QinetiQ report on stability investigation of mv *Riverdance*

MV RIVERDANCE Stability Investigation for MAIB

August 2009

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1 Introduction

1.1.1 This report provides an investigation into the potential causes of an incident that occurred to the Irish Sea ferry, the MV RIVERDANCE on the 31st January 2008 in heavy weather, which led to the loss of the vessel when it grounded on the beach at North Shore, Blackpool. The basic details of the vessel are shown in Table 1-1.

Ship Details	
Vessel Type:	Ro-Ro Freight Ferry
Vessel LOA	116.3m
Gross Tonnage	6041 Tonnes
Owner:	Seatruck Ferries
Keel Laid	20/12/1976
Flag:	Bahamas

Table 1-1 - Ship Details

1.1.2 The MV RIVERDANCE first got into difficulties in the Irish Seas in storm conditions, eight nautical miles off Fleetwood whilst encountering waves reported as over seven metres in height and wind in excess of fifty knots. The vessel sent out a mayday at 1956 GMT. The ship had developed a mean combined heel and list angle of 35 degrees after an incident in the heavy weather. It was thought by the crew that some of her cargo of lorry trailers had shifted and contributed to the incident.

1.1.3 Nine of her crew stayed aboard during the incident and the ship grounded on Blackpool's North Shore. After re ballasting the vessel, the crew were initially able to re float the vessel but it then capsized back onto the beach. Despite further efforts they were unable to get the vessel re-floated again. Further attempts to re-float the vessel also failed.

1.1.4 The ship was carrying approximately 1,199 tonnes of freight in the form of lorry trailers and their contents. It is understood that some of the contents from trailers and one trailer had fallen overboard during the incident.

1.1.5 The MV RIVERDANCE ran twice a day between Warrenpoint and Heysham and was operated by Seatruck Ferries, a subsidiary of Clipper Group. She was built in 1977 and had a gross tonnage of 6041 tons. She was built at the Rickmers shipyard in Germany as the MASHALA and was operated by Gilnavi Line and had a variety of owners/operators since 1986. Her work in the Irish Sea started in 1991 with Belfast Freight Ferries until 1993. Seatruck purchased her in 1996.

2 Investigation of the MV RIVERDANCE

The assumptions made during this investigation into the most likely events that led to the loss of the vessel were as follows:

- The data provided by the MAIB through the investigation was the best available information.
- The stability book information and calculation methodology was correct.
- The trailer VCG positions from the stability book were correct. This was verified during the investigation.
- The loading of the trailers was assumed to have assumed to have a net TCG effect of zero, i.e. the cargo was loaded so as to not induce a list.
- The data provided on the sister vessel MV MOONDANCE was equally applicable for the MV RIVERDANCE. However, it should be noted that there were significant differences found with the lightship condition in the stability book of MOONDANCE compared to the approved RIVERDANCE stability book.

2.1 MV RIVERDANCE Track

2.1.1 Utilising the vessels' GPS track information and recorded data from the vessel heading, it is possible to shows the track of the MV RIVERDANCE during the evening of 31st January 2008 on Admiralty Chart 1121, Figure 2-1, showing the location of where the incident occurred. From this data it can be seen that the MV RIVERDANCE was on a steady heading Easterly when at 1930 (approximately) an incident occurred resulting in a sharp and rapid turn to Starboard. From this point on she drifted in close to beam seas until she ran aground on the beach. Prior to the incident the MV RIVERDANCE was travelling at around 13Kts.

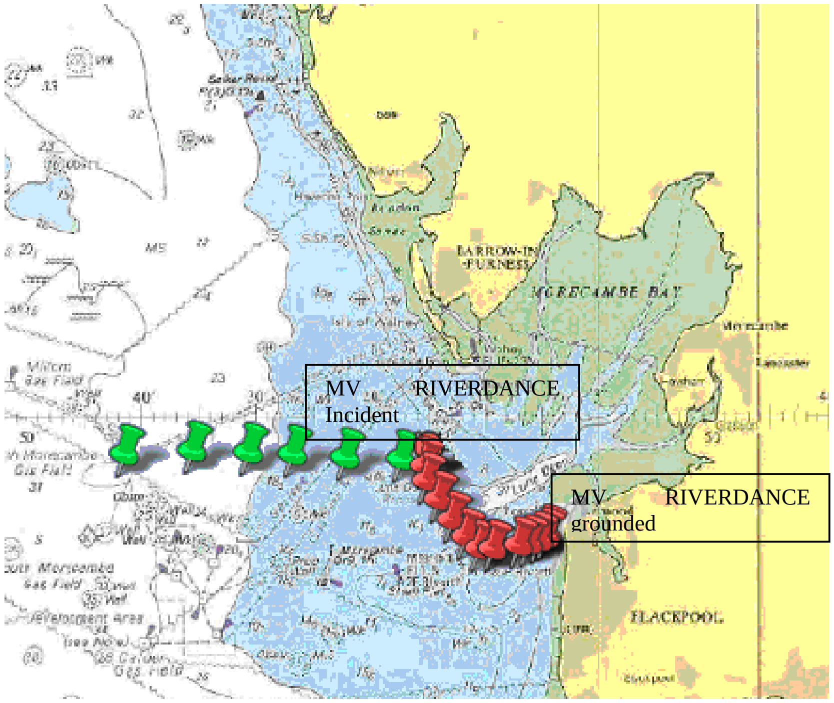


Figure 2-1 - MV RIVERDANCE track

2.2 Environmental Conditions in the Area of the Incident

2.2.1 A detailed investigation into the environmental conditions in the area at the time of the incident has been conducted. Wind and wave height data has been collected from a number of sources in the area and combined with hindcasting data to generate a detailed picture of the environmental conditions in the area during the time of the incident.

2.2.2 Wind and wave data for the time of the incident was collected from a number of static data recording stations located at Liverpool Bay, Morcambe Bay, Shell Flats and Barrow wind farm. The following table summarizes the environmental data from these locations:

Location	Liverpool Bay	Morecambe Bay	Shell Flats	Barrow wind farm
Mean Windspeed (m/s)	18	25	23	24
Wind Direction (deg)	260	260	260	211 (not north adjusted)
Sig Wave height (m)	4.2	6.5	-	4.8
Modal Period (s)	8.4	10	-	-

Table 2-1 – summary of collected wind and wave data

2.2.3 At the time of the incident the shipping forecast for the Irish Sea was for a general Gale warning with a forecast South West veering North West wind of Gale Force 8 to Storm Force 10, with moderate rain and a rough seaway. Closer inshore a Westerly Gale of Force 8 or 9, occasionally 7 was forecast, veering North West later with showers and very rough seas expected.

2.2.4 In parallel with the collection of weather data from sources in the area, an investigation into the wave spectra that would be expected in the area of the incident was also made. The wave spectra are affected by many parameters such as the wind speed and direction, the length of the wave fetch and the depth of the water. In order to select a spectrum for use in the numerical modelling in the study, a spectrum was calculated from each of the weather data sources using a number of methods of spectrum calculation in order to select the best fit. The JONSWAP (Joint North Sea Wave Project) spectrum was selected to be used for the study. This spectrum has been developed to model limited fetch, shallow water wave conditions and is often used in hydrodynamic studies to represent the conditions of inshore waters with a limited fetch such as the North Sea.

2.2.5 Data regarding tidal movements was obtained from a measuring station located at Heysham. The water depth for the time of time of interest is shown in Figure 2-2 below. From this data it can be seen that at the time of the incident the tide was ebbing, with high tide at 1715 (approximately).

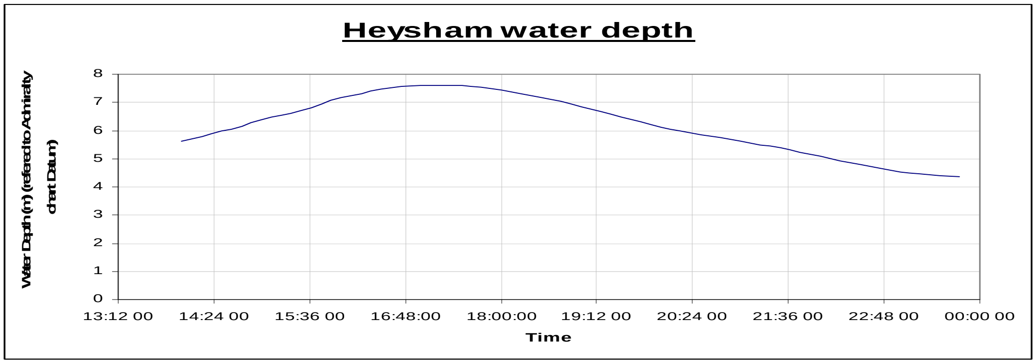


Figure 2-2 - Water Depth

2.2.6 From the position data of the MV RIVERDANCE, the position where the rapid turn event occurred was 53^{o} 56’ 20.5”, -3^{o} 15’ 27”. At this point the depth (reduced to chart datum) is 10.05m. Water depth (based on Heysham tide data) at the time of the event was 6.5m, therefore the total water depth was 16.55m, Table 2-2 - Water depth Information.

Location	Water depth at 19:30 (m)
Barrow Wind Farm	12.3
Event	16.55
Morecambe bay	31.5
Liverpool Bay	22.55
Shell flats	14.1

Table 2-2 - Water depth Information

2.2.7 The ebbing tide induces a current, details of which have been taken from the Admiralty Chart at the nearest point of reference, where the current was at 0.7 knots (0.36 m/s) flow at 250^{o}.

2.3 Loading Condition and Stability of MV RIVERDANCE

2.3.1 In order to investigate the potential causes of the incident, detailed computational modelling of the vessel was required to provide the static and dynamic stability characteristics of the vessel in representative loading conditions for the vessel.

2.3.2 In order to achieve this, drawings of the vessel, the ship stability book and the cargo manifest were provided by the MAIB to help generate the computational models. The GRC PARAMARINE solid modelling tool was used to generate a full solid 3D model of the MV RIVERDANCE and all the tank and compartment subdivision in the vessel based on the drawings provided. The available drawings were unfortunately of poor quality.

2.3.3 A nonlinear time domain program named FREDYN was also used to dynamically model the MV RIVERDANCE in six degrees of freedom in the wind and waves that were present at the time of the incident.

2.3.4 Paramarine is an object oriented Naval Architecture software package for the Windows® operating system (2000, XP) developed by GRC, a QinetiQ owned company. The software includes modules that allow the designer to construct many types of model ranging from concept sizing parametric models to complex stability analyses that will automatically re-calculate when constituent items change.

2.3.5 Given a subdivided solid model of a ship or submarine, the stability calculator part of the software provides all the functionality necessary for a designer to perform general stability analyses. This module is normally used in conjunction with one or more of the three advanced stability modules, which provided more specific stability calculations and GZ criteria for warships, commercial ships and submarines.

2.3.6 A nonlinear time domain program named FREDYN was also used to dynamically model the MV RIVERDANCE in six degrees of freedom in the wind and waves that were present at the time of the incident.

2.3.7 FREDYN was developed by Marin for the Co-operative Research Navies (CRN), and has been extensively applied – both to intact and damaged ships. This time-domain program is able to take account of nonlinearities associated with drag forces, wave excitation forces, large-angle rigid-body dynamics and motion control devices. The FREDYN program permits investigations into the dynamics of intact and damaged vessels operating in realistic environments.

2.3.8 An investigation of the tank loadings using information provided by the MAIB was carried out to provide an estimation of the tank fill levels of the vessel at the time of the incident.

2.3.9 The MV RIVERDANCE Approved Trim and Stability book (SIB) [4] and cargo manifest data provided was used along with CAD drawings of estimated cargo loading arrangements to produce a detailed estimate of the loading condition at the time of the incident.

2.4 Stability Book Version

2.4.1 It is understood that there are a number of versions of preliminary and approved Stability Information Books available for the MV RIVERDANCE and MV MOONDANCE. There were significant differences found with the lightship condition in the stability book of MOONDANCE compared to the approved RIVERDANCE stability book.

2.4.2 There are approved RIVERDANCE, provisional RIVERDANCE and MOONDANCE stability books available and in use. All these stability books are understood to have differences between them. The approved MV RIVERDANCE stability book was used for all calculations in the study.

2.4.3 The MV RIVERDANCE Approved Trim and Stability book used for this analysis was published by Cammell Laird in June 2000 after the vessel had been modified to install a new fixed ramp and additional accommodation.

2.4.4 QinetiQ were issued with the approved version of the SIB, with the updates reflecting the changes made to the vessel. It is important to utilise the version of the SIB which reflects the current build standard of the vessel. The modifications to the vessel affected the distribution of mass within the vessel significantly which affects the understanding of the vessel's loading condition and hence stability. The differences between the modifications carried out to the RIVERDANCE and MOONDANCE would make the use of the other versions of the stability books unwise.

2.5 Evaluation of the Stability Book

2.5.1 The General Particulars given reflect these changes and accord with the General Arrangement produced at the same refit [6].

2.5.2 The tank capacities accord with the tank plan [5].

2.5.3 The Instructions to the Master gives standard advice for Ro-Ro vessels stressing the importance of maintaining the watertight integrity of the vessel and requiring all watertight openings to spaces below the Main Deck (assumed to mean the Upper (Weather) Deck) to be closed prior to sailing.

2.5.4 The naming conventions of the decks are not consistent within the document, and it is unclear whether the main deck referred to here is the Upper (Weather) Deck or the Main Cargo Deck. Since a number of the openings seen in the Main Cargo Deck are clearly not intended to be watertight, it is assumed that the main deck referred to here is the Upper (Weather) Deck. This section also stresses the importance of correctly loading cargo such that the stability criteria can be achieved and the correct securing of such cargo.

2.5.5 The Special Notes Regarding Stability state that the vessel is required to comply with the Merchant Shipping (Load Line) Rules 1968. The stability requirements therefore consist of a minimum set of criteria relating to the shape of the GZ righting arm curve and are still included as part of the current IMO Intact Stability Code. Unlike the current intact stability requirements, the 1968 IMO Load Line Convention does not have any of the weather or wind heeling requirements to account for the effects on the vessel of wind and waves in the latest intact stability criteria

2.5.6 The loading conditions detailed in the SIB were recalculated in PARAMARINE and are summarised in Table 2-3 below. These conditions are taken from the approved RIVERDANCE SIB [4] and modelled in PARAMARINE, hence there are some small differences in the actual values shown in Table 2-3 when compared to the values in the actual SIB (Further detail on the modelling can be found in Section 2.6).

	2 - Ballast Departure	3 - Ballast Arrival	4 - Full load departure	5 - Full load arrival	6 - Normal service departure	7 – Normal service arrival	8 - Upper deck only loaded departure	9 - Upper deck only loaded arrival
Displacement	3909	3745	5662	5497	4856	4695	4248	4087
KGs	6.73	6.92	8.30	8.48	8.20	8.42	7.98	8.22
FSM correction	0.00	0.00	0.04	0.05	0.01	0.01	0.01	0.02
KGf	6.73	6.92	8.35	8.53	8.22	8.43	7.99	8.23
LCG	47.88	48.67	47.32	47.83	47.28	47.91	48.51	49.28

Table 2-3 - Summary of the loading conditions listed in the SIB but calculated in PARAMARINE

2.5.7 A number of inconsistencies were found with the approved stability book data, these were:

- Stores and effects loads were absent in conditions 6, 7, 8 and 9.
- In certain conditions the maximum GZ value quoted does not agree with the GZ curve provided.
- In the table of critical KG's the flood angle is identical for all displacements and trims.
- The limiting KG tables in the approved stability book have the lightship displacement and VCG listed as that of the provisional stability book and not that in the rest of the approved document. The limiting value of GM would be unaffected but the available deadweight moment would change. The difference in lightship condition would result in a reduction of approximately 500 tonne.m compared to 38,000 tonne m for the entire vessel. This is a difference of approximately 1.4%.

These inconsistencies in the SIB could lead to a misunderstanding of the actual stability of the vessel and lead to some inaccuracies in any loading assessment. Although each of these inconsistencies would have a very small effect on any calculations carried out using the SIB, when considering marginal conditions these may prove important to resolving whether the vessel is safe to sail.

2.6 Vessel loading condition

2.6.1 An estimate of the actual condition for the vessel was derived using the data provided by MAIB.

2.6.2 The cargo manifest was used to model the positions of the cargo on the Upper (Weather) Deck and Main Cargo Deck and hence define the total cargo mass for each deck and the LCG positions. The VCG positions of the cargo were taken from the trim and stability book, as following checks on the drawings provided, it was found to be a realistic value for a typical trailer. The net TCG position of the cargo upon each deck was assumed to be zero, this is because using the masses and locations reported in the cargo manifest would have resulted in a net cargo TCG of 0.7m resulting in a 10 degree list to Starboard which was neither reported nor realistic as the heeling tanks were reported as equal on departure.

2.6.3 On arriving at Warrenpoint, the RIVERDANCE was loaded with cargo. A number of data sources are available to determine the type, loading order and weight of this cargo at the start of the voyage. These are;

- A handwritten list of the cargo separated into the Main and Upper (Weather) Decks
- The 'Ships manifest'
- The Stowage Plan provided by Brookes Bell (contracted by Sea Truck to investigate the MV RIVERDANCE incident on their behalf) which is based on photographs and trailer recovery

2.6.4 The handwritten list of cargo and the ships manifest were combined to give the cargo plans shown below;

Contents							
Weather Deck (12.2m)		Plastic (10 Te)	Returns (22 Te)	Peat (30 Te)	Timber (30 Te)	Insulation (10 Te)	Empty (6 Te)
		Foam (10 Te)	Plastic cups (15 Te)	Pallets (18 Te)	Peat (30 Te)	Peat (30 Te)	Empty (7 Te)
		Timber (30 Te)			Scrap (30 Te)	Peat (30 Te)	Waste Plastic (30 Te)
		Balcas (30 Te)		Empty (6 Te)	Scrap (30 Te)	Peat (30 Te)	Scrap (30 Te)
		Groupage (30 Te)	Peat (30 Te)	Empty (6 Te)	Empty (6 Te)	Flooring (30 Te)	Peat (30 Te)
Main Deck (5.7m)		Oil tanks (10 Te)	Pallets (8 Te)	Insulation (10 Te)	Plastic Tanks (12 Te)	Foam (8 Te)	
	Scrap (30 Te)	Plastic cups (12 Te)	Cement (30 Te)	Empty (6 Te)	Plastic pipes (15 Te)	Peat (30 Te)	Steel (30 Te)
	Empty (6 Te)				Timber (30 Te)	Roof Tiles (30 Te)	Timber (30 Te)
	Roof tiles (30 Te)			Concrete Flooring (30 Te)	Doors (30 Te)	Roof Tiles (30 Te)	Steel (30 Te)
	Car (6 Te)	Peat (30 Te)	Scrap Steel (30 Te)	Timber (30 Te)	Peat (30 Te)	Timber (30 Te)	

Table 2-4 - Cargo Weight and Type (Tonnes)

2.6.5 The cells coloured yellow are those which were in doubt due to conflicting evidence between the handwritten list and the ship's manifest.

2.6.6 The Stowage Plan received later from Brookes Bell includes information gained during the salvage operation and hence can be taken as the most definitive source of data regarding the cargo plan on sailing.

2.6.7 On comparing these two data sources, it can be seen that there are some differences. The differences are illustrated in the following diagram with cells coloured green indicating where there is no change, yellow where there is a difference and red where there is a difference in the weight at that position;

Plastic 10t	Returns 22t now 10t	Peat 30t	Timber 30t		Foam 10t	Piggybacked flatbeds 12t Difference +6t
Foam 10t	Plastic cups15t	TL848 Pallets 30t	Timber 30t No weight difference		Peat 30t	Stillages 10t Difference +9t
Timber 30t			Empty 16t Difference +16t	T68 Scrap engines 30t	Peat 30t	Wooden pallets 8t Difference -22t
Bafcas 30t				T1 Scrap aluminium 30t	Peat 30t	Scrap engines 30t
Biscuits 30t	Peat 30t	Peat 30t Difference +24t	Empty 6t No weight difference		Timber 30t	Plastic 30t No weight difference

Table 2-5 - Weather deck cargo layout comparison

	Empty 6t Difference -4t	Foam 6t Difference -2t	Plastic 10t No weight difference	Oil tanks 10t Difference -2t	Roof tiles 30t Difference +22t	
Scrap 30t	Empty 10t Difference -2t	Plastic tanks 12t Difference -18t	Insulation 10t Difference +4t	Plastic pipes 15t	Roof tiles 30t No weight difference	Doors 30t No weight difference
Empty 6t				Cement 30t No weight difference	Concrete 30t No weight difference	House 30t
Roof tiles 30t			Steel 30t No weight difference	Steel 30t No weight difference	Peat 30t No weight difference	Peat 30t No weight difference
BMW car	Peat 30t	Steel 30t	Timber 30t	Timber 30t No weight difference	Peat 30t No weight difference	

Table 2-6 - Main deck cargo layout comparison

It can be seen that there is an overall difference of +33 tonnes on the weather deck and -2 tonnes on the main deck. This difference falls within the variation in cargo modelled within the study but it should be noted that the Estimated Condition does not match this exactly as it was provided after the analysis had been carried out.

2.6.8 It was also noted that there were four trailers marked as shipped on the ships manifest which in fact were replaced by other trailers.

2.6.9 This Estimated Condition could be compared with the loading conditions detailed within the SIB. The following Table 2-7 (and Estimated Condition in Annex A) shows the summary of conditions taken from the approved RIVERDANCE SIB [4] and modelled in

PARAMARINE, hence there are some small differences in the values in Table 2-7 when compared to the actual SIB.

	Estimated condition	2 - Ballast Departure	3 - Ballast Arrival	4 - Full load departure	5 - Full load arrival	6 - Normal service departure	7 - Normal service arrival	8 - Upper deck only loaded departure	9 - Upper deck only loaded arrival
Displacement	4648	3909	3745	5662	5497	4856	4695	4248	4087
KGs	8.25	6.73	6.92	8.30	8.48	8.20	8.42	7.98	8.22
FSM correction	0.01	0.00	0.00	0.04	0.05	0.01	0.01	0.01	0.02
KGf	8.38	6.73	6.92	8.35	8.53	8.22	8.43	7.99	8.23
LCG	47.87	47.88	48.67	47.32	47.83	47.28	47.91	48.51	49.28

Table 2-7 - MV RIVERDANCE Loading Conditions with Best Estimated Condition calculated from PARAMARINE

2.6.10 In comparing the Estimated Condition to the SIB conditions, it can be seen the Condition 7 – Normal Service Arrival is closest in displacement to the Estimated Condition, however the assumptions regarding the method of loading of the vessel give rise to the KGs, KGf and LCG values being considerably different to Condition 7 and do not match consistently with any of the SIB conditions.

2.6.11 Hence the Estimated Condition based on the data supplied for the vessel at departure was used rather than one of the SIB conditions to create the PARAMARINE model to allow detailed static stability analysis on the vessel.

2.6.12 Some further differences and inconsistencies were found with the stability book provided, including inconsistencies with the inclusion of weights for crew and related items. In creating the PARAMARINE model a series of systematic checks were undertaken to ensure the accuracy of the model. The drawings for the MOONDANCE and RIVERDANCE which were used to generate the PARAMARINE solid model were of poor quality, which could have lead to the small differences seen in some of the stability calculations when compared to the stability book.

2.6.13 The lightship condition was set up and compared with the stability book. With the draughts defining the displacement the displacement agreed within <0.5%. The lightship LCG was however different by 0.7%. In Condition 7, loaded as defined in the SIB, the displacement agreed within 0.01% and draughts also agreed within 0.8%. The comparison of KM and GM highlighted a difference which was deduced to possibly relate to the defined baseline used in the stability book. The VCG height of the lightship in PARAMARINE (relative to the keel) could be modified to account for the possible difference of origin of the lightship between PARAMARINE and the stability book model. The GMts of the lightship then matched that of the approved stability book. Using this modified Lightship VCG and the load condition as Condition 7 in the Stability book, the GZ curves matched closely with those in the stability book over the first 35 degrees and last 35 degrees of the GZ curve.

2.6.14 Some small variations in the GZ curves, particularly at the mid roll angles were seen when compared to the stability book calculation. Some difference is not unexpected as it is likely that a curve definition of the hull would have been used for the original stability book calculations many years previously, rather than the full solid model used in PARAMARINE. The SIB calculations were found to be on the marginally optimistic side compared to the PARAMARINE model due to the increased accuracy of the modelling technique.

2.6.15 The draughts read by ship's staff prior to departure were provided to QinetiQ only after the independent calculation of the best estimate of the loading condition at departure had been completed, as described above. The draughts were given as 4.6m fwd and 4.8m aft. On comparison with the independent calculation of the best estimate, the mean draft was actual within 0.01m at 4.71m, and hence within 1.4% on displacement. The difference in trim was closely examined and it was found to be not feasible to load the vessel as required to achieve the 0.2m stern trim using the LCG of the lightship for RIVERDANCE as stated in the approved SIB. An examination of the SIB for the MOONDANCE was conducted and was found that the lightship LCG was 2.8m further forward than that of RIVERDANCE. On questioning the difference of the lightship LCG position, no explanation could be provided. An investigation was made using the loading for RIVERDANCE with the lightship LCG from MOONDANCE. It was found that a reduction in the stern trim in line with the reported draughts was achievable. However, as the lightship condition from the approved RIVERDANCE SIB was to be taken as correct as defined in the assumptions, the best estimate condition was used as the base case for the analysis. A selection of the dynamic analysis was conducted with further reduced stern trim to assess any impact of the greater bow trim but few dynamic differences were found.

	RIVERDANCE	MOONDANCE	Difference
Weight (Te)	2822.02	2745.96	76.06
VCG (m)	8.25	8.18	0.07
LCG (m)	48.54	51.09	2.55

Table 2-8 – Difference between RIVERDANCE and MOONDANCE Lightship

2.6.16 With this best estimation of the loading condition from the data available, a number of variations were made to identify the effect on stability of variations to the overall loading condition, such as greater cargo weight than defined. It should be noted that higher cargo masses combined with higher cargo VCG is unlikely and is examined to identify what would be needed to exceed the stability criteria. The definition of these conditions is given below and their summary details are given in Table 2-9 (Full details in Annex A).

- The 'lightship' condition is based on details in the RIVERDANCE approved trim and stability book with a modified VCG to achieve the GMts of the lightship.
- The 'estimated' condition uses the aforementioned lightship condition, with the addition of tank fill levels as specified by the MAIB and a cargo loading estimate based on the reported manifest, CAD drawings and video evidence.
- The 'plus 10 cargo' condition uses the estimated condition with the Main Cargo Deck and Upper (Weather) Deck cargo loads increased in weight by 10%, to consider inaccuracies in the cargo mass in the manifest details.
- The 'plus 15 cargo' condition uses the estimated condition with the Main Cargo Deck and Upper (Weather) Deck cargo loads increased in weight by 15%, to consider inaccuracies in the cargo mass in the manifest details.

- The 'cargo up' condition uses the estimated condition with 50te of cargo removed from the Main Cargo Deck load and added to the Upper (Weather) Deck cargo load, to consider inaccuracies in loading positions as described in the cargo manifest.

- The 'cargo down' condition uses the estimated condition with 50te of cargo removed from the Upper (Weather) Deck load and added to the Main Cargo Deck load to consider inaccuracies in loading positions as described in the cargo manifest.

- The 'VCG up' condition uses the estimated condition with the VCG positions of the Main Cargo Deck load and Upper (Weather) Deck load increased by 0.9m, to consider uncertainties in the cargo VCG details by raising by 10% of the overall VCG height of the cargo.

- The 'plus 10 cargo VCG up' condition uses the estimated condition with the Main Cargo Deck and Upper (Weather) Deck cargo loads increased in weight by 10% and the VCG positions of the main cargo deck load and Upper (Weather) Deck load increased by 0.9m to consider uncertainties in the cargo mass and VCG details .

- The 'plus 15 cargo VCG up' condition uses the estimated condition with the Main Cargo Deck and Upper (Weather)Deck cargo loads increased in weight by 15% and the VCG positions of the Main Cargo Deck load and Upper (Weather) Deck load increased by 0.9m to consider greater uncertainties in the cargo mass and VCG details.

Condition	*Lightship*	*Estimated*	*Plus 10 cargo*	*Plus 15 cargo*	*Cargo up*	*Cargo down*	*vcg up*	*Plus 10 cargo vcg up*	*Plus 15 cargo vcg up*
Disp (Te)	2822	4648	4766.835	4827.684	4647.834	4647.835	4647.833	4766.845	4827.697
Trim (m)	1.042	0.515	0.451	0.418	0.515	0.516	0.516	0.451	0.418
Heel/List (deg)	0	-0.448	-0.471	-0.484	-0.474	-0.425	-0.546	-0.589	-0.577
GMtf (m)	1.246	1.367	1.309	1.28	1.296	1.438	1.137	1.062	1.024

Table 2-9 - Loading conditions investigated in PARAMARINE

2.6.17 The Stowage Plan distribution of cargo weight falls within the cargo deviations considered, however, to ensure that this condition was considered in detail, it has been run as a separate condition in Paramarine.

2.6.18 It is then necessary to consider the positioning of the cargo relative to the ship, i.e. it would be possible to position all the cargo as far forward within the ship as can be physically achieved. The RAF video has been used to establish the most likely positioning of the cargo relative to the ship on leaving Warrenpoint. This is illustrated by Figure 2-3.

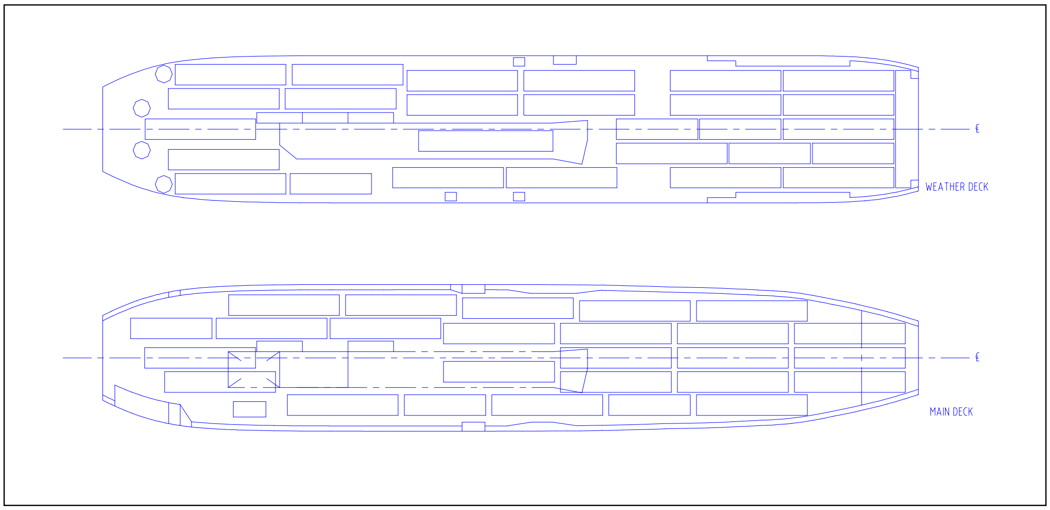


Figure 2-3 - Most likely cargo positioning

2.6.19 As shown in Table 2-10, the Paramarine model indicates that the majority of conditions passed the GZ area criteria. The best estimate load condition is actually well within the stability criteria.

2.6.20 The load conditions with increased cargo weight and VCG do start to fail the GZ area criteria. The +10% cargo condition with raised VCG and the +15% cargo condition with raised VCG fail the GZ righting lever criteria.

2.6.21 This illustrates the importance of understanding the weight of the cargo being embarked. It demonstrates that a difference of 10% in cargo mass and VCG from that which has been estimated on loading is all that is required for this vessel to potentially fall outside the stability criteria.

2.6.22 This also illustrates the importance of understanding the VCG of the cargo being embarked. The VCGs and weights of cargoes such as trucks are highly variable and assumptions that were made when the SIB was produced can become obsolete because of changes in factors such as vehicle size, weight and shape.

IMO shape criteria	Limit	Conditions							
		Estd.	+10% cargo	+ 15% Cargo	Cargo up	Cargo down	VCG up	+10% VCG up	+15% VCG up
GMTf	0.15 [m]	1.367	1.269	1.238	1.258	1.401	1.097	1.021	0.981
area 0 to 30	0.055 [mrad]	0.104	0.091	0.085	0.094	0.113	0.073	0.058	0.051
area 0 to 40	0.09 [mrad]	0.158	0.138	0.128	0.142	0.175	0.104	0.08	0.068
area 30 to 40	0.03 [mrad]	0.055	0.047	0.043	0.048	0.062	0.031	0.022	0.017
GZ above 30	0.2 [m]	0.475	0.406	0.374	0.417	0.532	0.288	0.21	0.173
GZ max angle	25 [deg]	53.854	52.624	51.972	53.653	54.349	52.834	51.369	50.699

Table 2-10 - GZ shape criteria

2.6.23 In addition to the Paramarine modelling, the failed conditions were recreated from the KN curves defined in MV RIVERDANCE stability book - a KN curve is a VCG independent way of presenting the stability information. Displacement, trim, KG and free surface moment were calculated by Paramarine. KM and KN were taken from the stability book and interpolated to the exact condition used. Due to the coarse 10° increments used in the stability book to define the KN curve the GZ area criteria were calculated using Simpson's first and second rules. Table 2-11 details the results of this calculation.

IMO shape criteria	Limit	Conditions		
		VCG up	+10% VCG up	+15% VCG up
GMTf	0.15 [m]	1.19	1.16	1.11
area 0 to 30	0.055 mrad]	0.090	0.078	0.071
area 0 to 40	0.09 [mrad]	0.132	0.113	0.100
area 30 to 40	0.03 [mrad]	0.042	0.034	0.0296
GZ above 30	0.2 [m]	0.298	0.239	0.200
GZ max angle	25 [deg]	50	50	50

Table 2-11 - GZ shape criteria using KN curves from approved stability book

2.6.24 Using the stability book values it is found that the condition with 10% increased cargo mass and cargo VCG raised would pass the IMO shape criteria. The 15% increased mass and VCG raised marginally fails the area 30°-40° criterion and comes close to failing the maximum GZ above 30° criterion.

2.6.25 This illustrates that the use of the approved Stability book loading condition data, which is generated from the KN curves, would have shown an operator that the vessel would pass the criteria in these conditions, whereas the PARAMARINE data indicates that it would not. It is important to note from this that the degree to which the vessel would pass the criteria in Table 2-9 is in the second or third decimal place – 'only just' passing the criteria in this way should provide the operator with a clear indication that the condition that the vessel is proposing to sail in be carefully considered.

2.6.26 The VCGs and weights of cargo such as trailers could vary, as all trailers are not the same. Differences in factors such as size, weight, loading and shape will all influence the mass and VCG of the trailer. The masses of the trailers are provided in the cargo manifest; however there is no detailed VCG information of the trailers. The typical value that is taken in the stability book for trailer VCG could be optimistic if the actual cargo loaded had a majority of tall trailers, however when the trailer VCG value from the stability book was reviewed, the value used was believed to be a realistic for a typical (average) trailer.

2.6.27 It should be noted that although not required for the vessel due to the age and criteria it was designed to, this vessel would not comply with the new wind heeling criteria in the current IMO Intact Stability Code in the estimated load condition. A weather criterion was adopted for passenger and cargo ships as well as fishing vessels of 45 m in length or over as IMO resolution A.562(14) in 1985. The basic principle of the weather criteria is an energy balance between beam wind heeling and righting moments with a roll motion taken into account. This criterion was originally developed to guarantee the safety against capsizing for a ship losing all propulsive and steering power in severe wind and waves, which is known as a dead ship. It was decided at IMO that vessels built before this date were not required to meet these criteria.

3 MV RIVERDANCE - Scenario Assessments

3.1 Prior to the incident

3.1.1 It has been shown that the MV RIVERDANCE was running with the waves at about 13kts, just off stern seas. Based on the wave periods derived in the environmental investigation the approximate wave speed would be close to 18kts. This meant that the MV RIVERDANCE was running within 4.5kts (slower) of the wave speed.

3.1.2 The motions and 'ride' aboard the MV RIVERDANCE would have felt quite comfortable with relatively low motions for the weather conditions. This was confirmed in reports that the motions were low even in the very bad weather. There were however, several occurrences of large but slow roll angles reported prior to the incident, which was sufficient enough for some of the trailers to move on their lashings on the main deck. The peak roll motion was reported to be in the order of 15-20 degrees.

3.2 Dynamic Stability of MV RIVERDANCE in Stern Seas

3.2.1 Travelling at close to wave speed can cause some dangerous situations which can develop very quickly and without warning. Travelling close to the speed of the waves can commonly lead to undesirable dynamic stability behaviours including parametric rolling, surfriding, loss of stability on a wave crest and broaching incidents.

3.2.2 In order to investigate the dynamic behaviour of the MV RIVERDANCE in waves, a non linear time domain program called FREDYN was used to simulate the vessel in six degrees of freedom. The FREDYN program was designed to enable the simulation of the motions of an intact steered ship in wind and waves. Unlike the currently available frequency domain seakeeping programs, FREDYN is able to take account of the non-linearities associated with the drag forces, excitation forces and rigid body dynamics. The approach is a physical one, where all physical factors are considered. Both viscous and potential forces are added to complete the physical model. Non-linearities have to be considered when investigating large roll angles, as they arise from :-

- Effect of large angles on excitation forces,
- Rigid body dynamics with large angles,
- Drag forces associated with hull motions, wave orbital velocities and wind,
- Integration of wave induced pressure up to the free surface.

3.2.3 Parametric rolling occurs where the righting arm of a ship travelling in longitudinal waves varies with time, sometimes drastically. As a result, if the wave encounter period is a multiple of half of the natural roll period of the ship, a roll motion can develop with a period equal to the natural roll period of the ship. This is commonly known as parametric roll resonance. The regime of parametric resonance in which the encounter period is half of the natural roll period is often known as low cycle resonance or principal resonance; it is the most significant regime and may easily lead to large roll angles or in the extreme to capsize. 'Parametric rolling' can occur in head and stern seas if the correct conditions occur.

3.2.4 In experiments [1] with a container ship model complying with the Intact Stability Code, the model was found to capsize due to low cycle resonance. Such capsizes occur with relatively small metacentric heights (GM) in model tests at low Froude numbers in following seas. This danger occurs mainly for ships with a small GM and high freeboard. In the case the encounter period is so long that the pitch and heave motion can be regarded as static. When the heading angle to the waves increases, this danger decreases.

3.2.5 Experimental evidence also exists of parametric roll motion in head and beam seas [2]. In this case low cycle resonance requires a larger GM and does not easily lead to capsize. In addition, when the natural pitch period is half the natural roll period of the ship and equal to the encounter wave period, this phenomenon in head seas can be significant. Here the coupling between roll and pitch is essential unlike the phenomenon in following seas.

3.2.6 The condition required for parametric roll resonance of the MV RIVERDANCE cannot occur in stern waves, which the vessel was at the time of the incident, due to the required encounter period. However, it should be noted that the conditions for parametric rolling could occur in head seas. These ideal conditions were evaluated using regular waves in the FREDYN time domain program and it was found that a small disturbance could lead to parametric roll resonance in head seas with a roll motion building to over 15 degrees, as shown in Figure 3-1. Due to the fact that the MV RIVERDANCE was in stern seas at the time of the incident it is suggested that parametric rolling was not a contributing factor in this incident and can be discounted.

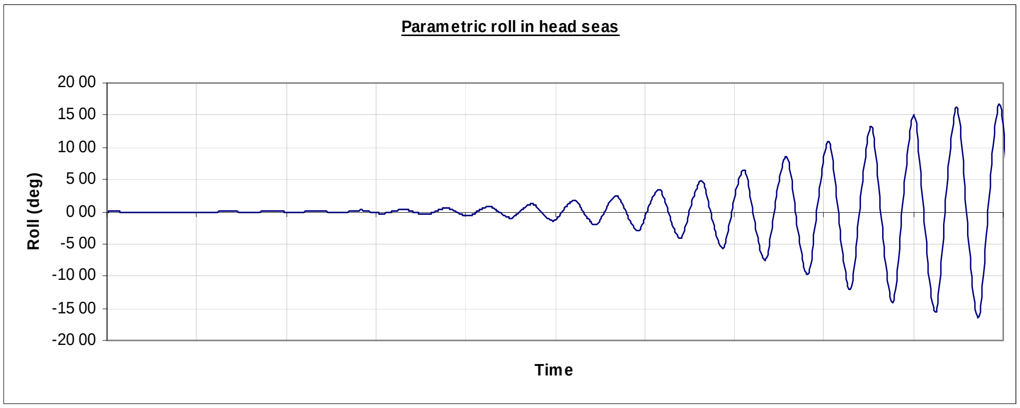


Figure 3-1- Parametric roll in regular head seas.

3.2.7 Surf riding and broaching are closely coupled phenomena. Broaching is a phenomenon in which a ship cannot maintain a constant course despite the maximum steering effort of her helmsman. This phenomenon can be realised when running in following and quartering seas with relatively high speed (relative to the waves). For broaching to occur, the vessel is accelerated by the approaching wave and is captured on the down slope of the wave face. This is known as surf riding. Whilst the ship is captured on the down slope of the wave, the ship can become directionally unstable due to the change in flow conditions on the face of the wave. Despite the maximum rudder application due to a helmsman or auto pilot, the ship course continues to deviate from the desired one. Such uncontrollable yaw angular velocity, together with the resultant sway velocity, can result in large roll angles and in worst cases in complete capsize. Prior to the turn to Starboard on the RIVERDANCE the autopilot was reported to be using 25 degrees of rudder to maintain course. This indicates a marginal level of control and hence the vessel is likely to have been close to surf riding and broaching.

3.2.8 If the nominal speed of the ship is lower than the critical speed of surf-riding, the ship experiences a periodic motion in the waves. The vessel spends a longer duration on the wave crest than in the wave trough due to the non-linear nature of the periodic surging motion. Whilst on a wave crest the righting arm of a ship can decrease significantly, due to the significant change in shape of the submerged water plane. In the case of pure following seas, a ship could capsize simply due to loss of static balance by such a reduction of transverse stability on the wave crest. This phenomenon is known as pure loss of stability. This has been seen both experimentally and numerically for vessels in steep stern waves. Published numerical and experimental studies on commercial vessels have observed this phenomenon with different types of ship including fishing vessels and container ships.

3.2.9 Examining the GZ righting arm curves for the estimated loading condition at the time of the incident, both with the vessel balanced on a wave crest and with the wave positioned at the ends of the vessel, provide an indication of the susceptibility of this loss of stability on a wave crest phenomenon for the MV RIVERDANCE.

3.2.10 As can be seen in Figure 3-2 there is a very large reduction in the GZ righting arm as the wave slowly passes amidships.

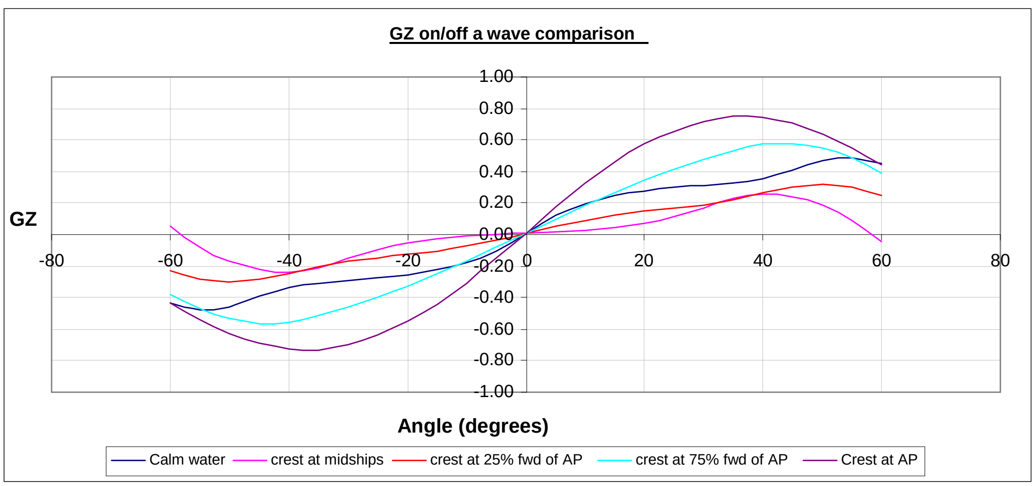


Figure 3-2 - GZ comparison on a wave crest

3.2.11 Plotting the virtual metacentric height (GM) as a regular wave (λ=103.4m, ht=8.0m) passes the length of the ship, Figure 3-3, shows the considerable reduction in GM, righting arm and hence stability as the wave crest reaches amidships and then a slight increase when the wave crest is at the forward and aft perpendicular.

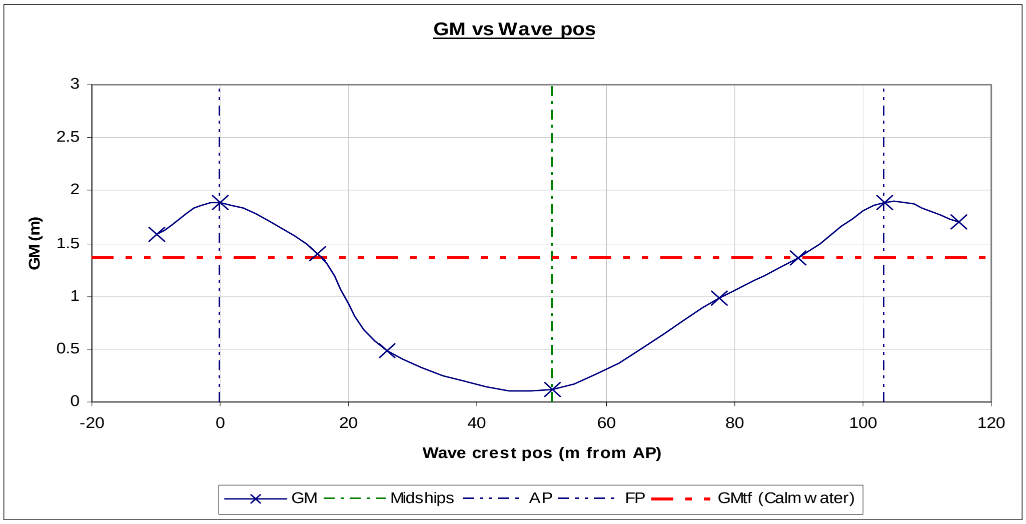


Figure 3-3 - Effective GM variation on a wave crest

3.2.12 If the vessel heading angle is also changed to stern quartering seas, the ship can suffer both a reduction of the restoring arm on a wave crest as well as a wave exciting roll moment. The dynamically coupled sway-yaw-roll motion then becomes significant and the roll motion can build to the point where the vessel could reach capsize on the wave crest. This cannot be named as ‘pure loss of stability’ because of the significant dynamic motion effect leading up to capsize. Experimental observations of this capsize mode has been seen for commercial ships during studies in Japan [3]. This dynamic roll motion is different to parametric roll resonance, because its motion period can be far from the natural roll period of the vessel.

3.2.13 With the vessel modelled in FREDYN at the best estimated load condition and travelling at 13kts in stern seas, as the vessel MV RIVERDANCE was prior to the incident, the vessel behaviour was first investigated in regular waves. The regular waves were representative of a steep ‘packet’ of waves in the irregular wave train, which could generate the condition for a reduced GZ righting arm with the wave crest slowly passing amidships. This allows the potential for these conditions to be evaluated without long irregular wave simulations. The roll angle trace from the simulation is shown in Figure 3-4.

3.2.14 At the peak of the roll trace in Figure 3-4, the vessel is rolling 17 degrees to Port. At this point the wave crest is amidships and has reduced the righting arm. As the wave passes along the vessel and reaches the bow or stern, the righting arm increases, the stability increases and the vessel returns to close to upright – shown by the roll trace passing through the zero roll point..

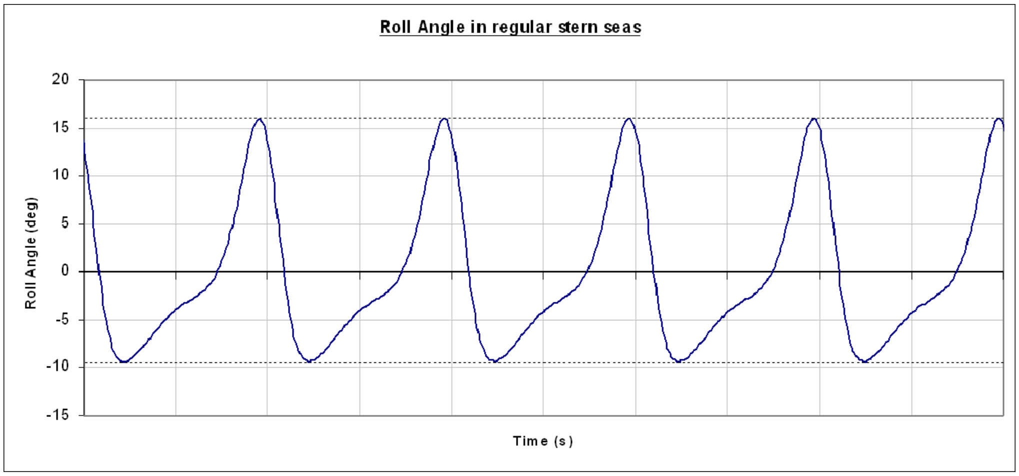


Figure 3-4 - MV RIVERDANCE Roll motion in regular stern seas

3.2.15 The roll angle experienced is also influenced by the angle of incidence of the waves. In order to assess the sensitivity of the vessel to changes in angle of incidence, dynamic simulations were carried out in 5 degree heading intervals from stern seas (Simulation = 0 degrees) to stern quartering seas (Simulation = 30 degrees) and the resultant single roll event traces for a single wave can be seen in Figure 3-5.

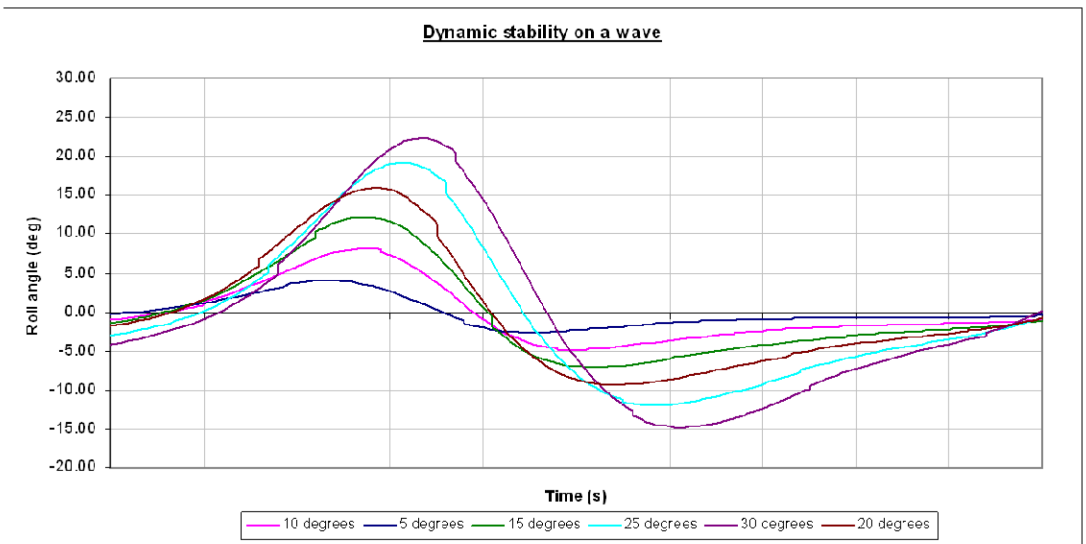


Figure 3-5 - MV RIVERDANCE roll motion in regular stern seas

3.2.16 The tests were repeated in irregular waves representing the wave conditions at the time of the incident and run for much longer duration. Several large slow roll motions were again measured in the simulation as a set of larger waves in the wave train slowly passes the ship. An extract of the simulation time history of the roll motion is shown in Figure 3-6 and a large roll event can be clearly seen (20 degrees Port Roll). These roll events are non-linear in nature, but approximately one large roll motion was experienced every 500 seconds in the simulation, this behaviour fits with the reports of occasional long slow roll motions of 15-20 degrees and would be a likely cause of the large slow roll motions which led to the reported initial movement of the cargo on the Main Cargo Deck. Thus is can be concluded that the most likely cause of the rolling motion prior to the turn to Starboard was partial loss of stability on a wave crest.

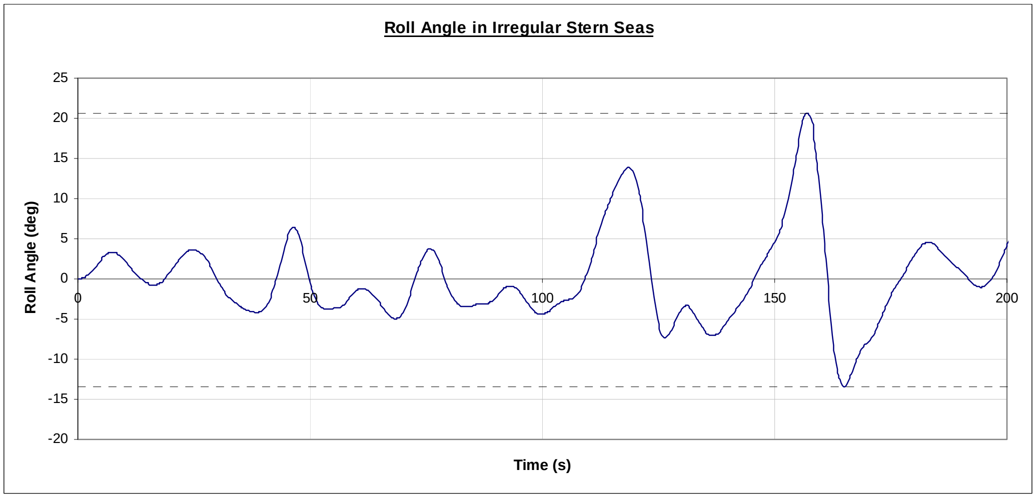


Figure 3-6 - MV RIVERDANCE Roll motion in irregular stern seas

3.3 The Turn to Starboard

3.3.1 Prior to the incident, the vessel's course had been relatively steady. Due to the movement of some cargo on the Main Cargo Deck it was estimated that an angle of list (around 10 degrees) was then taken up by the vessel. The autopilot was using 25 degrees of rudder to maintain course, until it was disengaged and the wheel applied hard to Starboard. All of the subsequent analysis is based upon an initial 10 degree list to Port.

3.3.2 The vessel was then reported to have rapidly turned to Starboard and took up a significant angle of heel/list. The vessel then remained in close to beam seas at a mean angle of approximately 35 degrees to Port, rolling up to 45 degrees.

3.3.3 Reviewing the heading data at the point of the incident, Figure 3-7, it can be seen that the vessel yawed around uncontrollably from stern seas heading into beam seas. The experienced rate of turn, measured from the ship's data was approximately 2 deg/s.

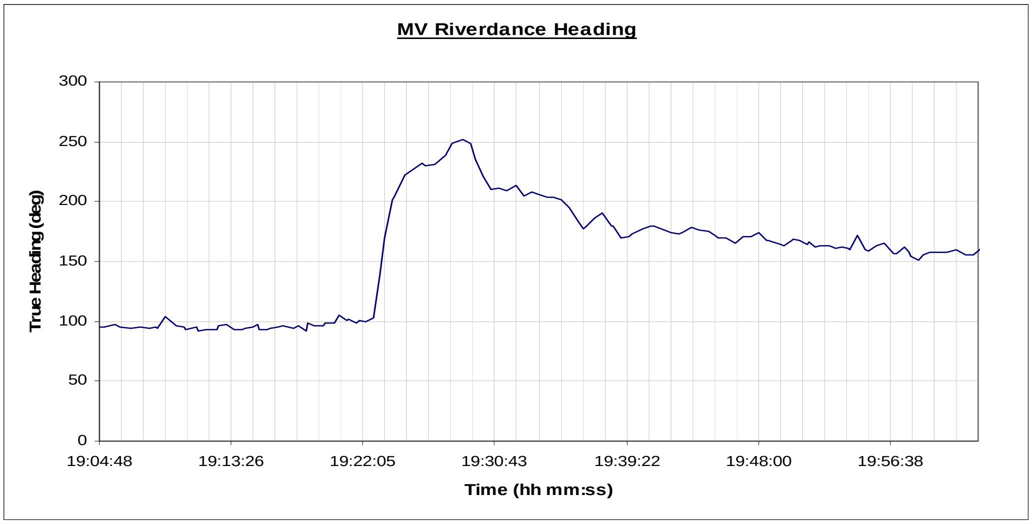


Figure 3-7 - Heading plot at point of incident

3.3.4 FREDYN simulations have been carried out to simulate the vessel turning by demanding a rudder angle, these simulations have been carried out both in waves and calm water for a range of rudder angles.

3.3.5 The rate of turn for a given rudder angle (in calm water) is shown in Figure 3-8. From the ship's heading data the actual rate of turn is approximately 2 deg/s, this can be seen to be equivalent to a 20deg rudder angle. Under full control, a ship of this type is likely to be able to achieve this rate of turn through the use of the rudders although it would not be recommended. The MV RIVERDANCE was fitted with a high lift type of rudders which would be more efficient at turning the ship than presented in Figure 3-8 and hence the data displayed is conservative.

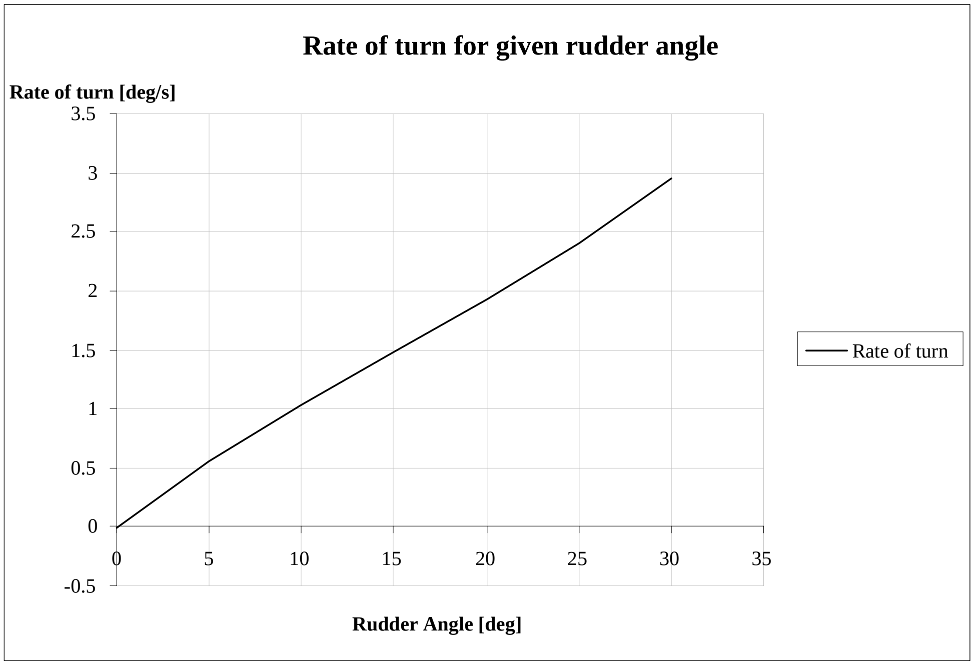


Figure 3-8 - Rate of turn for given rudder angle

3.3.6 The turn rate could have occurred due to rudder failure. However, there is no evidence of rudder failure as after grounding the vessel was manoeuvred for an extended period in an attempt to move further off the beach, thus the rudders were still functioning at this time.

3.3.7 The turn to starboard was reported to have been initiated by a demanded rudder angle while the vessel was close to wave speed in large stern seas. It is most likely that the turning of the rudder even a small amount initiated a broach leading to the high roll angle regardless of the initial rudder angle.

3.3.8 The vessel autopilot was quickly responding to the forces on the vessel by using up to 25 degrees of rudder. The amount of rudder being used and the rapid cycling shows that the autopilot was only just able to retain this control. Applying steering effort manually would not have been able to react quickly enough to the forces to control the vessel and it is likely that merely breaking reactionary cycle of the autopilot would have induced the broach.

3.3.9 When a broach occurs, the vessel is accelerated by the approaching wave and is captured on the down slope of the wave face. This is known as surf-riding. Whilst the ship is captured on the down slope of the wave, the ship can become directionally unstable due to the change in flow conditions on the face of the wave. Uncontrollable yaw angular velocity, together with the resultant sway velocity, can result in large roll angles and in worst cases in complete capsize. While a ship in waves normally experiences a periodic motion, broaching is a transition from a stable periodic motion to a non-periodic motion.

3.3.10 A detailed investigation of the MV RIVERDANCE in large seas was conducted using the FREDYN program to look at the susceptibility of broaching. As well as interactive simulations, the vessel was tested in hundreds of simulations covering 6 speeds and 13 heading combinations, resulting in 1950hrs of seaway data for the three load conditions that were tested. The three load conditions were the best estimated load condition and the best estimated condition with 10% and 15% more cargo mass on both the Main Cargo Deck and Upper (Weather) Deck, which were believed to be the most likely of the variations examined (Section 2 – Table 2-7). This would allow the effect on the dynamic stability due to the uncertainty in the cargo masses to be assessed.

3.3.11 Based on the theory and the FREDYN investigations, it was concluded that the MV RIVERDANCE could broach in the load condition and environmental conditions that it experienced. It was also reported that the autopilot, which was operating at the time of the incident, was using its maximum of 25 degrees in both directions (Port and Starboard) to maintain course. It was shown that a small change to the rudder to initiate a turn was enough to trigger a broach – indicative of the change of disengaging the autopilot, which once started was not possible to pull out of.

3.3.12 It was also evident from the FREDYN investigation that independent of where the turn was applied in relation to a wave crest/trough it was possible to reach the most severe roll angles and in some cases reach complete capsize in the 10% and 15% increased cargo mass loading conditions. It is therefore concluded that any turn that was initiated manually to turn away from the course was sufficient to trigger a severe broach that could then lead to the large combined list and heel angle experienced during the turn.

3.4 Cargo Shift Prior to and After the Turn to Starboard

3.4.1 Following a large hanging roll incident the vessel took up a constant list to Port just prior to the turn to starboard. As the long slow rolling motions being experienced by the vessel were in the order of 15 to 20 degrees, any down flooding was unlikely to have occurred. This suggests that the reported list to Port was possibly due to a shift in cargo. This is supported by crew reports which stated that some shifting cargo could be heard.

3.4.2 An analysis of cargo shift and its effect has been carried out in order to determine the effect of cargo shift on list angle.

3.4.3 Whilst it is not possible to ascertain exactly how much cargo shifted prior to the turn or indeed exactly what the angle of list was, it can be demonstrated in an initial assessment that an angle of list of 10 degrees could be sensibly obtained with a moderate cargo shift. This cargo shift would have been equivalent to the contents of 27 of the trailers shifting by 1.9m to port, or any of the following combinations (Table 3-1):

Percentage cargo	No. Trailers	Distance moved by trailers (m)	Distance moved by contents (m)
100%	54	0.70	0.96
50%	27	1.40	1.92
33%	18	2.12	2.91
25%	14	2.80	3.84
10%	5	7.00	9.59

Table 3-1 - Required cargo shift for 10 deg list.

3.4.4 The reported list angle was up to 15 degrees, however, the analysis carried out suggests a figure closer to 10 degrees is more realistically achievable through cargo shift alone, as 15 degrees would require an unrealistically large amount of cargo to have moved. Hence 10 degrees has been used as the initial list angle for the simulations. It should be noted that the vessel would have been rolling about the 10 degree list angle and so greater maximum roll angles would have been experienced.

3.4.5 On reviewing the RAF helicopter video footage, which was on scene to airlift off the crew, the vessel can be seen drifting in beam waves after the turn to Starboard, the vessel took up a mean combined heel/list angle of approximately 35 degrees to Port, rolling up to 45 degrees in the large waves.

3.4.6 Following an initial cargo shift assessment, a detailed investigation was made of the most likely cargo shift prior to and after the turn to Starboard. The RAF helicopter video of the vessel after the turn shows that many of the trailers on the weather deck remained in position in their securing chains, with some of the cargo lost off the Port side.

3.4.7 Photographic evidence from the salvage operation after the incident clearly shows that many of the trailers on the main cargo deck actually remained secured by their chains or lay securely against other trailers or ship's structure even when the vessel was at 90 degrees to Starboard on the beach. Figure 3-9, 3-10 & 3-11.

Figure 3-9 - Trailers on the Main Deck still secured by lashing chains

Figure 3-10 - Trailers on the Main Deck chocked against other trailers or ship's structure

Figure 3-11 - Intact trailers on the Main Deck during salvage

3.4.8 In order to further evaluate the most likely shift in cargo, CAD sketches were used to identify actual and potential cargo shift to investigate the most likely possibilities and what effect it would have on the vessel. There are some minor differences in the trailer alignment since the exact dimensions of the trailers are unknown, and hence a standard trailer size has been assumed.

3.4.9 Initially the trailers were drawn in CAD onto both the Main and Upper (Weather) Decks in the positions that were most likely in at the start of the voyage based on the cargo manifest details. At the start of the voyage the most likely layout of the trailers is shown in Figure 2-3. The position of each of the trailers was then used to calculate the overall centroid of the cargo on each of the decks for use in the stability calculation of the best estimated condition as discussed in Section 2.

3.4.10 Prior to the turn to Starboard a list angle of 10 degrees was considered likely following some shift in cargo on the Main Deck.

3.4.11 If it was assumed that all of the trailers on both the Main and Upper (Weather) Decks broke their lashings and moved to Port, where possible, then the layout of trailers would likely be as shown Figure 3-14 below. This figure shows all of the trailers stacked next to each other, shifted as far to Port as possible, on both Main and Upper (Weather) Decks. This also takes accounts of the internal arrangements of the vessel that restricts the movement of the trailers. This most extreme cargo shift case, with all of the cargo shifted results in a maximum list of 25.4 degrees and hence the observed mean combined list and heel angle of 35 degrees could not have been caused by cargo shift alone. Although in combination with beam wind effects the vessel could reach 34 degrees combined list and heel. However, based on the evidence from the RAF video and salvage photographs, including those shown in Figures 3-10 and 3-11, this extreme case did not occur prior to or after the turn.

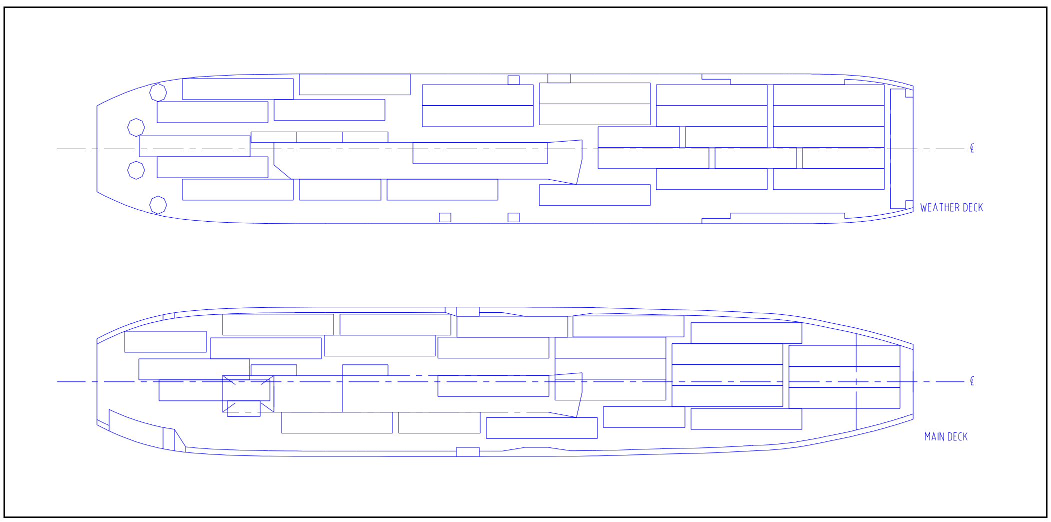


Figure 3-12 - CAD Sketch of Trailer layout with the most extreme cargo shift case with all cargo on Main Deck and Upper (Weather) Deck shifted to Port where possible

3.4.12 On examination of the RAF video following the turn, an updated detailed CAD sketch of the shift of the trailers on the Upper (Weather) Deck was created and analysed. With the cargo shift seen in the RAF video after the turn and without any loss of cargo taken into account, Figure 3-13 shows the most likely layout of the Main and Upper (Weather) Decks. The Main Deck is shown still with all the trailers shifted to Port where possible (taking into account the restrictions of ships structure and other trailers), which is know to be a worst case cargo shift for this deck, as photographs clearly show trailers still in position hanging in their restraints. The resulting list angle for this case is 8.9 degrees to Port.

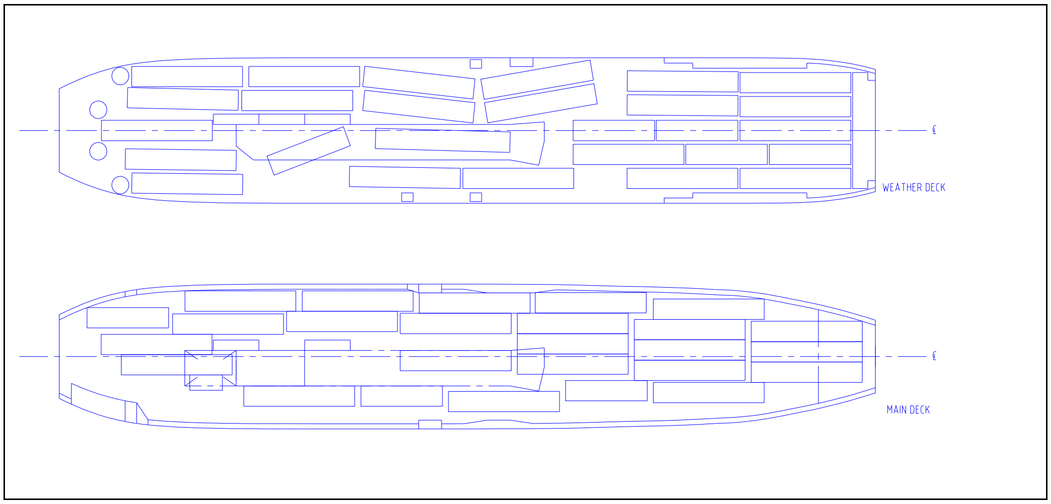


Figure 3-13 - CAD Sketch of trailer layout with Upper (Weather) Deck cargo shift as per RAF video and with all cargo on Main Deck shifted to Port where possible

3.4.13 From the RAF Video it is clear that the contents of some of the trailers have been washed away by the waves. Two trailers located on the Port side of the vessel lose their cargo (The trailer shown in red in Figure 3-14 plus the one immediately forward of it), and the trailers at the aft of the vessel suffer severe damage which is likely to have resulted in cargo loss. Hence it is approximated that 44te of cargo in total is lost. The third trailer from the stern on the Port side was lost overboard (a loss of an additional 6 te, 50 te lost in total). The loss of cargo on the Port side Upper (Weather) Deck results in a decrease of the list angle to 4.5 degrees to Port. The video picture of the upper deck is shown in Figure 3-15 and 3-16. Figure 3-16 shows the skirt side of the trailer flapping and the severe damage to the trailers at the aft of the vessel.

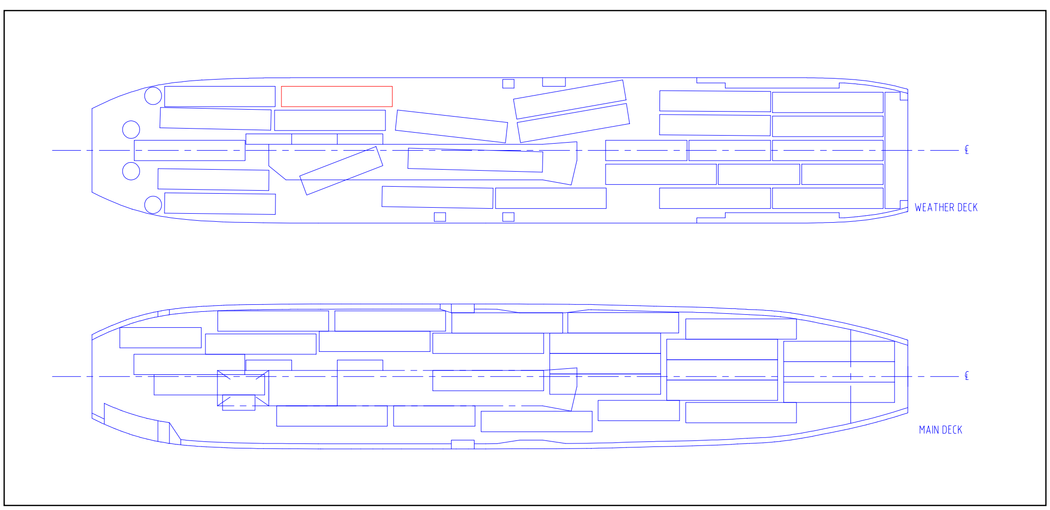


Figure 3-14 - CAD Sketch of trailer layout with Upper (Weather) Deck cargo shift and loses as per RAF video and with all cargo on main deck shifted to Port where possible

3.4.14 In order to consider the most likely case for cargo shift contribution to the incident, for the remainder of the analysis the contribution by cargo shift is considered as 4.5 degrees, which with the wind effects (45kts) would produce a combined list and heel angle of approximately 10 degrees.

Figure 3-15 - Video of Upper (Weather) Deck trailer layout after the turn

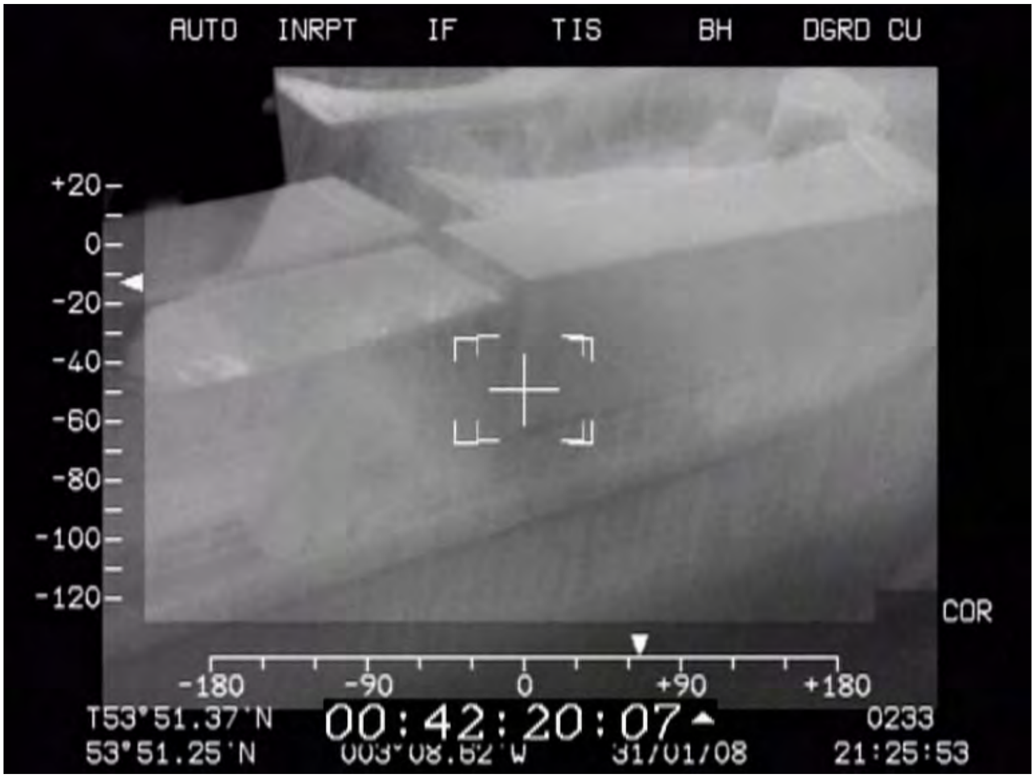


Figure 3-16 – Video of Weather Deck trailers showing damage to trailers

3.4.15 The hydrostatics of the vessel following the turn due to the most likely cargo shift as shown in Figure 3-14 is included (Table 3-2):

Total Cargo weight (te)	1157.4000				
	x (m)	y (m)	Z (m)		
Overall Cargo centroid	49.3191	0.3906	11.3702		
			Centroid		
	Weight (te)		**X (m)**	**y (m)**	**z (m)**
Lower Hold Cargo	0.0000		58.6000	0.0000	3.1200
Main Cargo	603.0000		48.9500	1.0150	8.2000
Upper (weather) deck Cargo	546.0000		49.1100	-0.2930	14.8000
Crewstores	8.4000		89.4000	0.0000	16.0100

trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List _angle (deg)	displacement (te)
0.49	**4.67**	**4.91**	**4.42**	**-4.49**	**4597.78**

Table 3-2 - Cargo Centroids and Main Vessel Hydrostatics from Cargo Shift alone after the turn to starboard[1]

3.5 Wind Effects

Figure 3-17 shows the added effect that a beam wind has on the heel of the vessel in the best estimate condition with no changes to loading condition. The magnitude of the wind heeling lever is directly affected by the existing list/heel of the vessel and the righting arm, the more upright the vessel the larger surface area is exposed to the wind and hence the greater the wind heeling lever. The wind effects do however depend heavily on what is happening to the ship condition and the angle of heel of the vessel. With additional water through ballasting or flooding in the vessel, the effect of the wind is different to when the vessel is not flooded.

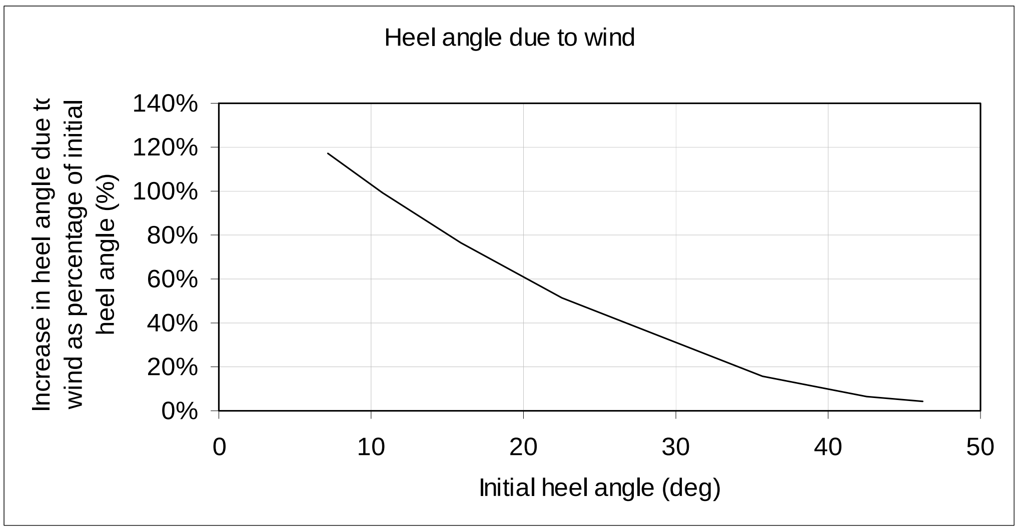


Figure 3-17 - Heel angle due to wind without flooding or ballasting

3.5.1.1 This shows that with the realistic cargo shift described above and the inclusion of wind heeling effects, the combined list and heel angle of the vessel would be around 10 degrees (accounting for gusting wind) and so does not explain the mean 35 degree combined list and heel angle seen in the RAF video after the turn to starboard.

3.6 Other potential contributing factors on the vessel angle following the turn

3.6.1 Following this rapid turn to Starboard the vessel took up a mean combined heel/list of approximately 35 degrees to Port, rolling up to 45 degrees in large waves.

3.6.2 On reviewing the RAF helicopter video footage of the vessel drifting in beam waves after the turn to Starboard, it could be clearly seen that the stanchions, deck fittings and even the sides of the curtain sided trailers on the Port side of the Upper (Weather) Deck, had been ripped off, possibly due to the force of the water or by the movement of cargo during the

[1] These conditions are taken from the approved RIVERDANCE SIB [4] and modelled in PARAMARINE, hence there are some small differences in the values (Further detail on the modelling can be found in Section 2.6)

severe roll and rapid turn to Starboard. This indicates that significant amounts of water had flowed rapidly along the Upper (Weather) Deck during the turn. The video footage also shows that while the vessel was initially over at approximately 35 degrees to Port (at 2100) this angle can be seen to have slowly reduced to approximately 20 degrees by 2135, Figure 3-18 & 3-18.

Figure 3-18 - Vessel at 35 degrees in waves at 20:54

Figure 3-19 - Vessel at 20 degrees in waves at 21:32

3.6.3 There are only three realistic possible contributing factors that could cause the sustained list angle, these are;

- cargo shift,

- pumping or siphoning of water within the vessel,
- influx of water into the vessel.

3.6.4 Whilst cargo shift is certainly a contributory factor it has been shown that the mean 35 degree combined heel/list angle is not likely to have been due to the cargo shift alone even with the inclusion of wind heeling effects. The crew reported that no ballasting was carried out prior to or immediately post the incident and examinations of the ship following the incident did not reveal any failures in the ballast pumping arrangements. However, from recordings made during the rescue operations it is confirmed (at approximately 2120) that the heeling system pump had been started but it was not confirmed whether it was actually operating.

3.6.5 The possible influx of water during the turn was initially investigated based on information available at the start that there was no transfer of fluid between tanks. No damage to the external hull was found following the grounding so traditional damage flooding events were not considered.

3.6.6 *Potential Down-Flooding of Water*

3.6.7 This violent and fast turn combined with an angle of heel/list would have caused the vessel to roll severely to Port, approximately 45 degrees was reported, causing the vessel to submerge the Upper (Weather) Deck edge Port side. Dynamic simulations in FREDYN were carried out in both calm water and regular following seas (6m wave height, 90m wave length), comparing the maximum roll angle experienced during a turn for a number of rudder angles.

3.6.8 Figure 3-20 shows the results of these simulations. It can be seen that in waves even a small turn of the rudder can result in angles between 45 and 52 degrees during the turn.

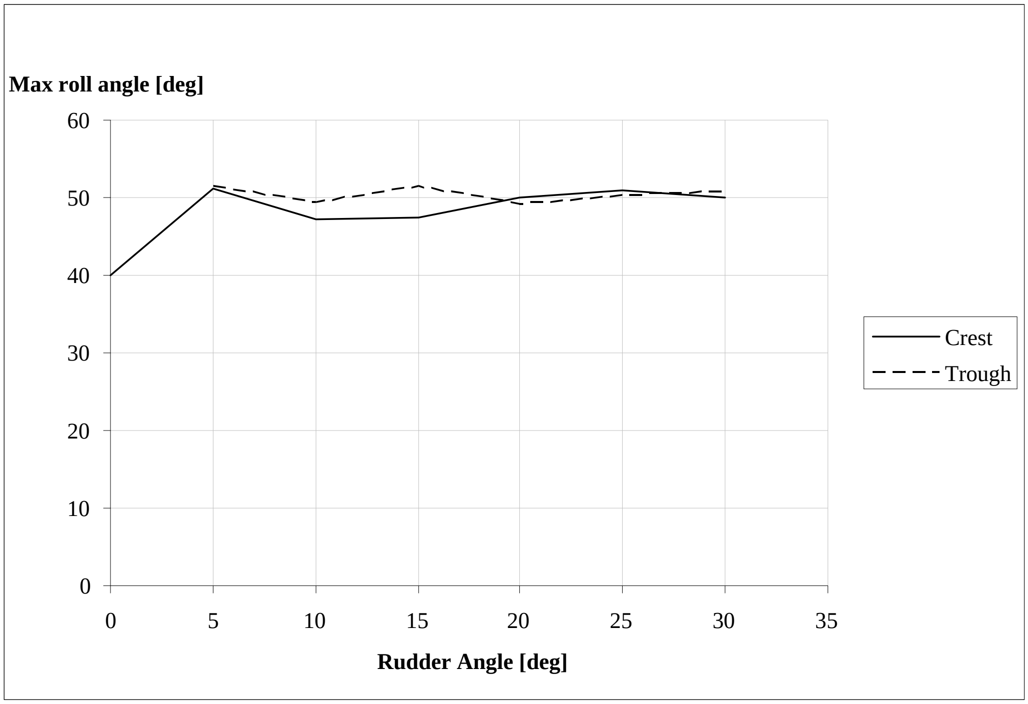


Figure 3-20 - Maximum roll experienced during a turn in regular waves

3.6.9 On investigation of potential points that could downflood water into the vessel, it was reported that after a crewman visited the Main Cargo Deck sometime after the initial large roll angles prior to the turning incident, the access door to the Main Cargo Deck on the Port side of the Upper (Weather) Deck may have been pinned open by cargo shifting in one of the curtain sided trailers. Later reports state that the door was secured shut. Sloshing noises were also reported to have been heard on the Main Cargo Deck after the turn to Starboard.

3.6.10 Additional potential downflooding points were also identified but flooding would be more restricted. The covers to the upper deck vents were found to have not been secured for sea. The potential down flooding points were:-

- One mushroom vent aft of the Port access door to the lower hold;
- One Forward Vent (Port & Stbd) (capable of being closed weathertight) down to Lower Hold (at Frs.106-108 approx);
- Two Open trunk vents (Port & Stbd) (covered by a grille) down to Main Deck (at Frs.116-118 & 120-122 approx. respectively).

These main down flood points are shown pictorially with those most likely to down flood due to their position are marked in red in Figure 3-21 and on photograph Figure 3-22.

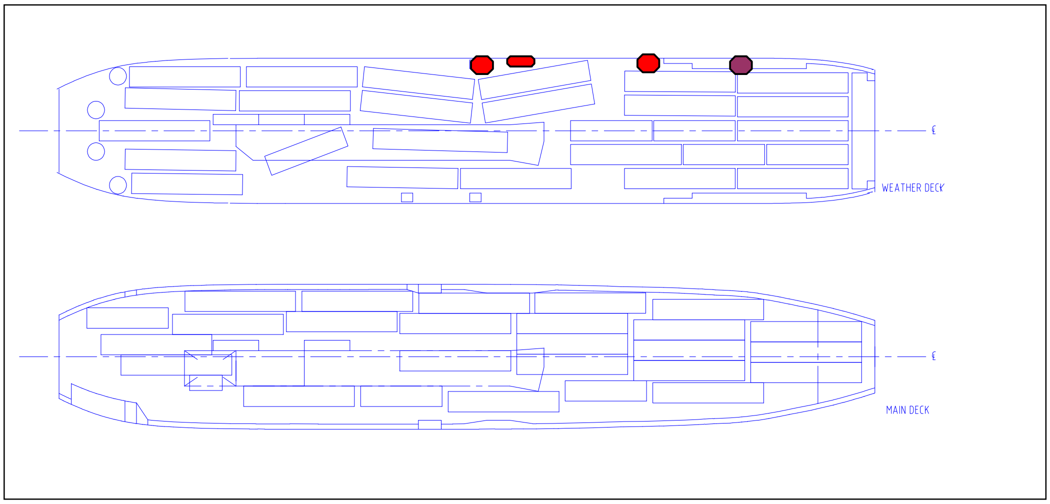


Figure 3-21 - Main potential downflooding points

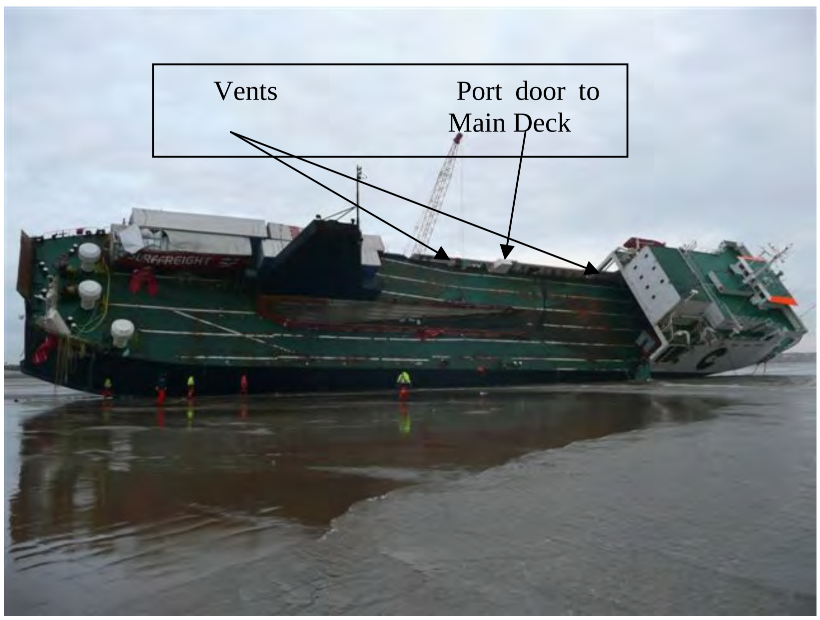


Figure 3-22 - Picture of upper (weather) deck showing potential downflooding points

3.6.11 An open door on the Port side would have been the largest and most unrestricted opening straight on to the Main Cargo Deck. Based on the FREDYN analysis and the video evidence from the RAF helicopter, it is clear that the Port Upper (Weather) Deck edge and part of the Upper (Weather) Deck were submerged during the turn and was continuing to have green water wash over it whilst drifting in the beam seas. It is therefore likely that if the door was not secured shut, it would have been at least partly submerged during the incident, leading to flooding of water onto the Main Cargo Deck. The other of the potential downflooding points likely to have been submerged at the 45 degree combined heel and list angle is the vent to the Lower Hold located on the Port side of the Upper (Weather) Deck close to the aforementioned doorway and the Port side forward vent.

3.6.12 The turning simulations in FREDYN initially used an intact FREDYN model to assess the list/heel angles during the turn and the potential submergence of the identified openings. These simulations were repeated with the inclusion of an opening to represent the open access door on the Port side Upper (Weather) Deck, which would allow water to flow down onto the Main Cargo Deck if the door was open and submerged.

3.6.13 Both sets of FREDYN simulations have shown that an open door on the Port side and the vents would be likely submerged for between 20 and 80 seconds during the turn, which lasted a total of 120 seconds, based on the log of the ship's heading. A screen shot of the FREDYN simulations of the turn is shown Figure 3-23.

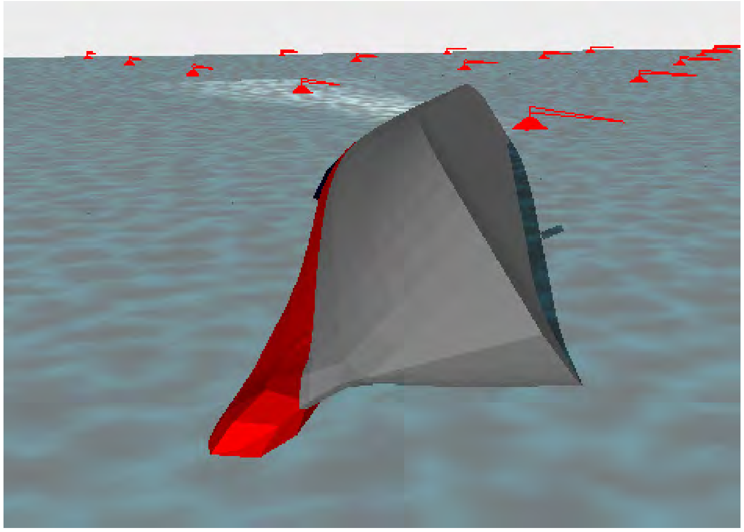


Figure 3-23 - Extreme roll angle experienced during turn

3.6.14 *Floodwater Mass*

3.6.14.1 The time that the vent and door were submerged is a function of the wave profile and subsequent roll motions of the vessel during the turn. The total time of the turn is 120 seconds. From the FREDYN simulations a most likely range of submergence times can be estimated for different waves, as it is not known exactly. Therefore a range describing the most likely amount of water that could have downflooded has been calculated by assuming a minimum submergence time of 20 seconds and a maximum submergence time of 80 seconds.

3.6.14.2 The calculations assume a constant head of 0.8m of water (depth of vent/door). This depth is based on the height of water above the vent/door with the vessel at the maximum angle experienced during a turn based on the FREDYN simulations discussed above.

3.6.14.3 Using Bernoulli flow through an orifice theory it is possible that, depending on what percentage of the turn the Upper (Weather) Deck edge was submerged for (which depends on the wave profile) between 38te (based on 20 seconds submergence) and 154te (based on 80 seconds submergence) of water would have downflooded to the Lower Hold via the Lower Hold vent and between 95te and 380te would have downflooded to the Main Cargo Deck via the door if it was open, based on the same submergence times.

3.6.14.4 Using the PARAMARINE static stability model, the effect of flood water on the Main Cargo Deck and Lower Hold was investigated. The calculations were carried out both with and without the inclusion of the wind heeling moment which would have been present due to the vessel drifting in beam seas with mean wind speeds in excess of 45 Knots. Figure 3-24 below shows a plot of mass of flood water distributed between the Main Cargo Deck and Lower Hold versus the mean angle of list. The x-axis represents the mass of water and the y-axis represents the resulting angle of list. The different curves represent differing distributions of water between the Lower Hold and Main Cargo Deck. With zero water there is 4.5 degrees heel due to cargo shift and wind effects.

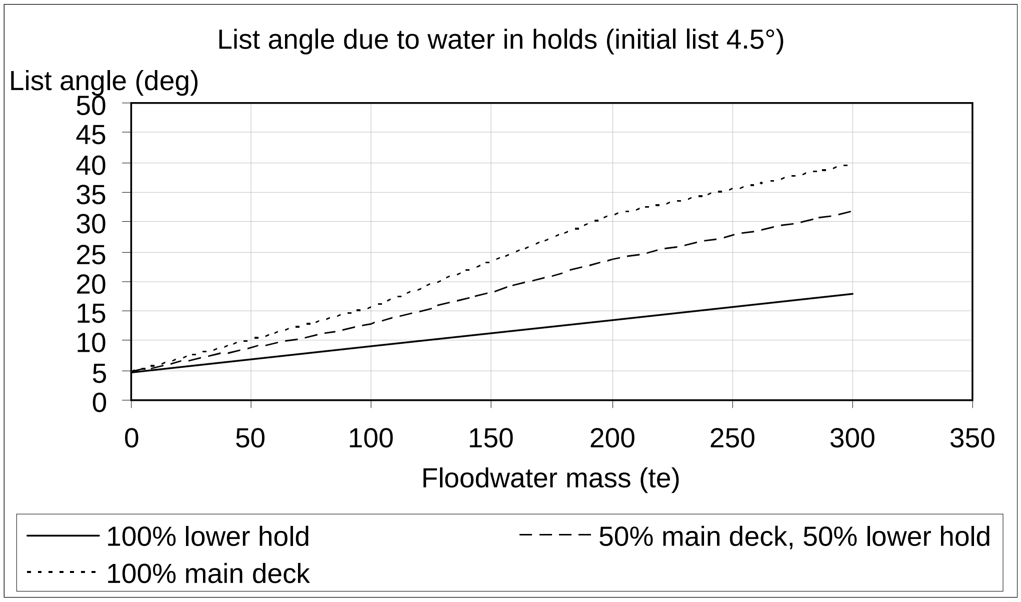


Figure 3-24 - List angle due to water on decks with 4.5 degree cargo shift

3.6.14.5 Figure 3-24 shows the effect of water on decks on the vessel heel angle. It can be seen that downflooding through the Lower Hold vent would have contributed between around 3 and 8 degrees of list angle (without wind effects), and potential downflooding from the access door (if open) would have contributed a maximum (assuming no water then downflooded into the Lower Hold) of 10 and 45 degrees of list angle (without wind effects).

3.7 Combined List and Heel after turn - Cumulative effect of downflooding with cargo shift and wind effects

3.7.1 FREDYN analysis indicated that during the rapid turn to Starboard large roll angles up to 45 degrees to Port, with downflooding occurring, could have been experienced. From this approximately 166te of water could have downflooded onto the Main Cargo Deck and 84te downflooded into the Lower Hold. Accounting for the effects of cargo shift as discussed in 3.4 above, results in typical hydrostatics of the vessel as follows:

List angle due to cargo alone	4.5	(deg)
Water on main deck	166.7	(te)
Water in lower hold	83.4	(te)
Trim between perpendiculars	-0.3	(m)
Mean draught	4.4	(m)
Draught AP	4.2	(m)
Draught FP	4.5	(m)
Displacement	4847.8	(te)
Heel/list angle in calm water (port)	28.0	(deg)
Heel/list angle with wind (port)	34.5	(deg)

Table 3-3 - Hydrostatics following turn due to potential downflooding

3.7.2 It should be noted that the mean draught in Table 3-3 is lower than that previously quoted. This is due to heel and trim effects.

3.7.3 It was not reported that any of the crew visited the Main Cargo Deck specifically to look for water, but some crew reported that they entered this deck to gain access to the Engine Room during the time of the rapid turn and suspected downflooding, their reports are conflicting as to where or whether water in sufficient quantity was seen within the vessel.

3.7.4 Towards the stern on the Main Cargo Deck the scuppers are shown to drain into a small aft sludge tank with a capacity of 5.52m3 (Figure 3-25). Even if the aft sludge tank was empty prior to the flooding, it would have filled within seconds of the water starting to enter onto this deck. Due to the severe list/heel angle, it would have only been the Port stern scuppers that would have been submerged. Even in perfect operating conditions the rate of drainage through the scuppers would have been insignificant in comparison to the inflow through the submerged door opening and would rapidly overwhelm the sludge tank and continue to flood the deck. Due to the angle of the vessel it is likely that the pump to empty this tank when full would not have been able to function. Even if pumping was available, the pump serving this tank is likely to have had difficulties keeping up with the inflow of water on to the deck (pump capacity is 200 m3/hr). Even if the vessel had been fitted with scuppers out to the side of the vessel (not shown on the drawings), with the severe list/heel angle, the Port side of the vessel was continually submerged, so no water would have flowed out due to the greater external pressure head of water.

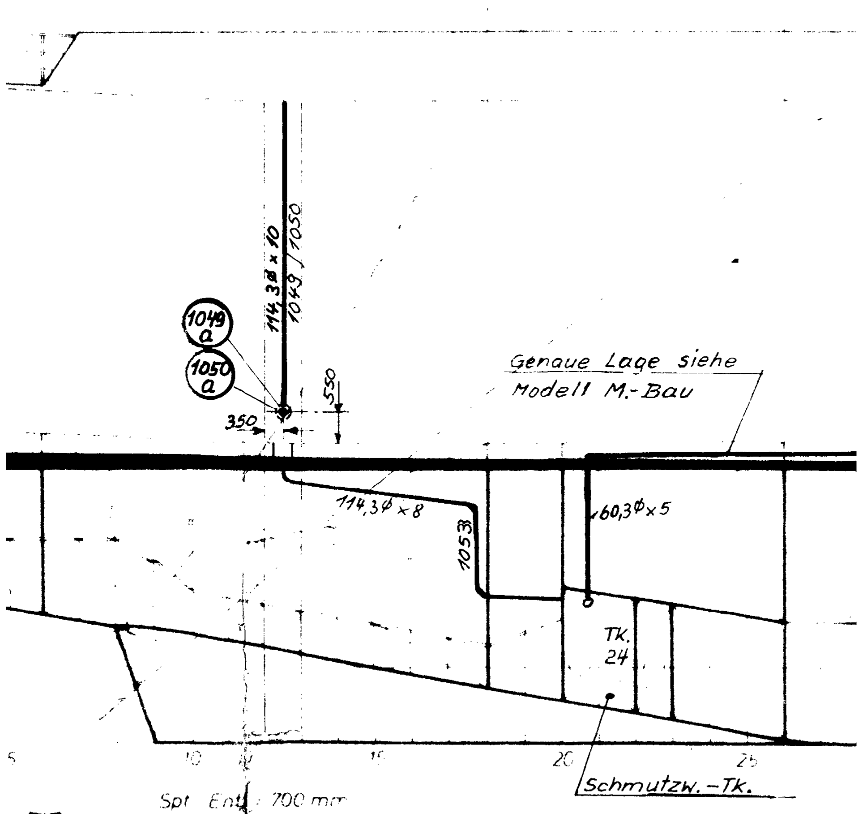


Figure 3-25 – Stern scupper arrangement

3.7.5 The forward scuppers and amidships scuppers on the Main Cargo Deck are shown to drain in to the bilge wells in the Lower Hold (Figure 3-26). The bilge wells may have not been emptied and if power was lost, which is likely at the large angles experienced, the bilge alarms and pumps may not have been available. This meant that these bilge wells would rapidly fill, (if not already full) and then would continue to flood the Lower Hold.

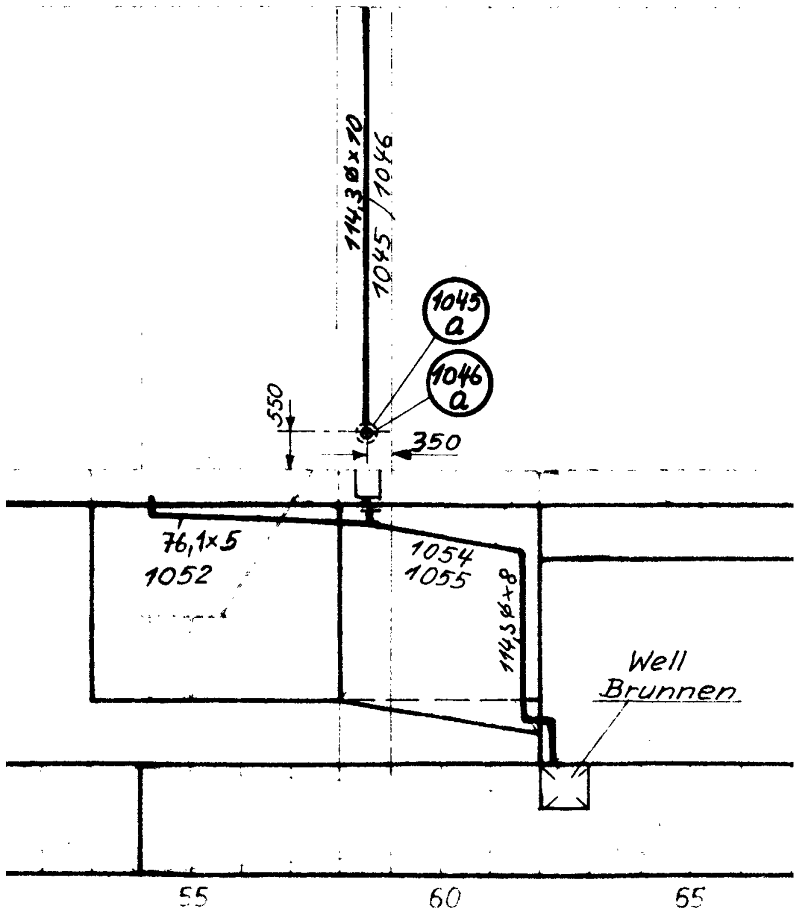


Figure 3-26- Midships scupper arrangement

3.7.6 Apart from the scuppers, the only other main potential downflooding points from the Main Cargo Deck are the port and starboard Lower Hold access hatches. Photographs presented by the MAIB showed the Port and Starboard access hatches to be non watertight, due to small coamings with multiple lightening holes in the hatch, allowing for potential down flooding from the Main Cargo Deck to the lower hold.

3.7.7 A survey by the MAIB of the MOONDANCE showed that the hatch into the bow thruster room was not likely to be fully watertight. It was reported that bilge alarms for the bow thruster room and Lower Hold were sounding after the turn to starboard. Some water from the Main Deck could have therefore also downflooded into the bow thruster room as well as into the Lower Hold. The ramp to the Lower Hold could have been another potential downflooding point, as the level of water tight integrity is unknown.

3.7.8 Based on the size of the scuppers and the holes in the Port side Lower Hold access hatch the down-flooding rate from the Main Cargo Deck to the Lower Hold with a maximum of 0.5m head of water would have been approximately 2 tonnes/minute. This means that after approximately 100 minutes the water that had downflooded onto the Main Cargo Deck would have drained to the Lower Hold, the vessel track indicates that the rapid turn incident took place at 1925. The RAF helicopter footage starts at 2045, showing that the vessel remained at an extreme angle for approximately 80 minutes. This reduction in VCG and free surface effect caused by the water draining from the Main Cargo Deck to the Lower Hold has the following effect on the vessel's hydrostatics (Table 3-4):

Heel angle due to cargo alone	4.5	(deg)
Water on main deck	0.0	(te)
Water in lower hold	250.0	(te)
Trim between perpendiculars	-0.1	(m)
Mean draught	4.8	(m)
Draught AP	4.7	(m)
Draught FP	4.8	(m)
Displacement	4847.8	(te)
Heel/list angle in calm water (port)	13.7	(deg)
Heel/list angle with wind (port)	23.0	(deg)

Table 3-4 - Hydrostatics after downflooding[2]

3.7.8.1 It can be seen that at this point in time (2125) the vessel has a static list/heel of approximately 20-23 degrees to Port (due to the wind) which agrees with the RAF video footage. See Figure 3-19.

3.7.8.2 It was reported that approximately 2 hrs after the incident one of the crew looked down into the Lower Hold and reported about three feet of water in the corner of the lower hold. This access was reported to be via the Starboard (high) side. Initial reports stated that the Lower Hold was not entered and the crew member viewed the water from the Main Cargo Deck, if this was the case, only a small portion of the Lower Hold can be seen. Later reports were revised to state that the crew member actually entered the Lower Hold.

3.7.8.3 The water encroaching into this area was reported as being approximately 3 ft deep. Given the list angle estimated at 20 degrees at this time if 250te of water is modelled in the lower hold, it can be estimated that the depth of water visible from the Main Cargo Deck hatch would have been approximately 1.1m (3.6 ft) which agrees well with the reports of approximately 3ft.

3.7.8.4 However, the report that the Lower Hold was entered and that the 3ft of water was seen only in the corner does not agree well with the modelling. The trim of the vessel at this time was approaching level trim. The lower hold scuppers drain to a small tank and are located in the aft corners of the hold and hence for 3ft of water to be seen in this location only would require the vessel to have had a significant stern trim..

3.8 Potential Transfer of Fluid between Heeling Tanks (13)

3.8.1 The MV RIVERDANCE has two heeling tanks, designated Tank 13 Port and Starboard, which reach from the double bottom to 5.7m above the base Port and Starboard. It was reported that these tanks were loaded with 78 tonnes of ballast water each side at departure.

[2] These conditions are taken from the approved RIVERDANCE SIB [4] and modelled in PARAMARINE, hence there are some small differences in the values (Further detail on the modelling can be found in Section 2.6)

The free surface heights of the fluid in these tanks can be seen in Figure 3-29 below, as 2.68m above the inlet at the bottom of the tank.

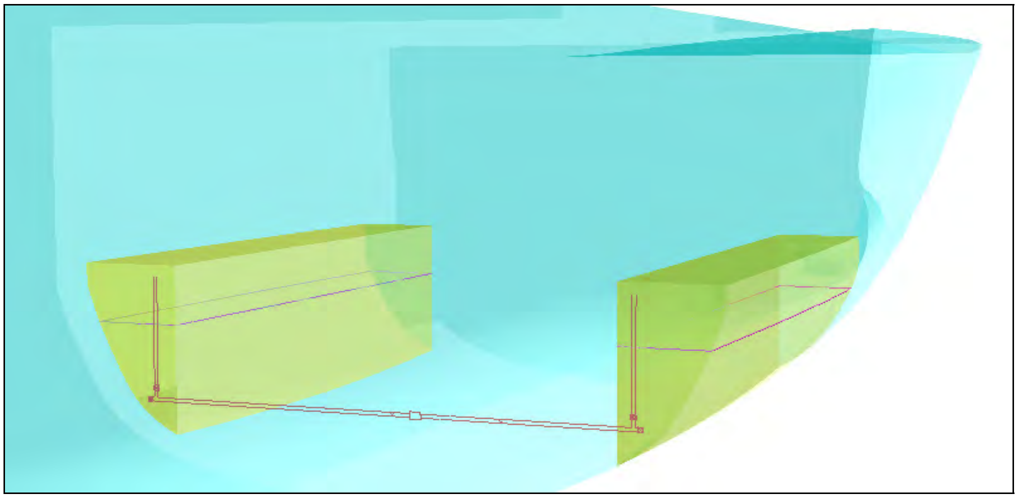


Figure 3-27 - Tanks 13 Port and Starboard with 78te of fluid at departure

3.8.2 These tanks have an arrangement of pipes and valves with a central pump that allows the transfer of fluid between the two wing tanks when required. A simple diagram of the arrangement of the pipes, pump and valves is shown in Figure 3-30, with an indication of critical heel/list angle above which the Starboard inlet is above the Port discharge tube.

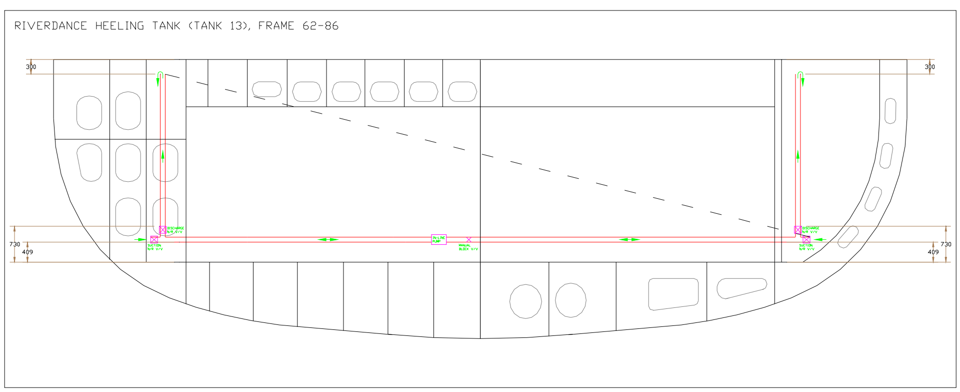


Figure 3-28 - Diagram of cross connection arrangement in Tanks 13 Port and Starboard

3.8.3 A crew member reported that the valve on the main cross connect between the main heeling tanks 13 Port and Starboard, was opened at some time shortly after 1 hours notice at 1830, approximately 50 minutes prior to the turn to Starboard. If this valve is opened, the pump would not restrict fluid transfer and would spin freely with any movement of fluid in the pipe. The possibility of transfer of fluid between these tanks hydrostatically is investigated. As can be seen in Figure 3-28, once the main cross connection valve between the two tanks is opened there are the sprung non return valves on the pipe inlets and the height of the discharge pipe exits stopping the flow between the tanks. The valve is shown in Figure 3-29 below. The render at Figure 3-30 is shown to further indicate the pipe and valve arrangement in the vessel.

Figure 3-29 - Picture of Starboard tank suction non return valve

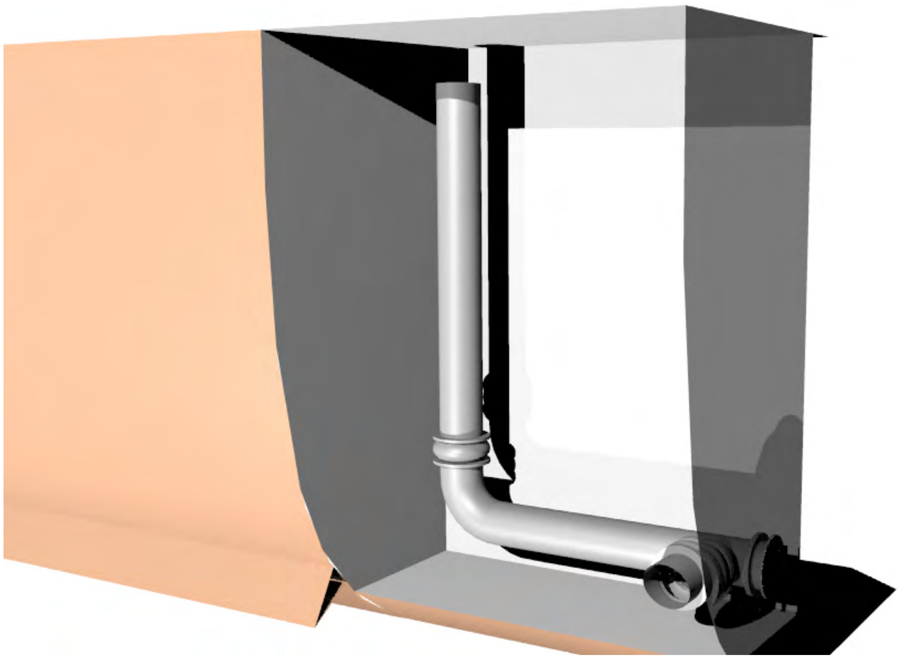


Figure 3-30; Indicative wing tank piping arrangement

3.8.4 Following the examination by MAIB of the valves during demolition, it was found that the discharge valves both sides were stuck in the open position. The suction valves appeared to be closed and operating correctly when visually inspected.

3.8.5 It was reported by the crew that on using the heeling tank pumps the system operated and did not suck air as maybe expected with open discharge non return valves. This leads us to believe that the force of the spring on the suction non return valve is not large, as the system would have likely pumped air and not water if the spring was as strong as the force resulting from the pressure head of water in the tank pressing on the valve.

3.8.6 Under normal conditions with the centre valve closed, the inlet non return values do not have any pressure differential across them, as the water in the pipe from the inlet valve to the central pump valve can not compress or flow through the central valve. When the valve is opened with the vessel near level, the height of the discharge pipe exits is higher than the level of water in the tanks and so there would not be fluid transfer between tanks.

3.8.7 From Figure 3-28 it can be seen that although the discharge valve is low down in the discharge pipe, the pipe exit is 300mm from the tank top. As can be seen in Figure 3-31 & 3-30 below, even at a high list/heel angles, the fluid within the Starboard tank does not reach the top of the discharge vent with 78 tonnes of water in the tank to allow it to cross flood.

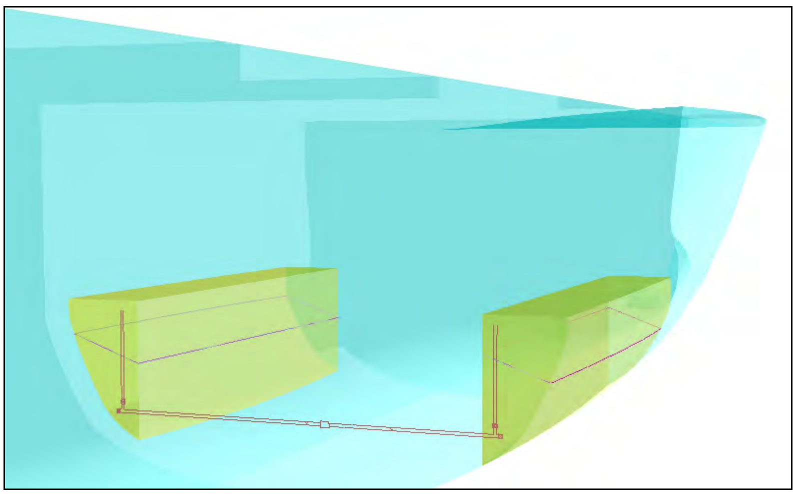


Figure 3-31 - Diagram of cross connection arrangement in Tanks 13 Port and Starboard with 78 tonnes at 20 degrees Port list

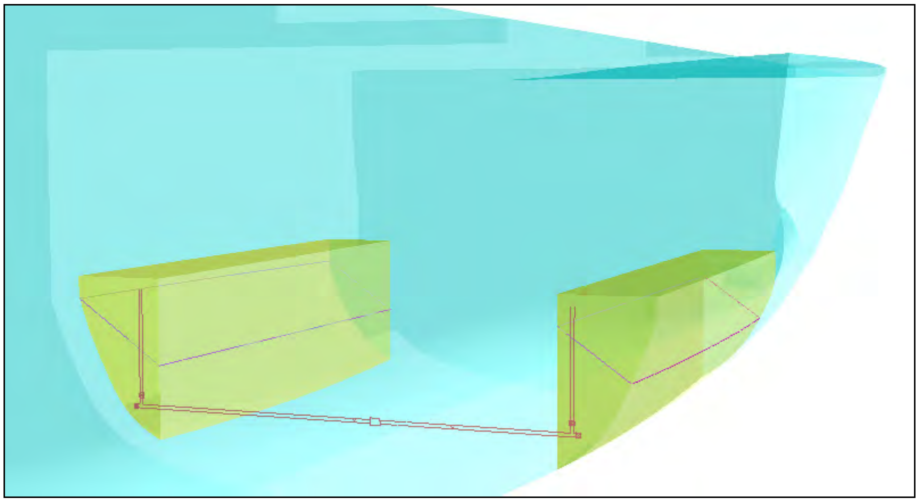


Figure 3-32 - Diagram of cross connection arrangement in Tanks 13 Port and Starboard with 78 tonnes at 35 degrees Port list

3.8.8 In order for fluid to reach the top of the discharge pipe the Starboard tank contents would need to be in excess of 85 tonnes of fluid, with a list/heel of 35 degrees or greater. Based on the departure condition, which has 78 tonnes in each tank, then it is not likely this could have occurred.

3.8.9 The vessel reported that it reached 15 to 20 degrees roll angle, which has been shown to be likely due to a reduction of stability on a wave crest prior to the turn to Starboard, it reached over 45 degrees to Port during the 120 second turn to Starboard and remained at around 35 degrees Port heel/list whilst drifting in waves after the turn, Figure 3-34. From Figure 3-30 it can be seen that at these angles there is a situation within the tanks that would never normally occur. With the cross connect valve open and with the vessel listing or heeling to Port by 17 degrees or more, the inlet of the starboard tank is higher than the discharge pipe exit of the Port tank, with approximately 2.68m of fluid pressure head applied by the contents of the Starboard tank. The only restriction on the transfer of fluid from the Starboard to the Port tank apart from fictional losses in the pipes is the spring on the inlet non return valve on the Starboard side. A 2.68m pressure head over the 0.3m diameter inlet pipe would result in a force of 1904N on the valve spring holding it closed.

Figure 3-33 - MV RIVERDANCE at mean combined heel and list angle of 35 degrees

3.8.10 Detailed drawings of the valve arrangement were not available, so only photographs taken by the MAIB during the demolition phase were available to undertake an approximate calculation on the force of the spring on the inlet valve. The valves from the salvage process are shown in photographs in Figure 3-34, 3-33 & 3-34.

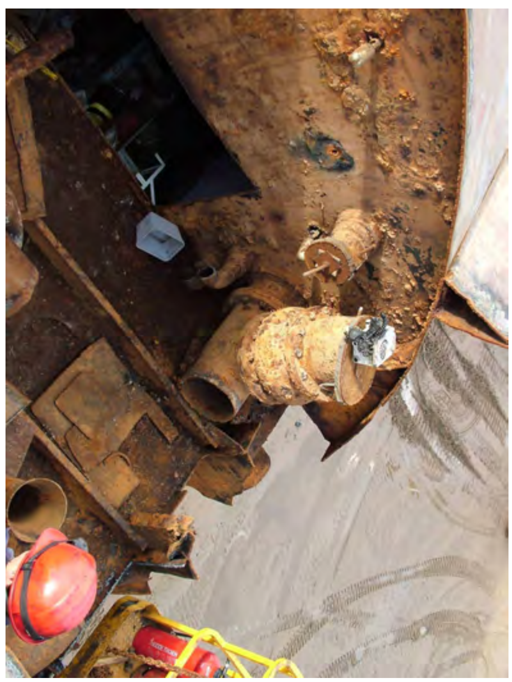


Figure 3-34 - Picture of Port heeling tank during demolition

Figure 3-35 - Picture of Starboard discharge valve in the open position – note extended centre shaft

Figure 3-36 - Picture of Starboard suction valve

3.8.11 The dimensions of the spring are estimated from the photographs, so some uncertainty is assumed.

3.8.12 Based on the 0.3m diameter pipe, the wire thickness of the spring was calculated to be 0.8cm. There appear to be 6 active coils in the spring with a spring diameter of approximately 15cm (half diameter of the valve) with a height of the spring of approximately 20cm.

$$k = \frac{Gd^4}{8D^3 n_a} \quad G = \frac{E}{2(1+\nu)} \qquad F_{max} = k\left(L_{free} - L_{solid}\right) \qquad (1)$$

K = Spring constant
d = Spring wire diameter
D = Mean spring diameter
n_a = Number of active coils
E = Young Modulus of material
v = Poisson ratio of material
L_{free}= Free length of spring
L_{solid} = Solid length of spring
F_{max} = Max force of spring
G = Shear Modulus

3.8.13 Using the standard calculation for a compression spring (1), the maximum force the spring could apply is 311N. Even with increases to the spring wire thickness, the maximum force that can be produced by the spring appears to be significantly less than then that applied by the pressure head of water with the Starboard inlet above the Port discharge pipe exit, which could be 1904N with 2.68m of pressure head in the tank. The MAIB representatives present at the disposal where able to open the inlet valve by pushing it by hand, which confirms that the spring was not heavily loaded and that the 311N calculated may be slightly conservative. This 311N is the maximum force when the spring is fully compressed and so less force would be required to partially open the valve.

3.8.14 It is therefore assumed that once the vessel was at an angle of more than 17 degrees and the discharge pipe exit was level or vertically below the inlet of the Starboard tank, fluid would have started to transfer. Due to the vessel not rolling significantly to starboard and the discharge pipe exits remaining above the tank levels, the reverse process would not occur and the fluid would not return to the Starboard tank without pumping. This would result in the migration of the some of the tank contents from tank 13 Starboard to tank 13 Port. Due to the calculated maximum spring force, the valve would start to close and reduce the flow when the pressure head of fluid in the tank reached approximately 0.5m. The valve would still be partially open and continue to close as the spring pressure and the water head equalised.

3.8.15 The calculation of the flow rate can be examined using two processes. The calculation of an instantaneous flow rate of the flow can be carried out using the following formulas:

$$V_{jet} = \sqrt{2g\left(z_{surface} - z_{spout}\right)} = \sqrt{2g\Delta z} \qquad Q = A_{jet}V_{jet} = CA_{spout}V_{jet} \qquad (2)$$

V = Velocity of the jet
Q = Mass flow rate
A = Area of duct
G = Acceleration due to gravity
C = Flow reduction factor for the duct

Z = Height

3.8.16 The calculations assume a constant head of water and hence provide a snapshot of the instantaneous flow rate. This method can be used to calculate the flow rates at a number of tank fill levels. The depth is based on the height of the pressure head of water above the inlet with the vessel at angles experienced during the incident.

3.8.17 The current practice for a designer assessing the performance of a standard cross-flooding system involves using an approximate formula that was derived by Dr Ing Gino Solda in 1961 and is used in IMO Resolution A266 [3]. This formulation takes account of the static water head at the start and end point of the cross flooding and the amount of water to cross-flood. The shape and length of the pipe is also taken into account through the inclusion of a total pipe friction coefficient. This formulation then provides a simple answer to the time to cross-flood based on static calculations.

3.8.18 The Solda formula is as follows:

$$To = \frac{2W}{sf}\left(\frac{1-\sqrt{\frac{Hf}{Ho}}}{\sqrt{2gHo}}\right)\frac{1}{\left(1-\frac{Hf}{Ho}\right)} \tag{3}$$

To	=	Time to cross-flood
W	=	Total volume of water for equalisation
s	=	Cross-sectional area of cross-flooding pipe
f	=	Flow reduction factor for the duct
g	=	Acceleration due to gravity
Ho	=	Head of fluid before equalisation
Hf	=	Final head of water (after complete equalisation)

3.8.19 This formulation is suitable for calculating an initial figure for the time to cross-flood at the early stages of design. Care must be taken in the calculation of the ‘f’ term, which is the flow reduction factor that is based on calculations for flow in pipes. This formulation does not take account of any roll motion of the vessel during the cross-flooding process.

3.8.20 This methodology can be applied to look at the amount of transfer that could have occurred during the turn to starboard and the mean 35 degree combined list and heel following the turn to Starboard.

3.8.21 Calculation of the friction effects in the system is conducted in the same manner as for the calculation of cross-flooding rates using the standard values defined in IMO Resolution A266. It has been assumed that the pump would spin freely with the flow of fluid in the pipe and would not restrict the flow. The following calculation of the likely frictional coefficient for the cross connection between the tanks can be made based on the length, pipe route and valves, Table 3-5:

	Riverdance
Duct diameter (m)	0.3
Duct length (m)	16
No. 90 degree elbows	0
No. 90 degree curves	1
No. 30 degree bends	0
Valves	3
k inlet	0.4500
k length	0.7733
k elbow 90	0.0000
k curve 90	0.3000
k elbow 30	0.0000
k outlet	1.0000
Valve	0.6000
Sigma k	3.1233
Friction Coefficient	**0.4925**

Table 3-5 - Pipe flow friction calculation

3.8.22 Based on the calculations above, it can be assumed that once 0.5m pressure head difference is established between the fluid level in the Starboard tank over the Port tank discharge pipe exit, flow of water will initiate, due to the pressure head difference being equal to the maximum force the spring could apply (this is optimistic as the valve would start to open as the pressure head increases). As shown on Figure 3-29, as soon as the vessel reaches 17 degrees the Starboard side inlet is above the port side discharge outlet and has a water height pressure of 2.68m. With 0.5m to account for the pressure to open the valve, leaves a maximum of 2.18m pressure head to drive the flow in pipe. Example instantaneous flow rates derived using formula (3) are shown in Tables 3-6 and 3-7.

Fluid density	1025.000	kg/m^3
Vent diameter	0.300	m
flow coef	0.492	-
Tank Water H	2.180	m
Area vent	0.071	m**2
Exit velocity	6.540	m/s
Volume flowrate	0.228	m^3/s
Mass flowrate	233.351	kg/s

Table 3-6 - Maximum flow calculation with 2.18m tank fill level (78 Tonnes) calculation

Fluid density	1025.000	kg/m^3
Vent diameter	0.300	m
flow coef	0.492	-
Tank Water H	1.500	m
Area vent	0.071	m**2
Exit velocity	5.425	m/s
Volume flowrate	0.189	m^3/s
Mass flowrate	193.565	kg/s

Table 3-7- Maximum flow calculation with 1.5m tank fill level calculation

3.8.23 The MV RIVERDANCE has been shown in the investigation to have experienced hanging roll events prior to the turn to Starboard, which resulted in the vessel rolling to 20 degrees. It experienced these events approximately every 8 minutes. It would have spent approximately 5 seconds above 15 degrees (based on the FREDYN simulations) during each of these events. This would have then resulted in approximately 1.16 tonnes of fluid transferring to the Starboard tank with a 2.68m tank level. This would reduce as the level in the Port tank dropped, for example to 0.96 tonnes with just 1.5m fluid level in the tank. From when the valve was opened at sometime after 1830 to when the vessel turned to Starboard at 1923, the vessel could have experienced up to six of these hanging roll events, which could result in the transfer of up to 7 tonnes of fluid.

3.8.24 During the turn to Starboard the vessel rolled up to 50 degrees and following the turn where the vessel was at a combined heel and list of 35 degrees rolling up to 45 degrees, the Starboard tank inlet would have been above the Port tank discharge vent. This would result in a quasi static situation where the Starboard inlet would be continually above the Port discharge pipe exit, so the fluid would again transfer. Based on the assumption that the fluid starts at 2.52m fill level in the tank (i.e. with 7 tonnes transfer prior to this) and that the pressure head is reducing as it cross floods, the cross-flooding calculation provides a time to complete the transfer of approximately 8.8 minutes to transfer 59 tonnes of fluid. This leaves the Starboard tank contents at 0.5m deep, which is assumed to then close the inlet valve. The rate of transfer would be decreasing as the resulting pressure head difference reduces to zero.

3.8.25 The effect this would have on the vessel after the turn would be significant. Assuming the vessel has 4.5 degrees of list due to cargo shift, the effect of the fluid transfer of 59 tonnes from Tank 13 starboard to Tank 13 Port is sufficient to list the vessel to 21.3 degrees without wind, but with the wind effects in this loading condition would result in a mean combined list and heel angle of approximately 32 degrees. The hydrostatics for this condition are shown below in Table 3-8:-

Heel angle due to cargo alone	4.5	(deg)
Water on main deck	0.0	(te)
Water in lower hold	0.0	(te)
Trim between perpendiculars	0.0	(m)
Mean draught	4.4	(m)
Draught AP	4.4	(m)
Draught FP	4.4	(m)
Displacement	4597.8	(te)
Heel/list angle in calm water (port)	21.3	(deg)
Heel /list angle with wind (port)	31 9	(deg)

Table 3-8 - Vessel hydrostatics after fluid transfer[3]

3.8.26 The crew initially reported that no ballasting was carried out prior to, or immediately post, the incident. However, from the RAF video commentary it is confirmed to the pilot (at approximately 2120) that the crew had started the heeling system pump but were unsure if it

[3] It should be noted that the draught is calculated in Paramarine as lower than the vessel draught on sailing due to the vessel list.

was actually operating. As the vessel returned to around twenty degrees from 2100 to 2125 this could indicate that the pump was working for a while and transferred some fluid to the Starboard tank. At around 2130 the vessel appeared to the pilot to have got slightly worse again. This could have been due to the pump stopping then the water starting to migrate again as the vessels' angle was close to or above the 17 degree angle which could have lead to the tank content starting to transfer again from the Starboard tank to the Port tank.

3.9 The attempted re-floating of MV RIVERDANCE

3.9.1 When the vessel eventually grounded on the beach, it returned to a list of 10 to 15 degrees to Port as the tide ebbed and the vessel settled on the beach, not withstanding the still significant list to Port. It was reported that the crew then counter flooded ballast to the Starboard side to counteract the list that was thought to be due to a cargo shift alone. No 3 Port side water ballast tank was emptied to the maximum extent possible, this would have left a very small amount of fluid in the tanks which has been treated as negligible. The No 8 Starboard side water ballast tank was filled completely and the heeling water was transferred from the Port to the Starboard tank.

3.9.2 As the tide then came in and the vessel started to re-float, the vessel was manoeuvred in an attempt to move away from the beach. However, the tidal conditions made this very difficult and the vessel was grounded further up the beach. The counter ballasting to Starboard caused a significant moment to Starboard. This then caused any water in the Lower Hold on the main deck to then flow across from the Port side to the opposite Starboard side. This in combination with the ballasting moment caused a very large listing moment to starboard, leading to a significant angle of list to starboard. The vessels hydrostatics at this time would have been as follows (Table 3-9):

Heel angle due to cargo alone	4.5	(deg)
Water on main deck	0.0	(te)
Water in lower hold	250.0	(te)
Trim between perpendiculars	-0.3	(m)
Mean draught	4.3	(m)
Draught AP	4.1	(m)
Draught FP	4.5	(m)
Displacement	4863.3	(te)
Heel/list angle in calm water (stbd)	30.1	(deg)
Heel/list angle with wind (stbd)	N/A	(deg)

Table 3-9 - Hydrostatics upon re-floating.[4]

3.9.3 It can be seen from Table 3-8 that had the vessel been completely afloat she could have taken up a static list of 30 degrees to Starboard if the down-flooding had occurred.

3.9.4 If the heeling tank transfer occurred following the turn then during the re-ballasting on the beach the heeling tank contents that could have contributed 17 degrees to the list to Port was then pumped to the opposite Starboard side where it would have had a similar effect in combination with the other ballasting. This re-ballasting would have caused a list angle to

[4] These conditions are taken from the approved RIVERDANCE SIB [4] and modelled in PARAMARINE, hence there are some small differences in the values (Further detail on the modelling can be found in Section 2.6)

Starboard if the vessel had fully refloated. In reality she was in very shallow water, probably only partly afloat, and would have re-grounded (due to contact with the turn of bilge) at these high angles of list.

3.10 The most likely sequence of events

3.10.1 It seems most likely that a combination of cargo shift combined with the likely transfer of the contents of the heeling tanks Port to Starboard and some smaller intake of down flood water onto the main deck through the side vent led to the 35 degree mean combined heel and list angle after the turn. The pumping of the heeling tank that was initiated at 2100 when the crew left the engine room is the most likely reason for the vessel returning to 20 degrees mean combined heel and list, then getting slightly worse prior to grounding on the beach.

3.10.2 As previously mentioned, the total shift in moment from Port to Starboard is caused by a combination of re-ballasting and either the presence of water in the Lower Hold or the transfer of fluid that had migrated to the Port heeling tank from the Starboard tank. Table 3-10 shows the contribution of these components.

3.10.3 The combined heel and list angles observed can be explained using Table 3-10. Section 3.4 shows that cargo shift alone (even with wind effects) cannot explain the mean heel/list angle of 35 degrees following the turn. Calculations show that the maximum realistic cargo contribution to the angle was 4.5 degrees. The wind effect on the angle can also be calculated with some accuracy as discussed in Section 3.4 and is shown to contribute differing amounts dependant on the loading of the vessel and the angle of list/heel of the vessel. With both down-flooded water cases the wind effects are up to 5 degrees of heel at the observed angle. In the transfer of tank contents scenario the wind has a greater effect and can cause up to 10 degrees of heel.

3.10.4 The hypothesis regarding downflooded water could contribute between 12 and 45 degrees of list angle, dependent on the openings in the vessel which were able to take on water. The most likely downflooding scenario as shown in section 3.7, would contribute 23.5 degrees resulting in the mean 35 degree combined heel and list angle when the wind effects are included in this condition.

3.10.5 The hypothesis regarding siphoning or pumping of water from the heeling tanks could contribute the remainder of the observed list angle. The calculations in Section 3.8 show siphoned water prior to the turn would contribute 0.4 degrees, and following the turn would contribute 16.8 degrees giving the mean 32 degree combined heel and list angle when the cargo shift and wind effects are included.

3.10.6 In reality, it is likely that a combination of downflooding through open vents, and siphoning or pumping of heeling tank water would have provided, in combination with the known cargo and wind effects, the total mean list angle of 35 degrees.

3.10.7 By around 2100, the mean combined heel/list angle of the vessel had reduced to a mean list of 20 degrees. If the most likely cause for the 35 degree mean combined heel/list had been shown to be water on the Main Deck, then the progressive downflooding of this water into the Lower Hold would have been a potential cause However, the most likely amount of water taken into the vessel via the vents does not alone support the initial high angle. The most likely cause for the return to a mean combined heel/list of 20 degrees is the pumping of a proportion of the heeling tank water back to the Starboard tank.

3.10.8 The result of the re-ballasting of the vessel whilst on the beach, when combined with the effects discussed above, would have resulted in a significant list angle to Starboard if the vessel had been able to refloat. Dependent on the combination of heeling tank water siphoning and downflooding seen, this list angle would have been up to 30 degrees to Starboard. However, this would have been significantly greater if the cargo then shifted again from the position discussed in Section 3.4.

Component	**Resulting Heel/List angle**
Final cargo position	4.5
Wind	4-10

Effect of Cargo Only

Component	**Resulting Heel/List angle**
Final cargo position	4.5
Wind	4-10
Downflooded water in Lower Hold	3 to 8
Downflooded water on Main Cargo Deck	10 to 45
Final cargo position, wind and effect of water on Main Cargo Deck	37
Final cargo position and effect of water in Lower Hold	14
Final cargo position, wind and effect of water in Lower Hold	23

Effect of Flooding only

Component	**Resulting Heel/List angle**
Final cargo position	4.5
Wind	4-10
Siphoned water from Starboard to Port Heeling tanks prior to turn	0.4
Siphoned water following turn	16.8
Final cargo position & siphoned water between heeling tank and winds	32

Effect of Siphoning only

Component	**Resulting Heel/List angle**
Final cargo position	4.5
Wind	4-10
Final cargo position, wind and effect of water in Lower Hold	23
Final cargo position, wind and effect of water on Main Cargo Deck	35
Added affect of re-ballasting to Final cargo position, wind and effect of water in Lower Hold (not including cargo shifting back)	30 to Starboard

Added effect of re-ballasting to Final cargo position & siphoned water between heeling tanks (not including downflooded water or cargo shifting back)	16 to Starboard

Effect of Reballasting on Refloating

Table 3-10 **-** *Components of final combined heel and list angle*

4 Conclusions

4.1 Conclusions

4.1.1 The incident of the MV RIVERDANCE on the 31st January 2008, which resulted in the loss of the vessel, was most likely to be the result of a combination of unfortunate events that when experienced one after another resulted in the loss of the vessel.

4.1.2 The shipping forecast for the Irish Sea, there was a general Gale warning with a forecast South West veering North West wind of Gale Force 8 to Storm Force 10, with moderate rain and a rough seaway. Closer inshore a Westerly Gale of Force 8 or 9, occasionally 7 was forecast, veering North West later with showers and very rough seas expected. It was concluded that the environmental conditions in the area and at the time of the incident can be summarised as follows:

- The wind was blowing WSW (at 260 degs) with a speed of 45 Knots with gusts in excess of 55 Knots.
- Significant wave height was 5.5m-6.5m, resulting in wave packets within the wave train of in excess of 7m in height.
- Modal Wave period was 8-10 seconds, which when combined with the wave height experienced would result in a very steep seaway.
- Wave spectra were representative of a JONSWAP Spectrum (waves with limited fetch) with a peak enhancement factor of 3.3,
- The current was 0.7kts on an ebbing tide.

4.1.3 It was found that the loading condition of the MV RIVERDANCE on the night in question was likely to have been within the stability criteria with which it was designed to (The Special Notes Regarding Stability state that the vessel is required to comply with the Merchant Shipping (Load Line) Rules 1968), which are purely based on the righting arm curve GZ parameters. Accurate calculation of the loading condition prior to departure would have allowed the Master to better understand the stability characteristics of the vessel prior to sailing. This vessel design has been shown to have significant changes in shape and area of the submerged water plane as a wave passes the ship. This change in water plane area results in a change in the effective GM and can lead to the large hanging roll events that were experienced. This is however not uncommon, particularly with vessel designs of this age.

4.1.4 A number of inconsistencies were found with the approved stability book data, each of these were of a minor nature, but when considering marginal conditions, could prove important to resolving whether a vessel is safe to sail.

4.1.5 It has been shown that it is important to have a good understanding of both cargo weight and VCG position in order to accurately assess the stability of the vessel prior to sailing

4.1.6 It was found that the MV RIVERDANCE initially suffered long slow rolling events which are likely to be due to the reduction of righting arm as the waves slowly passed amidships. This was found to be the most likely cause of the roll angles of up to 20 degrees. One of these events caused a cargo shift to Port resulting in a static list to Port of up to 8.9 degrees (4.5 degrees after loss of cargo from upper deck following the turn).

4.1.7 Regarding the turn to Starboard, the MV RIVERDANCE is most likely to have suffered a broach, which was shown to be capable of being initiated manually by a small rudder movement in the steep wave conditions the vessel was in. This will have caused the rapid turn to Starboard, this then caused large roll angles in excess of 50 degrees.

4.1.8 The broach caused cargo to be lost overboard and for other cargo to shift, as well as submerging the Port side Upper (Weather) Deck edge, which could have allowed approximately 200te water to flood through a door (if not secured) on the Port side of the Upper (Weather) Deck onto the Main Cargo Deck and approximately 100te of water to flood down onto the Upper (Weather) Deck Port side Lower Hold vent into the Lower Hold.

4.1.9 It has also been found that the unusual scenario that Tank 13 Port and Starboard were in during the MV RIVERDANCE incident would have likely resulted in a transfer of fluid between Tank 13 starboard and Tank 13 Port. The calculations have been made based on the supplied photographs only, but they show there to have been sufficient resulting pressure head difference to open the non return inlet valve Starboard so that it could transfer fluid between tanks. Up to 84% of the tank contents could have migrated in under 10 minutes from the Starboard tank to the Port tank. This transfer of up to 66 tonnes of fluid across the beam of the vessel was sufficient to anglel the vessel with some cargo shift to 35 degrees, which is the angle seen in the RAF video.

4.1.10 From available information it is most likely that a combination of cargo shift combined with the likely transfer of heeling tanks Port to Starboard and some smaller intake of down flood water onto the main deck through the side vent led to the 35 degree mean roll angle after the turn. The pumping of the heeling tank that was reported to have been initiated at 2100 when the crew left the engine room was the most likely reason for the vessel returning to 20 degrees, then worsening prior to grounding on the beach.

4.1.11 If the vessel had slowed down in the large stern seas, the vessel would have been less likely to have experienced the slow 15-20 degree hanging roll motions that led to the initial movement of some of the cargo.

4.1.12 In heavy weather, for most vessels travelling at close to wave speed will increase the risk of undesirable dynamic stability situations, due to the phenomena such as wave capture, surf riding, and reduced stability on a wave crest or loss of control leading to a broach. A deeper understanding of these phenomena would lead to the dangerous situations being avoided where possible.

4.1.13 Dangers in heavy weather stern seas were identified at IMO in the mid nineties, where generic information was provided as guidance to the Master for avoiding dangerous situations in following and quartering seas. MSC / Circ. 707, was adopted in 1995, in which critical nominal Froude number (speed of the ship related to ship length) for avoiding surf-riding, e.g. 0.3, was determined with results calculated from analysis of surf-riding in stern seas using a wave steepness of 1/10 for various hull forms. Guidance has also been produced more recently for some vessels giving the conditions to ensure that parametric rolling does not occur.

4.1.14 Opening the cross connect value prior to reaching sheltered or harbour conditions, could allow the heeling tank contents to transfer between the tanks at high heel or list angles.

4.1.15 If the use of emergency response technical support services were adopted when MV RIVERDANCE first grounded onto the beach and any water on the Main Cargo Deck and lower hold were detected, then it would have helped to possibly recover the vessel.

5 References / Bibliography

References

[1] Hamamoto, M., Enomoto, T. et al., 1996, "Model Experiments of Ship Capsize in Astern Seas -2nd Report-", Journal of Society of Naval Architects of Japan, 179:77-87.

[2] Umeda, N. and Hashimoto, H., 2002, "Qualitative Aspects of Non-linear Ship Motions in Following and Quartering Seas with High Forward Velocity" Journal of Marine Science and Technology, 6:111-121.

[3] Umeda, N. and Hamamoto, M., 2000, "Capsize of Ship Models in Following/ Quartering Waves –Physical Experiments and Non-linear Dynamics-", Philosophical Transactions of the Royal Society of London, Series A, 358:1883-1904.

[4] CL/653/98/D2 Rev A, MV RIVERDANCE Trim and Stability Book, June 2000

Drawings

[5] 2700-001, Diagram of bilge, ballast and fire line, 13/12/1976

[6] CL/653/99/A3, M.V. RIVERDANCE General Arrangement, 12/08/1999

[7] 1320-101, Werftseitige Blechverkleidungen, 11/3/1977

[8] 1010-280, Trailerplan, 1976

[9] 1020-010, Hauplspant,

[10] CE 281 2010-100, Machinery Arrangement, 13/10/1992

[11] CL/417/95/A1, M.V. LION General Arrangement, 10/10/1995

[12] CL/417/95/T1, M.V. LION Lines Plan, 19/1/1996

[13] 1110-310, Rudder, 27/12/1976

[14] 389-390, Accommodation 3rd Superstr deck, 16/12/1976

6 Abbreviations

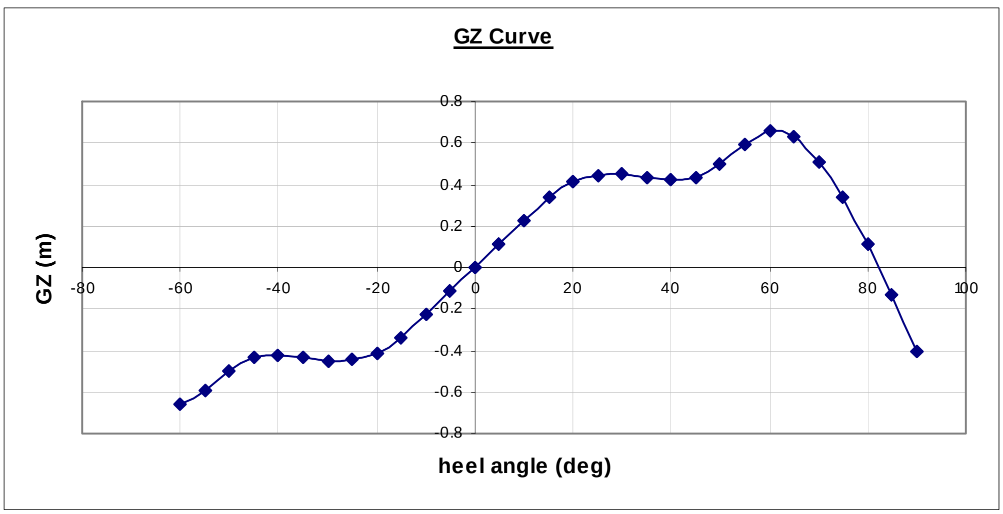
GZ	Righting lever
GM	Metacentric height
GMt	Transverse metacentric height
GMtf	Transverse metacentric height (fluid)
GMts	Transverse metacentric height (solid)
GMl	Longitudinal metacentric height
GMlf	Longitudinal metacentric height (fluid)
GMls	Longitudinal metacentric height (solid)
KG	Vertical distance between keel and the vertical centre of gravity
KN	The length of the righting lever about the keel
KM	The height of the transverse metacentre above the keel
KMt	The height of the transverse metacentre above the keel
KMl	The height of the longitudinal metacentre above the keel
TCG	Transverse centre of gravity
LCG	Longitudinal centre of gravity
VCG	Vertical centre of gravity
TCB	Transverse centre of buoyancy
LCB	Longitudinal centre of buoyancy
VCB	Vertical centre of buoyancy
TCF	Transverse centre of flotation
LCF	Longitudinal centre of flotation
VCF	Vertical centre of flotation
FSCt	Transverse free surface correction
FSCl	Longitudinal free surface correction
MCT BP	Moment causing trim, between particulars
TPI	Tonnes per inch immersion
LOA	Length Overall
CAD	Computer aided design
SIB	Stability Information Book
IMO	International Maritime Organisation
GMT	Greenwich Mean Time
JONSWAP	Joint North Sea Wave Project

A Loading Conditions

A.1 Lightship

Condition Name	Lightship	
Tank load	0	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	0	Te
Cargo3 Load (Weather Deck)	0	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

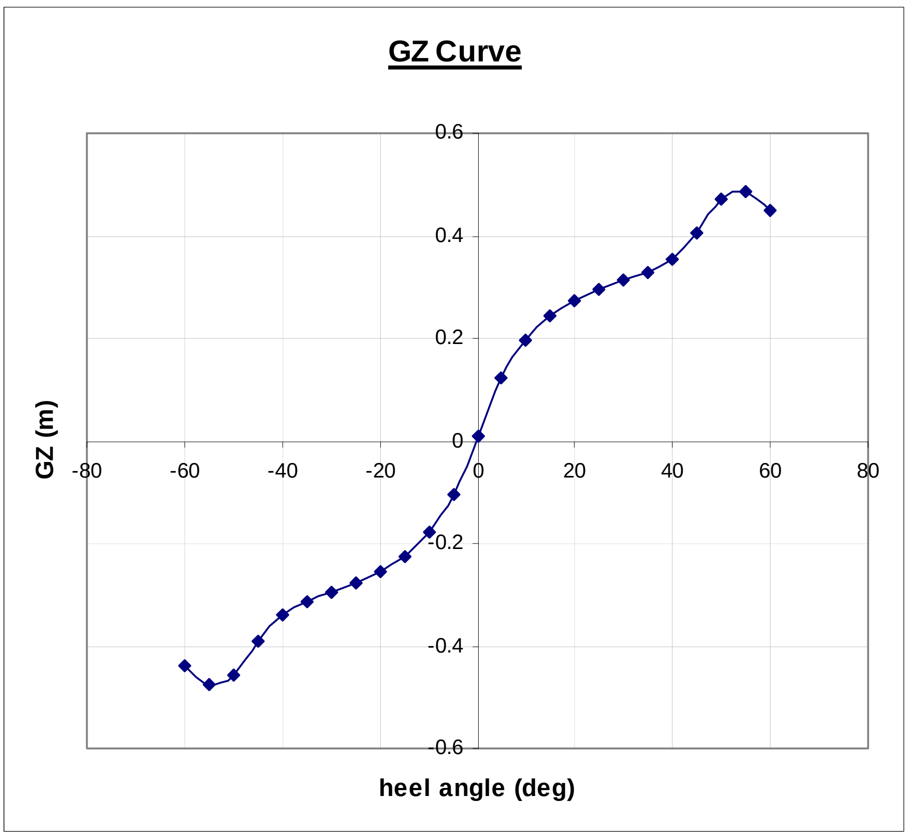
trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List_angle (deg)	displacement (te)
1.042	3.398	3.919	2.877	0	2822
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
48.215	0	8.189	48.153	0	2.071
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
46.418	0	12.838	9.435	290.594	0
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te m/cm)
0	1.246	282.405	1.246	282.405	77.074



A.2 Estimated Load Condition

Condition Name	Estimated	
Tank load*	618.475	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	603	Te
Cargo3 Load (Weather Deck)	596	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

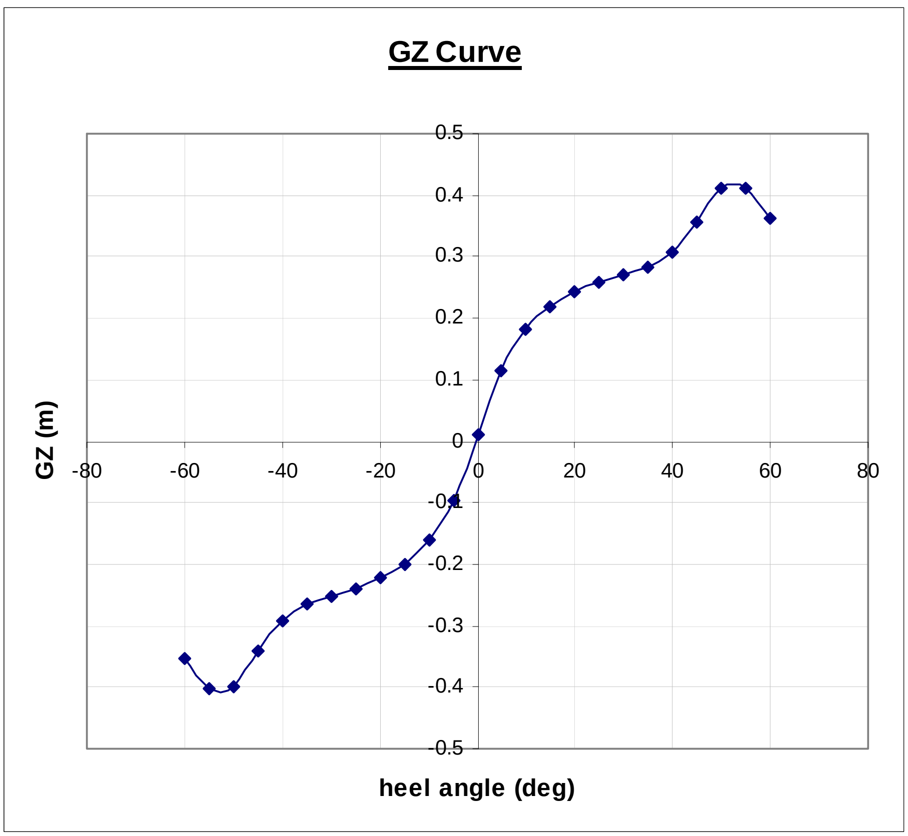
trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List_angle (deg)	displacement (te)
0.515	4.717	4.975	4.46	-0.448	4647.835
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
47.865	0.011	8.253	47.839	0.054	2.878
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
43.046	0.055	15.69	9.717	254.831	0.097
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te m/cm)
1.809	1.464	246.578	1.367	244.769	110.024



A.3 Plus 10% Cargo

Condition Name	Estimated_plus10p_cargo	
Tank load*	618.475	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	663	Te
Cargo3 Load (Weather Deck)	655	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

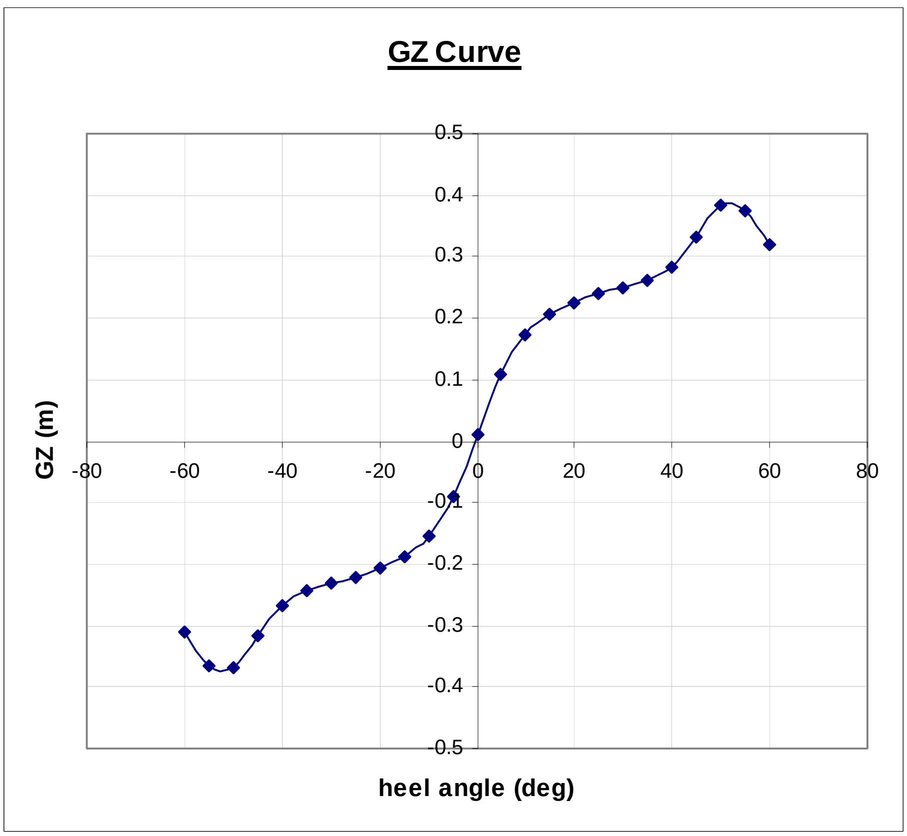
trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List angle (deg)	displacement (te)
0.451	4.798	5.024	4.573	-0.471	4766.835
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
47.895	0.011	8.334	47.872	0.056	2.925
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
42.938	0.057	15.829	9.738	252.271	0.096
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te m/cm)
1.823	1.405	243.938	1.309	242.115	111.617



A.4 Plus 15% Cargo

Condition Name	New	
Tank load*	618.475	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	693	Te
Cargo3 Load (Weather Deck)	685	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

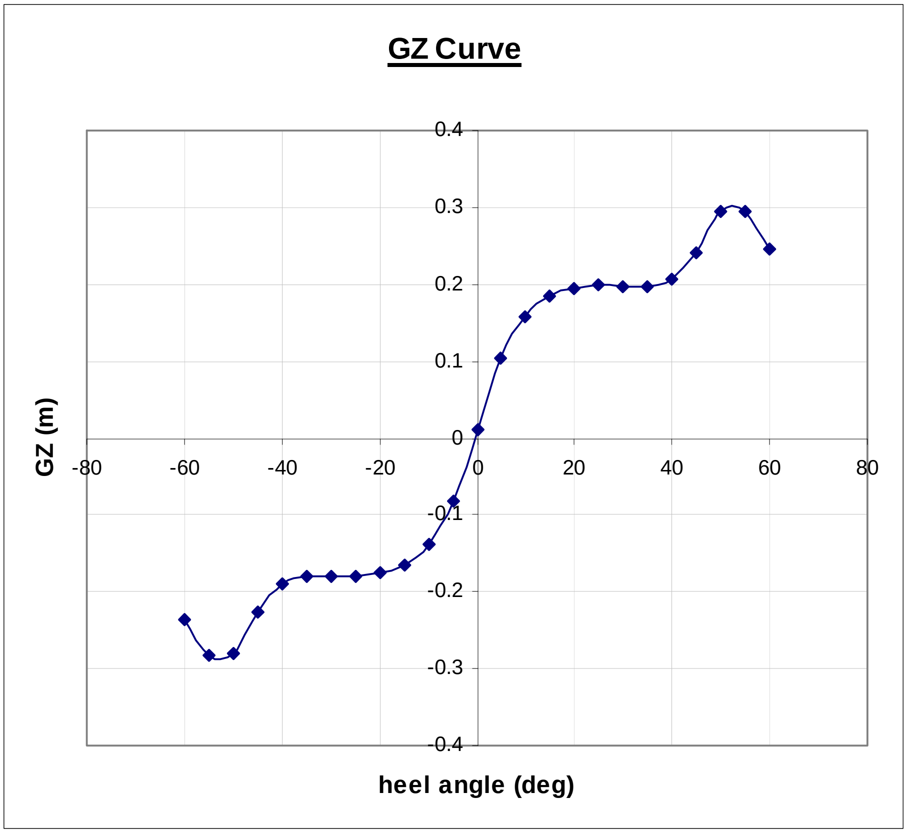
trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List_angle (deg)	displacement (te)
0.418	4.84	5.048	4.631	-0.484	4827.684
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
47.91	0.011	8.373	47.889	0.057	2.949
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
42.882	0.059	15.898	9.748	250.978	0.095
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te_m/cm)
1.839	1.375	242.604	1.28	240.765	112.412



A.5 VCG Up

Condition Name	New	
Tank load*	618.475	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	603	Te
Cargo3 Load (Weather Deck)	596	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

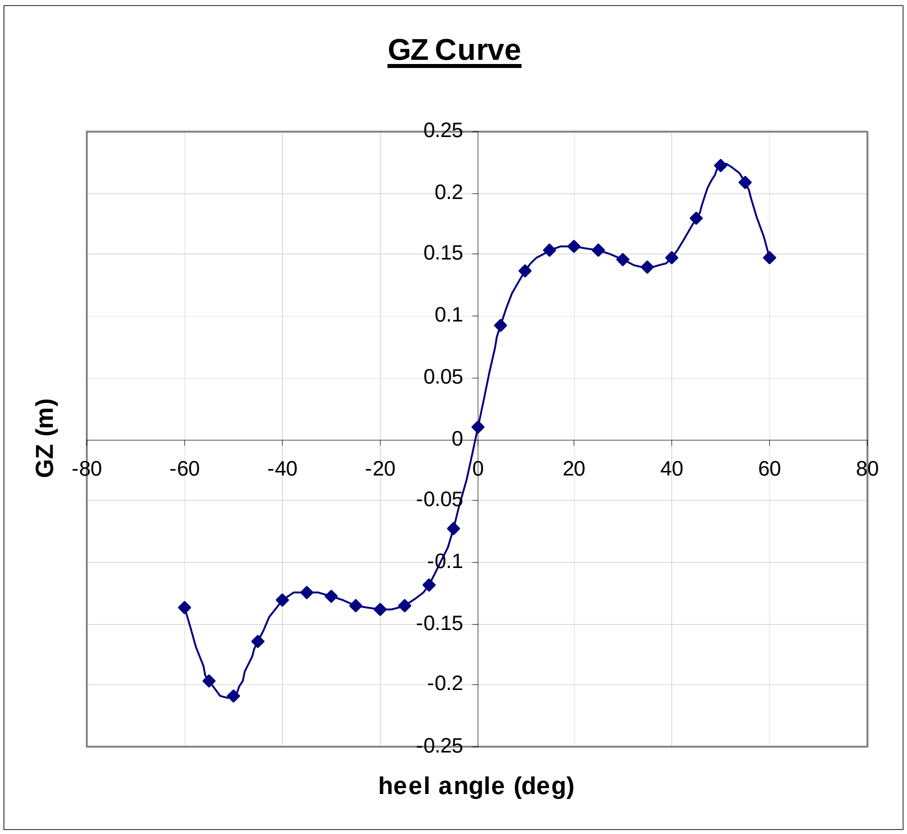
trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List_angle (deg)	displacement (te)
0.516	4.717	4.975	4.46	-0.546	4647.833
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
47.865	0.011	8.485	47.838	0.065	2.878
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
43.043	0.067	15.69	9.718	254.854	0.096
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te_m/cm)
1.82	1.233	246.369	1.137	244.549	109.925



A.6 VCG Up plus 10% Cargo

Condition Name	New	
Tank load*	618.475	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	663	Te
Cargo3 Load (Weather Deck)	655	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

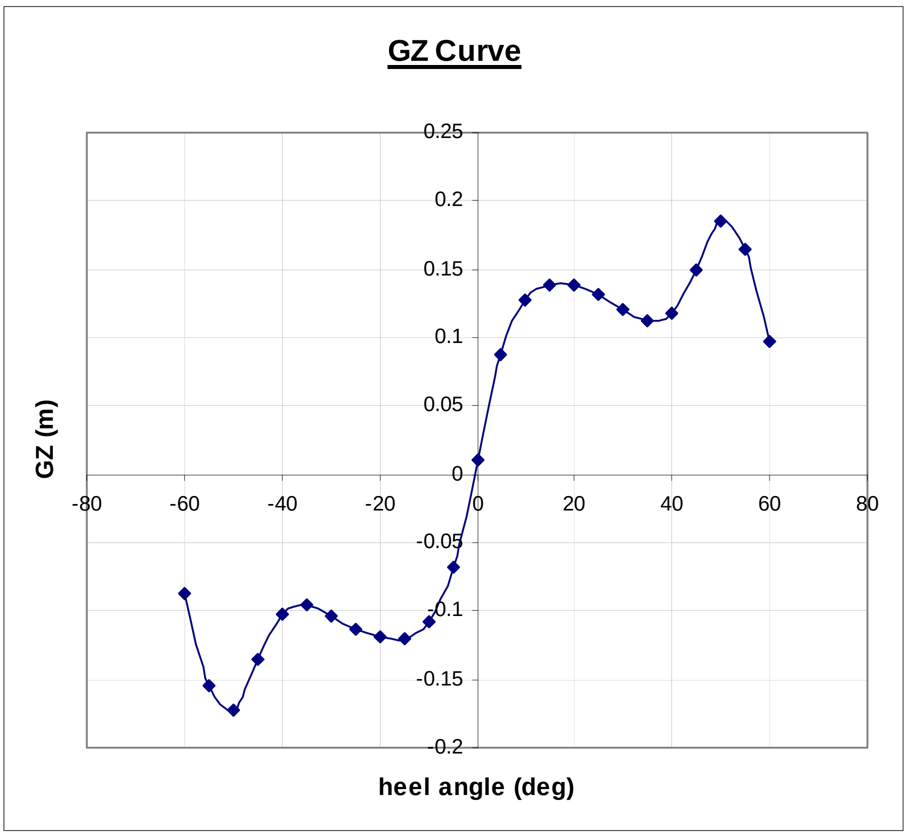
trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List_angle (deg)	displacement (te)
0.451	4.798	5.024	4.573	-0.589	4766.845
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
47.895	0.011	8.582	47.871	0.07	2.926
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
42.936	0.072	15.829	9.739	252.296	0.094
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te_m/cm)
1.84	1.156	243.713	1.062	241.873	111.506



A.7 VCG Up plus 15% Cargo

Condition Name	New	
Tank load*	618.475	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	693	Te
Cargo3 Load (Weather Deck)	685	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

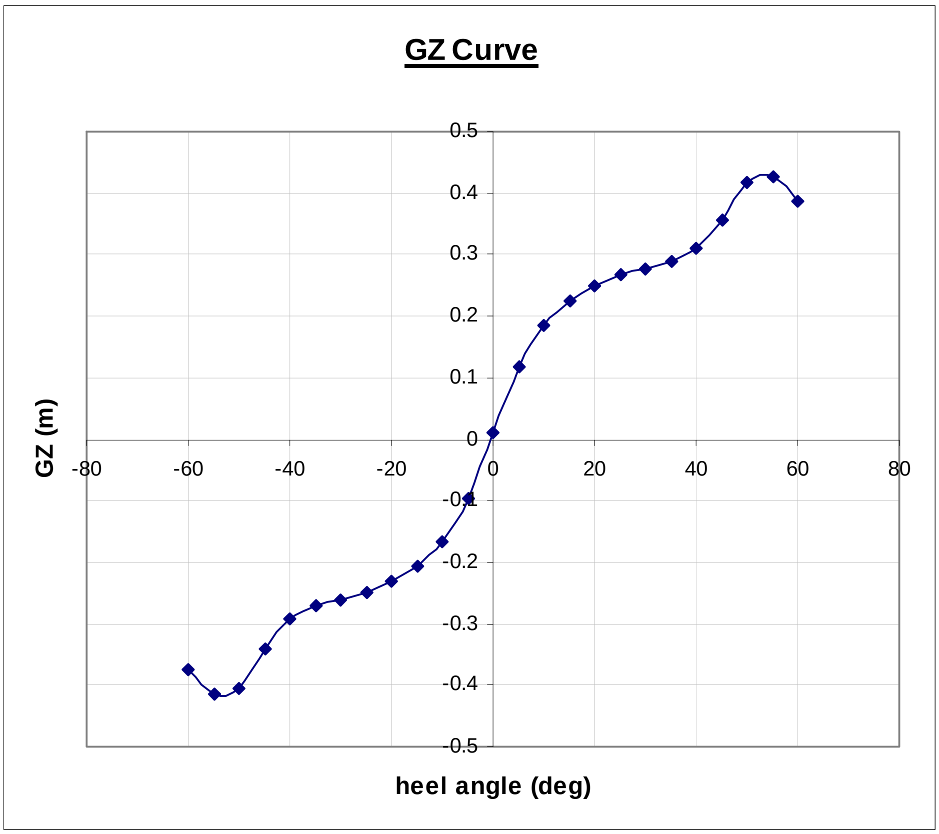
trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List_angle (deg)	displacement (te)
0.418	4.839	5.048	4.631	-0.577	4827.697
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
47.91	0.011	8.63	47.888	0.068	2.95
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
42.88	0.07	15.898	9.749	250.995	0.094
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te_m/cm)
1.849	1.119	242.365	1.024	240.515	112.295



A.8 Cargo Shifted Up

Condition Name	Estimated_cargo_up	
Tank load*	618.475	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	553	Te
Cargo3 Load (Weather Deck)	646	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

trim_BP (m)	mean_draught (m)	draught_AP (m)	draught_FP (m)	Heel/List_angle (deg)	displacement (te)
0.515	4.717	4.975	4.46	-0.474	4647.834
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
47.867	0.011	8.324	47.84	0.057	2.878
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
43.046	0.058	15.69	9.717	254.825	0.097
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te_m/cm)
1.812	1.393	246.501	1.296	244.689	109.988

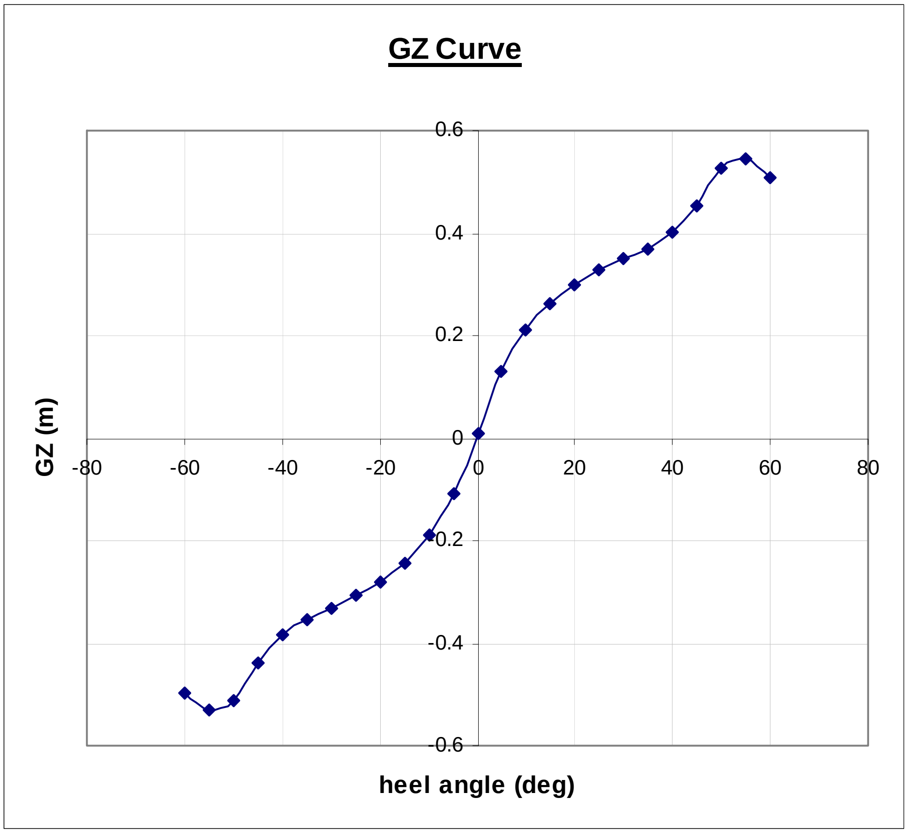


COMMERCIAL IN CONFIDENCE

A.9 Cargo Shifted Down

Condition Name	Estimated cargo down	
Tank load*	618.475	Te
Cargo1 load (Lower Hold)	0	Te
Cargo2 load (Main Deck)	653	Te
Cargo3 Load (Weather Deck)	546	Te
Lower hold water	0	Te
Vehicle deck water	0	Te

trim BP (m)	mean_draught (m)	draught AP (m)	draught_FP (m)	Heel/List_angle (deg)	displacement (te)
0.516	4.717	4.975	4.459	-0.425	4647.835
LCGs (m)	TCGs (m)	VCGs (m)	LCB (m)	TCB (m)	VCB (m)
47.863	0.011	8.182	47.837	0.051	2.878
LCF (m)	TCF (m)	TPI (te/cm)	KMt (m)	KMl (m)	FSCt (m)
43.045	0.052	15.69	9.717	254.838	0.097
FSCl (m)	GMts (m)	GMls (m)	GMtf (m)	GMlf (m)	MCT_BP (te_m/cm)
1.806	1.535	246.656	1.438	244.85	110.06



A.10 Tank states for all loading conditions

Group	Tank	Fluid	Weight [te]	LCG [m]	TCG [m]	VCG [m]	FSM [te.m]
Fuel oil	FO 2	Fuel Oil	0.0	0.00	0.00	0.00	0.0
	FO 3 stbd	Fuel Oil	45.0	48.56	-1.33	0.46	33.3
	FO 3 port	Fuel Oil	45.0	48.56	1.34	0.46	33.3
	FO 4 overflow	Fuel Oil	0.0	0.00	0.00	0.00	0.0
	FO 18 daily	Fuel Oil	13.0	21.04	0.00	3.02	1.0
	FO 19 settling	Fuel Oil	10.0	15.59	0.00	3.46	1.1
	FO 32 settling	Fuel Oil	8.5	14.76	3.64	3.02	7.7
Dieso	Dieso 6 port	Dieso	21.5	29.87	2.11	0.89	61.9
	Dieso 6 stbd	Dieso	21.5	29.84	-2.07	0.89	60.1
	Dieso 25 daily	Dieso	0.0	0.00	0.00	0.00	0.0
Gas oil	GO 31 storage	Gas Oil	16.0	15.02	-3.83	3.34	8.3
	GO 33 daily	Gas Oil	0.0	0.00	0.00	0.00	0.0
Lube oil	LO 5 port	Lube Oil	2.7	33.35	0.97	0.58	0.9
	LO 5 stbd	Lube Oil	2.7	33.35	-0.96	0.58	0.9
	LO 26 port	Lube Oil	1.0	22.53	4.81	2.60	0.2
	LO 27 port	Lube Oil	3.2	21.11	4.89	3.58	0.2
	LO 28 port	Lube Oil	0.5	20.06	4.82	2.92	0.1
	LO 29 port	Lube Oil	0.6	19.36	4.84	3.07	0.1
	LO 30	Lube Oil	7.1	18.31	3.92	3.35	2.3
Water ballast	WB 1	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 2 port	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 2 stbd	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 3 port	Sea water	77.8	45.24	4.32	1.07	88.7
	WB 3 stbd	Sea water	77.8	45.28	-4.32	1.08	42.3
	WB 7 port	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 7 stbd	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 8 port	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 8 centre	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 8 stbd	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 9	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 11	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 12	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 34	Sea water	0.0	0.00	0.00	0.00	0.0
	WB 13 port	Sea water	78.0	51.09	6.94	3.02	20.8
	WB 13 stbd	Sea water	78.0	51.09	-6.93	3.00	20.8
	WB 13 connection	Sea water	30.0	58.20	0.01	5.25	0.7

Group	Tank	Fluid	Weight [te]	LCG [m]	TCG [m]	VCG [m]	FSM [te.m]
Fresh water	FW 14 port	Fresh water	35.0	41.45	2.41	3.69	26.2
	FW 14 stbd	Fresh water	35.0	41.45	-2.40	3.80	24.0
Misc	10 sewage	Sewage	1.9	88.15	-1.53	2.89	9.9
	15 dirty water	Dirty water	0.1	34.75	5.51	1.74	0.3
	16 sludge	Sludge	4.0	31.77	5.07	1.92	4.8
	17 dirty oil	Dirty oil	1.5	27.48	4.75	2.00	0.9
	20 leak oil	Leak oil	0.3	22.14	0.01	0.07	0.4
	LO 21 port	Lube Oil	0.1	19.70	0.28	0.08	0.0
	LO 21 stbd	Lube Oil	0.1	19.70	-0.28	0.08	0.0
	LO 22	Lube Oil	0.3	16.55	0.00	0.09	0.2
	23 dirty oil	Dirty oil	0.1	15.15	0.00	0.10	0.1
	24 dirty water	Dirty water	0.2	14.10	0.00	0.09	0.1

Annex 2

Seatruck sailing schedule

SEATRUCK

Sailing Schedule

Heysham to Warrenpoint

	AM departures		PM departures			
	Departs Heysham	Arrives Warrenpoint	Departs Heysham	Arrives Warrenpoint	Departs Heysham	Arrives Warrenpoint
Monday	-	-	19:00	04:00	22:30	07:30
Tuesday	08:00	17:00	19:00	04:00	22:30	07:30
Wednesday	08:00	17:00	19:00	04:00	22:30	07:30
Thursday	08:00	17:00	19:00	04:00	22:30	07:30
Friday	08:00	17:00	19:00	04:00	22:30	07:30
Saturday	08:00	18:30	-	-	21:00	06:00
Sunday	-	-	-	-	21:00	06:00

Tel - +44 1524 853512 **Fax - +44 1524 853549**

Warrenpoint to Heysham

	AM departures			PM departures		
	Departs Warrenpoint	Arrives Heysham	Departs Warrenpoint	Arrives Heysham	Departs Warrenpoint	Arrives Heysham
Monday	-	-	-	-	20:00	05:00
Tuesday	07:00	15:30	10:30	19:30	20:00	05:00
Wednesday	07:00	15:30	10:30	19:30	20:00	05:00
Thursday	07:00	15:30	10:30	19:30	20:00	05:00
Friday	07:00	15:30	10:30	19:30	20:00	05:00
Saturday	07:00	15:30	-	-	18:00	03:00
Sunday	-	-	-	-	18:00	03:00
					20:00	05:00

Tel - +44 28 4175 4400 **Fax - +44 28 4177 3737**

Annex 3

Riverdance - checklist arrival procedure

DATE

Riverdance: Checklist Arrival Procedure

At 1 Hours notice of EOP given by Bridge.

- ☐ • Before Standby ensure that two Diesel Alternators are running on Load.
- ☐ • If passage has been on Shaft Alternator, inform Bridge before changing to Diesels to check it is safe to do so.

At Standby E.O.P.

- ☐ • Confirm Standby with Telegraphs.
- ☐ • Close Breaker for Bow Thruster and Confirm Ready Light is lit.
- ☐ • Open Deck Air Isolating v/v
- ☐ • Open Heeling Pump v/v. and close breaker.

At F.W.E.

- ☐ • Confirm F.W.E. with Telegraphs.
- ☐ • Switch off Bow Thruster Breaker.
- ☐ • Switch off M.E. Hour Meters.
- ☐ • Reduce M.E.'s to 500 RPM
- ☐ • Open drains of T/C, Charge Air Manifold and Air Cooler.
- ☐ • **After 10 min.** reduce to 400rpm and stop main engines
- ☐ • Start Harbour S.W. Cooling Pump and Stop Main S.W. Cooling Pump.
- ☐ • Close M.E. S.W.Inlet v/v's and S.W. inlet to Gearbox L.O. and CPP Coolers.
- ☐ • Stop CPP Pumps.
- ☐ • Stop Nozzle Cooling Pump.
- ☐ • Change M.E. Jkt F.W. and Air Cooler Controllers to Manual.
- ☐ • **After 15 min.** stop Standby L.O p/p, Standby Gearbox L.O. p/p and F.W. Cooling p/p
- ☐ • Open Indicator Cocks.
- ☐ • Open v/v to M.E. Jkt F.W. Heating pump and start pump.
- ☐ • Stop two E.R. Fans.
- ☐ • Shut Deck Air Isolating v/v.

SEATRUCK
APPROVED BY
DATE 06/11/06

Annex 4

Extract from Seatruck SMS -
Crisis Management

5.2 CRISIS MANAGEMENT

5.2.1 Crisis Management Team (CMT)

The optimum make-up of the CMT and their roles are listed below:

Team Member	Role
SQM Manager(Crisis Manager)	Coordinate CMT / Marine Liaison
Managing Director	External Business / PR Liaison
Technical Director	Technical Liaison (External)
Ship Manager	Technical Liaison (Internal)
Superintendent	Technical Liaison (with Ship)
Personnel Manager	Personnel Liaison
Office Administrators	Administration

In the absence of any member of the CMT, their role will be given to another suitably qualified member. Additionally the CMT must remain flexible to adapt to the absence of other members and to the nature of the crisis.

5.2.2 Activating the Crisis Management Team

The Masters first point of contact in a crisis is the vessel's Superintendent.

The Superintendent will call the Crisis Manager and an evaluation will be made of the best course of action. If it is decided to activate the CMT, the Superintendent will proceed directly to the Crisis Management Room. The Crisis Manager will call the Crisis Management Team, before making his way to the Crisis Management Room. On his arrival the Crisis Manager will receive a full handover from the Superintendent. The Crisis Manager will then take control of the CMT.

5.2.3 Crisis Management Room (CMR)

The Meeting Room of Seatruck Ferries Shipholding Ltd, Port of Heysham, is the designated CMR. In the event that the CMT is activated, the Meeting Room is to be made immediately available. Some equipment required by the CMT is securely held in the CMR.

5.2.4 Crisis Manager (CM)

The SQM Manager or, in his absence, the Superintendent will act as CM. If the CM is not in the Office when the crisis occurs, he must decide if he can manage the crisis from where he is, or move to the Office, considering the following factors:

- Time lost in moving to the office
- Better communication facilities at the office
- Equipment and documentation at the office
- Ease of assembling the CMT at the office

In formulating his plan of action, the CM should consult the Emergency Checklists, Crisis Management Emergency Checklist and Flowchart, bearing in mind the need to adapt to the particular incident.

5.2.5 Superintendent

The Superintendent is the first point of contact for the ship in the event of an emergency. The Superintendent should ascertain as much detail as practicable from the ship before calling the Crisis Manager.

5.2.6 Company Lawyers and P & I Club

The CM should be mindful of the assistance available and expertise in crisis coordination and world-wide contacts held by the Company lawyers and P & I Club. They are to be contacted at an early stage and kept up-dated as the situation develops.

5.2.7 Managing Director

On initial contact from the CM, the Managing Director shall immediately inform the Parent Company, the ship's owners, Company lawyers, media consultants, the P & I Club and other insurers.

5.2.8 Master's Responsibility and Authority

THE MASTER HAS OVERALL RESPONSIBILITY FOR TAKING SUCH ACTION AS HE DEEMS NECESSARY TO SAFEGUARD HIS SHIP, CREW AND THE ENVIRONMENT.

The Master has the full authority of the Company to sign Lloyd's Open Form (LOF) should he ever consider it necessary to do so.

5.2.9 Crisis Record Book

The CM will delegate one member of the CMT (ideally an Office Administrator) to keep a log of events. The log shall be a complete narrative, and should include:-

- Times of events
- Messages received and transmitted
- Decisions made
- Action taken

This log is to be retained and may be required by at any subsequent enquiry held either by the Company, MAIB, MCA or other competent authority.

5.2.11 Communications

- Communications between the ship and the CMT should be via the Crisis Manager exclusively. One exception to this rule is that the Superintendent may communicate with them on technical matters.

- Before communicating with the ship, messages should be composed and the content limited to essential information only.

- When receiving a message from the ship it is essential that it is repeated, word-for-word, to limit the possibility of misunderstanding.

- The CMT should bear in mind that the Master's work load will be considerable and, to this end, should limit outgoing calls to the ship to a minimum.

5.2.12 Crisis Exercise

To ensure the Company is able to respond promptly and effectively to crisis situations, a Crisis Exercise will take place at least once a year. The exercise will be conducted in such a manner to resemble a real life situation as closely as possible. Where practicable, emergency services, port authorities and others will be involved in the exercise.

Following an exercise the Crisis Manager will chair a formal review meeting with the Master and members of the CMT. Lessons learned, improvements to procedures, facilities, equipment, personnel and preparedness will be identified. The results of the review will be recorded.

5.2.13 Crisis Media Management

The Company have engaged a public relations company, TRS Consultants, to provide media management in the event of an incident attracting media attention. TRS are a leading firm of consultants in the field of crisis media management. They will provide the Company with a prompt and efficient media response service in the event of a major emergency or crisis:

- Handling press enquiries to the offices
- Preparing public statements
- Briefing Directors and Senior Managers
- Developing positive media strategies
- Analysing media coverage

It is the policy of the Company to provide media training for all Senior Managers. TRS Consultants will run such courses.

CRISIS MANAGEMENT TEAM EMERGENCY CHECKLIST

	Crisis Manager	Managing Director	Technical Director	Ship Manager	Superintendent	Personnel Manager & Office Administrators
Role	Coordinate CMT Marine Liaison	External Business & PR Liaison	Technical Liaison (external)	Technical Liaison (internal)	Technical Liaison (with ship)	Personnel Liaison & Administration
Liaise with	▪ Ship ▪ Coastguard ▪ MCA / MAIB ▪ Harbour authorities ▪ PFSOs ▪ TRANSEC	▪ Parent Company ▪ Charterers ▪ Underwriters ▪ P&I Club & Insurers ▪ Cargo owners ▪ Company lawyers ▪ Media consultants	▪ Emergency services ▪ Salvage Association ▪ Towage ▪ Authorities ▪ Flag State ▪ Classification Society	▪ Seatruck Ferries (operations)	▪ Ship (technical matters)	▪ Next-of-kin ▪ Hospital
Duties	▪ Chair CMT ▪ Muster CMT ▪ Brief CMT ▪ Delegate duties ▪ Provide resources / support for ship	▪ Provide names: charterers/ shippers/ others ▪ Media liaison ▪ Authorise announcements & visits to N-o-K ▪ Liaise with & utilise operations departments & charterers	▪ Acquire resources	▪ Utilise operations departments for technical assistance	▪ Technical assistance to CM & ship ▪ Drawings & plans ▪ Resources / support for ship ▪ Meet ship on arrival	▪ Maintain log ▪ Telephones, fax & e-mail ▪ Crew list ▪ Travel arrangements ▪ Arrange personnel visits (if authorised)
Determine & Consider	▪ Nature of incident ▪ Action taken ▪ Ship's position ▪ Crew safety ▪ Casualties ▪ POB ▪ Weather & Tides ▪ DGs			▪ Environmental implications	▪ Required spares ▪ Emergency repairs ▪ Repair facilities	▪ Crewing requirements & repatriation

Annex 5

Extract from Seatruck SMS -
Emergency checklist (grounding/stranding)

GROUNDING / STRANDING

- ☐ The OOW must call the **Master** immediately after taking priority action to safeguard life
- ☐ The Master must call the **Superintendent** at the earliest opportunity after effecting the ships emergency priorities

- ☐ ME pitch to zero. Note time of grounding
- ☐ Sound the GENERAL EMERGENCY ALARM
- ☐ Inform Engine Room. Sea suctions to high
- ☐ Close watertight / fire doors
- ☐ Switch on deck lighting at night
- ☐ Exhibit lights/shapes and make appropriate sound signals
- ☐ Inform vessels in immediate vicinity
- ☐ Inform port authority
- ☐ Inform local Coastguard
- ☐ Fix ship's position and update GMDSS station if necessary
- ☐ Broadcast ALERT and MESSAGE: DISTRESS, URGENCY or SAFETY
- ☐ VHF to Channel 16
- ☐ Fire-fighting equipment ready for immediate use
- ☐ Damage assessment:

  Sound all compartments
  Casualties
  External damage
  Internal damage (visual inspection where possible) Check all watertight closures, stern glands and access doors remain tight
  Watertight integrity of hull
  Engine Room status
  Fire risk
  Pollution risk
- ☐ Check depth of water around ship. Determine where the deeper water lies. Determine nature of sea bed
- ☐ Ascertain time and height of tide. Obtain information on local tides and currents, particularly rise and fall.
- ☐ Monitor draughts and compare with flotation draughts
- ☐ If flooding refer to **Emergency Checklist 10 - FLOODING**
- ☐ If pollution: refer to **Emergency Checklist 15 Spills – Damage to Vessel**
- ☐ Consider:

  Possibility of floating off if no damage or if tide rising rapidly. This may be aided by pumping out ballast or adjusting trim
  Possibility of remaining in position particularly if bottom damage plugged by seabed
  Ballasting tanks to harden ship in position and reduce wave induced damage
  Tugs
  Port of refuge

☐ **When the emergency is over, broadcast to ALL STATIONS to cancel**

Annex 6

Extract from Seatruck SMS -
Emergency checklist (cargo shift)

CARGO SHIFT

- ☐ The OOW must call the **Master** immediately after taking priority action to safeguard life
- ☐ The Master must call the **Superintendent** at the earliest opportunity after effecting the ships emergency priorities
- ☐ Check:
  - Watertight integrity
  - Extent of damage
  - Stability
  - Weather forecast
  - If carrying dangerous goods refer to DG plan and IMDG Code
- ☐ Inform local Coastguard
- ☐ Fix ships' position and update GMDSS station if necessary
- ☐ Broadcast ALERT and MESSAGE: DISTRESS, URGENCY or SAFETY
- ☐ Consider:
  - If spillage: refer to **Emergency Checklist 14 – Spills from Cargo**
  - Ballasting to correct list
  - Adjust course/speed to minimise vessels movement
  - Re-securing cargo
  - Port of refuge / safe haven

- ☐ **When the emergency is over, broadcast to ALL STATIONS to cancel**

Annex 7

Riverdance loading list

_/02/2008 14:35 SEATRUCK WPT

Voyage Number M Deck (Main Deck) Date W Deck (Aux Deck) Time

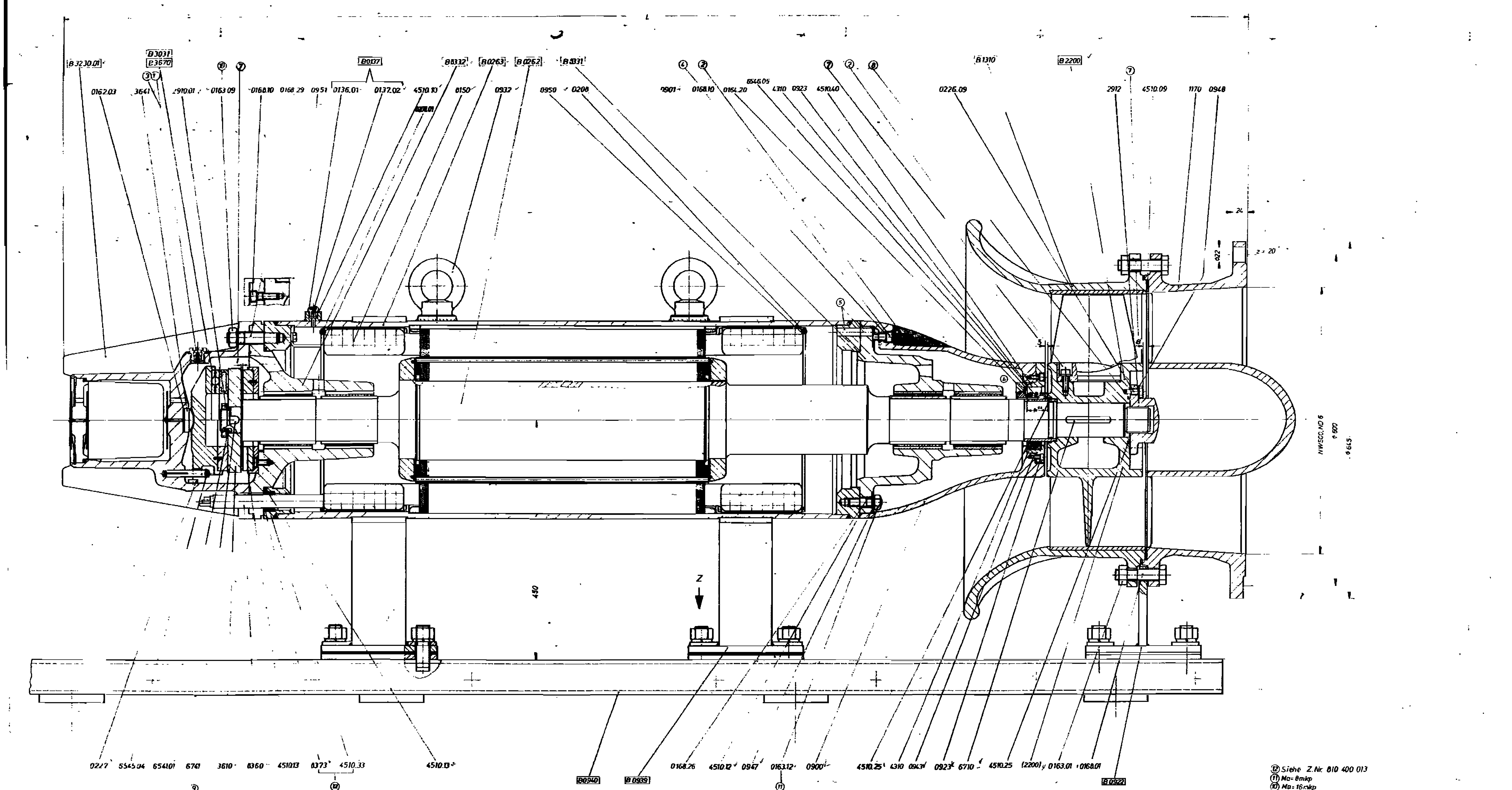
No	COMPANY NAME	TRAILER NUMBER	L	W	ROW	LOG
1	[redacted]	13607F				
2	—"—	13661FX				
3	—"—	BK647F				
4	—"—	45158C				
5	—"—	4503C				
6	—"—	4576C				
7	[redacted]	184H				
8		LTT377				
9	—"—	XX507				
10	[redacted]	9030				
11		RM04				
12		ORT594				
13		TR2				
14		45111				
15	—"—	45177				
16	[redacted]	PMT46				
17		SS854				
18		LTT381				
19		ORT796				
20		PSMCD28				
21		4580				
22		45161				
23	—"—	45107				
24	[redacted]	ORT663				
25		TUK206				
26	—"—	T112				
27	[redacted]	ORT764				
28						
29	[redacted]					

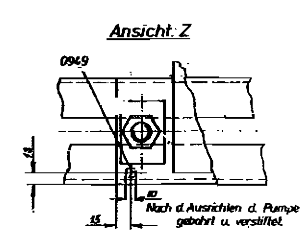
No	COMPANY NAME	TRAILER NUMBER	L	W
30	[redacted]	BK695 BK605		
31		SFL 110		
32	—"—	124H		
33	—"—	228H		
34	—"—	192H		
35	—"—	64H		
36	[redacted]	T162		
37	—"—	TUK217		
38	—"—	T1		
39	—"—	T124		
40	—"—	T68		
41	[redacted]	XX523		
42		7769		
43	—"—	9031		
44	[redacted]	4556		
45		DX1008	WASTE OIL	
46		45/24		
47	—"—	45/40		
48	[redacted]	BMS44		
49		TL1194		
50		90634		
51		TL848		
52		TRT08		
53		SC7010		
54		4503		
55		DCL68		
56				
57				
[redacted]				

W3/0107R

Annex 8

Diagram of heeling system transfer pump





P	400	500	600	700	800	900	1000	1100	1200
L	2085	2185	2285	2385	2485	2585	2685	2785	2885

(12) Siehe Z.Nr. 810 400 013
(11) Ma= 8mkp
(10) Ma= 16mkp
(9) Um 90° versetzt gezeichnet
(8) 3 Bohrungen ⌀ 9,2, 8tief nach dem Festziehen der Propellermutter gebohrt
(7) Kontrollmaß

(5) Entlüftungsbohrungen oben liegend und miteinander fluchtend.
(4) Mit Loctite CVV gesichert
(3) Um 60° versetzt gezeichnet
(2) Bei der Endmontage mit wasserfesten Beton ausgefüllt
(1) Nach dem Auffüllen des Motors durch Gewindestift verschlossen

1:25	Schöpfwerkspumpe S 48...-1+V16-40...120-6	471 030

PLEUGER Unterwasserpumpen GmbH Hamburg

Annex 9

Mv *Moondance* “Worst Case Scenario” (WCS) stability condition

MV Moondance

Manual Stability Check Worstcase

28.2.08

Comp't	Weight	VCG	Moment	LCG	Moment	FSM
Mn Dk	0.00	7.70	0.00	49.50	0.00	
Top Dk	529.00	14.20	7511.80	55.50	29359.50	
TOTAL	529.00		7511.80		29359.50	0.00
Forepeak	0.00	6.83	0.00	102.69	0.00	0.00
No.1	10.25	1.72	17.63	88.85	910.71	15.00
No.2P		1.09	0.00	63.80	0.00	0.00
No.2S		1.09	0.00	63.80	0.00	0.00
No.3P outer	6.15	1.02	6.27	45.26	278.36	0.00
No.3S outer	6.40	1.03	6.59	45.32	290.05	0.00
No.7 P	0.00	4.98	0.00	17.30	0.00	0.00
No.7 S	0.00	4.98	0.00	17.30	0.00	0.00
No.8 P	0.00	4.89	0.00	6.30	0.00	0.00
No.8 C		4.16	0.00	7.09	0.00	
No.8 S	0.00	4.89	0.00	6.83	0.00	
No. 9	0.00	5.31	0.00	-4.70	0.00	0.00
No. 11		4.34	0.00	80.89	0.00	0.00
No. 12		5.25	0.00	50.36	0.00	0.00
TOTAL	22.80		30.50		1479.11	15.00
No. 34		5.25	0.00	67.71	0.00	
Port Heel	0.00	3.78	0.00	51.42	0.00	0.00
Stbd Heel	0.00	3.78	0.00	51.31	0.00	0.00
Centre Heel	0.00	5.25	0.00	58.20	0.00	
TOTAL	0.00		0.00		0.00	0.00
DO 6P		0.95	0.00	29.96	0.00	
DO 6S	11.00	0.95	10.45	29.96	329.56	
TOTAL	11.00		10.45		329.56	0.00
No.2 HFO		1.30	0.00	73.65	0.00	
No.3P HFO	7.00	0.84	5.88	48.73	341.11	50.00
No.3S HFO	22.00	0.84	18.48	48.73	1072.06	50.00
No.31 GasOil	22.00	3.81	83.82	14.95	328.90	
TOTAL	51.00		108.18		1742.07	100.00
No.25 DO Daily	5.90	4.17	24.60	21.17	124.90	0.00
No.18 Daily	20.00	4.00	80.00	21.10	422.00	0.00
No.19 Daily	18.00	4.16	74.88	15.58	280.44	0.00
No.32 Settling	21.00	3.89	81.69	14.57	305.97	0.00
No.33 Gas Oil	3.00	4.05	12.15	18.31	54.93	0.00
No. 30 Lube	10.91	4.05	44.19	18.31	199.78	0.00
TOTAL	78.81		317.51		1388.01	0.00
No5 Lub P	2.20	1.03	2.27	33.35	73.37	0.00
No26 Lub	2.50	4.08	10.20	22.51	56.28	0.00
No27 Lub	3.50	4.17	14.60	21.11	73.89	0.00
TOTAL	8.20		27.06		203.53	0.00
No28 Lub	1.50	4.23	6.35	20.05	30.08	
No29Lub	2.30	4.29	9.87	19.35	44.51	
No 6 Lub S	2.50	1.03	2.58	33.35	83.38	
Misc Water	25.60	4.12	105.47	87	2227.20	25
TOTAL	31.90		124.26		2385.16	25.00
FW 14 P	20.00	4.13	82.60	41.44	828.80	10.00
FW 14 S	20.00	3.99	79.80	41.41	828.20	10.00
Misc Oils	12.20	1.65	20.13	20.80	253.76	0.00
TOTAL	52.20		182.53		1910.76	20.00
STORES	30.00	14.89	446.70	93.90	2817.00	0.00
CREW	5.00	25.00	125.00	93.90	469.50	0.00
PASS		25.00	0.00	93.00	0.00	
TOTAL	35.00		0.00		0.00	0.00
DEADWEIGHT	819.91	10.14	8312.28	47.32	38797.69	160.00
LIGHTSHIP	2775.30	8.18	22701.95	47.00	130439.10	
DISP	3595.21	8.63	31014.24	47.07	169236.79	160.00

INSTRUCTIONS

1

*Enter weights in shaded area for respective compartments. If your tanks are slack, do not forget to add in your Free surface moments into FSM columns (these FSM moments can be found in the last column of figures for the tank in question, named M*T) and adjust your tanks VCG for appropiate weight, interpolation required I am afraid.*

2

Once these figures have been entered you will have your KG solid, KG Fluid final LCG and your solid and fluid GM figures

3

Enter hydro data at front of stability book with your disp and trim at 0, and obtain mean draft for that disp and your LCF (XCF), LCB (XCBA), KM figures. You will have to interpolate I am afraid !! DO NOT ADJUST FIGURES (LCF,LCB) for LBP AS THIS IS DONE AUTOMATICALLY BY THIS SPREADSHEET

4

Enter these figures on sheet 2 of this programme and your calculated drafts will be worked out. (Do not forget to enter your mean draft at bottom of this column)

5

Enter your observed drafts and the difference will be worked out.

NOTE THIS PROGRAMME WILL ONLY WORK FOR A STERN TRIM

MEAN DRAFT

4.01

Workings

	Figures from stability book	Corrected figures for LBP	Vessels final LCG
LBP	103.40	103.40	Total moments / final disp
LCB	49.27	49.27	
MCTC	90.05	90.05	47.07
LCF	45.61	45.61	
KM	9.40	9.40	

KG Solid = Moments/ Disp	8.63
GM Solid = KM - KG Solid	0.77
KG Fluid = (Moments + FSM) / Disp	8.67
GM Fluid = KM - KG Fluid	0.73
Trim = Disp x (LCB - LCG) / MCTC x 100	0.88
CoT Aft = (Dist LCF from AP) / LBP) * CoT	0.39
CoT Fwd = CoT - CoT Aft	0.49
Draft Fwd = Mean draft -/+ CoT Fwd	3.52
Draft Aft =	4.40

Draft as read fwd =	3.52	Difference =	0.00
Draft as read aft =	4.40	Difference =	0.00

Notes

24 drop trailers on weather deck at 22T each. Main deck MT.

Annex 10

Seatruck's ISM Document of Compliance -
audit observations

DET NORSKE VERITAS

ISM CODE / ISO CERTIFICATION / OTHER

Observation

Note No.: 1 of 1
Date: 2007-09-10

Company Name: Seatruck Ferries Shipholding Ltd.	DNV Id. No.: 124692
Ship Name: ———	DNV Id. No.: ———

Company Audit ☒ Ship Audit ☐ Lead Auditor: [redacted] Signature: [redacted]

Audit Team:

Descriptions with references to relevant requirements or guidelines:

1. **It is suggested that a means of tracking open NC, incident reports etc. be investigated.**
2. ***It is suggested that 'root cause' identification be made for each and every incident/accident.***
3. **It is noted that there are very good levels of communication between the ships and the office.**
4. **It is suggested that some form of benchmarking be applied to the vessels in the fleet so that trends can be identified.**
5. **It is noted that the majority of forms are in the process of being revised – this opportunity should be used to ensure that all relevant information is being captured.**
6. **It is noted that the company's crisis management procedure is in the process of being revised and when complete will be exercised.**
7. **Everybody interviewed was most helpful – Thank You.**

DET NORSKE VERITAS 1864 Southampton

Annex 11

Mv *Riverdance* - ISM internal audit report memo

From: [redacted]

To: [redacted] (Safety & Quality Manager)
CC: Master Riverdance

INTERNAL ISM AUDIT on M/V RIVERDANCE

18th December 2007, on passage Heysham to Warrenpoint

An internal ISM audit was carried out by [redacted] on board the Riverdance whilst the vessel was in Heysham and on passage from Heysham to Warrenpoint.

Throughout my visit safe working practices and good seamanship were observed along with the correct use of personal protective clothing. The vessel was clean & tidy with good housekeeping evident in all departments.

The master, [redacted], officers and crew extended to me every assistance during the audit and were helpful and open during the interviews.

The following crewmembers were interviewed.
Master [redacted]
Chief Officer [redacted]
2nd Officer [redacted]
Chief Engineer [redacted]
2nd Engineer [redacted]
Bosun [redacted]
AB [redacted]
AB [redacted]
Cook [redacted]
Steward [redacted]

The officers & ratings had a good knowledge of the parts of the safety management system that applies to their duties. All crew know who the designated person ashore is. All crew were familiar with their duties and their duties in an emergency. There was a good level of understanding of the company's security, drug & alcohol, safety, & environmental policies.

The following observations can be made

1) There is no feedback from the office regarding the ships end of month report. It would be good to know that the report has been seen by the ship manager and passed on to relevant personnel such as superintendent, S&Q manager etc, and even if the comment "all points noted" was used it would indicate the report had been read.
2) The safety officer's record book is still in the Crescent shipping format. A revised copy in Seatruck format has not been received. The guidelines for filling in the change of safety officer and the safety officers hand over are being interpreted differently between

the 2 vessels so some clarification may be needed from S&Q manager

3) Hours of rest forms are all completed on a monthly basis and signed, but some are done on the old style forms and some on the new style
4) Last incident report was 03/07 dated 09/06/07, there is no office reply / response to this incident report on file.
5) In the Safety Management manual section 4 the index sheet is incorrect as RD01 is now the ships Alcohol Policy (this needs to be changed on the ships notice board as well)
6) A new procedure for confirming bunker orders has been recently put in place, so that the ship gets a confirmation note from the office that bunkers have been ordered, but this procedure is not yet in the manual and I'm not sure if it's being used on the Moondance. (I will check and report back next week).

Publications, documentation & certification all appear to be in good order, corrected up to date and easy to locate. Company policies and work instructions are being followed, and procedures set out in the safety management manual are understood and complied with.

I would like to thank the master, officers and crew for their assistance to me during this audit.

Best Regards

[redacted]

[redacted]

Annex 12

Extract from Seatruck SMS - cargo operations

Scope
To ensure that the measures in place for acceptance, loading/discharge and carriage of cargo and passengers are adequate for the safe operation of the vessel, and in compliance with company and statutory requirements.

Responsibilities
The Master is responsible for ensuring that Deck Officers are fully aware of the contents of this procedure. He has overriding authority to reject cargo or passengers, if, in his opinion they are unsuitable or may present an unacceptable risk to the safety of the vessel and persons on board.

He is also responsible for ensuring that the vessel is safely and securely moored alongside the berth for cargo operations to take place.

The Chief Officer is responsible for all shipboard preparations for accepting/loading/stowage and securing of all cargo units. This includes verification of suitability of cargoes including hazardous cargoes.

Deck Officers are responsible for carrying out the measures contained in this procedure.

Deck crew are to assist as directed by the Officer in charge of cargo operations and in accordance with the provisions of these procedures

References
Code of Safe Working Practices
MCA Notices
IMDG Code
Cargo Securing Manual
Ro-Ro Ships – Stowage and Securing of Cargo, Code of Safe Working Practices
Hazardous Stowage Plan
Passage Plan/Voyage Monitoring Form

Accepting Cargo & Passengers
Prior to loading, Chief Officer is to liaise with the Freight Supervisor to determine details of the anticipated load. He should obtain a loading list and satisfy himself that cargo for shipment is fit for that purpose.

The loading list should include:

- Number and type of self-drives and number of drivers
- Number of drop / unaccompanied trailers
- Number and type of mobiles
- Number of foot passengers
- Details of any hazardous cargoes
- Details of any abnormally sized cargoes
- Details of any freight vehicles requiring special consideration with regard to embarkation, stowage and securing
- Number of units intended for weather deck stowage

The Chief officer is to satisfy himself that all cargo is adequately secured taking into account current and expected weather conditions.

If required, the Chief Officer is to complete a Cargo Shipment Rejection Form and send original to Freight Office and retain a copy onboard.

Hazardous Cargoes – the Chief Officer must ensure that he obtains full 'Notification information and Documentation' and liase with the Freight Supervisor to ensure that all hazardous goods are displaying the appropriate labels/placards. No hazardous cargo will be loaded until the above conditions are satisfied. Hazardous cargo will be stowed in accordance with the IMDG Code.

The Chief Officer is responsible for notifying all relevant ship and terminal staff when departures from a standard loading pattern occur.

Cargo Operations
Cargo is always to be stowed and secured in accordance with the vessel's approved Cargo Securing Manual

The Chief Officer must liase with the Freight Supervisor / Terminal Staff to update cargo information to vessel at regular intervals during cargo operations

Throughout cargo operations the Chief Officer is to remain on duty and is to ensure that:

- There is safe access between the vessel and shore linkspan via the stern ramp
- There is control at all times on the movement of vehicles in the vessel to maintain safety of personnel and to minimise damages
- All deck crew are properly attired in hi-visibility clothing and other appropriate safety gear
- All deck crew are equipped with a whistle and are aware of the appropriate signals
- Moorings are tended as required
- All freight vehicles and their loads are fit for carriage
- All lashings are being applied correctly
- A safe working environment is maintained, i.e. ventilation, lighting, deck conditions etc.
- All cargo operations are carried out in a manner that maintains acceptable trim, list and stability values
- The loading plan is reviewed at frequent intervals and is amended as necessary
- Crew and terminal staff are advised of any changes to the loading plan or order of load
- Pollution control equipment is available at all times

Cargo damage
All Deck crew are to ensure the Chief Officer is informed immediately when damage, however minor, to cargo and or vessel occurs during cargo operations

The Chief Officer is to investigate all such occurrences and assess damage and cause

A verbal report is to be made to the Freight Supervisor as soon as possible and is to include, if appropriate, the number of any shore vehicles and driver's name

As soon as practicable Cargo Damage report form is to be completed. The report is to contain a full and factual description of the damage and its cause, and should identify to whom the initial verbal report was made.

Damage noted to any freight unit during embarkation which has not been previously recorded is to be recorded by the Chief Officer on a Cargo Damage report form.

Hazardous Cargoes
All hazardous cargoes are to be stowed in accordance with the separation and segregation requirements as contained in the IMDG Code

Hazardous cargoes are to be stowed in such position as to minimise their movement caused by the vessels motion in a seaway

Heavy Weather
When heavy weather is current or forecast, additional consideration should be given to the stowage position, securing and proximity to other vehicles of cargo units known to be prone to movement, for example:

- Tankers / tank containers – full or part loaded
- Hanging meat
- Pallets – single or multi-stacked
- Tri / piggy back trailers
- Bagged polythene granules
- Paper rolls; and
- Laminated chipboard

Careful consideration is to be given to the stowage position of hazardous goods in relation to these cargoes.

Pre-departure checks
On completion of loading the Chief Officer is to ensure that:

- All terminal staff are ashore
- All crew members are onboard
- Cargo documentation is onboard
- All loose gear, lashing equipment and trestles are secured
- All drivers have vacated their vehicles and are clear of the vehicle decks
- The vessel is secured for sea
- A Hazardous Goods stowage plan and declaration has been completed and is posted on the Dangerous Goods board on the Bridge
- All cargo details have been entered on Passage Plan / Voyage Monitoring form

A report is made to the Master that these checks have been made and a corresponding entry made in the Deck Log Book.

Mv *Riverdance* - shipboard procedures (ballast operations)

Title: Shipboard Ballast Operations

Scope: To describe the arrangements in place for the control, intake, transfer and discharge of ballast water.
To demonstrate that adequate arrangements are in place to maintain the safety and integrity of the vessel and the preservation of the environment.

Responsibilities:

Chief Officer: Implementing the contents of this procedure.

Second Officer: Weekly soundings of ballast tanks and recording of same.

E.O.O.W: Operating ballast pumps as required by Chief Officer.

Procedure:

1. Under normal operating procedures ballast conditions remain unchanged. However ballast may have to be adjusted for a number of reasons including the following:

   To maintain an effective stern ramp interface with the shore link-span at Warrenpoint during periods of low water springs.

   To correct unacceptable values of trim and heel which cannot be corrected by the usual means.

   "Ballast only" voyages.

   To ensure required trim values for egress to / from a graving dock.

2. Requests for adjusting ballast conditions are made verbally by the Chief Officer to the EOOW (except for Heeling Tanks 13 P&S).
3. The EOOW is to verbally inform the Chief Officer on completion of the ballast operation.
4. When loading ballast water every effort should be made to ensure that only clean water is taken onboard and that uptake of sediment is minimised.
5. Note: WB Tanks numbers 12 & 34 should not be used as the free surface effect is exceptionally large.

APPROVED BY

DATE 22/10/04.

crescent marine services

Annex 14

IMO MSC.1/Circ.1228 11 January 2007 -

Guidance to the Master for avoiding dangerous situations in adverse weather and sea conditions

INTERNATIONAL MARITIME ORGANIZATION
4 ALBERT EMBANKMENT
LONDON SE1 7SR

Telephone: 020 7735 7611
Fax: 020 7587 3210

IMO

E

Ref. T1/2.04

MSC.1/Circ.1228
11 January 2007

REVISED GUIDANCE TO THE MASTER FOR AVOIDING DANGEROUS SITUATIONS IN ADVERSE WEATHER AND SEA CONDITIONS

1 The Maritime Safety Committee, at its eighty-second session (29 November to 8 December 2006), approved the Revised Guidance to the master for avoiding dangerous situations in adverse weather and sea conditions, set out in the annex, with a view to providing masters with a basis for decision making on ship handling in adverse weather and sea conditions, thus assisting them to avoid dangerous phenomena that they may encounter in such circumstances.

2 Member Governments are invited to bring the annexed Revised Guidance to the attention of interested parties as they deem appropriate.

3 This Revised Guidance supersedes the Guidance to the master for avoiding dangerous situations in following and quartering seas (MSC/Circ.707).

***

ANNEX

REVISED GUIDANCE TO THE MASTER FOR AVOIDING DANGEROUS SITUATIONS IN ADVERSE WEATHER AND SEA CONDITIONS

1 GENERAL

1.1 Adverse weather conditions, for the purpose of the following guidelines, include wind induced waves or heavy swell. Some combinations of wave length and wave height under certain operation conditions may lead to dangerous situations for ships complying with the IS Code. However, description of adverse weather conditions below shall not preclude a ship master from taking reasonable action in less severe conditions if it appears necessary.

1.2 When sailing in adverse weather conditions, a ship is likely to encounter various kinds of dangerous phenomena, which may lead to capsizing or severe roll motions causing damage to cargo, equipment and persons on board. The sensitivity of a ship to dangerous phenomena will depend on the actual stability parameters, hull geometry, ship size and ship speed. This implies that the vulnerability to dangerous responses, including capsizing, and its probability of occurrence in a particular sea state may differ for each ship.

1.3 On ships which are equipped with an on-board computer for stability evaluations, and which use specially developed software which takes into account the main particulars, actual stability and dynamic characteristics of the individual ship in the real voyage conditions, such software should be approved by the Administration. Results derived from such calculations should only be regarded as a supporting tool during the decision making process.

1.4 Waves should be observed regularly. In particular, the wave period T_W should be measured by means of a stop watch as the time span between the generation of a foam patch by a breaking wave and its reappearance after passing the wave trough. The wave length λ is determined either by visual observation in comparison with the ship length or by reading the mean distance between successive wave crests on the radar images of waves.

1.5 The wave period and the wave length λ are related as follows:

$$\lambda = 1.56 \cdot T_W^2 \text{ [m] or } T_W = 0.8\sqrt{\lambda} \text{ [s]}$$

1.6 The period of encounter T_E could be either measured as the period of pitching by using stop watch or calculated by the formula:

$$T_E = \frac{3T_W^2}{3T_W + V\cos(\alpha)} \text{ [s]}$$

where V = ship's speed [knots]; and
α = angle between keel direction and wave direction (α = 0° means head sea)

1.7 The diagram in figure 1 may as well be used for the determination of the period of encounter.

1.8 The height of significant waves should also be estimated.

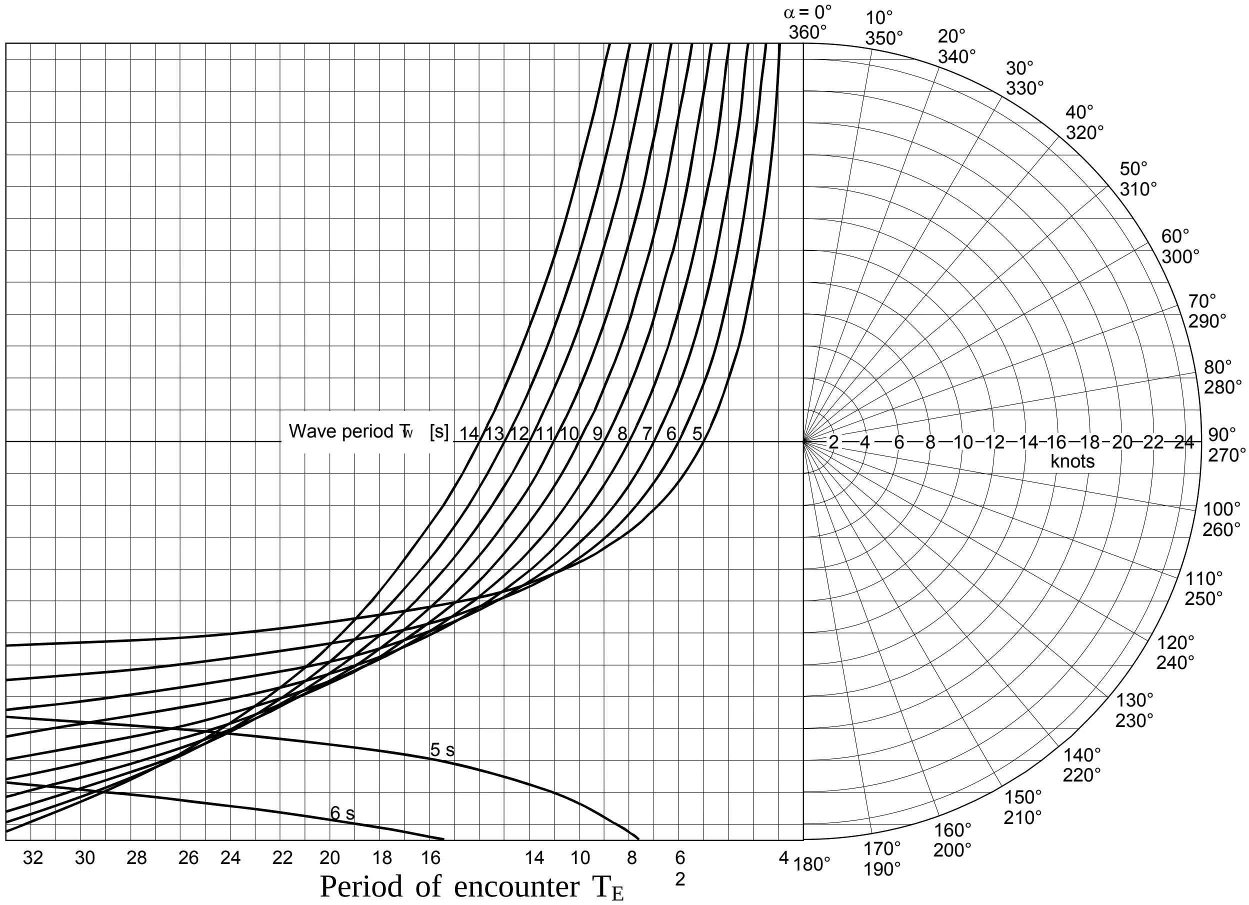


Figure 1: Determination of the period of encounter T_E

2 CAUTIONS

2.1 It should be noted that this guidance to the master has been designed to accommodate for all types of merchant ships. Therefore, being of a general nature, the guidance may be too restrictive for certain ships with more favourable dynamic properties, or too generous for certain other ships. A ship could be unsafe even outside the dangerous zones defined in this guidance if the stability of the ship is insufficient. Masters are requested to use this guidance with fair observation of the particular features of the ship and her behaviour in heavy weather.

2.2 It should further be noted that this guidance is restricted to hazards in adverse weather conditions that may cause capsizing of the vessel or heavy rolling with a risk of damage. Other hazards and risks in adverse weather conditions, like damage through slamming, longitudinal or torsional stresses, special effects of waves in shallow water or current, risk of collision or stranding, are not addressed in this guidance and must be additionally considered when deciding on an appropriate course and speed in adverse weather conditions.

2.3 The master should ascertain that his ship complies with the stability criteria specified in the IS Code or an equivalent thereto. Appropriate measures should be taken to assure the ship's watertight integrity. Securing of cargo and equipment should be re-checked. The ship's natural period of roll T_R should be estimated by observing roll motions in calm sea.

3 DANGEROUS PHENOMENA

3.1 Phenomena occurring in following and quartering seas

A ship sailing in following or stern quartering seas encounters the waves with a longer period than in beam, head or bow waves, and principal dangers caused in such situation are as follows:

3.1.1 Surf-riding and broaching-to

When a ship is situated on the steep forefront of a high wave in following or quartering sea conditions, the ship can be accelerated to ride on the wave. This is known as surf-riding. In this situation the so-called broaching-to phenomenon may occur, which endangers the ship to capsizing as a result of a sudden change of the ship's heading and unexpected large heeling.

3.1.2 Reduction of intact stability when riding a wave crest amidships

When a ship is riding on the wave crest, the intact stability can be decreased substantially according to changes of the submerged hull form. This stability reduction may become critical for wave lengths within the range of 0.6 L up to 2.3 L, where L is the ship's length in metres. Within this range the amount of stability reduction is nearly proportional to the wave height. This situation is particularly dangerous in following and quartering seas, because the duration of riding on the wave crest, which corresponds to the time interval of reduced stability, becomes longer.

3.2 Synchronous rolling motion

Large rolling motions may be excited when the natural rolling period of a ship coincides with the encounter wave period. In case of navigation in following and quartering seas this may happen when the transverse stability of the ship is marginal and therefore the natural roll period becomes longer.

3.3 Parametric roll motions

3.3.1 Parametric roll motions with large and dangerous roll amplitudes in waves are due to the variation of stability between the position on the wave crest and the position in the wave trough. Parametric rolling may occur in two different situations:

.1 The stability varies with an encounter period T_E that is about equal to the roll period T_R of the ship (encounter ratio 1:1). The stability attains a minimum once during each roll period. This situation is characterized by asymmetric rolling, i.e. the amplitude with the wave crest amidships is much greater than the amplitude to the other side. Due to the tendency of retarded up-righting from the large amplitude, the roll period T_R may adapt to the encounter period to a certain extent, so that this kind of parametric rolling may occur with a wide bandwidth of encounter periods. In quartering seas a transition to harmonic resonance may become noticeable.

.2 The stability varies with an encounter period T_E that is approximately equal to half the roll period T_R of the ship (encounter ratio 1:0.5). The stability attains a minimum twice during each roll period. In following or quartering seas, where the encounter period becomes larger than the wave period, this may only occur with very large roll periods T_R, indicating a marginal intact stability. The result is symmetric rolling with large amplitudes, again with the tendency of adapting the ship response to the period of encounter due to reduction of stability on the wave crest. Parametric rolling with encounter ratio 1:0.5 may also occur in head and bow seas.

3.3.2 Other than in following or quartering seas, where the variation of stability is solely effected by the waves passing along the vessel, the frequently heavy heaving and/or pitching in head or bow seas may contribute to the magnitude of the stability variation, in particular due to the periodical immersion and emersion of the flared stern frames and bow flare of modern ships. This may lead to severe parametric roll motions even with small wave induced stability variations.

3.3.3 The ship's pitching and heaving periods usually equals the encounter period with the waves. How much the pitching motion contributes to the parametric roll motion depends on the timing (coupling) between the pitching and rolling motion.

3.4 Combination of various dangerous phenomena

The dynamic behaviour of a ship in following and quartering seas is very complex. Ship motion is three-dimensional and various detrimental factors or dangerous phenomena like additional heeling moments due to deck-edge submerging, water shipping and trapping on deck or cargo shift due to large roll motions may occur in combination with the above mentioned phenomena, simultaneously or consecutively. This may create extremely dangerous combinations, which may cause ship capsize.

4 OPERATIONAL GUIDANCE

The shipmaster is recommended to take the following procedures of ship handling to avoid the dangerous situations when navigating in severe weather conditions.

4.1 Ship condition

This guidance is applicable to all types of conventional ships navigating in rough seas, provided the stability criteria specified in resolution A.749(18), as amended by resolution MSC.75(69), are satisfied.

4.2 How to avoid dangerous conditions

4.2.1 For surf-riding and broaching-to

Surf-riding and broaching-to may occur when the angle of encounter is in the range 135°<α<225° and the ship speed is higher than $\left(1.8\sqrt{L}\right)/\cos\left(180-\alpha\right)$ (knots). To avoid surf riding, and possible broaching the ship speed, the course or both should be taken outside the dangerous region reported in figure 2.

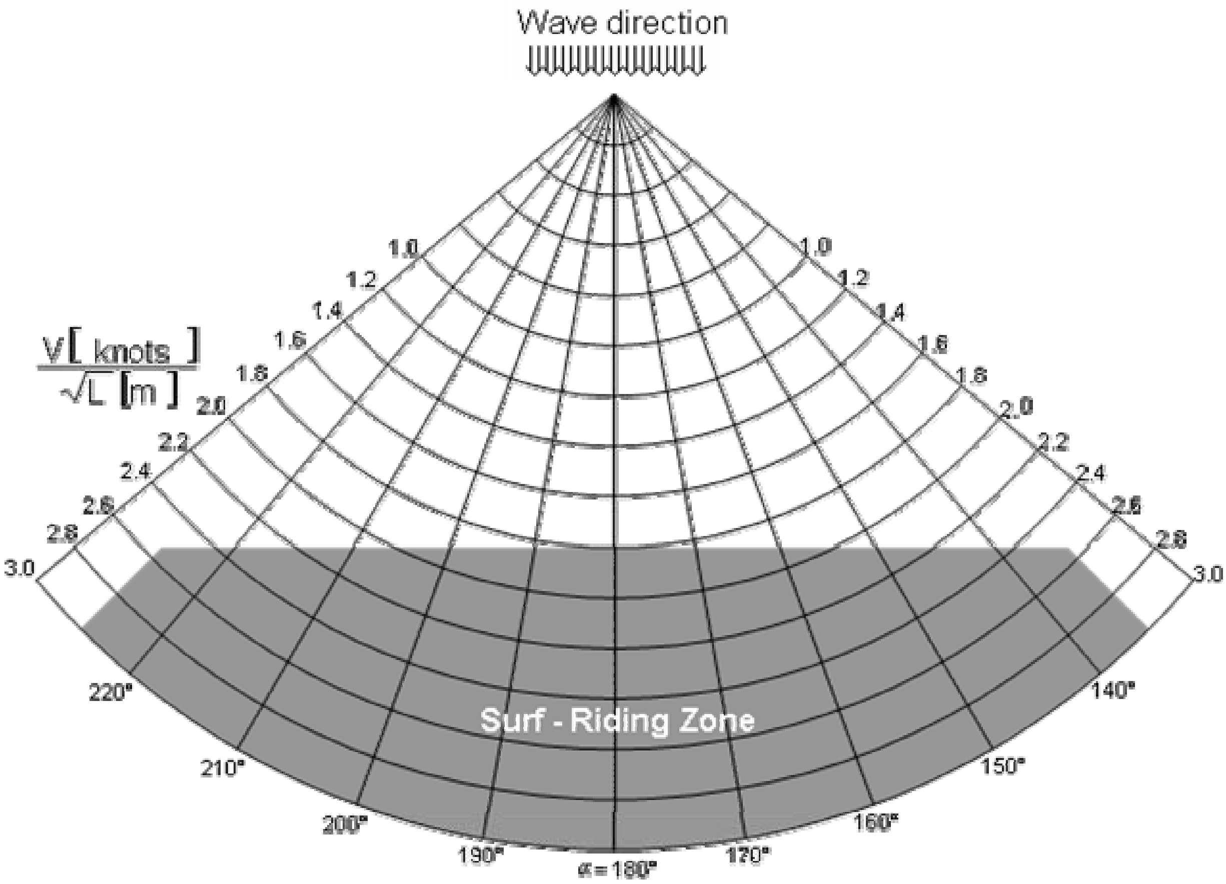


Figure 2: Risk of surf-riding in following or quartering seas

4.2.2 For successive high-wave attack

4.2.2.1 When the average wave length is larger than 0.8 L and the significant wave height is larger than 0.04 L, and at the same time some indices of dangerous behaviour of the ship can be clearly seen, the master should pay attention not to enter in the dangerous zone as indicated in figure 3. When the ship is situated in this dangerous zone, the ship speed should be reduced or the ship course should be changed to prevent successive attack of high waves, which could induce the danger due to the reduction of intact stability, synchronous rolling motions, parametric rolling motions or combination of various phenomena.

4.2.2.2 The dangerous zone indicated in figure 3 corresponds to such conditions for which the encounter wave period (T_E) is nearly equal to double (i.e., about 1.8-3.0 times) of the wave period (T_W) (according to figure 1 or paragraph 1.4).

4.2.3 For synchronous rolling and parametric rolling motions

4.2.3.1 The master should prevent a synchronous rolling motion which will occur when the encounter wave period T_E is nearly equal to the natural rolling period of ship T_R.

4.2.3.2 For avoiding parametric rolling in following, quartering, head, bow or beam seas the course and speed of the ship should be selected in a way to avoid conditions for which the encounter period is close to the ship roll period ($T_E \approx T_R$) or the encounter period is close to one half of the ship roll period ($T_E \approx 0.5 \cdot T_R$).

4.2.3.3 The period of encounter T_E may be determined from figure 1 by entering with the ship's speed in knots, the encounter angle α and the wave period T_W.

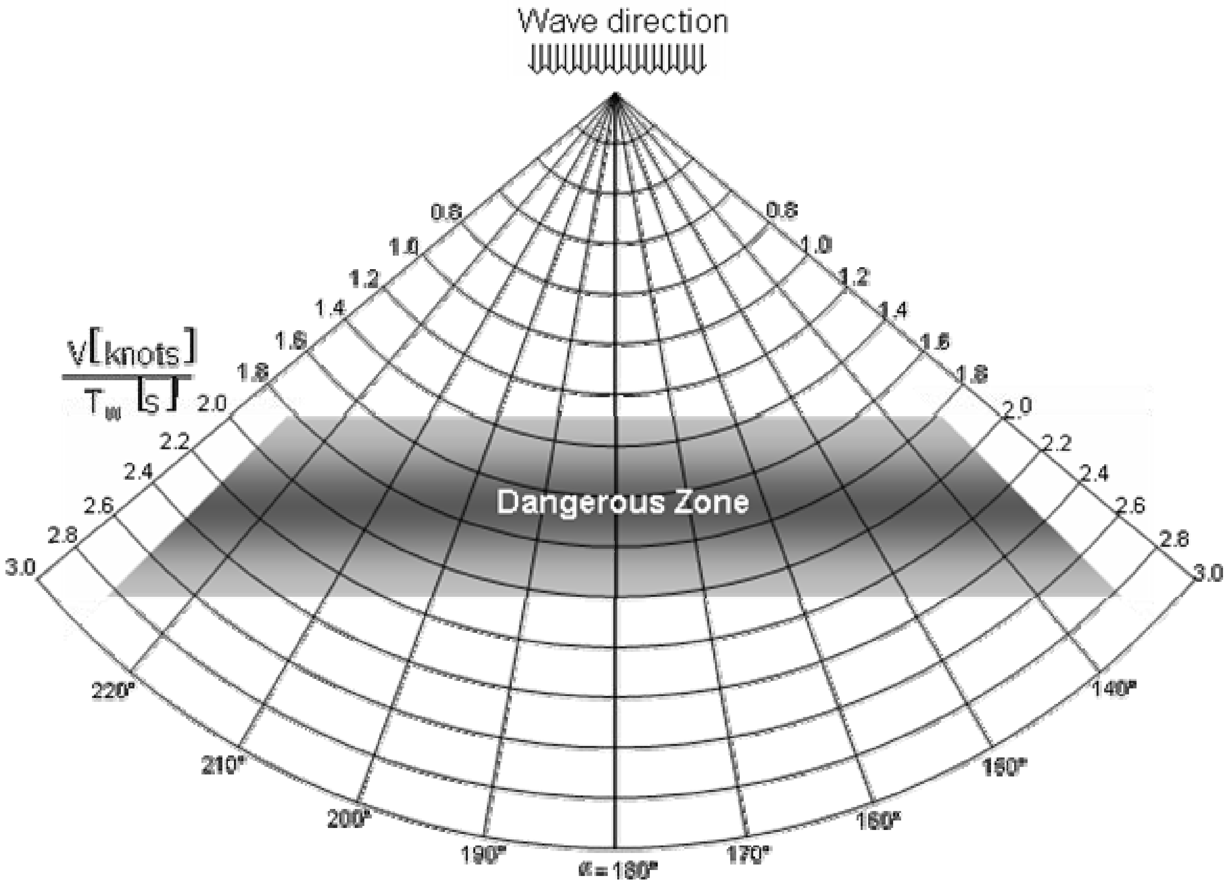


Figure 3: Risk of successive high wave attack in following and quartering seas

Abbreviations and symbols

Symbols	Explanation	Units
T_W	wave period	s
λ	wave length	m
T_E	encounter period with waves	s
α	angle of encounter (α = 0° in head sea, α = 90° for sea from starboard side)	degrees
V	ship's speed	knots
T_R	natural period of roll of ship	s
L	length of ship (between perpendiculars)	m

Extract from Trim & Stability booklet -
"Instructions to the Master"

Instructions to The Master

1 The typical Loading Conditions given in this booklet show that the vessel has adequate stability in all normal operating states. For all operating conditions the KG_f must be checked and must be within the limits shown in the KG envelope tables, shown on pages 45-49.

2 The Master's attention is drawn to 'M' Notice No. 1361 "Dangers of Flooding". The Master must be aware of the adverse effect that water trapped on the vehicle decks will have on stability. For example, when the drencher system is operated. Therefore, it must be ensured that all drainage scuppers are maintained free of obstructions, rubbish, etc at all times.

3 Compliance with the stability criteria indicated in this booklet does not ensure immunity from capsize regardless of the circumstances and does not absolve the Master from his responsibilities. The Master should therefore exercise prudence and good seamanship having regard to the season of the year, weather forecasts and the navigational zone and should take the necessary action as to course and speed warranted by the prevailing conditions.

4 Care should be taken that the cargo allocated to the ship is capable of being stowed and secured such that compliance with the stability criteria is achieved. If necessary, the amount of cargo should be limited to the extent that ballast may be required to ensure compliance.

5 Prior to sailing, care should be taken that all cargo and sizeable pieces of equipment have been properly stowed and lashed so as to minimise the risk of both longitudinal and lateral shifting while at sea, under the effects of accelerations caused by the ship's motions.

6 The stern door, inner ramp and all shell side doors must be closed and secured weathertight before the ship leaves port and are to be kept closed during navigation. The Cross Curves of Stability and the Maximum KG tables given in this booklet assume that these openings are weathertight. It must be noted that the Stability Standards obtainable in this vessel are wholly dependent on exposed openings being securely closed weathertight. Therefore, all such closing devices, including ball valves in air pipes, must be properly maintained in order to function as designed.

7 All hatches, manholes and portable plates leading to spaces below the main deck are to be closed and secured watertight before the ship leaves port and are to be kept closed during navigation.

8 All watertight and weathertight doors are to be kept closed at sea, except when they are required to be opened for the working of the ship.

9 In order to maintain free surface allowances below those values shown on the condition sheets, the DB fuel tanks should be worked so that not more than one tank (or pair of tanks) is less than full at any time.

10 The datum for KN, KM, KG and VCG used in this booklet is the "Moulded Base Line" (K), while the datum for draughts is the "Bottom of Keel" (BoK), ie. 16mm below the Moulded Base Line.

11 The Free Surface Moments listed in the tank capacity tables assume that the Heeling Tanks cross flooding valve has been closed, and therefore lateral transfer is not possible. It must be noted, that large free surface effects will exist in these tanks if this valve is left open, and therefore this valve should be closed upon completion of loading.

12 Water ballast tanks no.12 & 34 (below 2nd deck in way of lower cargo hold) should not normally be used as the free surface effect is exceptionally large.

Annex 16

Mv *Riverdance* **-** final ship's manifest

Seatruck Logo

Final Ships Manifest
Ship Name : RIVERDANCE
Route : WPTHEY
Departure Day : Thursday
Departure Date : 31/01/08
Departure Time : 11:30
Sailing Notes : 2 X SELFDRIVES FOR THE RAMP ONLY.
ETA 0900 / ETD 1130

Sailing Totals

Total Self Drives	2
Total Drops	52
Total Mobiles	0
Total Bookings	54

Total Length	698.9
Total Hazardous Bookings	0
Total OverWide Bookings	0
Total Weight	1199

Main Manifest

Booking No.	Customer	Reg	Unit ID	Type	Contents	Length	Weight	Cust Ref	Empty	Notes
Self Drive										
WPT0071856	[redacted]		[redacted]	SD	Empty	16.5	6		Y	
WPT0067498	[redacted]		[redacted]	SD	p/car x3 pax	4.0	6		N	[redacted]
Drop										
WPT0071842	[redacted]		[redacted]	TAU	TIMBER	13.6	30	TBA	N	
WPT0071686	[redacted]		[redacted]	TAU	PEAT	13.6	30	TBA	N	
WPT0071930	[redacted]		[redacted]	TAU	PEAT	13.6	30		N	
WPT0069919	[redacted]		[redacted]	TAU	peat	13.6	30	TBA	N	
WPT0071931	[redacted]		[redacted]	TAU	TIMBER	13.6	30		N	
WPT0071870	[redacted]		[redacted]	TPR	scrap	10.0	30	TBA	N	
WPT0071790	[redacted]		[redacted]	TAU	Empty	13.6	6	TBA	Y	
WPT0067484	[redacted]		[redacted]	BOX	Empty cages	13.6	7		N	
WPT0071924	[redacted]		[redacted]	TAU	Empty	13.6	6	TBA	Y	WEEKEND SHIPPER
WPT0071865	[redacted]		[redacted]	FLT	STEEL	13.6	30	196537	N	MUST GO
WPT0071909	[redacted]		[redacted]	FLT	TIMBER HOUSE	13.6	30	196592	N	MUST GO
WPT0071910	[redacted]		[redacted]	FLT	STEEL	13.6	30	196733	N	MUST GO
WPT0071838	[redacted]		[redacted]	DST	Empty	13.6	6	TBA	Y	REMOVE 4 X STRAPS
WPT0069892	[redacted]		[redacted]	TAU	peat	13.6	30	196539	N	MUST GO
WPT0069894	[redacted]		[redacted]	TAU	PALLETS	13.6	8	196520	N	MUST GO

WPT0069895	[redacted]		[redacted]	TAU	PLASTIC TANKS	13.6	12	196525	N	MUST GO
WPT0071703	[redacted]		[redacted]	TAU	CONCRETE FLOORING	13.6	30	TBA	N	
WPT0069925	[redacted]		[redacted]	TAU	flooring	13.6	30	1654775	N	
WPT0069923	[redacted]		[redacted]	TAU	RETURNS	13.6	22	6101	N	
WPT0071720	[redacted]		[redacted]	TAU	GROUPAGE	13.6	30	108037A	N	
WPT0071812	[redacted]		[redacted]	TAU	OIL TANKS	13.6	10	109699A	N	
WPT0071827	[redacted]		[redacted]	TAU	PLASTIC CUPS	13.6	12	109698A	N	
WPT0071821	[redacted]		[redacted]	TAU	ROOF TILES	13.6	30	183211	N	must ship ref dmg
WPT0067479	[redacted]		[redacted]	TAU	FOAM	13.6	8	183160	N	must ship ref dmg
WPT0071824	[redacted]		[redacted]	TAU	PLASTIC PIPES	13.6	15	TBA	N	
WPT0071897	[redacted]		[redacted]	TAU	TIMBER	13.6	30	183196	N	
WPT0071849	[redacted]		[redacted]	TAU	PLASTIC	13.6	10	B453563	N	
WPT0071834	[redacted]		[redacted]	TAU	PLASTIC CUPS	13.6	15	TBA	N	
WPT0071920	[redacted]		[redacted]	BOX	Empty	13.6	6	TBA	Y	
WPT0071830	[redacted]		[redacted]	FLT	TIMBER	13.6	30	TBA	N	
WPT0070790	[redacted]		[redacted]	TAU	Empty	13.6	6		Y	
WPT0071803	[redacted]		[redacted]	TAU	roof tiles	13.6	30	16969	N	
WPT0067452	[redacted]		[redacted]	TAU	insulation	13.6	10	16946	N	
WPT0067451	[redacted]		[redacted]	TAU	CEMENT	13.6	30	16974	N	
WPT0069868	[redacted]		[redacted]	TAU	DOORS	13.6	30	16969	N	
WPT0069867	[redacted]		[redacted]	TAU	ROOF TILES	13.6	30	16975	N	
WPT0071836	[redacted]		[redacted]	TAU	PEAT	13.6	30		N	
WPT0071902	[redacted]		[redacted]	TAU	BALCAS	13.6	30	TBA	N	
WPT0071874	[redacted]		[redacted]	TAU	WASTE PLASTIC	13.6	30		N	
WPT0067460	[redacted]		[redacted]	TAU	timber	13.6	30	TBA	N	
WPT0069885	[redacted]		[redacted]	TAU	foam	13.6	10		N	
WPT0069883	[redacted]		[redacted]	TAU	INSULATION	13.6	10		N	
WPT0071835	[redacted]		[redacted]	TPR	PEAT	10.0	30	85753	N	
	[redacted]									

WPT0071854	[redacted]		[redacted]	TPR	scrap	10.0	30	85755	N	
WPT0071851	[redacted]		[redacted]	TPR	SCRAP	13.6	30	85833	N	
WPT0071921	[redacted]		[redacted]	TPR	PEAT	10.0	30	TBA	N	
WPT0071823	[redacted]		[redacted]	TAU	PEAT	10.0	30	TBA	N	
WPT0071852	[redacted]		[redacted]	TPR	PEAT	10.0	30	85752	N	
WPT0071871	[redacted]		[redacted]	TPR	SCRAP STEEL	10.0	30	85759	N	
WPT0069905	[redacted]		[redacted]	TPR	SCRAP	10.0	30	85757	N	
WPT0069908	[redacted]		[redacted]	TAU	PEAT	13.6	30	55305	N	
WPT0069916	[redacted]		[redacted]	TAU	EmptyPALLETS	13.6	18	1007652	N	

Drivers Summary

Booking No.	Registration	Customer	Haulier	Driver Surname	Driver Firstname	DOB
WPT0071856	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
WPT0067498	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Annex 17

Comparison of approved lightships
for mv *Moondance* and mv *Riverdance*

DET NORSKE VERITAS

DET NORSKE VERITAS AS
Division Technology and Products
Hydrodynamics, Materials & Structures
Veritasveien 1
N-1322 Høvik
Norway
Tel: +47 67 57 99 00
Fax: +47 67 57 99 11
http://www.dnv.com
Org. No: NO 945 748 931 MVA

RECEIVED -5 JUN 2000

OFFICE COPY
-5 JUN 2000
752

Det Norske Veritas
621 India Buildings, Water Street
lverpool L2 0QN
UNITED KINGDOM

Att: [redacted]

Your ref.:	Our ref.:	Date:
LVP/OM/lc	DTP366/PBRE/20796-J-18	1999-04-29

MOONDANCE, Id.No. 20796
Light check report

Reference is made to your letter LVP/OM/lc dated 1999-04-21. Please find enclosed 2 copies of the following drawing:

Drawing No.	Rev.	Title	Code	Status
CL/653/99/D6	A	Lightship check	ITR	Appr.w/comm

Drawing No. CL/653/99/D6/ A, "Lightship check" is approved, with the following comments:

1 The lightweight data are approved as follows:

Lightweight:	2745.3	tonnes
VCG:	8.206	m above baseline*
LCG:	51.09	m fwd of AP

*The VCG is corrected by assuming the weight deviation from sister vessel at the most unfavourable position.

2 The final stability documentation revised in accordance with the above approved lightweight data is to be submitted for approval.

Yours faithfully
for DET NORSKE VERITAS AS

[redacted]

Head of Section
Stability Approval and Tonnage Certification

[redacted]

Enclosure

DET NORSKE VERITAS

RECEIVED
-5 JUN 2000

DET NORSKE VERITAS AS
Division Technology and Products
Hydrodynamics, Materials & Structures
Veritasveien 1
N-1322 Høvik
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Tel: +47 67 57 99 00
Fax: +47 67 57 99 11
http://www.dnv.com
Org. No: NO 945 748 931 MVA

Det Norske Veritas
621 India Buildings, Water Street
Iverpool L2 0QN
UNITED KINGDOM
Att: [redacted]

OFFICE COPY
-5 JUN 2000
TS1

Your ref.:	Our ref.:	Date:
LVP/OM/lc	DTP366/PBRE/20268-J-34	1999-04-29

RIVERDANCE, Id.No. 20268
Light check report

Reference is made to your letter LVP/OM/lc dated 1999-04-21. Please find enclosed 2 copies of the following drawing:

Drawing No.	Rev.	Title	Code	Status
CL/653/99/D5	B	Lightship check	ITR	Appr.w/comm

Drawing No. CL/653/99/D5/ B, "Lightship check" is approved, with the following comments:

3 The lightweight data are approved as follows:

Lightweight:	2822.02	tonnes
VCG:	8.247	m above baseline*
LCG:	48.54	m fwd of AP

*The VCG is corrected by assuming the weight deviation from sister vessel at the most unfavourable position.

4 The final stability documentation revised in accordance with the above approved lightweight data is to be submitted for approval.

Yours faithfully
for DET NORSKE VERITAS AS

Head of Section
Stability Approval and Tonnage Certification

Enclosure

A18(a) **-** Mv *Moondance* - stability check (showing total ballast carried, excluding heeling system 539.30 tonnes approx)

A18(b) **-** Mv *European Mariner* - stability calculation (showing total ballast carried, excluding heeling system 490 tonnes approx)

Annex 18a

MV Moondance

Manual Stability Check 02 April 2008 (Wpt 2 Heys)

Comp't	Weight	VCG	Moment	LCG	Moment	FSM
Mn Dk	730.40	7.70	5624.08	55.50	40537.20	
Top Dk	259.60	14.20	3686.32	48.50	12590.60	
TOTAL	990.00		9310.40		53127.80	0.00
Forepeak	192.80	6.83	1316.82	102.69	19798.63	0.00
No.1	23.00	1.72	39.56	88.85	2043.55	50.00
No.2P		1.09	0.00	63.80	0.00	0.00
No.2S		1.09	0.00	63.80	0.00	0.00
No.3P outer	7.00	1.02	7.14	45.26	316.82	10.00
No.3S outer	7.00	1.03	7.21	45.32	317.24	10.00
No.7 P	0.00	4.98	0.00	17.30	0.00	0.00
No.7 S	61.50	4.98	306.27	17.30	1063.95	0.00
No.8 P	102.80	4.89	502.69	6.30	647.64	0.00
No.8 C		4.16	0.00	7.09	0.00	
No.8 S	95.20	4.89	465.53	6.83	650.22	
No. 9	0.00	5.31	0.00	-4.70	0.00	0.00
No. 11	50.00	4.34	217.00	80.89	4044.50	720.70
No. 12		5.25	0.00	50.36	0.00	0.00
TOTAL	539.30		2862.22		28882.55	790.70
No. 34		5.25	0.00	67.71	0.00	
Port Heel	78.00	3.78	294.84	51.42	4010.76	28.30
Stbd Heel	78.00	3.78	294.84	51.31	4002.18	28.30
Centre Heel	30.00	5.25	157.50	58.20	1746.00	0.00
TOTAL	186.00		747.18		9758.94	56.60
DO 6P	0.00	0.95	0.00	29.96	0.00	0.00
DO 6S	0.00	0.95	0.00	29.96	0.00	0.00
TOTAL	0.00		0.00		0.00	0.00
No.2 HFO	0.00	1.30	0.00	73.65	0.00	0.00
No.3P HFO	39.40	0.84	33.10	48.73	1919.96	39.00
No.3S HFO	39.70	0.84	33.35	48.73	1934.58	39.00
No.31 GasOil	12.60	3.81	48.01	14.95	188.37	8.80
TOTAL	91.70		114.45		4042.91	86.80
No.25 DO Daily	5.10	4.17	21.27	21.17	107.97	0.00
No.18 Daily	14.80	4.00	59.20	21.10	312.28	1.30
No.19 Daily	13.00	4.16	54.08	15.58	202.54	1.30
No.32 Bilge	8.70	3.89	33.84	14.57	126.76	8.30
No.33 Gas Oil	5.80	4.05	23.49	18.31	106.20	2.20
No. 30 Lube	7.70	4.05	31.19	18.31	140.99	2.20
TOTAL	55.10		223.07		996.73	15.30
No5 Lub P	2.90	1.03	2.99	33.35	96.72	1.60
No26 Lub	1.10	4.08	4.49	22.51	24.76	0.10
No27 Lub	0.80	4.17	3.34	21.11	16.89	0.10
TOTAL	4.80		10.81		138.36	1.80
No28 Lub	0.55	4.23	2.33	20.05	11.03	0.1
No29Lub	0.65	4.29	2.79	19.35	12.58	0.1
No 5 Lub S	2.95	1.03	3.04	33.35	98.38	1.6
Misc Water	9.70	4.12	39.96	87	843.90	10
TOTAL	13.85		48.12		965.89	11.80
FW 14 P	40.00	4.13	165.20	41.44	1657.60	0.00
FW 14 S	40.00	3.99	159.60	41.41	1656.40	0.00
Misc Oils	6.70	1.65	11.06	20.80	139.36	4.50
TOTAL	86.70		335.86		3453.36	4.50
STORES	75.00	14.89	1116.75	93.90	7042.50	
CREW	5.00	25.00	125.00	93.90	469.50	
PASS	1.00	25.00	25.00	93.00	93.00	
TOTAL	81.00		1266.75		7605.00	0.00
DEADWEIGHT	2048.45	7.28	14918.85	53.20	108971.54	967.50
LIGHTSHIP	2775.30	8.18	22701.95	47.00	130439.10	
DISP	4823.75	7.80	37620.81	49.63	239410.64	967.50

INSTRUCTIONS

1

Enter weights in shaded area for respective compartments. If your tanks are slack, do not forget to add in your Free surface moments into FSM collums (these FSM moments can be found in the last collum of figures for the tank in question, named M*T) and adjust your tanks VCG for appropiate weight, interpolation required I am afraid.

2

Once these figures have been entered you will have your KG solid, KG Fluid final LCG and your solid and fluid GM figures

3

Enter hydro data at front of stability book with your disp and trim at 0, and obtain mean draft for that disp and your LCF (XCF), LCB (XCBA), KM figures. You will have to interpolate I am afraid !! DO NOT ADJUST FIGURES (LCF,LCB) for LBP AS THIS IS DONE AUTOMATICALLY BY THIS SPREADSHEET

4

Enter these figures on sheet 2 of this programme and your calculated drafts will be worked out. (Do not forget to enter your mean draft at bottom of this collum)

5

Enter your observed drafts and the diffrence will be worked out.

NOTE THIS PROGRAMME WILL ONLY WORK FOR A STERN TRIM

DRAFT FROM DISPLACEMENT

4.86

Difference obs & calc disp

224.66

MEAN DRAFT

5.00

Workings

	Figures from stabilty book	Corrected figures for LBP	Vessels final LCG
LBP	103.40	103.40	Total moments / final disp
LCB	48.78	48.78	
MCTC	115.90	115.90	49.63
LCF	43.27	43.27	
KM	9.72	9.72	

KG Solid = Moments/ Disp	GM Solid = KM - KG Solid	KG Fluid = (Moments + FSM) / Disp
7.80	1.92	8.00

GM Fluid = KM - KG Fluid
1.72

Trim = Disp x (LCB - LCG) / MCTC x 100	-0.35		
CoT Aft = (Dist LCF from AP) / LBP) * CoT	-0.15		
CoT Fwd = CoT - CoT Aft	-0.21		
Draft Fwd = Mean draft -/+ CoT Fwd	5.21		
Draft Aft =	4.85		
Draft as read fwd =	4.90	Diffrence =	0.31
Draft as read aft =	4.90	Diffrence =	-0.05

Notes

47 drop trailers, 3 lorries, 1 car I mobile, allowing +10% on weights

Signed Chief Officer

Annex 18b

EUROPEAN MARINER – STABILITY CALC[illegible] 7 [illegible]TP, No.1 Ballast Tank Full)

Voyage No.	961	From:	LARNE [illegible]	Date:	01 - 04 - 08	Time:	

Tank	Tonnes	VCG	Moment	FSE
FUEL OIL				
DO 18	19	4.00	76	1
DO 25	10	4.17	41.7	1
DO 33	7	4.05	28.4	2
FIXED DO	**36**		**146.1**	**4**
DO 3P	32	0.84	27	38
DO 3S	32	0.84	27	39
DO 19	14	4.16	58	1
DO 31	18	3.81	69	9
DO 32	18	3.89	70	8
IN USE DO	114		251	**95**
BALLAST & FRESH WATER				
NO.1 DB	106	1.71	181.3	
NO.2 DB	135.2	1.09	147.4	
NO.3 DB	154.2	1.03	158.8	
HEELING TANKS	180	3.78	680.4	56.6
FW BALLAST	**575**		**1168**	**57**
AP	94.3	5.31	500.7	
SW BALLAST	**94.3**		**500.7**	
FW PORT	37	4.13	153	26
FW STBD	38	3.99	152	10
FRESH WATER	75		305	**36**

Ballast carried

STABILITY	KG_S		**TRIM:**
	FSE	+ 0.07	**≤ 1.0m by the stern or the head**
	KG_F		
	KM		
	GM		**KG:**
	MAX KG		**KG_F ≤ MAX KG**

STABILITY SUMMARY			
FIXED DO	36	146	4
TOTAL LO	14	40	11
MISC. TANKS	26	69	43
CONSTANT	12	192	
FW BALLAST	575	1168	57
SW BALLAST	94	501	
LIGHT SHIP	2775	22702	
SUB TOTAL	**3532**	**24818**	**115**
IN USE DO	114	251	95
FRESH WATER	75	305	36
SUB TOTAL	3721	25374	**246**
CARGO			
CALC. △			
OBS. △			
DIFF x AVERAGE VCG			
CORRECTED MOMENT			

CALC > OBS > (2 x TPC) USE OBS △ FOR CALC

OBS > CALC > (2 x TPC) MULTIPLY DIFF BY AVERAGE VCG & ADD TO CALC. MOMENT TO GIVE A CORRECTED MOMENT DIVIDE BY OBS △

CARGO WEIGHTS				
	UNITS	WT.		MOMENT
UVD			14.8	
MVD			8.2	
TOTAL				
AVERAGE VCG = CARGO MOMENTS ÷ CARGO WTS				

DRAUGHTS	PAX	
	HAZ	
	FWD	
	AFT	
	MEAN	

Mv *Riverdance* - heeling pump data

DATEN-KARTE

V 1394.1

Achtung: "Pumpe darf nicht gegen geschlossenen Schieber fördern"

Beim Einbau:

Aggregat nie trocken anlaufen lassen

Vor Einbau den Motor mit Wasser füllen

ca. 15 liter

PLEUGER
UNTERWASSERPUMPEN GMBH
HAMBURG

Unterwasserpumpe

Typ S 284-2+V10 - 60		
Masch.-Nr. 282.663	Baustufe	
Q 600 m^3/h	H 10 m	
Stufenzahl 2	P 33 kW	
U 440 V	I 65 A	f 60 Hz
n 1750 1/min	Schaltung Y	

Beim Wiederausbau:

Vor dem Einlagern entleeren und säubern

Nicht liegend nur stehend aufbewahren

Betriebsanleitung mit Auffüllvorschrift beachten!

Motorschutzschalter-Einstellung für Betriebspunkt	:	55	A
Motorschutzschalter-Einstellung höchstens	:	65	A
Zweckmäßig träge Grobsicherung	:	100	A
Notfalls flinke Grobsicherung	:	125	A

s.u.

☐ LKW	☐ Bahn	☐ See	☐ Luft	☐ Abh
☐ frei	☒ unfrei	☒ verp.	☐ unverpackt	
☒ Frachtgut		☐ Expreß	☐ Post	

[redacted]

Preis: unverp. ab Werk

Lieferung:

PLEUGER UNTERWASSERPUMPEN GMBH
Friedrich-Ebert-Damm 105 D 2000 Hamburg 70
Fernsprecher 040/6 94 81 · Fernschreiber 02 13 275

Lieferschein

Bahnhof/Hafen

Pleuger Unterwasserpumpen GmbH · Postfach 70 13 20 D-2000 Hamburg 70

Rickmers Rhederei GmbH
Rickmers Werft
Postfach 20 66

2850 Bremerhaven 12

Auftrags-Nr	519 789
Kunden-Nr	7251
Vertreter / Länder-Kennz	962
Sachbearbeiter	[redacted]
Ausstellungsdatum	22.7.81

Packer

Kiste Nr.					
Kisten-Innenmaß					
L					
B					
H					
Kisten-Außenmaß					
L					
B					
H					

Zahlung: Sofort nach Rechnungsdatum, netto

Komm. 6321 Auft. 1 12294 TLB

Pos.	Menge	Bestellung: 6299 M/V Mahala Nr. 260
1)	1	PLEUGER-Pumpe S 284 - 2 + V 10 - 60 -4
		B/C für horizontalen Einbau reservierbar
		2-stufig für Drehstrom 440 V 60 HZ
		Maschinen Nr. ~~284-872~~ 202663
		Förderstrom 600 m3/h
		Förderhöhe 10 m
		Motorleistung 33 KW
		Nennstrom 65 A
		Nenn-Drehzahl ~~3450~~ 1750 1/min
2)	4	m Kabel 4x10 mm2 Cu
		Durchzusehen und aufzuarbeiten, Kostenvoranschlag folgt.
		Zzgl.verausl.Eingangs-Rollgeld

Betr. Tafel in	Leistungsschild in	Prüfprot.

Netto kg						
Verp.						
Brutto kg						

Annex 20

Extract from Seatruck's SMS -
passage planning

Passage Planning

Scope

This procedure defines the requirements for passage planning.

Responsibilities

The Master is responsible for ensuring that a plan is prepared and for checking and approving the plan.

References

Bridge Procedures Guide (ICS)
Bridge Team Management
Mariners Handbook
MCA Notices

Procedures

Each passage plan is to be carefully prepared and planned to ensure:

- It is safe (e.g. sufficient safety margins)
- It complies with legislation (e.g. ships routeing)
- It is laid off on the largest scale charts available
- All relevant publications and navigation warnings are consulted

It is recognised that different ships have different requirements, in this respect ships on regular runs may use ship specific planning forms. The Ship Manager must approve these. If no other approved system is in use, passage plans are to be recorded on the standard Company form.

In any event the passage plan is to be from berth to berth and the Master, in his absence from the bridge, is to provide the OOW clear instructions on its execution.

Passage plans are to be prepared whether or not a pilot is carried.

Under Keel Clearance, when on passage

Where the coast shelves and offshore soundings increase gradually the intended track should ensure that adequate under keel clearances are maintained.

As a guide:

- when the vessel's draught is 3 - 6 metres pass outside the 10m contour
- when the vessel's draught is 6 - 10 metres pass outside the 20m contour
- when the vessel's draught is in excess of 10 metres, then the master must ensure that there is sufficient UKC and due caution should be exercised

Where the coast is steep to and offshore soundings increase quickly, the minimum passing distance should be 1½ to 2 miles

Under Keel clearance, at all other times

The Master should consider that 0.50 metres or 10% of the vessel's draught, whichever is the greater, should be an acceptable under keel clearance. If a calculated clearance is less than this then permission to proceed should be obtained from the Ship Manager or their accredited deputy at the passage planning stage.

In all cases the Master should be aware of the effects of:

- squat (including the effect of the channel width in such cases as the channel width is less than the width of influence of the vessel)
- sea conditions (including swells),

either of which may have adverse effects on the handling characteristics of the vessel.

The Master is to be aware of the consequent need to reduce speed in order to mitigate these effects.

Progress along the planned route is to be regularly monitored. Parallel indexing techniques must be used. All significant events, including alterations of course, are to be recorded in the Deck logbook.

In open waters the frequency of position fixing is such that the vessel will not stand into danger in between the period selected for fixing the vessel. In any event the vessel's position is to be fixed at intervals not exceeding one hour.

In confined waters the frequency of position fixing is to be increased.

In pilotage waters the vessels position is to be fixed at intervals not exceeding six minutes

All passage plans are to be signed by the Master prior to the commencement of the voyage.

Frequency of position fixing should be specified in the passage plan for all stages of the intended passage.

Position fixing should be effected by as many means as possible and whenever available, concurrent multi-position fixing must be employed, i.e. the simultaneous use of more than one method of fixing is to be used in order to verify the accuracy of the methods utilised. Sole reliance on GPS should not be made and corrections must be applied to any satellite-derived positions which are not calculated on a similar datum to the chart in use.

Annex 21

Merchant Shipping Notice No. M.1393

DEPARTMENT OF TRANSPORT

MERCHANT SHIPPING NOTICE No. M.1393

Weighing of Goods Vehicles and Other Cargo for Class II and Class II(A) Ro/Ro Passenger Ship Operations

Notices to Owners, Masters and Officers of United Kingdom Class II and II(A) Passenger Ro/Ro Ships and other Class II and II(A) Passenger Ro/Ro Ships serving UK Ports; and to Operators of Ports and Berths served by such ships.

1. The Merchant Shipping (Weighing of Goods Vehicles and Other Cargo) Regulations 1988 (SI 1988/No. 1275) ("the principal Regulations") came into force on 1 February 1989. The Merchant Shipping (Weighing of Goods Vehicles and Other Cargo) (Application to Non-United Kingdom Ships) Regulations 1989 (SI 1989/No. 568) came into force on 31 March 1989. The Merchant Shipping (Weighing of Goods Vehicles and Other Cargo) (Amendment) Regulations 1989 ("the Amendment Regulations") (SI 1989/No. 270) also came into force on 31 March 1989, amending both the principal Regulations and the non-UK Regulations. The primary purpose of this Merchant Shipping Notice is to amplify the amended Regulations. This M Notice supersedes M Notice No. 1337.

2. The purpose of the principal Regulations is to require owners of UK ro/ro passenger ships operating on Class II and II(A) certificates to ensure that all goods vehicles (ie lorries, trailers, semi-trailers and combinations) whose actual or maximum gross weight exceeds 7.5 tonnes, and all other individual (vehicular or non-vehicular) cargo items exceeding 7.5 tonnes except buses, are individually weighed before loading. The Regulations follow a recommendation in the Report of the Court of Formal Investigation into the loss of the Herald of Free Enterprise (Report of Court No. 8074). That Report pointed out that, whilst overloading can be prevented by careful reading of draughts, accurate control over the calculation of the stability of a ship (ie its centre of gravity in relation to its transverse metacentre) before sailing can only be achieved from a detailed knowledge of the weight and disposition of the cargo.

Application and Interpretation

(Regulation 1)

3. Regulation 1(2) of the principal Regulations makes clear that they apply only to ships operating on Class II and II(A) Certificates. The Department recommends, however, that vehicles and other cargo be weighed for all the services that are basically Class II(A) services even on occasions when, due to the time of day and weather conditions, a ship is operating on another Certificate (Class III or Class IV).

4. Whilst the Regulations set no requirements for ships that are not Class II or II(A) ships there is nothing in the Regulations to prevent a port operator from requiring the weighing of "qualifying cargo items" for all services from its port, or a ferry operator from requiring all qualifying cargo items to be weighed on all his services. Equally, port and ferry operators will be free to require the weighing of goods and other vehicles of less than 7.5 tonnes, should they wish to do so.

5. The full definition of "bus", "motor vehicle", "trailer" etc are given in the Road Traffic Act 1988 and the Road Vehicles (Construction and Use) Regulations 1986 (SI 1986/No. 1078). A lorry or a trailer (or semi-trailer) is a "vehicle", and the term "motor vehicle" does not include a trailer (or semi-trailer) that a lorry may be drawing. A "bus" is a motor vehicle which is constructed or adapted to carry more than eight seated passengers in addition to the driver.

Requirement for weighing of cargo items, and the use of weights for stability calculations

(Regulation 2)

6. Regulation 2(1) of the principal Regulations indicates the routes and ports that are covered. The Regulations only cover sailings *from* United Kingdom ports. They cover all international services, services to and from Northern Ireland, services to the Isle of Man and Channel Islands (which are Crown Dependencies and "outside the United Kingdom"). The ports and routes in Schedule 1 are the main ports and routes serving the

Scottish Islands at the present time; the Amendment Regulations (regulation 2(j)) add the ports of Burwick and Gills Bay to the Schedule. If other new services are established, the Department would consider extending the Schedule, taking into account the new traffic flows, and competitive and other factors.

7. Regulation 2(1) places the primary duty of ensuring vehicles (and other cargo) are weighed before loading upon a shipowner (or, under regulation 1(5), the ship's manager) and master. There is no specific legal duty upon the harbour authority (or any other person) to provide a weighbridge, but in practice it will not be possible for the port to be used by ro/ro passenger ferries carrying cargo unless such a weighbridge is installed. It will normally be for the harbour authority, any berth operators and the shipowners using the port to agree which of them is to install the weighbridge, and how the cost of its installation and operation is to be recouped. Whichever party assumes responsibility for managing the weighbridge becomes the "weighing manager" and assumes certain duties in relation to its accuracy in operation under regulation 3. The Department of Transport and the local Trading Standards Department should be formally advised of which person or body has taken on the role of weighing manager.

8. Regulation 2(1)(iv) requires there to be reliable arrangements for the retention of evidence of weighing, etc for enforcement purposes under these Regulations, made under the auspices of the Merchant Shipping Acts—see paragraph 39 below.

9. The calculations of stability referred to in regulation 2(2) are required by the Merchant Shipping (Loading and Stability Assessment of Ro/Ro Passenger Ships) Regulations 1989 (SI 1989/No. 100) and the Merchant Shipping (Loading and Stability Assessment of Ro/Ro Passenger Ships) (Non-United Kingdom Ships) Regulations 1989 (SI 1989/No. 567). Guidance on those Regulations is given in Merchant Shipping Notice No. 1366.

10. The Amendment Regulations (regulation 2(a)) define what a weighbridge certificate is, and who should issue it in the case of manned weighbridges (self operated weighbridges are dealt with under paragraphs 16–17 below). The person issuing the certificate must have a certificate of competence from an inspector of weights and measures. It must either be a certificate showing that "he has sufficient knowledge for the proper performance of his duties" (section 18(1) of the Weights and Measures Act 1985) or a certificate of competency issued by an inspector by virtue of regulation 3(3) of the principal Regulations.

Accuracy of weighing machines and persons qualified to use them
(Regulation 3)

11. Weighbridges within ports, if they are available solely to weigh goods to be loaded onto ferries for the purpose of satisfying the principal Regulations, are not "available for use by the public" and are therefore not in "use for trade" under section 7 of the Weights and Measures Act 1985. Accordingly, such machines will not fall within the scope of the Weighing Equipment (Non-Automatic Weighing Machines) Regulations 1988 (SI 1988/No. 876).

12. Regulation 3(1) of the principal Regulations sets out a choice of three standards of accuracy for a weigh bridge used within the port premises, for the purposes of these Regulations, to meet. A machine which is already in use for trade will already have been required to meet the requirements of regulation 3(1)(a) or its EEC alternative—regulation 3(1)(b) (unless it is of low—Class IV—accuracy and for restricted use such as for the weighing of ballast). This standard is also acceptable for weighbridges newly installed, purely for the purposes of these Regulations. However, such machines may alternatively satisfy regulation 3(1)(c) which requires such a weighbridge to be accurate to plus or minus 2 per cent. This level of accuracy is determined as being sufficient to allow satisfactory calculation of ship stability and also has the effect of permitting the use of dynamic axle weighers conforming to the Department of Transport's Code of Practice on such weighers.

13. There is no requirement for individual axle weights to be recorded, or to be measured to any degree of accuracy other than that needed to achieve the required accuracy in the overall weight, by such a machine. The accuracy of such a machine must be certified by an inspector of weights and measures. Under section 74(4) of the Weights and Measures Act 1985, inspectors are empowered to report on request upon the accuracy of any weighing equipment, and are entitled to charge for this service.

14. Attention is drawn to the fact that, under the Weights and Measures Act 1985, cargo weights obtained by machines tested under regulation 3(1)(c) are not passed for use for trade and cannot be used for the purposes of a tariff based upon weight.

15. The inspector is empowered, under regulation 3(2), to lay down conditions of use for ensuring that the required accuracy is met. Those conditions could include general conditions (for example, to ensure that the maximum speed for a lorry to pass over an axle weigher is not exceeded), or more specific (eg to permit draw bar trailer combinations to be "double weighed"

if they were too long to be accommodated on a particular static weighbridge installation). In the case of a machine which is also in use for trade (and of at least Class III accuracy) it can generally be assumed that use in compliance with the requirements for such use would also be approved as satisfactory for the purposes of these Regulations. Under regulation 3(3) weighbridge operators must be certified as competent, and there is a power (implied by the words “or on his authority”) for a chief inspector to delegate such certification to suitably qualified trading standards officers.

16. Regulation 3(4) makes provisions for self-operated weighing machines, operated (for example) by the drivers of vehicles. It is the duty of the weighing manager to ensure that instructions are displayed, and the duty of the user to comply with those instructions. Just as for non-self-operated machines it will be for the inspector to lay down requirements to ensure that weighing is accurate.

17. This regulation makes specific provisions that there must be arrangements to ensure that the vehicle weighed is that which purports to have been weighed. These arrangements can fall into two categories; if the vehicle is to be photographed at the point of weighing, the photographs should include frames of the registration plate, to be checked against the vehicle by the operative processing the weight data. When a vehicle is not photographed, a strict traffic management regime should be utilised to ensure, for instance, that the vehicle cannot leave the port premises without the weighing manager’s authority once it has been weighed. All such arrangements (photographic or non-photographic), since they are not concerned with the accuracy of the weighing, are subject to approval by the Department of Transport (regulation 3(4)(c)).

18. Weighing machines used for the purposes of these Regulations outside the port premises (to obtain possibly a mean operating weight, or a weigh bridge ticket in connection with regulation 5) are required to conform to the requirements of weighing machines used for trade - in other words, the option of regulation 3(1)(c) is not, in general, available for such machines.

19. Regulation 7, paragraphs (3), (4) and (5), lays down the offences committed if there is a breach of regulation 3: except when the equipment is outside the port premises, or improper usage of self-operated equipment is involved, breaches of regulation 3 are offences by the weighing manager.

Manner of weighing

(Regulation 4)

20. Regulation 4(1) of the principal Regulations states that the normal procedure will be for cargo items to be weighed alone. Regulation 4(2) allows motor vehicles or combinations to be weighed with or without the driver, but requires that weighing to be recorded whether the driver is included or not so that this can be taken into account when a ship's stability calculation is made. (Although the weight of a driver is considerably less than the permitted tolerance in weighing, systematic neglect or double counting of the driver’s weight will generate inaccurate weights which would feed through to the stability assessment.) There is no requirement for the presence of other passengers to be recorded.

21. Regulation 4, paragraphs (3) and (4), deals with the weighing of unaccompanied trailers (including semi-trailers) and non-wheeled cargo items. The trailer may be weighed with the tractor and the weight of the tractor subtracted. The weight to be subtracted may be obtained by weighing the tractor in the port after the trailer has been detached; or it may be a weight obtained in a similar manner at the same port on a previous occasion; or a “mean operating weight” as defined in regulation 2(b)(7) of the Amendment Regulations. The mean operating weight must be obtained from a weigh bridge conforming to regulation 3(1) or (5) as appropriate.

22. The tractor could either be the haulier’s tractor delivering the trailer to the port, or a tractor belonging to the operator’s fleet. This is intended to permit ports to develop databases of tractor weights, including those of hauliers regularly using ports. The attention of Trading Standards Departments is drawn to the possibility that there may be occasions when hauliers request mean operating weight certificates at inland weighbridges.

23. Non-wheeled qualifying cargo items delivered on lorries, trailers or combinations may be weighed on those lorries, trailers or combinations, with similar adjustments being made, except when in the case of a trailer, the normal certificated tare weight may be used. Regulation 4(5) provides similar flexibility for determining the weights of empty lorries and trailers when they are to be loaded as cargo.

24. The Amendment Regulations define how a mean operating weight is to be determined—see regulation 2(b)(7)(i)–(ii). The person presenting the vehicle or combination must endorse the weighbridge certificate to the effect that the vehicle or combination has been presented for weighing in accordance with the definition of a mean operating weight. Because most ports have begun to establish databases this endorsement requirement need not be complied with until 1 April 1990, enabling operators to replace, over a period of time, files and databases of unendorsed mean operating weights. The mean operating weight can be

obtained from self-operating weighbridges or a weighbridge manned by an operator certificated by an inspector of weights and measures.

25. The Amendment Regulations (regulation 2(b)(6)- enable a weighing manager to exchange one tractor unit (which has pulled a trailer and load to the port and over the weighbridge) for another (which will pull the trailer and load onto the vessel and remain with it on the voyage) where mean operating weights of both tractor units involved are known to the weighing manager.

Place of weighing

(Regulation 5)

26. Regulation 5 of the principal Regulations makes provision for custom-sealed loads and oversized vehicles to be weighed outside the port. In the case of excess weights, which cannot be tolerated on port weighbridges, and which are not prohibited by the Road Traffic Act 1988, if a weight certificate is not available from a weighbridge (approved by Trading Standards Departments) outside a port premises, then the weight can be calculated by the sum of the gross weight of goods shown on the consignment note; plus the mean operating weight of the trailer; plus the mean operating weight of the prime mover.

27. In the case of self-propelled vehicles—such as large agricultural machinery—which could not be tolerated for weight or size reasons on weighbridges, operators should use a mean operating weight obtained from a weighbridge outside a port, or if this is not practicable, the weight shown on the manufacturer's or exporter’s consignment note.

28. Regulation 5(4)(b) enables alternative arrangements to be approved in advance when a qualifying cargo item is too heavy, etc for the port weighbridge.

29. The Department has granted separate exemptions and approvals in relation to Ministry of Defence vehicles.

30. Regulation 5(4)(a) provides for prior authorisation of arrangements to apply when a weighbridge breaks down. In general, the Department would much prefer if alternative weighbridges were utilised, but if this is operationally impracticable a declared weight, as set out in Merchant Shipping Notice No. 1366 (Appendix 3, paragraph 1.4) can be utilised ie the declared weight of qualifying cargo items should be uplifted by 7 per cent. A 7 per cent uplift need not be utilised in the case of unaccompanied *empty* trailers and semi-trailers, though a 7 per cent uplift must be applied to unaccompanied *loaded* trailers and semi-trailers when a weighbridge has broken down. Weighing managers are advised that an approval is required from the Secretary of State for Transport to utilise any proposed alternative method of calculating weights in the event of weighbridge breakdowns.

Prevention of fraud

(Regulation 6)

31. Regulation 6 of the principal Regulations requires the person who has submitted arrangements to prevent fraud, for the Department's approval under regulation 2(1)(ii), to comply with those arrangements when approved. The kind of measures an authority, an operator or shipowner might adopt to discourage alterations of loads after weighing could include traffic handling arrangements; CCTV; secure fencing: 24-hour patrols; and possibly the use of time limits between weighing and loading. Submissions to the Department have revealed that, in general, current security arrangements—to prevent pilfering for example—need very little alteration in order to satisfy prevention of fraud arrangements. Traffic handling arrangements should include a system whereby a lorry cannot leave port premises unchallenged once it has been weighed; and weighing managers may want to consider a system whereby registration numbers and weights are checked off against the manifest list just prior to boarding.

32. Under regulation 2(1)(ii) of the principal Regulations it will be an offence by the shipowner to load cargo without arrangements to prevent fraud having been approved at that port and under regulation 7(3)(e) it would also be an offence by the weighing manager to carry out weighing. Once those arrangements are approved (and so long as that approval remains in force) the shipowner’s and weighing manager’s responsibilities in this respect cease, and the body that has submitted arrangements is required to comply with the arrangements that have been approved. Any person changing the composition of a load after weighing without first making arrangements for reweighing commits an offence under regulation 7(7)(c).

Offences and Defence

(Regulations 7–9)

33. Apart from the offences already referred to, it is an offence under regulation 7(7)(a) and (b) of the principal Regulations for any person to supply information knowing it to be false, etc. This offence relates, *inter alia*, to false declarations on weighbridge tickets—see paragraph 24 above. Regulation 7(8) makes it clear that offences concerned with the use of unsuitable weighing machines, or failure to comply with conditions imposed for the purpose of ensuring their accuracy are for Trading Standards Officers to enforce (as they have the expertise). The Amendment Regulations include offences (regulation 2(e)) for contravention of matters relating to those Officers’ powers (see paragraph 38 below).

34. There is a general defence in regulation 9 which is intended to limit, *inter alia*, the liability of shipowners

and masters under regulation 2(1) in so far that fulfilment of that regulation requires regulations 3, 4 and 5 to have been satisfied. Provided a shipowner has taken reasonable precautions to ensure that those regulations have been complied with, he can use this defence; but under regulation 8, and so far as the default of some other person has brought about a situation with requires the shipowner to use that defence, that other person is himself liable for the offence (see also paragraph 37).

Penalties

(Regulation 10)

35. The maximum penalties in regulation 10 of the principal Regulations are those permitted under the enabling legislation, section 21 of the Merchant Shipping Act 1979 as amended. Attention is drawn to section 46(1) of the Act, as amended by Schedule 5 of the Merchant Shipping Act 1988, which makes officers of bodies corporate personally guilty if they have consented to, or connived at, an offence.

Exemptions

(Regulation 11)

36. Regulation 11 of the principal Regulations is a general. power of exemption. It could be used, for example, to exempt occasional sailings from ports without weighbridges, particular types of vehicles or in particular circumstances not foreseen in the Regulations; and it has been utilised over a short period of time to enable weighing managers to complete weighbridge installation after the operative dates of particular sets of Regulations.

Approvals and Enforcement

37. The Amendments Regulations (regulation 2(a)) define what a weighbridge certificate is, and who should issue it in the case of a manned weighbridge—self operated weigh bridges are dealt with at paragraphs 16–17 above. The person issuing the certificate must have a certificate of competence from an inspector of weights and measures. Under regulations 2(1) and 7(1) it is an offence by the shipowner if cargo is loaded without having been weighed in accordance with the Regulations. However, the effect of regulations 8 and 9 is that if the shipowner takes all reasonable precautions to ensure that an effective system is set up within the port and is operating effectively, he will have a defence if there is a lapse that is not his fault—though the person (or body) responsible for the lapse will generally be liable.

38. The Amendment Regulations (regulation 2(d)) outline the powers which Trading Standards Officials possess in connection with the weighing Regulations: they are, substantially, powers granted to Trading Standards Officers by virtue of the Weights and Measures Act 1985.

39. Regulation 2(1)(iv) of the principal Regulations requires there to be reliable arrangements in place for the retention, within the port premises or on board the ship, of records or documents demonstrating that weighing has taken place in accordance with the Regulations. (Again, the duty to ensure that this requirement is complied with falls on the shipowner in the first instance). Such records (which could be electronic) or documents should include the identity of the cargo item, the weight, the date and time of weighing and the details of any subtraction of tractor weight, trailer weight etc. For cargo covered by regulations 4(4) and (5), and 5(3) and (4) that has not been weighed it will include documentation relevant to the determination of that weight—in other words the endorsed weighbridge ticket of a mean operating weight. Records and documents should be retained for a minimum of two weeks to permit checking and enforcement by the Department's surveyors and the local Trading Standards Department.

Department of Transport
Marine Directorate
London WC1V 6LP
November 1989

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Extract from Department for Transport Code of Practice “Safety of Loads on Vehicles” and IMO Resolution A.533 “Safe Stowage and Securing of Cargo Units and Vehicles in Ships”

Department for Transport

CODE OF PRACTICE

Safety of Loads on Vehicles

Third edition

TSO: London

Following the reorganisation of the government in May 2002, the responsibilities of the former Department for Transport, Local Government and the Regions (DTLR) in this area were transferred to the Department for Transport.

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SECTION 1
Introduction

1.1 The Road Traffic Act 1991 Introduced provisions into the Road Traffic Act 1988 making new offences, applicable to the state of loads on vehicles. These provisions reflect the seriousness with which the safety of loads on vehicles is now viewed.

1.2 Legal requirements and common sense require that all loads carried on vehicles are secured, whatever the journey. This is to protect the people involved in loading, unloading and driving the vehicle, together with other road users and pedestrians.

1.3 Both loading and unloading should be subject to a risk assessment, as required by the Management of Health and Safety at Work Regulations 1999. A basic checklist for risk assessment is given in Appendix D. Comprehensive advice on how to carry out risk assessments can be obtained from the HSE.

1.4 Loading and unloading should be carried out by trained staff who are aware of the risks involved. Drivers should also be aware of the additional risk of the load, or part of the load, moving when the vehicle is being driven. This applies to all vehicles and to all types of load. The driver is ultimately responsible for the load carried on their vehicle, whether or not they were involved in the securing of the load.

1.5 This Code of Practice is not restricted only to the load being carried by the vehicle; it also covers any equipment on the vehicle such as loader cranes, landing legs, tailgates etc. All of these must be stowed and secured to manufacturer instructions so not to be a danger to other road users and pedestrians.

1.15 All vehicles with an overall travelling height above 3 metres must have the maximum height of the vehicle in feet and inches displayed inside the cab so that it is clearly visible to the driver. (Regulation 10 of The Road Vehicles (Construction and Use) Regulations 1986 as amended by S.I. 1997 No 530)

1.16 Any vehicle fitted with high level equipment that is capable of exceeding a height of 3 metres must be fitted with a visual warning device. This device must tell the driver if the equipment has been left in the extended position. (Regulation 10A of The Road Vehicles (Construction and Use) Regulations 1986 as amended by S.I. 1997 No 530)

Ferry Operations

1.17 When a vehicle is carried on a ship, as in roll-on, roll-off ferry operations, the vehicle and its load will be subject to forces due to the rolling and pitching motions of the vessel. A restraint system that is suitable for road use will not necessarily be adequate at sea.

1.18 The Department for Transport Marine Directorate's Roll-on/Roll-off ships – Stowage and Securing of Vehicles – Code of Practice, and the Department of Trade Merchant Shipping Notice M849 or BS EN29367 gives some guidance on the securing of vehicles on ships and an indication of the forces likely to be encountered at sea. Vehicle operators intending to use ferries should ensure that their load restraint systems are capable of withstanding such forces.

1.19 The securing of the vehicle to the ship is also important and the vehicles should therefore be fitted with lashing points that are of adequate strength to withstand the forces likely to be encountered at sea. The lashing points should be easily accessible to deck crews and not obstructed by fuel tanks, batteries etc. If necessary, advice on this latter point should be sought from the ferry operators.

1.20 The maritime rules also apply to domestic open water crossings such as the UK mainland to the various islands around it.

Suggestions for Improvement

1.21 Inevitably, as a result of further experience and a continual development of load securing systems, this Code of Practice will need to be periodically reviewed and amended. Suggestions for improving or adding to is content are welcomed and should be sent to:

The Department for Transport
Vehicle Standards and Engineering Division
Zone 2/01, Great Minster House,
76 Marsham Street
LONDON SW1P 4DR

or

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BS 6451
Specification for Netting and Fibre Rope load restraints for surface transport (Sections 5.6)

BS 6210
Code of Practice for wire rope slings. (Section 5.3)

BS EN 29367
Gives some guidance on the securing of vehicles on ships. (Section 1.18)

BS EN 12640:2001
Minimum requirements and testing for lashing points on commercial vehicles. (Section 4.1)

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RESOLUTION A.533(13)

Adopted on 17 November 1983
Agenda item 10(b)

ELEMENTS TO BE TAKEN INTO ACCOUNT WHEN CONSIDERING THE SAFE STOWAGE AND SECURING OF CARGO UNITS AND VEHICLES IN SHIPS

(SOLAS Ch VI)

THE ASSEMBLY,

RECALLING Article 16(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations concerning maritime safety,

RECALLING FURTHER that at its twelfth session it adopted resolution A.489(XII) regarding strafe stowage and securing of cargo units and other entities in ships other than cellular container ships,

TAKING ACCOUNT of the IM0/ILO guidelines for training in the packing of cargo in freight containers,

RECOGNIZING that cargo units and vehicles are transported in increasing numbers on seagoing ships,

RECOGNIZING FURTHER that the cargo is stowed on and secured to cargo units and vehicles in most cases at the shipper's premises or at inland terminals and transported by road or rail to ports prior to the seagoing voyage and that the cargo on cargo units and vehicles may not always be adequately stowed or secured for safe sea transport,

REALIZING that adequately stowed and secured cargoes on cargo units and vehicles for road and rail transport in most cases would also be capable of withstanding the forces imposed on them during the sea leg of the transport,

ACKNOWLEDGING that there is a need for cargo units and vehicles presented for transport by sea to be fitted with satisfactory securing arrangements for securing them to the ship, arrangements for the securing of the cargo with in the cargo unit or vehicle to facilitate its safe stowage and securing therein and for ships to be fitted with adequate securing points,

BELIEVING that the universal application of improved standards and securing arrangements is best facilitated if the elements to be taken into account when considering such matters are known to, and considered by, all links in the transport chain,

BELIEVING FURTHER that this can best be achieved on an international basis,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its forty-eighth session,

1. INVITES Governments to issue recommendations to the different links in the transport chain in their countries, responsible for the transport of cargo units and vehicles intended for, and including, sea transport, taking into account the elements set out in the Annex to this resolution;

2. REQUESTS the Secretary-General to bring these elements to the attention of Member Governments and international organizations responsible for the safety of road, rail and sea transport in order that they can be taken into account in the design and construction of cargo units and vehicles and the design and construction of the ships in which they are carried.

ANNEX

ELEMENTS TO BE TAKEN INTO ACCOUNT WHEN CONSIDERING THE SAFE STOWAGE AND SECURING OF CARGO UNITS* AND VEHICLES IN SHIPS

* Cargo units in this context means wheeled or tracked cargo, containers, flats, portable tanks, vehicles and the ship's mobile cargo handling equipment not fixed to the ship.

The elements which should be taken into account relate specifically to the safe shipment of cargo units, including vehicles. The aim is to indicate to the various parties involved the principal factors and features which need to be considered when designing and operating the ship or presenting the cargo unit, or vehicle, for such shipment. In addition, it is hoped that the elements will facilitate and promote better understanding of the problems and the needs of the masters of ships so engaged.

1 THE PARTIES INVOLVED.

1.1 The elements are intended primarily for the information and guidance of the following parties which, it is considered, are in some way associated with either the design or the operation of the ship or, alternatively, with the design, presentation or loading of cargo units including vehicles. They are:

- .1 shipbuilders;
- .2 shipowners;
- .3 shipmasters;
- .4 port authorities;
- .5 shippers;
- .6 forwarding agents;
- .7 road hauliers;
- .8 stevedores
- .9 cargo unit and vehicle manufacturers;
- .10 insurers;
- .11 railway operators; and
- .12 packers of containers at inland depots.

2 GENERAL ELEMENTS.

2.1 It is of the utmost importance to ensure that:

- .1 cargo units including vehicles intended for the carriage of cargo in sea transport are in sound structural condition and have an adequate number of securing points of sufficient strength so that they can be satisfactorily secured to the ship. Vehicles should, in addition, be provided with an effective braking system; and
- .2 cargo units and vehicles are provided with an adequate number of securing points to enable the cargo to be adequately secured to the cargo unit or vehicle so as to withstand the forces, in particular the transverse forces, which may arise during the sea transport.

3 ELEMENTS TO BE CONSIDERED BY THE SHIPOWNER AND SHIPBUILDER.

3.1 The ship should be provided with an adequate number of securing points of sufficient strength, a sufficient number of items of cargo securing gear of sufficient strength and a Cargo Securing Manual. In considering the number and strength of the securing points, items of cargo securing gear and the preparation of the Cargo Securing Manual, the following elements should be taken into account:

.1 duration of the voyage;
.2 geographical area of the voyage;
.3 sea conditions which may be expected;
.4 size, design and characteristics of the ship;
.5 dynamic forces under adverse weather conditions;
.6 types of cargo units and vehicles to be carried;
.7 intended stowage pattern of the cargo units and vehicles; and
.8 weight of cargo units and vehicles.

3.2 The Cargo Securing Manual should provide information on the characteristics of cargo securing items and their correct application.

3.3 Ship's mobile cargo handling equipment not fixed to the ship should be provided with adequate securing points.

4 ELEMENTS TO BE CONSIDERED BY THE MASTER.

4.1 When accepting cargo units or vehicles for shipment and having taken into account the elements listed in paragraph 3.1 above, the master should be satisfied that:

.1 all decks intended for the stowage of cargo units including vehicles are in so far as is practicable free from oil and grease;
.2 cargo units including vehicles are in an apparent good order and condition suitable for sea transport particularly with a view to their being secured;
.3 the ship has on board an adequate supply of cargo securing gear which is maintained in sound working condition;
.4 cargo units including vehicles are adequately stowed and secured to the ship; and
.5 where practicable, cargoes are adequately stowed on and secured to the cargo unit or vehicle.

4.2 In addition, cargo spaces should be regularly inspected to ensure that the cargo, cargo units and vehicles remain safely secured throughout the voyage.

5 ELEMENTS TO BE CONSIDERED BY THE SHIPPER, FORWARDING AGENTS, ROAD HAULIERS AND STEVEDORES (AND, WHERE APPROPRIATE, BY THE PORT AUTHORITIES).

5.1 Shippers or any other party involved with presenting cargo units including vehicles for shipment should appreciate that such items can be subjected to forces of great magnitude, particularly in the transverse direction and especially in adverse weather conditions. Consequently, it is of importance that they should be constantly aware of this fact and that they ensure that:

.1 cargo units including vehicles are suitable for the intended sea transport;
.2 cargo units including vehicles are provided with adequate securing points for the

securing of the cargo unit or vehicle to the ship and the cargo to the cargo unit or vehicle;

.3 the cargo in the cargo unit or vehicle is adequately stowed and secured to withstand the forces which may arise during sea transport; and

.4 in general the cargo unit or vehicle is clearly marked and provided with documentation to indicate its gross weight and any precautions which may have to be observed during sea transport.