Emissions of the Marella Discovery

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Content

Samenvatting

De Marella Discovery ligt sinds 17 maart 2021 in de Damen werf in Amsterdam. Foto's van omwonenden laten zien dat het schip in de eerste dagen opvallend zwarte rook uitstootte. Dit zou het gevolg kunnen zijn van plotselinge veranderingen in motorvermogens, van motorproblemen, van storingen in de rookgasreiniging, of van andere oorzaken. Recentelijk is de uitstoot afgenomen.

Op verzoek van omwonenden berekent dit rapport hoe groot de uitstoot van kooldioxide (CO_2), stikstofoxiden (NO_x), zwaveloxiden (SO_x) en fijnstof (PM) van de Marella Discovery kan zijn. De geschatte dagelijkse uitstoot van NO_x staat gelijk aan de uitstoot van 31.000 extra vrachtwagens die een volle ronde op de ring A10 per dag rijden, of 370.000 personenauto's. De PM_{10}-uitstoot staat gelijk aan de uitstoot van 12.000 extra vrachtwagens die een volle ronde van de A10 rijden per dag of 52.000 personenauto's.

1 Introduction

The Marella Discovery is a cruise ship which is currently moored at Shipyard Damen in Amsterdam North. According to AIS websites, she has been in dock at the shipyard since the 17th of March 2021. Since that moment, smoke has been visible from the funnel which can be smelled in the distant environment (see Figure 1). According to the Omgevingsdienst Noordzeekanaalgebied, the ships was using clean fuel, presumably marine gasoil (MGO) and the smoke was due to the low engine load (see Annex A).

Residents of Amsterdam North have asked CE Delft to calculate the ship emissions and to compare these emissions with the traffic emission of Amsterdam. CO_2, SO_x, NO_x and PM_{10} emissions will be compared.

In line with the information provided by the Omgevingsdienst Noordzeekanaalgebied, we have assumed that the ship uses MGO. However, it is unusual for ships running on MGO to have visible smoke. Figure 1 gives the impression that the exhaust gas cleaning system, with which the Marella Discovery is equipped, was either turned off or not functioning well, while heavy fuel oil were used. Normally, black smoke is not emitted when ships are using distillate fuels or when the EGCS is functioning properly, unless the engine power is ramped up quickly. In that case, the smoke will quickly become colourless after the engine power has reached its constant level.

Figure 1 - Marella Discovery at Shipyard Damen

2 Ship and engine details

Table 1 provide information regarding the ship details and Table 2 provide information regarding the engine details.

Table 1 - Ship details

Ship details	
Ship name	Marella Discovery
IMO number	9070632
Built	1996
Propulsion	Diesel Electric
Engine type	Five diesel generators
Scrubber system	Five open-loop scrubber systems - installed in 2021
Current number of persons on board	109
Maximum number of persons on board (crew + passengers)	2,794
Current occupancy rate (%)	3.9%

Source: (Alberts 2021, Clarkson Research Portal 2021).

Table 2 - Engine details

Engine details	
Engine type	Wartsila 12V46
Cylinder output	1,200 kW
Number of cylinders	12
Total power per engine	14,400 kW
Speed	600 rpm
Number of engines	5
Total ship power	72,000 kW

Source: (Wärtsila 2020).

The Marella Discovery is currently in dock and has 109 people on board which equals an occupancy rate of 3.9%. We therefore expect the ship to require little power at the moment. Since we do not exactly know the required and used amount of power, we have calculated the amount of emission for 5, 10 and 15% of the total ship power. Just one diesel generator is necessary for these three assumed required power options, which also means that we assume that the other four generators are not being used.

Table 3 shows the required power, the required engine load and the specific fuel oil consumption (SFOC) of the three options.

Table 3 - Required power, engine load and SFOC for 5, 10 and 15% share of the total ship power

Share of total ship power	Total required engine power	Required engine load (1 engine necessary)	SFOC HFO (g/kWh)	SFOC MGO (g/kWh)
5%	3,600 kW	25%	204.2	204.1
10%	7,200 kW	50%	194.1	195.0
15%	10,800 kW	75%	184.0	185.9

Source: (Wärtsila 2020).

3 Fuel data and emission factors

Table 4 provide the global average fuel Sulphur content in percentage per year, Table 5 the fuel costs and Table 6 the corresponding emission factors.

Table 4 - Average fuel sulphur content in percentage per year

Fuel type	Global average fuel sulphur content in % per year
HFO	2.60
MGO	0.07

Source: (IMO 2020).

Table 5 - Fuel costs at 21/04/2021

Fuel type	Fuel costs in Rotterdam ($/mt)	Global average fuel costs ($/mt)
HFO	378.50	399.00
MGO	528.00	573.50

Source: (Ship & Bunker 2021).

Table 6 - Emission factors for marine fuels

Emission type	HFO	MGO	Unit
NOx	12.52	12.52	g NO_x/kWh
SOx	0.0508	0.0014	g SO_x/ g fuel
PM10	1.39	0.18	g PM_{10}/kWh
CO2	3.114	3.206	g CO_2/g fuel

Source: (IMO 2020).

4 Expected ship emissions

Table 7 shows the expected fuel consumption and emissions in the event that 10% of the total ship power will be used. The fuel costs would then amount to about USD 20,000 per day.

Table 7 - Estimated fuel consumption and emissions in the event that 5% of the total ship power is used

Fuel type	Fuel consumption (tonne/day)	NO_x (kg/day)	SO_x (kg/day)	PM_{10} (kg/day)	CO_2 (tonne/day)
MGO	34	2,200	47	31	110

5 Comparison with traffic emissions

To compare the emissions of the Marella Discovery in dock with the traffic emissions in Amsterdam, we have calculated the emissions of a car and a heavy duty vehicle driving one full lap of the A10 ringway (32 kilometers at 80 kilometers per hour), using the standard Dutch emission factors.

The emission factors for a car and a heavy duty vehicle (> 20 ton) at the highway in 2021 are shown in Table 8.

Table 8 – Emissions of a car and a heavy duty vehicle per km in 2021

	NO_x (g/km)	PM_{10} (g/km)
Car on highway, at 80 km/h in 2021	0.184	0.019
Heavy road traffic (> 20 ton) highway, at 80 km/h in 2021	5.719	0.151

Source: (Rijksoverheid 2021).

These emission factors mean that if the Marella Discovery uses 10% of her engine power, she emits the equivalent amount of NO_x of 30,000 trucks per day driving one full lap of the A10, or 370,000 cars. She emits an amount of PM_{10} which is equivalent to 12,000 truck laps on the A10 per day or 52,000 car laps.

It is important to realize that the harmfulness of air polluting emissions is not constant, but depends on the height and location of the released emissions. For example, emissions in densely populated areas are generally more harmful than emission in sparsely populated areas, especially when it comes to emission that occur close to the grounds, such as cities. The air polluting emissions from sea going vessels, where emission release by the funnels take place at a height of a few meters will therefore be less harmful than from road traffic. CE Delft (2021) provide a first indicative estimate for the differences in harmfulness of particulate matter.

6 Literatuur

Alberts, P. (2021). Ship details, private communication. CE Delft.

CE Delft (2020). Nulmeting CO2-uitstoot mobiliteit Noord-Holland en Flevoland. Delft, CE Delft.

CE Delft (2021). Toelichting gebruik milieuprijzen in tool Schone Luchtakkoord - Voor de Specifieke Uitkering.

Clarkson Research Portal (2021). "World Fleet Register." Retrieved April, 2021.

IMO (2020). Fourth IMO GHG Study 2020. London, International Maritime Organization (IMO).

INFRAS (2021). "Handbook Emission Factors for Road Transport (HBEFA) : Truck emissions." 2021, from https://www.hbefa.net/e/index.html.

Rijksoverheid (2021). "Emissiefactoren voor snelwegen en niet-snelwegen." Retrieved April, 2021, from https://www.rijksoverheid.nl/onderwerpen/luchtkwaliteit/documenten/publicaties/2021/03/15/emissiefactoren-voor-snelwegen-en-niet-snelwegen-2021.

Ship & Bunker (2021). "Bunker Prices." Retrieved April, 2021, from https://shipandbunker.com/prices/emea/nwe/nl-rtm-rotterdam#MGO.

Wärtsila (2020). "Wartsila 46F - Product Guide." Retrieved April, 2021, from https://www.wartsila.com/docs/default-source/product-files/engines/ms-engine/product-guide-o-e-w46f.pdf?utm_source=engines&utm_medium=dieselengines&utm_term=w46f&utm_content=productguide&utm_campaign=msleadscoring.

A E-mail Omgevingsdienst Noordzeekanaalgebied

Omgevingsdienst
noordzeekanaalgebied

Beste heer Alberts,

We hebben uw melding van overlast behandeld. De oorzaak van de overlast die u heeft gemeld, is bekend.
Het schip kan niet op de walstroom worden aangesloten, omdat het teveel vermogen vraagt. Het schip draait op schone brandstof, dus niet op stookolie. Het kan zijn dat de rookvorming ontstaat doordat de motor niet op vol vermogen draait, omdat er minder vermogen nodig is en dat hierdoor meer rookontwikkeling ontstaat.

Hiermee sluiten we de melding met zaaknummer 10261695 af.

Met vriendelijke groet,

Martin van Leuven
Omgevingsdienst Noordzeekanaalgebied

B Emissions with different fuels and engine loads

Table 9 shows the expected fuel consumption and emissions in the event that 10% of the total ship power will be used. Calculations are made for both HFO and MGO as fuel type. The same information is provided in Table 10 and Table 11 for respectively 10 and 15% of the total ship power.

Table 9 - Estimated fuel consumption and emissions in the event that 5% of the total ship power is used

Fuel type	Fuel consumption (kg/hour)	NO_x (kg/hour)	SO_x (kg/hour)	PM_{10} (kg/hour)	CO_2 (kg/hour)
HFO	740	50	40	5.0	2,300
MGO	740	50	1.0	1.0	2,400

Table 10 - Estimated fuel consumption and emissions in the event that 10% of the total ship power is used

Fuel type	Fuel consumption (kg/hour)	NO_x (kg/hour)	SO_x (kg/hour)	PM_{10} (kg/hour)	CO_2 (kg/hour)
HFO	1,400	90	70	10	4,400
MGO	1,400	90	2.0	1.0	4,500

Table 11 - Estimated fuel consumption and emissions in the event that 15% of the total ship power is used

Fuel type	Fuel consumption (kg/hour)	NO_x (kg/hour)	SO_x (kg/hour)	PM_{10} (kg/hour)	CO_2 (kg/hour)
HFO	2,000	140	100	20	6,200
MGO	2,000	140	3.0	2.0	6,400