MARIN

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Expected collision and stranding frequencies of incineration vessels sailing from Antwerp to the area for burning refuse materials on the North Sea.

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EXPECTED COLLISION AND STRANDING FREQUENCIES OF INCINERATION VESSELS SAILING FROM ANTWERP TO THE AREA FOR BURNING REFUSE MATERIALS ON THE NORTH SEA

CONTENTS

1. INTRODUCTION

1.1. GENERAL

The North Sea Directorate of the Dutch Ministry of transport and public works requested that a survey be carried out concerning the collision and grounding probabilities of incinerator vessels en route from Antwerp to an area for burning refuse materials in the North Sea. The area for burning refuse materials is a circular area with a radius of 15 nautical miles. The center lies approximately in the position 54°-17!5 N,003°-45'E. The calculated values give an indication of the probability that the ship will be involved in a collision or stranding. The damage ratio presents the ratio of the number of vessels that sustained critical damage as the consequence of a certain type of accident and the total number of ships that were involved in the same type of accident. Critical damage is so extensive that one must count on the sinking of the vessel or the release of cargo.
Within the area for burning refuse materials the incineration may be carried out while sailing.

1.2. The vessels

Two of the vessels which incinerate chemical refuse have approximately the same measurements. The main measurements are:

	VULCANUS I & II		VESTA	
- gross register tonnage	3400	GRT	1000	GRT
- length over all	94	m	72	m
- breadth	16	m	11	m
- draught aft	6.1	m	4.3	m
- speed	12.5	knots	11.5	knots

Above the standard equipment which is required for these vessels they possess:

Vulcanus I	VULCANUS II	VESTA
2nd radar	2nd radar	2nd radar
Decca receiver	Decca receiver	Decca receiver
ARPA	ARPA	
Bow thruster	Bow thruster	Bow thruster
Flap rudder		
Controllable pitch propeller		

The callsigns must be painted on the vessels in such a manner that they are clearly visible from the air. The Vulcanus I has two incinerator ovens aft. The accomodation is aft as well.
The Vulcanus II has three incincerator ovens aft. The accomodation has been placed on the fore part of the vessel.
The Vesta has one incinerator oven aft. The accomodation is forward.

1.3. The route

The route runs from Antwerp via the Westerschelde and the Oostgat to the Schouwendiep (51°44'N, 3°16'E). From the Schouwendiep the route runs in an almost straight line to the area for burning refuse materials (see the map in the back of this report). On account of the absence of sufficient accident data on that part of the route which runs from Antwerp to the Dutch border this part of the route will not be taken into consideration.
Considering the different traffic patterns and the different nature of the fairways the route is divided into three parts to facilitate the estimation of collision and stranding frequencies.

1. The Westerschelde from the Dutch-Belgian border up to and including the roads of Flushing.

2. From the roads of Flushing to the 52nd parallel North (approximately 3°20'E; the Oostgat and that part of the route off the coast of Zealand).

3. From the 52nd parallel North to the area for burning refuse materials.

2. TRAFFIC

2.1. Westerschelde

The traffic figures that have been used for this survey date from 1978. Recent statistics show that the figures have hardly changed, therefore calculated accident frequencies are assumed applicable to the present situation.

Traffic on the Westerschelde:

	IN	OUT	TOTAL
ANTWERP	17,700	17,700	35,400
TERNEUZEN	4,700	4,700	9,400
VLISSINGEN	2,100	2,100	4,200
OOSTGAT	11,200	12,000	23,200

The carferry between Flushing and Breskens makes approximately 25,000 movements a year. The carferry between Kruiningen and Perkpolder makes approximately 20,000 movements a year.
The inland vessel traffic has been omitted from the figures as inland vessels present less danger to the incinerator vessels than seagoing vessels do. Also since the Rhine-Scheldt canal was opened the number of inland vessels on the Westerschelde has diminished. For the same reasons recreational vessels have not been included.
The roads of Flushing are mentioned separately owing to the complicated traffic pattern there. The complicated traffic pattern is a result of the anchorage and the changing of the pilot on the roads. During strikes in Antwerp the anchorage harbours more vessels than usual. During high wind forces the number of anchored vessels increases due to discontinued pilot services.

2.2. Oostgat to A (52°00N, 003°20'E)

The character of the traffic from Oostgat to A can best be described in two parts. The first part concerns the Oostgat to the Schouwendiep. On this part of the route hardly any crossing traffic is met. The majority of traffic will follow parallel courses. On average 11,200 vessels enter the Oostgat from the North Sea and approximately 12,000 vessels leave via the Oostgat. From the Schouwendiep on a Northerly course to the 52nd parallel North, the traffic that is met consists mainly of vessels crossing the course of the incinerator vessels. These course crossing vessels have Rotterdam as their destiny or their port of departure. The total number of course crossing vessels in Easterly and Westerly directions amounts to approximately 24,000 a year.

2.3. A to the area for burning refuse materials

The traffic on this part of the route distinguishes itself by mainly following North-Easterly and South-Westerly courses. The total number of vessels that crosses the line from A to the area for burning refuse materials amount to approximately 39,000. Of these approximately 17,200 sail on North-Easterly courses and 21,900 on South-Westerly courses.

3. RISKS

Risk has two components. The first component is the chance that an event will take place. The second is the consequence when the event does take place. For each part of the route the frequencies of accidents will be calculated and enlarged upon.

3.1. Westerschelde

A number of measures have been taken to limit the risks for vessels carrying dangerous goods on the Westerschelde. The most important risk limiting measures are:

- An emphasized obligation to have a pilot aboard vessels carrying dangerous cargo(s).

- All gastankers are prohibited to sail when visibility is less than 1500 metres.

From earlier studies (Ref. 1) it is clear that during poor visibility conditions the collision ratio* is 10 to 20 times higher than during good visibility. Vessels without a pilot possess a collision ratio that is four times higher than piloted vessels.
From sunset to sunrise the collision ratio is two to three times higher than during daylight conditions. A possible safety measure would be to permit the incinerator vessels to sail on the Westerschelde during daylight hours only.
Wind force generally has no perceptible influence on the collision ratio. However, the stranding ratio is influenced by wind forces of over seven Beaufort. The stranding ratio then becomes three times as large as when the wind force is less than seven Beaufort. From "Scheepsongevallen op de Westerschelde over de periode 1966-1978" (Ref. 2) the following statements are applicable:

- West of the roads of Flushing the route is safer than on the Westerschelde both in absolute and relative sense.

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* See definitions

- The Oostgat is more accident prone than the Wielingen and Scheur.

- In the vicinity of the Zandvlietsluizen waiting causes an increased accident rate.

From (1) the following summaries of accident frequencies have been deduced for the tonnage class to which the incinerator vessels belong (500-5000 GRT).

Summary of accident frequencies per vessel movement

A) This summary concerns collision frequencies during good visibility conditions and a wind force of less than seven Beaufort for vessels with a pilot aboard.
The presented frequencies are average frequencies for the vessel class concerned. The incinerator vessels have well trained crews, good equipment and they do not sail in ballast. These are factors that definitely have a positive effect which, however, cannot be easily quantified.

route section	collision ratio	damage ratio	frequencies of critical damages
Border-Hansweert	1/19,000	1/12.6	1/239,000
Hansweert-Pas van Terneuzen	1/179,000	1/12.6	1/2,255,000
Terneuzen roads	1/26,000	1/12.6	1/328,000
Pas van Terneuzen-Honte	1/206,000	1/12.6	1/2,596,000
Flushing roads	1/12,000	1/12.6	1/164,000
Sardijngeul	1/18,000	1/12.6	1/227,000
Oostgat	1/53,000	1/12.6	1/668,000

As mentioned earlier the collision ratio during poor visibility is 10 to 20 times higher.

B) This summary concerns stranding frequencies during good visibility conditions, a wind force of less than seven Beaufort and for vessels with a pilot aboard.

Route section	strandings ratio	damage ratio	frequencies of critical damages
Border to Flushing roads	Compared to the frequency of critical damages as a result of collision, the frequency of critical damages as a result of stranding is negligible for the incenrator vessels concerned.		
Flushing roads	1/52,000	1/200	1/20,800,000
Sardijngeul	1/11,000	1/200	1/4,400,000
Oostgat	1/10,000	1/200	1/4,000,000

The presented damage ratio's are average damage ratio's of the vessel class concerned. The construction of the incinerator vessels justifies a damage ratio that is two times smaller when the wind force is less than seven Beaufort.
The strandings ratio is approximately three times as high when the wind force is seven Beaufort or more. In addition the damage ratio then increases to approximately 1/10.

3.2. Oostgat to A

The frequency of a certain type of accident on this route section is the sum of the frequencies of accidents in the Oostgat, the route section to the Schouwenbank and in the route section from the Schouwenbank to the 52nd parallel North.
The collision ratio for the route section Oostgat to the Schouwenbank is (Ref. 1): 1/53,000.
The strandings ratio for the mentioned route section is: 1/9,000.

The route section from the Schouwenbank to A has a collision ratio of 1/30,000 (Ref. 3).
The stranding ratio on this section of the route is not relevant for incineration vessels due to their small draught.

3.3. A to the area for burning refuse materials (A to B)

The number of vessel movements on this route section averages 39,000 per year. There was one relevant collision involving two vessels over a period of five years (Ref. 3). The majority of vessel movements cross the course line A-B of the incinerator vessels, therefore one can not suffice with calculating the collision frequency per vessel movement. In this case the collision frequency per nautical mile is calculated. The other route sections would permit calculating the collision frequency per nautical mile by simply multiplying the number of ship movements by the length of the route. The calculation of the number of miles crossing traffic ~~covers~~ covered by is done within a strip twenty miles wide (ten miles on either side of the course line A-B). The width of the strip has been so chosen because the traffic within this strip is characterized for the area which the incinerator vessels pass through. The calculation of the total number of ship miles takes the crossing angle of the traffic flows into account. The total number of covered ship miles within the 20 mile strip comes to 1,267,610.
There was one relevant collision involving two vessels within the 20 miles wide strip in a five year period. The expected frquency of collisions may be estimated to be:

$$\frac{2}{5*1,267,610} = 1/3,169,000 \text{ per ship mile}$$

The route section A-B is 124 miles long so the estimated frequency of collisions on this route section is:

$$\frac{124}{3,169,000} = 1/25,600 \text{ per covered route section A-B}$$

The route section from the Schouwenbank to A has a collision ratio of 1/30,000 (Ref. 3).
The stranding ratio on this section of the route is not relevant for incineration vessels due to their small draught.

3.3. A to the area for burning refuse materials (A to B)

The number of vessel movements on this route section averages 39,000 per year. There was one relevant collision involving two vessels over a period of five years (Ref. 3). The majority of vessel movements cross the course line A-B of the incinerator vessels therefore one can not suffice with calculating the collision frequency per vessel movement. In this case the collision frequency per nautical mile is calculated. The other route sections would permit calculating the collision frequency per nautical mile by simply multiplying the number of ship movements by the length of the route. The calculation of the number of miles covered by crossing traffic, is done within a strip twenty miles wide (ten miles on either side of the course line A-B). The width of the strip has been so chosen because the traffic within this strip is characterized for the area which the incinerator vessels pass through. The calculation of the total number of ship miles takes the crossing angle of the traffic flows into account. The total number of covered ship miles within the 20 mile strip comes to 1,267,610.
There was one relevant collision involving two vessels within the 20 miles wide strip in a five year period. The expected frquency of collisions may be estimated to be:

$$\frac{2}{5*1,267,610} = 1/3,169,000 \text{ per ship mile}$$

The route section A-B is 124 miles long so the estimated frequency of collisions on this route section is:

$$\frac{124}{3,169,000} = 1/25,600 \text{ per covered route section A-B}$$

3.4. Summary of the accident frequencies

To give an impression of the chance that an incineration vessel will be involved in an accident (collision, stranding) en route from Antwerp to the area for burning refuse materials a summary of accident frequencies is presented hereafter. From Antwerp to the pilot station near the Steenbank the reported frequencies are valid under good visibility conditions and a wind force of less than 7 Beaufort. When the wind force reaches values of 7 Beaufort or over the stranding ratio is approximately three times as high. Furthermore the frequency of critical damages for this type of accident becomes approximately 1/10. On the route section A-B the reported figures are valid regardless of the weather conditions.

Route section	Collision ratio	Critical damage frequency	Stranding frequency	Critical damage frequency
Border-Hansweert	1/19,000	1/239,000	-	-
Hansweert-P.v.Terneuzen	1/179,000	1/2,255,000	-	-
Roads of Terneuzen	1/26,000	1/328,000	-	-
P.v.Terneuzen-Honte	1/206,000	1/2,596,000	-	-
Roads of Flushing	1/13,000	1/164,000	-	-
Sardijngeul	1/18,000	1/227,000	1/11,000	1/4,400,000
Oostgat	1/53,000	1/668,000	1/10,000	1/4,000,000
Oostgat-Schouwenbank	1/53,000	1/668,000	1/9,000	1/3,600,000
Schouwenbank-52°N	1/30,000	1/378,000	-	-
52°-B	1/26,000	1/323,000	-	-
Total	1/2,900	1/38,000	1/3,300	1/1,324,000

Considering the main characteristics of the areas through which the incineration vessels sail, the areas can be grouped as follows:

1) The area from the border to the roads of Flushing

The vessels primarily sail through relatively thinly populated areas. The fairway concerned has river characteristics.

2) The roads of Flushing and the Sardijngeul

The traffic pattern is busy and complicated. Vessels sail close to densly populated areas.

3) The Oostgat

This is a narrow fairway near the coast.

4) From the Oostgat to 52°N

This is an approaching area near the coast.

5) From 52°N to the area for turning refuse materials

This part of the route is situated in open sea.

Route section	Collision ratio	Critical damage frequency	Stranding frequency	Critical damage frequency
1	1/10,000	1/144,000	-	-
2	1/8,000	1/95,000	1/11,000	1/4,400,000
3	1/53,000	1/668,000	1/10,000	1/4,000,000
4	1/19,000	1/241,000	1/9,000	1/3,600,000
5	1/26,000	1/323,000	-	-

4. RECOMMENDATIONS CONCERNING SAFETY MEASURES

The following safety measures could be considered:

1) During fog conditions avoid sailing on the Westerschelde as much as possible since the collision ratio is then 10 to 20 times as high as during good visibility conditions.

2) Avoid sailing on the route section Sardijngeul-Schouwenbank during wind force seven Beaufort or more.

5. REFERENCES AND DATA SOURCES

1. Nautisch Risico Aanlanding LPG, deel 4. PNAV-168, Westerschelde (MARIN).

2. Scheepsongevallen op de Westerschelde over de periode 1966 tot en met 1978 (DVK Rijkswaterstaat).

3. Ongevallen Noordzee in de periode 1978-1982 (MARIN).

6. DEFINITIONS

Collision ratio	The number of vessels, belonging to a certain category, that is involved in a collision, divided by the total number of vessel movements in the area by vessels of the same category.
Stranding ratio	The number of vessels, belonging to a certain category, that strand, divided by the total number of vessel movements in the area by vessels of the same category.
Critical damage	Damage to an extent that sinking or the release of cargo must be counted on.
Accident	The first accident which a vessel meets with.
Damage ratio	The ratio between the number of vessels that sustain critical damage owing to a certain type of accident and the total number of vessels that experienced the same type of accident.
Poor visibility	A visibility of is less than 1500 m.
Beaufort 7	Strong wind, 13-16 m/s.

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Area for burning refuse materials

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178

52Ω

52Ω

TEXEL

VLISSINGEN

DELFZYL

HARLINGEN

IJMUIDEN

AMSTERDAM

GREAT YARMOUTH

IPSWICH

HARWICH

NOORD HINDER

A

* GOEREE

HOEK VAN HOLLAND

ROTTERDAM

schouwenbank

FLUSHING

oostgat

WEST HINDER

ZEEBRUGGE

Terneuzen

ANTWERP

DOVER

DUNKIRK

54°

53°

52°

51°

50′ 40′ 30′ 20′ 10′

1° 10′ 20′ 30′ 40′ LONGITUDE 2° EAST FROM GREENWICH 30′ 40′ 50′ 3° 10′ 20′ 30′ 40′ 50′ 4° 10′ 20′ 30′ 40′ 50′ 5° 10′ 20′ 30′ 40′ 50′ 6° 10′ 20′ 30′ 40′ 50′ 7° 10′ 20′ 30′

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