitigating measures inclusive Cm
Sound pressure levels at Veldweg in dB(A)

| the Pegasus | 1/1 octave band frequencies in Hz | | | | | | | total dB(A) |
|-------------------------------|-----------------------------------|----|-----|-----|-----|----|----|-------------|
| | 31 | 63 | 125 | 250 | 500 | 1k | 2k | |
| no treatment | 18 | 24 | 29 | 35 | 37 | 33 | 22 | 40 |
| with reduction in ventilation | 18 | 22 | 22 | 26 | 27 | 15 | - | 31 |
| with reduction in exhaust | 18 | 21 | 29 | 35 | 36 | 31 | 22 | 40 |
| with both reductions | 18 | 17 | 20 | 25 | 24 | 13 | - | 29 |

Near the village of Westzaan (approximately 1.300 m) the low frequencies are dominant. For the two example cases this implies that both sound sources have to be treated.

9. Conclusions

From underlying investigation, the following conclusions can be drawn.

The SPW's of the various ships amount to 113 dB(A) up to 120 dB(A). The emission measurements on the ships and immission measurements on the bank on the other side of the North Sea Channel (P1-13), correspond within the margins with each other.

Considering the low sound levels, the data of the measurements carried out at the location Veldweg should be interpreted with caution.

Noise mitigating measures

Mitigating measures have to be applied on both outlet and ventilation. It has to be checked whether this is possible on the vessels.

Exhaust system of the auxiliary engine(s)

The exact frequencies of the narrow band peaks may slightly vary for each ship, requiring separate tuning of the resonance part (if present) of the new extra dampers for each ship individually. The suggested damper is a QAN damper. This can cause problems, because of the size and weight of the damper.

The ventilation system of the cargo space

When the required reductions for the funnels of the auxiliary engines are realised, an improvement of approximately 11 dB can be achieved. In our opinion there are two possibilities: low noise fans or extra damping realised by absorptive parallel panels.

The Hague, 10th February 2010

Figure 1: locations



Figure 1: locations