SJØFARTSDIREKTORATET
Norwegian Maritime Directorate

# REPORT ON SAFETY MEASURES

## FOR ANCHOR HANDLING VESSELS AND MOBILE OFFSHORE UNITS


10 FEBRUARY 2009

REPORT FROM THE NORWEGIAN MARITIME DIRECTORATE

# 1 ABBREVIATIONS

## Abbreviations – regulations and guidelines

| | |
|---|---|
| Activities Regulations, the | Regulations of 3 September 2001 No. 1157 relating to conduct of activities in the petroleum activities |
| Anchoring Regulations, the | Regulations of 4 September 1987 No. 857 concerning anchoring/positioning systems on mobile offshore units |
| Construction Regulations, the | Regulations of 15 September 1992 No. 695 concerning the Construction of Passenger Ships, Cargo Ships and Barges |
| Fire Regulations, the | Regulations of 22 June 1990 No. 536 concerning fire safety measures in ships to which the International Convention for the Safety of Life at Sea (SOLAS-74) applies |
| Framework regulations, the | Regulations of 31 August 2001 No. 1016 relating to health, environment and safety in the petroleum activities |
| Immediate measures | Guidelines published by the Norwegian Maritime Directorate on 16 May 2007, as subsequently amended by RSV (Circular) 04-2008. |
| ISM Regulations, the | Regulation of 14 March 2008 No. 306 concerning a Safety Management System for Norwegian ships and mobile offshore units |
| ISM Code, the | International Safety Management Code |
| ISPS Code, the | International Ship and Port Facility Security Code |
| LSA Code, the | International Life-Saving Appliance Code |
| Manning Regulations, the | Regulations of 17 March 1987 No. 175 concerning the Manning of Norwegian ships |
| Marine Equipment Regulations, the | Regulations of 29 December 1998 No. 1455 concerning marine equipment (the Marine Equipment Regulations) |
| Navigation Regulations, the | Regulation of 15 September 1992 No. 701 concerning Navigational Aids and Arrangements on the Bridge and in the Wheelhouse, and Communication Equipment in the Wheelhouse of Ships |
| Norwegian Maritime Code, the | The Norwegian Maritime Code of 24 June 1994 No. 39 |

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|---|---|
| Notification and reporting Regulation, the | Regulation of 27 June 2008 No. 744 concerning the notification and reporting of casualties and other incidents at sea |
| NWEA guidelines | Guidelines for the safe management of offshore supply and anchor handling operations NWEA (North West European Area) |
| Petroleum legislation, the | Acts relating to petroleum activities and Regulations and guidelines issued pursuant to these |
| Qualification Regulations, the | Regulation of 9 May 2003 No. 687 concerning Qualification requirements and certificate rights for personnel on board Norwegian ships, fishing vessels and mobile offshore units |
| Radio Regulations, the | Regulation of 17 December 2004 No. 1856 concerning radiocommunication for cargo ships |
| Rescue Regulations, the | Regulation of 17 December 2004 No. 1855 concerning life-saving appliances on cargo ships |
| Rescue Regulations, the (passenger ships): | Regulation of 11 October 2004 No. 1341 concerning life-saving appliances on passenger ships |
| Safety Measures Regulations, the | Regulations of 15 June 1987 No. 507 concerning Safety Measures, etc. on Passenger Ships, Cargo Ships and Lighters |
| Seaworthiness Act, the | Act of 9 June 1903 No. 7 relating to Public Control of the Seaworthiness of Ships, etc. |
| Ship Safety and Security Act, the: | Act of 16 February 2007 No. 9 relating to Ship Safety and Security |
| SOLAS | International Convention for the Safety of Life At Sea, 1974 |
| STCW Convention, the | International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 |
| STCW Code, the | Seafarers' Training, Certification and Watchkeeping Code |
| Watchkeeping Regulations, the | Regulations of 27 April 1999 No. 537 concerning watchkeeping on passenger ships and cargo ships |
| Working Environment Regulation, the | Regulation of 1 January 2005 No. 8 concerning the working environment, health and safety of workers on board ship |

# Other abbreviations

| | |
|---|---|
| AHTS: | Anchor Handling, Tug and Supply |
| AHT: | Anchor Handling and Tug |
| BP: | Bollard Pull |
| Commission: | The Commission of Inquiry into the loss of the "Bourbon Dolphin" on 12 April 2007 |
| DNV: | Det Norske Veritas |
| EPIRB: | Emergency Position Indicating Radio Beacon |
| DP: | Dynamic Positioning |
| GM: | The distance from the vessel's centre of gravity to the metacentre |
| GZ curve: | Curve for righting arm as function of heeling moment |
| IACS: | International Association of Classification Societies Ltd. |
| IMO: | International Maritime Organization |
| KG limit curve: | Maximum distance between keel (baseline) and centre of gravity to meet stability requirements for a given draught and trim |
| NMD: | Norwegian Maritime Directorate |
| OLF: | Norwegian Oil Industry Association |
| POB list: | Persons On Board list |
| PSV: | Platform Supply Vessel |
| RMP: | Rig Move Plan |
| S-VDR: | Simplified Voyage Data Recorder |
| VCG: | Vertical Centre of Gravity |

# Contents

# 2 SUMMARY

The proposed safety measures range from planning and training, via new requirements for stability, winches, voyage data recorders (VDRs), stability instruments, liferafts and EPIRBs to safety management actions. For the maritime activity, the measures cover requirements for mobile offshore units and vessels. In order to achieve a holistic approach to safety management, several of the measures should lead to changes in the Norwegian petroleum legislation. All together, the measures are expected to provide improved safety for anchor handling operations and the operation of anchor handling vessels.

The focus on planning from a safety perspective, where risk assessment is central, and demands for closer cooperation between the parties will lead to a better basis for carrying out safe anchor handling operations. Proposals include attention zones and suspension criteria.

A specification of the rules for stability assessments in relation to large external forces as well as a requirement for calculation of additional dynamic forces will provide the company and master with a simpler and improved basis for safe operation. Further, restrictions to loading conditions have been proposed. In line with the Commission, a requirement for a certificate for net bollard pull for anchor handling is proposed. In order to re-establish the safety factor previously provided by towing hooks with emergency release, new requirements for quick release of load/tension have been proposed. Based on the assessments that have been carried out, it is not proposed to introduce emergency exits from the engine-room through the bottom of the ship.

For more accurate assessment and planning, it is proposed to make stability instruments and a separate manual mandatory. The manual shall contain vessel-specific stability information, anchor handling procedure, information about winches and other anchor handling equipment. The procedures should be clearly aimed towards safety management.

Anchor handling can be a demanding operation, and in order to ensure that the proposed measures can be instituted, requirements for additional education and training for the master are proposed in the areas of; stability, assessment of forces and safe management of anchor handling operations. After an evaluation of the manoeuvring and effects from the rudders and propellers, education and training in this area is also proposed. For winch operators, a certificate requirement is proposed.

Amendments have been proposed for liferafts and EPIRBs so that deployment after capsizing is a criterion in addition to deployment after sinking. Today's possibility to move liferafts to the sides achieve the required capacity is proposed removed. There is also a proposal for increasing the

number of float-free EPIRBs from one to two, positioned so that the probability is as high as possible that at least one of these will float up to the surface, also in the event of capsizing. Based on a desire to carry out better assessments of safety measures after accidents, proposals have been made to introduce a requirement for S-VDR for certain types of vessels from 300 to 3,000 gross tonnage.

Changes to survival suits have not been proposed, but it is recommended that the placement of suits is thoroughly considered, keeping in mind that accidents can progress fast. For work on deck, working clothes with buoyant and insulation properties are recommended. The NMD further recommends that a project for the evaluation of the functional requirements for survival suits is initiated, that investigates, among other things, footwear and dressing time.

The areas overlap, familiarisation, identification of the need for qualifications and training are dealt with in the ISM Code. In relation to this, some recommendations have been proposed in addition to the recommendations from the Commission.

Safety-critical operations will be given greater attention in the revision of safety management systems. Closer and more frequent audits of recognized organizations that are delegated authority to perform ISM audits are planned.

A list of the persons on board all participating vessels is already a requirement for the activity on the Norwegian continental shelf. To internationalize this, proposals have been made for the industry to include it in its guidelines (NWEA) so that the subject becomes a regular item on the agenda at start-up meetings.

The recommendations in the report are expected to result in specific proposals for amendments to international and national regulatory systems, and will together with the impact assessments be circulated for consultation.

In parallel with the national consultations, proposals that will affect international regulatory systems will be presented to the relevant fora in the IMO and the EU. At the same time a position must be taken on whether to introduce Norwegian special requirements, pending the international processes.

In conclusion, it should be noted that the immediate measures of May 2007 with supplements are widely supported internationally. Several foreign authorities have expressed interest in the proposals drawn up in this report.

# 3 INTRODUCTION

The Norwegian Maritime Directorate (NMD) was on 10 April 2008 requested by the Ministry of Trade and Industry to follow-up the report and

recommendations from the Commission of Inquiry into the loss of the "Bourbon Dolphin" on 12 April 2007.

The NMD hereby submits its follow-up report to the "Bourbon Dolphin" accident.

The NMD has had comprehensive meetings with the industry and relevant bodies, including winch manufacturers, ship designers, companies, British authorities and the Norwegian Petroleum Safety Authority. For a complete overview of the NMD's meetings with external parties, see Annex 1.

The NMD has in the follow-up work co-operated with Det Norske Veritas (DNV). DNV has worked on an optional class notation for anchor handling vessels. In addition, relevant specialist fora and experts in the Directorate along with ship designers, equipment vendors, companies and the industry have been important contributors in the follow-up process.

The NMD has focused on the items that are dealt with in the Commission's report and which the directorate was assigned by the Ministry of Trade and Industry to follow up. The NMD's report, chapters 4 to 11, follows up the Commission's recommendations. The heading of each chapter refers to the items in the Commission's report. A brief introductory description of the matter to be addressed and the recommendation from the Commission is given. Then the regulatory system both at the time of the accident and at the present time is stated. The status at the time of the accident refers to the regulations that applied at the time of the accident. Whether a regulatory system applies to a given ship at a specific time may, however, be dependent on the ship's construction date (date on which keel was laid), as some amendments only apply to "new ships", or have a phasing-in period. The NMD's evaluation and recommendation is found at the end of each chapter.

In addition to the recommendations from the Commission, proposals for the installation and training in the use of stability instruments are presented in chapter 12.

The NMD's follow-up work has been organized in a working group that has been led by Technical Director Lasse Karlsen (Department of Vessels and Seafarers). The group also consisted of Bodil Pedersen, Mona Kristensen, Ole Morten Fureli (Section of Cargo Vessels), Torgeir Bjørntvedt (Section of Passenger Vessels), Ian C. Burman (Section of Legislation and Contracts), Bjørn Vik Mjeltebakk (Department of Inspection), Per Jostein Breivik, Per Morten Tennøy (Station Ålesund) and Arne Bakkevig (Department of Strategic Safety).

## 3.1 Terms of reference

On 15 December 2007 the Director General of Navigation and Shipping appointed an internal working group in the NMD responsible for following up the matters that were emphasized in the consultations and the follow-up

work after the "Bourbon Dolphin" accident. The working group also had to follow up other relevant matters that may provide lessons learned from the accident.

In the letter of 10 April 2008, the NMD was assigned by the Ministry of Trade to follow-up the report from the Commission of Inquiry into the loss of the "Bourbon Dolphin".

The Director General of Navigation and Shipping extended the existing terms of reference for the working group to the follow-up of the Commission's report and the recommendations that affect the NMD.

## 3.2 More on the measures

The accident has revealed a lack of adherence to:

- Compliance with legislation and guidelines, including preparation of and compliance with plans and procedures
- Specific requirements for anchor handling vessels
- Supervision and revision of safety management

This applies both at operator level, rig and vessel.

As also pointed out by the Commission, it is not a lack of regulations and procedures, but compliance with such that characterize the accident.

This creates challenges for the authorities when it comes to preventing similar accidents from happening in the future and learning from the experiences in order to contribute to the improvement of safety management in general. It is not desirable or appropriate to make the regulations too detailed, as this leads to a strong focus on single provisions in the rules rather than assessing overall safety.

Detailed rules have limitations to allow for any changes in technology or needs as these are evolving continuously. This, combined with an industry where complex solutions are constantly being developed, often makes the industry itself best placed to assess which specific measures that must be implemented to maintain the desired level of safety.

To achieve this, however, the competence that exists in objective-based and function-based regulatory systems, and the industry's own guidelines and procedures, must provide the basis for the industry's daily activities. This applies at all levels, also in the design phase, so that compromises in operational flexibility do not affect safety. The company's responsibility for this is laid down in the Construction Regulations and requirements for safety management.

The NMD primarily regulates vessels and units operating under the Norwegian flag. In the accident in question, two of the anchor handling vessels were Norwegian. However, in order to get a broader picture, the accident is assessed as if it occurred on the Norwegian continental shelf.

There is a generally good appreciation of risk in the industry. Plans and procedures for the rig move in question contained relevant information, but lacked safety assessments for the anchor handling vessels. Also, plans and procedures are not always complied with.

It has been proposed to the NMD to consider requirements for the testing of people who are responsible for demanding assignments, such as mooring operations. Such evaluations are not unusual for certain positions.

To achieve a proactive safety management, consecutive and systematic risk assessments are required to identify the need for improvements. It is therefore unfortunate that the assessments and actions made are largely based on previous problems and accidents, while potential risks are not assessed as thoroughly. This despite significant changes to the design of the vessels, as well as of the extent, forces and natural conditions on the assignments being carried out.

In evaluating the measures and how these should be implemented, the balance between technical criteria, training and requirements for the person in charge of the operation has been emphasized. Safety management requires commitment, time and resources from all involved.

## 3.3 More on the Ship Safety and Security Act

LEGAL FRAMEWOK AT THE TIME OF THE ACCIDENT

The Seaworthiness Act, with supplementary regulations, was the basis for the public control of the shipping in Norway in the last century. Pursuant to this Act, the responsibility for compliance with provisions contained in Norwegian statutes to ensure the seaworthiness of ships and protect the interests of those on board rested with the shipmaster. The responsibility of the owner included the establishment of routines with regard to the safe operation of the ship. Furthermore, the shipowner should not cause or participate in causing an unseaworthy ship to proceed to sea or to be employed contrary to the official permits issued for operation of the ship.

AMENDMENTS TO THE STATUTORY FRAMEWORK – NEW SHIP SAFETY AND SECURITY ACT

The Ship Safety and Security Act, which entered into force on 1 July 2007, has replaced the Seaworthiness Act. The structure of the new Act provides a better overview of the contents of the Act. The main responsibility now rests with the company, and not with the master. This Act also provides the NMD with greater flexibility and more response options during their supervisory work. The requirements given in the Seaworthiness Act are largely continued in the new Act and its appurtenant regulations.

The old Act contained several detailed provisions, while the new Act leaves the details to the regulations that are issued pursuant to the Act. The contents of today's technical regulations have not been amended, seen as in relation to the rules that applied under the Seaworthiness Act. The development of the regulations will take place continuously depending on requirements.

The greatest change in relation to the new Act has been the shift of responsibility from the master to the company, though the master and other persons working on board must participate. This means that it is the responsibility of the company, and partly the master, to ensure that the

regulatory system is complied with. The NMD has a general responsibility for supervising the safety management system and ensuring that other conditions prescribed in the Act are fulfilled.

The Directorate has several tools at its disposal to supervise the ships, including random inspections. This work can also be delegated to others, e.g. classification societies. The Ship Safety and Security Act has also provided the NMD with a new system of sanctions with more sanction mechanisms than before. Some of these mechanisms are coercive fines, violation fines and measures against the vessel, in addition to other penalties and imprisonment.

## 3.4 The Commission's comments to the NMD

The Commission criticises the NMD in its report, see the Commission's report chapter 5.11.3 p. 57 and chapter 12 p. 129:

> *"The vessel's stability book contains a chapter called "Instructions for Master". The contents of this chapter are standardised and provide no direct information about important matters related to the vessel's stability in various operations. This is an unfortunate practice that the Norwegian Maritime Directorate ought to have pointed out during its approval of the stability book."*
>
> *"It also merits criticism that DNV had not in previous audits pointed out the failure to prepare a procedure for anchor handling, since the ISM Code demands a procedure for key operations. This criticism is also directed against the Norwegian Maritime Directorate, which audits DNV. Questions may also be raised as to whether the non-conformances were so serious that the "Bourbon Dolphin" ought not to have been issued with a safety management certificate following the DNV audit."*

The NMD notes the commentaries from the Commission and other information in the report. The following measures are implemented and will be given priority in future follow-up and supervisory work:

- The follow-up of the stability information has already been improved in accordance with the immediate measures. However, in this report, amendments and improvements have been proposed in Chapter 4 concerning stability.
- Regular meetings med classification societies to quality assure the ISM audits they perform on behalf of the NMD.
- Systematic, supervisory monitoring of the classification societies by performing observations, unscheduled surveys, vertical audits and system audits, with regard to the approval of newbuildings and follow-up in the operation phase.
- Increased focus, when reviewing the documentation, whether the ships are suited for the assignments they are planned to be used for.

- Increased focus on controlling that the ship's procedures are ship-specific where required, and that all necessary details and factors are considered in relation to the vessel's function and area of operation.
- Evaluation of the qualification requirements for ISM auditors.
- Increased focus on training, overlap and familiarisation, including examination of crews that can be documented and re-examined.

## 3.5 Follow-up of recommendations from the Commission

Chapters 4-11 deal with the NMD's follow-up of the Commission's recommendations and contain proposals for measures.

# 4 STABILITY OF ANCHOR HANDLING VESSELS (13.3)

## 4.1 Stability calculations (13.3.1)

### 4.1.1 Problem as described in the Commission's report

*(Cf. 5.11.3 p. 57-58)*
*The "Bourbon Dolphin" was a combined PSV and AHT vessel, also described as an AHTS. Designing a combination vessel is more demanding than designing a PSV or an AHT.*

*The main focus for a PSV is cargo capacity, whereas for an AHT there is more focus on propulsion system and deck layout.*

*Factors affecting stability are directly affected by the compromise resulting from different needs. Important factors for an AHT in this context are:*

- *Overall dimensions*
- *Buoyancy configuration, including design of hull and superstructure on deck*
- *Weight and centre of gravity*
- *The winch's pulling-power*
- *Capacity for leading of wire*
- *Bollard pull*
- *Ballast capacity*

*The vessels are as a rule designed with a large beam in relation to their depth, so that they have little or no buoyancy over the deck aft of the superstructure forward. Developed stability requirements have been developed for this type of vessel (IMO Resolution A.469 (XII)), which means that in order to have sufficient stability in various load conditions, particularly with large draught and little freeboard, there will be a need for a high GM.*

*For most load conditions a high GM yields disadvantageous sailing characteristics in relation to rolling. It is therefore normal for these vessels to have one or more roll reduction tanks in order to enhance comfort on*

*board. Use of roll reduction tanks helps to reduce the vessels' static stability and can thus, for certain vessels in given operations, constitute a safety hazard.*

*In the light of the above, an AHTS vessel can be more demanding to operate in relation to stability. This is a challenge for the crews. It may therefore be more demanding to plan and control load conditions for these vessels than for others.*

*The Commission considers that in consequence of this there ought to be particular attention paid to the stability of these vessels, both in relation to scope and content of aids (stability book, load calculator [stability instruments]) and qualification/training of crews.*

### 4.1.2 Recommendation from the Commission

*(Cf. 13.3.1 p. 137-138)*
*In order to create robust safety barriers during anchor-handling operations, including making sure that bollard pull and winch pulling power for AH vessels at the design stage are chosen dependently of the stability criteria, the Commission would make the following proposals:*

*Preparation of rule conditions for anchor-handling:*

- *All conditions shall be prepared with 10 and 100% bunkers.*
- *All winches shall be full of the heaviest possible line type.*
- *External force with following characteristics:*

*1. Vertical load:*

- *In vertical load, the full winch capacity shall be used between the outer towing-pins. The winches have full pulling power in the first layer. The requirement that the weight of the wire shall at the same time be set equivalent to full drums is justified by the fact that an extra margin is desirable. List arm shall be calculated from the centre of the vessel to the outer edge of the roller and with vertical point of attack in the upper edge of the stern roller. During this vertical load, the vessel shall have a maximum list angle corresponding to a GZ value equal to 50% of max GZ.*

*2. Run-out of chain:*

- *In running-out of chain a maximum force from the mooring line shall be calculated. The maximum force shall have its basis in both static and dynamic loads. This force shall be decomposed into a vertical force and a horizontal force in the vessel's transverse direction. The list arm for the horizontal component shall be calculated from the height of the working deck at the towing-pins to the centre of the propulsion propeller, or the aft lateral propeller if this is deeper. The heeling arm of the vertical*

*component shall be calculated from the centre of the vessel to the outer edge of the stern roller and with vertical point of attack in the upper edge of the stern roller. The mooring line shall have an angle of attack of minimum 25° in relation to the vessel's longitudinal axis in the horizontal plane. The angle in relation to the vertical plane shall be set as the one that gives the biggest list angle for the vessel. If the force from the mooring line is less than the maximum bollard pull, the angle shall be set at 90º. Under the influence of forces from the mooring line, the vessel shall at maximum have a list angle that corresponds to a GZ value equal to 50% of max GZ. The maximum manageable force from mooring lines that emerges these calculations will be the vessel's capacity for this type of operation.*

- *If it is necessary to ballast the conditions to achieve a given manageable force, the ballast used shall form the basis for ballast instructions dedicated to anchor-handling.*

*KG-limit curves*

*Specific KG-limit curves shall be prepared for anchor-handling operations that introduce two new criteria (in addition to existing requirements for supply ships). A static moment shall be used, related to the vessel's maximum vertical load during operation of the winch. List arm shall be calculated as shown above. Under the influence of this moment, the vessel shall at a maximum develop a list angle that corresponds to a GZ value equal to 50% of max GZ.*

*Under the influence of the maximum manageable force from the mooring line, a curve for list moment shall be calculated. List arms for the vertical and horizontal component shall be calculated as shown above. Under the influence of this moment, the vessel shall at a maximum develop a list angle that corresponds to a GZ value equal to 50% of max GZ.*

*The proposed requirements for stability will mean that the shark-jaws can be used under all stability conditions in the whole area between the outer towing-pins.*

### 4.1.3 Status of the regulatory system

#### 4.1.3.1 AT THE TIME OF THE ACCIDENT

The Construction Regulations contain general requirements for intact stability as well as requirements for intact stability allowing for the transverse forces for ships engaged in towing. Equivalent additional requirements for intact stability for ships engaged in anchor handling have not been prepared.

The main requirements of IMO Res. A.469(XII) Guidelines for the design and construction of offshore supply vessels, are incorporated in the Construction Regulations.

These guidelines were amended by IMO Res. MSC.235(82) on 1 December 2006. However, national law was not amended as a consequence of this.

#### 4.1.3.2 TODAY

No amendments at national level, but the current Circular No. 04-2008 on immediate measures provides guidelines for anchor handling.

### 4.1.4 The NMD's evaluation

The NMD's work is based on the Commission's proposed solution. Questions regarding requirements for built-in and operational stability requirements have been subject to discussions with classification societies, shipyards, ship designers, companies and crew on this type of vessel. Moreover, test calculations have been carried out on a range of existing designs to show how capacity is affected when new stability requirements are introduced. These stability calculations have been done by naval architects on their own designs for the NMD, but DNV has also run calculations on selected vessels to map the consequences of stability requirement amendments.

The test calculations, cf. Annex 2, indicate that the vessel's maximum pull varies according to variations in the quantity of wire and the type of winch, the compressive force on the stern roller and the amount and distribution of tank content in general.

### 4.1.5 The NMD's recommendation

After an overall assessment of the limits that should be placed on the design and operational stability of anchor handling vessels, the NMD will propose specific stability requirements.

Traditionally, the dynamic aspects of increased limit values have been added to the criteria when preparing stability criteria. The NMD has nevertheless decided to use the Commission's proposal to include dynamic effects in the mooring line force. This will result in an increase in the total forces that must be considered on a vessel during anchor handling, and thus a reduction in the vessel's capacity.

#### 4.1.5.1 STABILITY CRITERIA:

The criterion proposed by the Commission of Inquiry was one of the three criteria recommended by the NMD in the immediate measures. The criteria in these recommendations will be used in the new regulations:

The list angle as a result of inflicted moments shall not exceed:

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|---|---|
| *15°:* | This angle is low enough to enable corrective action to be taken and make suspension of operation possible, at the same time as the angle is so large that it clearly indicates that the load is too high. |
| *angle for water on deck:* | A freeboard requirement that makes work on deck possible in a critical static situation, at the same time as the ship's stability is significantly reduced beyond this |

| | |
|---|---|
| | angle. |
| *Angle for 50% of $GZ_{max}$:* | Provides a safety barrier with regard to the righting arm. |

The Commission's recommendations mean that vessels will have a certain level of stability in reserve when tension from the mooring line is taken into account. This level is apparent from the criterion stating that the maximum righting arm (GZ) shall not be reduced with more than 50% after tension is imposed on the vessel.

The test calculations that were carried out indicate that the stability reserve can be relatively little when a vessel is loaded in such a way that the general requirements for stability are satisfied with small margin.

To ensure that an acceptable level of stability reserve exists in all loading conditions, it is necessary to introduce a minimum level of stability to provide this reserve. A minimum level of stability will be able to preserve the stability of the vessel when unpredictable variations in the forces acting on the vessel occur during an operation, such as waves, wind, current and tension in the mooring line.

The NMD proposes an area requirement of 0.055 mrad between heeling arm and righting arm up to the second intersection point, angle of flooding or 40°. The area requirement is based on the IACS area requirement for towing vessels, which is 0.09 mrad, adjusted for a dynamic increase of 40%. The area requirement is expected to contribute to a greater extension of the GZ curve.

Anchor handling vessels shall comply with the current towing requirements in relation to their maximum bollard pull.

#### 4.1.5.2 LOADING CONDITIONS:

Typical anchor handling vessels are often multifunctional vessels, with an option for the delivery of both fuel oil and freshwater to offshore petroleum installations. They are likely to have oversized fuel oil and freshwater tanks. These variables, along with the ship's ballast capacity, will then have a relatively large impact on the ship's capacity. In order to prepare simple and clear instructions to the ship's crew for the conditions related to the ship's capacity, limitations in the use of roll reduction tanks and necessary ballasting, a stated consumption sequence must be assumed.

The NMD therefore proposes that an emptying sequence of the consumption tanks from maximum capacity to empty vessel shall be determined for each vessel.

Based on this consumption plan, departure and arrival conditions shall be prepared, with respectively 100% and 10% fuel oil and freshwater, and the worst intermediate situation(s) shall be prepared. The other situations shall include a given deck cargo and at least one roll reduction tank with operational filling.

When it comes to load on the winches in the different conditions, the NMD will propose to introduce a requirement for 33%, 67% and 100% load on all winches. This is to illustrate a reduction in the ship's capacity as a result of increased load on the winches.

The effect of flooding of open chain lockers shall be illustrated with regard to impact on the vessel's capacity, although not to be decisive for the resulting capacity. This is because the potential for flooding during the operational conditions, including wave conditions, is not considered to be greater than can be addressed through drainage via the tank's associated bilge arrangements. Moreover, openings in the deck shall be equipped with frames as high as practically possible, however not less than 600 mm, loose or fixed, depending on the arrangement.

Conditions and assumptions for consumption plans shall be presented to and approved by the owner. The stability documentation, in its entirety, is proposed subjected to control by the NMD prior to the issue of certificate.

#### 4.1.5.3 HEELING MOMENT:

The NMD will continue the Commission's recommendation for moment arms, but suggests that the upper outer edge of the stern roller is used in the calculation of both moment arms. On the basis of standard arrangements with towing pins and stern rollers, a moment arm greater than the distance from centerline to the outer edge of the stern roller is not considered necessary. Arrangements controlling the wire and chain within a narrower area may result in other and reduced moment arms. In any case, this must be subject to special evaluation in the design phase.

#### 4.1.5.4 ANGLE VARIATIONS FOR THE TENSION:

The NMD will continue the decomposition angles the Commission has chosen, i.e. an angle (here defined as α) between the ship's centerline and the anchor line in the horizontal plane, and an angle (defined β) between the horizontal plane and the mooring line through the point of attack. This is because both of these, for instance in connection with the running-out of chain, can be determined by means of the navigational aids found on board an anchor handling vessel.

The angle α will be given as the angle between the line from the line's defined point of attack on the vessel to the point where the line leaves the rig and the vessel's heading.

The angle β will be given based on the following variables:

- the distance from the line's point of attack on the vessel and the point where the line leaves the rig,
- the run-out line's composition and
- the length of the run-out chain

These three variables can be controlled in such a way that the angle β can be determined.

#### 4.1.5.5 TABLES/CURVES FOR MAXIMUM PERMISSIBLE MOMENT:

Curves shall be prepared so that the master can easily determine the maximum forces that can be applied to the vessel, as a function of displacement/draught and vertical centre of gravity (VCG) so that the stability criteria are satisfied.

In 4.1.5.6 it is assumed that the dynamic additional forces are calculated and clearly presented in the anchor handling plans, so that the value in question can directly be compared to calculated/observed maximum permissible tension.

The limit curves should be given as curves exceeding the maximum permissible moment, as this would allow the use of the same curves for the whole range of the anchor handling operations the vessel is going to perform. The various anchor handling operations, such as pulling the anchor or running-out of chain, could be described by different variations of the angles α and β. When it comes to pulling an anchor when the vessel is positioned straight above the anchor's position at the bottom, α will probably be small and β be close to 90°. For running-out of mooring line β will vary, while α already after the manoeuvring of the vessel can be kept small. The maximum permissible moment can, by using the selected angle intervals, be calculated back to a maximum tension, which will appear as the minimum pulling power in the intervals.

#### 4.1.5.6 DYNAMIC LOADS:

Under the operational requirements the NMD has proposed that the master, through regulatory amendments, should have the responsibility to ensure that dynamic loads on the vessel are taken into account during an anchor handling operation. The master ensures that the maximum tensions shown in the anchor handling plans take account of the dynamic additional forces that may occur within the stated window of operation for waves, wind and current.

If such information is missing, and on the basis of the Commission's approximation value of 1.4, a preliminary reduction value of 29% of the maximum permissible static tension is proposed.

There is currently software for the calculation of dynamic additional forces, which can be used. The NMD will nevertheless take the initiative to have the dynamic effects in connection with line tension on anchor handling vessels

further discussed, and prepare proposals for common international guidelines for the assessment of dynamic forces.

#### 4.1.5.7 EFFECT OF STERN FORCES ON THE SHIP'S TRIM AND DISPLACEMENT:

In preparing the loading conditions, the effect of stern forces on trim and displacement shall be taken into account by considering the pressure by a concentrated load in the ship's centerline in the upper edge of the stern roller. The size of the concentrated load may be set as a conservative value. Alternatively, more accurate and iterative methods for the stipulation of the stern force may be used.

The NMD will consider initiating test calculations in order to examine whether the effect of free trim regardless of axis has a significant impact on certain types of vessels.

#### 4.1.5.8 SUSPENSION CRITERIA:

The two above-mentioned angles α and β will in practice be suspension criteria, considering that they are part of input values in the crew's calculations of the ship's available capacity in a given loading condition. The angles must be chosen in order to calculate the maximum permissible tension on the basis of the proposed tables/curves for maximum permissible heeling moment. The maximum tension is therefore only valid within the indicated angles.

If the displayed tension exceeds the calculated maximum permissible tension, the operation must be corrected or suspended.

The operation must also be corrected or suspended if the external forces that are used for the calculation of the dynamic additions in the anchor handling plan are exceeded.

#### 4.1.5.9 CONCLUSIONS:

On the basis of the proposed loading conditions, which cover varying levels of fuel oil and freshwater, in combination with a range of loads on all winches and limit curves, the NMD is of the opinion that general requirements for stability may be achieved, which will make it easier to assess whether the vessel has the capacity to perform a given job. However, in order to assess the assignments the ship is to be used for, the company must be familiarized with the vessel's characteristics before it is put into operation.

## 4.2 Stability booklet (13.3.2)

### 4.2.1 Problem as described in the Commission's report

*(cf. 5.11.3 p. 57)*
*"Instructions for Master". The contents of this chapter are standardised and provide no direct information about important matters related to the vessel's stability in various operations.*

*The company had not prepared instructions for use of the roll reduction tanks as required by the Building Regulations Section 15. It was thereby not communicated that the tanks of the "Bourbon Dolphin" ought to be empty during anchorhandling operations.*

*Load conditions for anchor-handling do not follow the standard for set-up of conditions that the shipyard had used for other vessels.*

*Use of winch power and appurtenant point of attack for this (against the inner towing-pin) is not compatible with the vessel's maximum winch power and the use of the shark-jaw.*

*(cf. 12.3.1 p. 128)*
*It is not documented that the vessel's stability characteristics were such that the equipment could be used at its full capacity. The restrictions were not communicated directly and clearly in the stability book or in any other way to those who were to operate the vessel.*

### 4.2.2 Recommendation from the Commission

*(Cf. 13.3.2 p. 138)*
*The stability book must contain a supplement of calculations in line with the recommendations described above, subject to the approval of the authorities.*
*Under the current regulatory system, it is a requirement that the stability book contain instructions "that in a rapid and simple manner enable the master of the vessel to enjoy precise guidance about the ship's trim and stability under different sailing conditions".*
*The Commission has the impression that these instructions have been standardised and consequently fail to communicate vessel-specific factors. A vessel-specific content would make it easier to safeguard stability on board. The following shall be dealt with in the instructions:*

- *concrete operational restrictions,*
- *capacities for given operations, and*
- *other operational factors of significance for the vessel's stability.*

*Operational restrictions may for example include the use of roll reduction tanks and ballast tanks in various operations.*
*Capacities for given operations may for example include maximum manageable force from the mooring line during running-out and maximum capacity for carriage of deck cargo.*
*Other factors may for example include the need, during any unusual use of the winch, for special attention related to stability, demanding that stability factors be studied more closely.*

### 4.2.3 Status of the regulatory system

#### 4.2.3.1 AT THE TIME OF THE ACCIDENT

The term "stability booklet" is not used in the NMD Regulations, but there are requirements for the information that is normally presented in the stability booklet.

According to the Construction Regulations "stability information shall be prepared to enable the shipmaster by rapid and simple processes to obtain accurate guidance as to the ship's trim and stability under varying conditions of service".

The Safety Measures Regulations contain provisions concerning stability data and aids for controlling the stability which shall be kept on board. Furthermore, there are provisions in the Regulations concerning what should be taken into account or provided for during normal operation.

SOLAS contained provisions about stability information in Reg. II-1/22 and Reg. II-1/25.8 that also applied to Norwegian ships.

#### 4.2.3.2 TODAY

Some amendments have been made to SOLAS with respect to the contents of the stability information the master shall have. The amendments are found in the new Regulation II-1/5-1 in SOLAS which are quoted in Res. MSC.216(82).

Current Circular No. 04-2008 on immediate measures provides guidelines for anchor handling operations.

### 4.2.4 The NMD's evaluation

The NMD shares the Commission's opinion of how the form and contents of the stability booklet should be. The NMD now requests that vessel-specific instructions be submitted prior to approval and that instructions for the use of roll reduction tanks are prepared.

The NMD has found that there is a lack of information from designers and consultants when describing limitations and capacity reductions in individual designs and vessels. This can to some extent be related to the formulation of the regulations regarding how stability information should be drawn up and what information to include here.

However, the responsibility for ensuring that information on the vessel's stability is available, in relation to the relevant load, lies with the shipping company.

### 4.2.5 The NMD's recommendation

The NMD recommends that, through regulatory amendments, the minimum requirements for the stability manual for anchor handling vessels is stated. The usability and availability of critical information must be emphasized.

The NMD will further recommend requirements that the master shall have tools and numerical examples available for the calculation of the vessel's stability. This information shall, as a minimum, include:

- An overview of the most favourable consumption sequence for fuel oil and freshwater, with its recommended use of ballast water.
- Instructions for the use of roll reduction tanks that clearly convey what stability-related consequences the use of such tanks have.
- A description of how the ship's trim, draught and vertical centre of gravity for a given loading condition is determined, as well as the formulas required to determine the maximum permissible tension from the maximum permissible heeling moment.
- A numerical example that shows how the maximum permissible tension is determined for a given loading condition for a selected set of the angles α and β.
- Vessel-specific instructions based on the consumption plan, which, among other things, shall be linked to the operational limitations as described under 4.1, described in an accessible way in the stability booklet.

However, the stability information is extensive, and it is therefore proposed that separate manuals are prepared for special operations. An anchor handling manual will naturally contain information related to any particular operational conditions, including stability, risk assessments and specific operational procedures. Information on winches and other anchor handling equipment should be in the same manual.

## 4.3 Training/operation (13.3.3)

### 4.3.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.3.3 p. 138)*
*Use of simulator training is a positive measure for raising the level of expertise, and is encouraged in the training of personnel. The very best thing would be for simulators to be vessel-specific. Simulator training should include variations in the forces that the vessel must be expected to handle and provide relevant feedback to the operator about the consequences.*
*The Commission would recommend to maritime educational institutions that they review existing training activities in stability with a view to these also addressing factors related to towing and anchor-handling operations.*

*It is also recommended that companies and the maritime milieu establish a stronger focus on maintenance of operational stability on board.*

### 4.3.2 Status of the regulatory system

#### 4.3.2.1 AT THE TIME OF THE ACCIDENT

The Qualification Regulations implement the STCW Convention, which contains requirements for the education which is a basis for the issue of certificates. The stability training here is general and does not deal with specific problems associated with anchor handling.

Further, the STCW Code sets out requirements for manoeuvring. The officer of the watch of ships of 500 gross tonnage and upwards shall have knowledge about the consequences of wind and current.

In accordance with the STCW Code, masters and chief officers shall be capable of manoeuvring and handling a ship under all conditions, this includes using the propulsion machinery and manoeuvring systems, handling the ship in poor weather, under towing operations, be able to determine the characteristics of the manoeuvring and propulsion machinery for common types of ships with special reference to the stopping distance and turning radius at various draughts and speeds.

Generally, the vessel's safety management system shall help ensure that the crew receives adequate training, cf. the ISM Code.

#### 4.3.2.2 TODAY

When it comes to training related to specific types of vessels, reference may, after the entry into force of the Ship Safety and Security Act, be given to the general provisions relating to qualifications.

### 4.3.3 The NMD's evaluation

#### 4.3.3.1 PROBLEMS RELATED TO MANOEUVRING

When manoeuvring a vessel engaged in towing or connected to an anchor chain, the crew must pay due regard to special conditions related to manoeuvring.

A vessel that has speed through the water is steered by the stern, which means that a port turn is done by placing the rudders over to the port side so that when the water hits the rudders the stern is pushed to starboard. When the stern moves towards the starboard side, the vessel's direction is changed to port resulting in a turn to port. The same principle will apply to vessels which manoeuvre without a rudder, e.g. an azipod propeller.

In an operation in which the vessel does not move forward or moves slowly forward, the vessel can be manoeuvred sideways by using the side thrusters. When the traditional main propellers are run at the maximum, and the vessel still does not accellerate through the water as a result of that it is held back by an inertia and water resistance force, the pushing force from the side thrusters will decline significantly due to water suction caused by the main propellers.

For traditional main propellers the greatest lateral force is therefore achieved by using propulsion propellers in combination with the vessel's rudder, see figure 1.

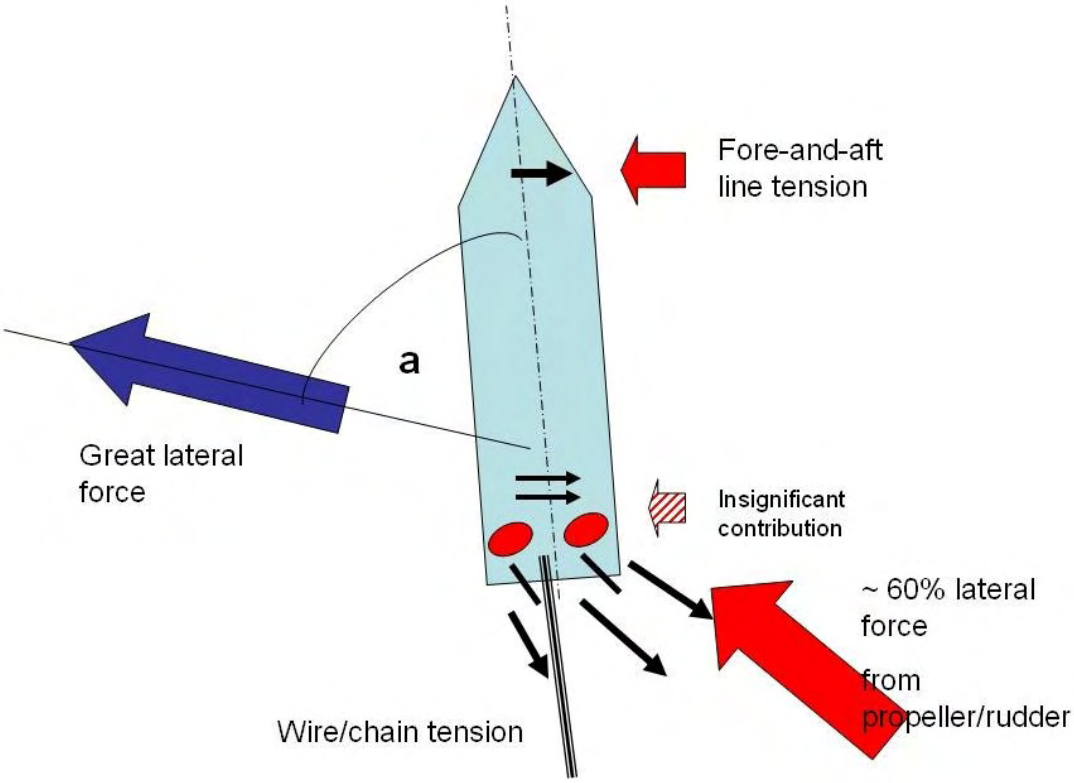


**FIGURE 1 EFFECTIVE SIDEWAYS MOVEMENT AT LITTLE OR NO FORWARD SPEED**

In order to achieve a lateral movement towards port from the propulsion propeller, the rudders, alternatively the azipod, must be rotated towards starboard, as for example in a starboard turn. This must be done because a starboard turn will cause propeller water to push the vessel's stern heavily towards the port side. This lateral force is considerable and can normally be considered to be approximately 60% of the vessel's bollard pull for traditional propeller systems.

Accordingly it is not very efficient to use the lateral thrusters when the main propellers are being used at near maximum effect. All available engine power should be used on the main propellers.

If the rudders are placed towards the port side during towing when a port turn is desired, the ship must be able to move the stern in a certain speed

and distance. This method is for instance applied when towing a trawl. Rudder deflection to the port side will, as mentioned above, attempt to push the stern towards the port side. If the stern of the vessel is prevented from moving or moves very slowly due to an external force, radial thrust force is all that is obtained.

If a vessel is further prevented form turning to port because of a towing fastening point astern of the propellers, the thrust force will actually be able to push the vessel to starboard, see figure 2.

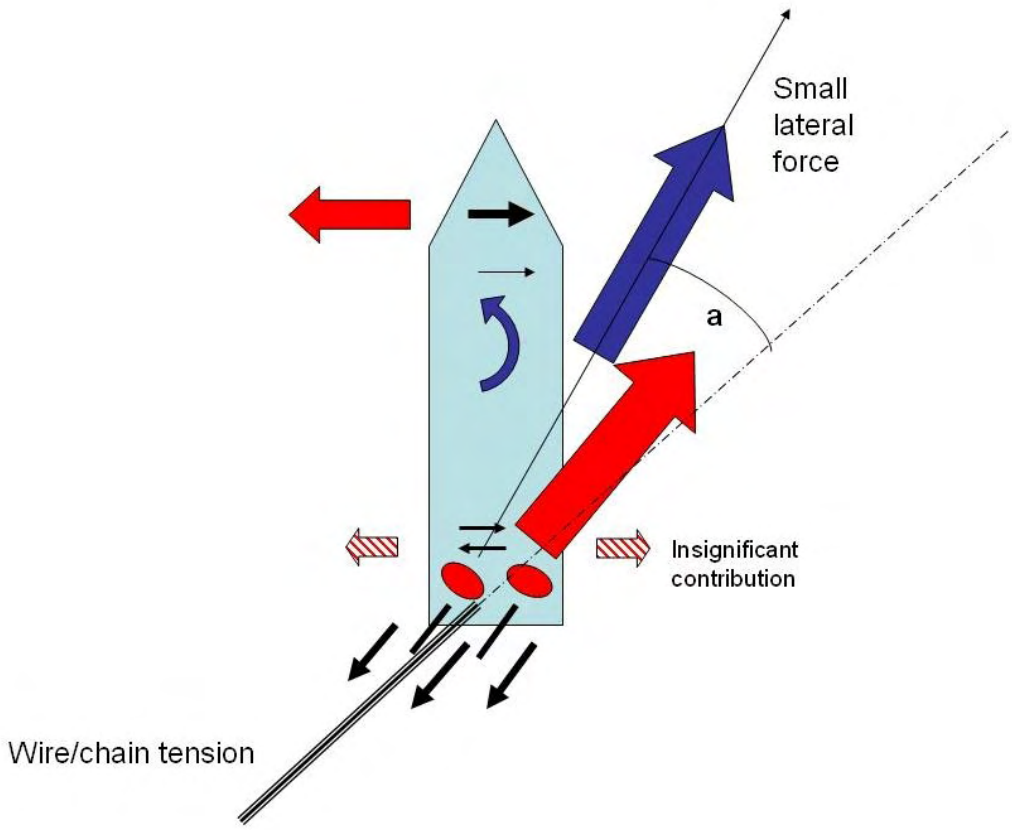


**FIGURE 2 UNFAVOURABLE SIDEWAYS MANOEUVRING AT LITTLE OR NO FORWARD SPEED**

In the case of the "Bourbon Dolphin", the problem of getting the vessel to change heading to port was identified in part through the action that was done to move the chain from the starboard towing pin to the port towing pin.

Thus, it is conceivable that the manoeuvring of the rudders and main propellers largely contributed to reducing the vessel's force and movement to port and that the drift to starboard could not be counteracted.

#### 4.3.3.2 PROBLEM RELATED TO STABILITY

Anchor handling in the form used for the anchoring of rigs and other special vessels like pipelaying barges and production ships is a relatively new activity that has progressed rapidly from the 1960s to the present. From only towing the rig's own mooring line via the centric towing pin, operations in deeper waters and stricter requirements for mooring have led to a significant change in the vessels' capacity, especially for lifting, see figure 3. Splicing of the mooring lines to insert alternative links or to increase the length beyond the capacity of the rig's anchor winches, has further led to, among other things, double towing pin sets which separately are positioned somewhat to the side of the vessel's centre. Thus, all vertical loads from the mooring line of the towing pin sets produce a heeling moment.

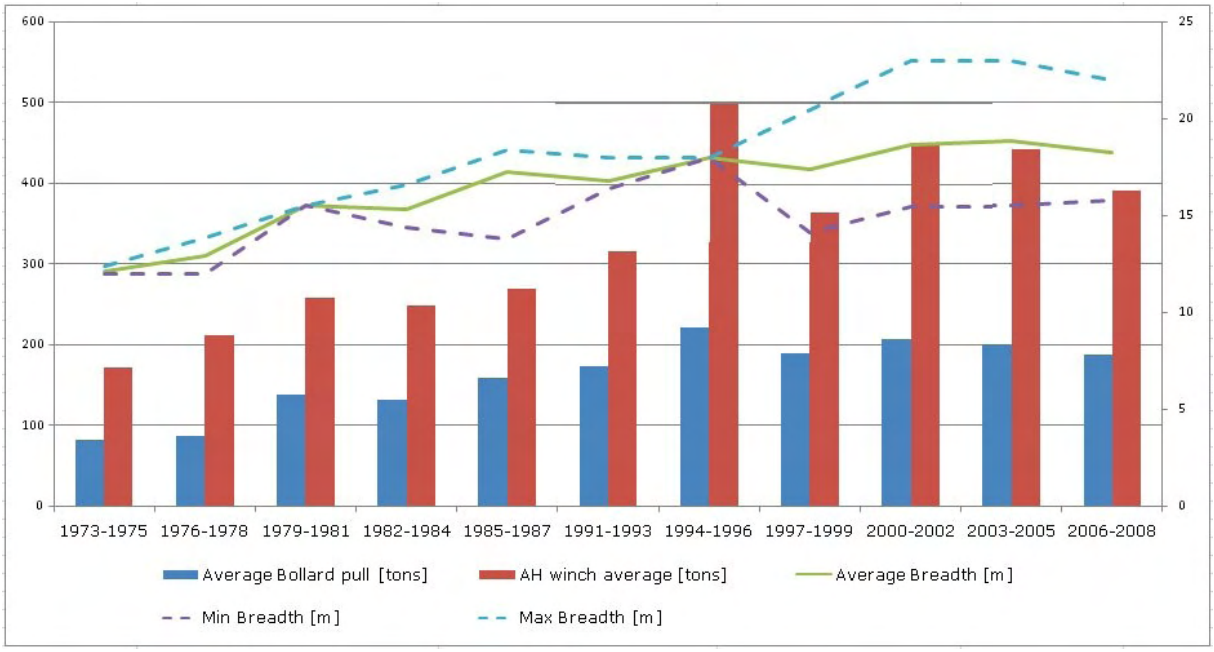


**FIGURE 3 THE PROGRESSION OF ANCHOR HANDLING VESSELS 1973-2008**

Anchor handling, which is a combination of lifting and towing, is performed by vessels which, in terms of stability, are constructed as supply vessels. Such vessels are permitted to have their maximum righting arm ($GZ_{max}$) at 15° of list. For regular cargo ships it is recommended that the righting arm should not reach its maximum until after 30°. However, the requirement is that the area before the peak point should increase from 0.055 mrad at 30° to 0.07 mrad at 15°.

The possibility of placing the $GZ_{max}$ down towards 15° provides operational advantages, but also disadvantages that may jeopardize the safety.

Anchor handling vessels with a $GZ_{max}$ of 15° are perceived as very rigid and hence stable since they, for example, will only list to approx. 5-6° at 50% of the maximum righting arm, while a merchant vessel with a $GZ_{max}$ of 30° will list to 15-18°. In practice a 5-6° list will not be experienced as dangerous, while a 15-18° list will be perceived as dramatic.

For personnel who operate on different types of vessels, the actual capacity may be misinterpreted if they are not aware that the vessel may reach its limit already at 15° of list.

A rapidly increasing GZ curve leads to fast acceleration when rolling occurs, which may be experienced as unpleasant. The rolling may be reduced by the use of roll reduction tanks as long as the vessel is not listing. All officers who were asked confirmed that the roll reduction tanks are used to ensure that work on deck can be carried out. What is not being focused on is that if the vessel has poor stability, filling the roll reduction tanks will reduce the freeboard so that the angle for water on deck is reduced. At the same time, the effect of the free liquid surface in the roll reduction tanks will reduce the GZ curve level. If the vessel is listing, water in a roll reduction tank will make the listing worse.

The use of roll reduction tanks may in the worst case contribute to that the vessel, in terms of stability, is no longer able to meet the minimum requirements. To soften rigid ships, characterized by a rapidly increasing GZ curve, in order to improve the working conditions on the deck, may increase the risk of capsizing. If, on the other hand, an anchor handling vessel is perceived to align slowly, there is an immediate reason to examine the stability closer.

#### 4.3.3.3 CHALLENGES IN MAKING USE OF ENGINE POWER

In its report, the Commission points out that the engine-room warned that the machinery was overloaded on several occasions prior to the accident. Manoeuvring in connection with demanding operations can be critical if the machinery falls out, or drops down to a reduced level. Loss of pulling power may lead to the vessel being pulled backwards, which, in combination with reduced manoeuvrability, may lead to the vessel being brought into an unfavourable position with respect to external forces. Although load beyond the maximum continuous effect output sometimes may be placed on the machinery, it must be regarded as unfortunate to do so if the operation is about to get out of control.

### 4.3.4 The NMD's recommendation

The NMD has, after an evaluation of information from interviews, meetings and the Commission's report found it necessary to propose special requirements for education and training of officers who are to operate tug and anchor handling vessels.

When carrying out towing and anchor handling operations, special attention must be paid to the manoeuvring. Vessels normally have speed through the water, but during towing and anchor handling vessels may be at a standstill, or nearly at a standstill, because the propulsion is hampered by external forces that are great compared to the available bollard pull. The manoeuvring in such a situation should be done in the opposite way of what would be

natural for a ship that has propulsion in the water. This topic should be part of the general training of officers and should be an essential topic in the special education and training of officers who are to perform towing and anchor handling.

The effect of the rudder, rotating propellers and the use of side thrusters should be practised in connection with simulator training and training of crew of the navigational bridge of anchor handling and tug vessels. Requirements for the crew's expertise in manoeuvring during special operations must also be identified and described in the company's safety management system. As with other criteria to assess whether the operation should be suspended, utilisation of propulsive effect beyond normal permissible continuous effect must also be considered as a clear suspension criterion.

Because of the great forces that may occur during anchor handling operations and the specific stability characteristics of such vessels, it is necessary that the crew is given special training to handle this. The operation of powerful winches is also an important aspect in this connection.

It is proposed that the training also include personnel on vessels engaged in trenching/dredging or other processes in which powerful winches or cranes are used for subsea operations.

The NMD proposes that the training includes:

- Calculation, evaluation and control of loading conditions, load changes and stability to plan the handling of great external forces that may lead to listing.
- Knowledge of ballasting and especially advantages and limitations related to roll reduction tanks and how they are affected by stability.
- Analysis of information regarding static forces and dynamic forces from waves, wind and current, both on the equipment in the sea and on the vessel, as well as the determination of the suspension criteria.
- The planning and carrying out of safe manoeuvring so that the vessel can properly handle the planned forces and have reserves to withstand unexpected incidents.
- Utilisation and limitations related to the use of available engine power and simulator training to illustrate challenges related to the loss of engine power.
- Knowledge of the properties of large power machinery, such as winches, and how the tension control, brake functions and emergency release work.
- Knowledge of load line requirements / means of closure and the effect of uncontrolled water flooding.

- Evaluation of alternative plans and the increase in the ship's emergency response for critical operations.
- The special need for communication and information exchange on board the vessel, with the company and with cooperating parties.
- Training schemes for crews for normal operation and in emergency response.
- Simulator training for normal operations and operations that require special manoeuvring.

The NMD has submitted a proposal to the IMO that guidelines should be prepared for the training of the officers of the watch and winch operators on anchor handling vessels.

# 5 DESIGN AND CERTIFICATION (13.4)

## 5.1 The bollard pull certificate (13.4.1)

### 5.1.1 Problem to be addressed as described by the Commission

*(Cf. 12.3.1 p. 129)*
*The "Bourbon Dolphin" was certified for 180 tonnes in continuous bollard pull. On the market the vessel was presented as a "DP 2 anchor handling tug supply vessel" with 194 tonnes in bollard pull and 400 tonnes pulling power on the winch. It was stated in the RMP that at certain stages of the operation one might encounter forces that demanded a bollard pull of over 174 tonnes. With full use of thrusters, however, bollard pull would be reduced to as little as 125 tonnes.*

### 5.1.2 Recommendation from the Commission

*(Cf. 13.4.1 p. 139)*
*A list of the Norwegian fleet operating as anchorhandling vessels shows that it includes some smaller vessels, i.e. vessels with certified bollard pull under 180 tonnes. It is therefore important that the companies have a realistic understanding of these vessels' real capacities and limitations under various operational conditions.*

*In order to certify that the vessel has a minimum manoeuvrability, the bollard pull certificate should indicate two kinds of effect output: first, it should specify a maximum continuous bollard pull that can be achieved by use of the vessel's main propeller alone. Second, it should register an effect output in which the reduction in bollard pull with full loading of the axle generator is taken into account.*

### 5.1.3 Status of the regulatory system

#### 5.1.3.1 AT THE TIME OF THE ACCIDENT

There are no requirements for a bollard pull certificate in the Norwegian regulatory system. Maximum bollard pull will, however, indirectly be set for anchor handling vessels when the vessel has to prove that the provisions on intact stability for ships engaged in towing set out in the Construction Regulations are met. The maximum bollard pull is also assumed known in the provisions on towing and anchor handling equipment. Thus, maximum bollard pull for anchor handling vessels is normally set by using the vessel's main propellers, but the reduction in bollard pull as a consequence of loading from e.g. generators or pumps is not calculated.

#### 5.1.3.2 TODAY

No amendments. However, the immediate measures address the problem of reduced bollard pull.

### 5.1.4 The NMD's evaluation

The NMD shares the Commission's perception of the problem with today's bollard pull certificates. The problem was raised in the immediate measures where the following is put forward:

*" A vessel specific curve must be prepared and arranged showing the maximum available continuous bollard pull (BP) for anchor handling as a function of the total power balance when required capacity to ensure sufficient operation of the winch pumps and side propellers/azimuth-thrusters has been taken into consideration."*

Following the Commission's report, the issue has been discussed in several meetings with the industry, both on the company side and with designers. Most of them understand this issue and think that a net bollard pull certificate would be useful. The industry referred to a DP plot showing a vessel's thrust capacity at 360° in various environment conditions and the resultant power output needed.

During conversations and correspondence with Marintek in Trondheim, reference was made to tank tests involving a model anchor handling vessel where the interactions between the main propellers and side thrusters in the stern were studied. These tests indicate that side thruster currents affect the maximum bollard pull to a negligible degree. Moreover, it appears that the main propellers' impact on the side thruster is significant, and that the side thrusters' ability to produce sideways movement is significantly reduced when the main propellers are running at full power.

### 5.1.5 The NMD's recommendation

The NMD recommends that, through regulatory amendments, a requirement is introduced for a bollard pull certificate indicating two levels of available bollard based on two different effect outputs:

- Gross continuous bollard pull obtained using only the vessel's main propellers alone, and with the standard available power into the propeller shafts, cf. MSC/Circ.884 Guidelines for safe ocean towing.

- Net continuous bollard pull obtained using only the ship's main propellers, and where available power to the propellers is reduced with the power that large power consumers, which has a power reducing impact on the main propellers (side thrusters, anchor handling winches, etc.), requires at full operation.

The gross continuous bollard pull will in principal be the same as it is defined in the current class requirements (DNV). Testing the net bollard pull can be done by reducing the revolutions of the main engines equal to possible reduction in output as defined above.

The effect of the aft side thruster is minimal when the main propellers are run up against the maximum. Knowing this, it might be appropriate to develop a special towing mode where the aft side thrusters can not be run. This, however, will be left to the industry to consider.

## 5.2 Requirements for the winch package (13.4.2)

### 5.2.1 Problem as described by the Commission

*(Cf. 5.11.4 p. 58)*
*Previously the anchor-handling winches had a quick-release function that caused a rapid and uncontrolled release of the winch so that chain and wire rushed out. Even if it is apparent from the user manual that the emergency release system had been altered, it appears to have been a widespread perception that they still had a quick-release option.*

*Even the officers on the "Bourbon Dolphin" shared this perception. The emergency release is more a support function for the winch than for the vessel as such. In the last phase of the situation that developed on 12 April, it is difficult to see that the emergency release would have had any preventive function.*

*(Cf. 9.11 p. 109)*
*In the Commission's opinion, this misunderstanding may help to explain why this emergency measure was not taken earlier.*

### 5.2.2 Recommendation from the Commission

*(Cf. 13.4.2 p. 139)*
*Before installation, the functions of the winch package should be tested with maximum operational capacities. Certification on the basis of a type approval can verify such a test. This is to ensure the equipment's functionality in all operational loads. The Commission would ask the Norwegian Maritime Directorate to consider requirements for a quick-release function, perhaps in a modified version, for use in a situation in*

*which crew and vessel are facing a clear and present danger (casualty situation).*

### 5.2.3 Status of the regulatory system

#### 5.2.3.1 AT THE TIME OF THE ACCIDENT

The Construction Regulations contain requirements for towing and anchor handling equipment, including winches. Dimensioning and testing of the winch for towing and/or anchor handling shall be done in accordance with ISO 7365.

Some requirements in the standard are related to the maximum bollard pull of each ship. Apart from this, functionality in the ship is not taken into consideration. The described tests can be performed on board or in the factory.

According to the Construction Regulations, all towing and/or anchor handling winches shall be capable of being "emergency released" from the bridge. ISO standard 7365 deals with "Emergency release". According to the standard, the maximum delay from the activation of the emergency release to the disengagement of the drum shall not exceed 10 seconds.

The term "quick-release" is not used in the Regulations or in the standard.

#### 5.2.3.2 TODAY

No amendments. However, the immediate measures address the need for specific knowledge about emergency release.

### 5.2.4 The NMD's evaluation

The Commission comments that the emergency release function is more a support function for the winch than for the vessel as such. The NMD wants to emphasize that the emergency release is intended to release cargo from the vessel in the same way as it can be done for emergency release of towing hooks. The effect for the winch is of secondary importance.

The NMD has held meetings with four winch manufacturers to get acquainted with the winch's design and the possibilities and limitations of the winch packages. The four manufacturers offer different technical solutions for motor drive, change of gears, running-in/running-out and emergency release. Only one of the manufacturers satisfies the current requirement that it shall be possible for the motor to be declutched from the winch drum. Two of them have hydraulic motors where the driving gear can be reset to zero to partly obtain the same effect as with declutching. The same two manufacturers consider it possible to carry out a free, or partly free, running-out of the anchor handling winches. The technical solution that is chosen may cause damage to the motors at high speeds. This should still not prevent a free run-out in an emergency situation. The fourth manufacturer offers a separate clutch and can release the drum via gearing. This manufacturer is the only

one which, to a certain degree, has tested free running-out of wire from a winch with free fall load.

Repeated tests involving release of load of 100 tons show that the winch drum is released in 1-2 seconds and that the load reaches a speed of 1.6 – 1.9 m/s after approx. 5 seconds. The numbers showing the reduction in line tension are not presented, but an increase in speed of 0.28 – 0.38 m/s² will be able to reduce dynamic additions. At a wave height of approx. 4.5 m and a frequency of 8 seconds, the vessel will, if it follows the wave, obtain a vertical speed of approx. 0.5 m/s. The tests show a running-out speed of approx. three times the lift of the waves.

During some parts of anchor handling assignments, the chain is run directly from the chain lockers over the gypsy. In operations similar to that of the "Bourbon Dolphin", chain was run over the gypsy at the same time as the chain was run out of the platform. That means that significant forces from the anchor chain are applied to the vessel's stern roller and a critical stability situation may arise during this stage of the operation. In this stage of the operation, an emergency release without deceleration will cause the chain to run uncontrolled out of the chain locker and over the gypsy, or straight from the chain locker. The NMD has been made aware of situations where the chain accidentally has run uncontrolled over the gypsy.

The NMD is aware that some companies use winches with two types of emergency release. One of the release systems has a speed control function, and the second release system is a free release.

The NMD has learned that systems that can quickly cut the wire and chain during an emergency are being developed. Such systems could provide an immediate release of the forces applied to the vessel through the mooring line. The systems' function or possible risk factors of such systems have not been presented to the NMD.

ISO 7365 operates with nominal winch sizes equal to drum loads up to 160 tons for ocean towing. The anchor handling winches we have today are significantly larger.

The NMD is still of the opinion that the fundamental principles of dimensioning and functionality shall also be complied with for winches that are larger than mentioned by the standard. This will include, but not be limited to:

- Permissible tensions
- Emergency release and disengagement of the drum

### 5.2.5 The NMD's recommendation

The NMD is of the opinion that a free running-out of wire from the winch is technically and practically possible. Friction over the stern roller may reduce the effect of the emergency release. Requirements for a free emergency

release are still recommended as the release speed according to the tests from one of the manufacturers seems to be high enough to reduce the forces that are acting on the vessel. Over-spinning of the drum is not considered a problem before the load reaches the bottom or the drum is empty. The brakes can therefore be applied after a time delay. The wire should be attached to the drum by a weak link.

Emergency release of the chain over the gypsy seems, this based on the chain's properties and the design of the gypsy, not to be possible. The equipment is mechanically too rough, and the danger of the chain climbing and jumping off the gypsy during a free run out, is too great with the consequent risks of the chain jamming.

The time for the release of the drum as it is described in ISO 7365, 10 seconds, is not considered sufficiently fast enough for an effective release of forces on the ship.

Based on the preceding paragraphs, the NMD therefore proposes the introduction of a functional requirement that stipulates that the vessel can get rid of heeling loads in stability-critical situations so that the vessel instantly regains its righting arm. The introduction of a new, stricter time requirement of 3 seconds from activation till the functional requirement is met, is proposed.

The greatest pulling power of the winches is proposed limited to the force the vessel can withstand from a given loading condition without exceeding the stability criteria for anchor handling. The loading condition should be an optimized 100% condition with full drums and a given deck cargo. If the final stability assessments reveal that the characteristics of a completed vessel are not adequate to handle the capacity that the winches have, this will lead to derating of the winches.

It is proposed that the winches should have a system to ensure that the winches' slip and brake holding forces can be set to the calculated maximum permissible tension the specific operational assessments have led to. If the winch still slips when performing the operation, this shall be considered a suspension criterion which implies that the operation has to be reviewed again.

For testing, the NMD recommends a practise where all new winch types are type approved by factory tests where the winch is tested at its specified tension. Each winch should in addition be function tested on board at the ship's maximum continuous bollard pull.

## 5.3 Certification of winch operator (13.4.3)

### 5.3.1 Problem to be addressed and recommendation from the Commission

*(cf. 13.4.3 p. 139)*
*The loss of the "Bourbon Dolphin" has uncovered a consistent lack of understanding of the emergency release function. The STCW Convention makes no qualification requirements for winch operators. In any use of the winch, the operator is a key player, and it is important that this person is well-qualified.*

*Requirements ought to be made that winch operators undergo formal training, preferably in collaboration with the manufacturer.*
*Certification of winch operators should also be considered.*

### 5.3.2 Status of the regulatory system

#### 5.3.2.1 AT THE TIME OF THE ACCIDENT

The Qualification Regulations do not contain any special qualification or certification requirements for winch operators. Neither the STCW Convention nor the STCW Code contain concrete requirements for winch operators. However, the STCW Code makes requirements for knowledge about the load's impact on the seaworthiness and stability of the ship for the officer of the watch on ships of 500 gross tonnage and upwards, including the effect of heavy lifts.

The ISM Code and the Safety Measures Regulations make general requirements that shall ensure that personnel serving on board receive adequate training and information with regard to stability, even though there are certificate requirements.

#### 5.3.2.2 TODAY

The Ship Safety and Security Act contains provisions on training and familiarization.

### 5.3.3 The NMD's evaluation

The NMD has discussed this issue in meetings with the industry and the conclusion is that there is a need for training qualifying to winch operator. Today, these winches have up to 600 tons pulling power and can be run in a number of different configurations.

### 5.3.4 The NMD's recommendation

The NMD shares the Commission's views regarding the need for winch operators to possess a high level of expertise in the use of winches and the forces that are handled in general, as well as specific knowledge of the winch equipment found on board the vessel they are working on.

The general training that will lead to the certificate should include introduction to:

- Regulatory requirements for winches
- The general design and mode of operation of winches
- Control systems

- The different operation modes of the winch
- The winch's pulling power and its impact on stability
- Relevant anchor handling operations
- The function and mode of operation for the emergency release
- Maintenance routines
- The use of towing pins, shark-jaws and equipment for the release of torque forces in the wire

The NMD will assess whether such training shall be based on mechanical engineering education.

In January 2009, the NMD put forward a proposal for supplementary qualification requirements in Chapter V of the STCW Code, to IMO's Sub-committee on Standards of Training and Watchkeeping.

## 5.4 Direct emergency exit from the engine-room (13.4.4)

### 5.4.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.4.4 p. 139)*
*The "Bourbon Dolphin" had in all five emergency exits, of which four (two on either side) left the area under the main deck. This was in conformity with the requirements of the regulatory system. In the loss of the "Bourbon Dolphin" the chief engineer, the first engineering officer and the electrician perished. They were probably in the engine-room.*

*The Commission has received a suggestion from the next of kin to the effect that a direct emergency exit be created from the bottom of the engine-room that can be used in a capsize where the vessel is lying upside down. The Commission thinks the suggestion is interesting. It does, however, involve technical and practical challenges that demand further professional evaluation. The Norwegian Maritime Directorate, in collaboration with the industry, is requested to consider the suggestion further.*

### 5.4.2 Status of the regulatory system

#### 5.4.2.1 AT THE TIME OF THE ACCIDENT

According to the Fire Regulations, the SOLAS requirements shall apply, unless otherwise provided in these regulations or other current legislation. The Construction Regulations also refer to SOLAS.

Category A machinery spaces should have two escape routes from the machinery space leading to the open deck.

#### 5.4.2.2 TODAY

No amendments.

### 5.4.3 The NMD's evaluation

The NMD sees that such a solution in given situations may make the evacuation of persons who are inside the ship easier. As the Commission points out, however, the proposal implies more challenges, both of a technical and operational nature.

Technical challenges:

- If the emergency exit is going to be used without risking to lose buoyancy as a consequence of air pockets inside the ship, the emergency exits must be equipped with double locks so that personnel can be locked out without risking water filling and reduction in buoyancy
- Challenges related to design and construction
- General risk related to large hatch openings in the bottom of ships
- Maintenance

Operational challenges:

- Access to emergency exit when the vessel has capsized
- Improper use
- Safety for rescue personnel

The NMD has discussed the proposal with the industry and the Rescue Service.

The feedback from the industry is that a solution involving emergency exit from the engine-room should not be recommended on the basis of safety considerations. The industry is of the opinion that the priority should rather be given to the implementation of risk-reducing measures, and emphasizes in this connection the following:

- Systematic training and evacuation drills, especially from rooms under deck
- Well-marked exits and escape routes from the engine-room and other rooms under deck
- Control room located on the deck or on the bridge (wherever possible, depending on design)
- Unmanned engine-room/ E0
- Good operational routines

The Rescue Service informs that they will not let rescue personnel enter a vessel through an emergency hatch to the engine-room as this would entail an unacceptable risk for the rescue personnel.

### 5.4.4 The NMD's recommendation

After a detailed evaluation in collaboration with the industry, the NMD will not require such a solution at the time being.

Instead, the NMD requests the industry to assess the possibilities of risk-reducing measures. In connection with critical operations, contingency plans should ensure that the crew stays at the appointed stations. The NMD will further assess whether it may be appropriate to introduce requirements that the control room be located on the deck of the bridge.

# 6 EQUIPMENT (13.5)

## 6.1 Liferafts (13.5.1)

### 6.1.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.5.1 p. 139)*
*When the ship capsized only one of the six rescue floats [liferafts] released immediately. Subsequent observation of the casualty showed that a further four floats were released, while the sixth was released, but is caught in the vessel. Similar release mechanisms have since been tested with good functionality. There is therefore reason to believe that this mechanism functioned.*

*Since only one float came to the surface after the capsize, the placement or installation of the floats in the cradles probably prevented them floating up.*

*Commission considers that requirements should be made for placement that would ensure that floats were freed even when the vessel is in an upside-down condition. It should also be considered whether current installation requirements for floats are sufficient for various casualty situations.*

### 6.1.2 Status of the regulatory system

#### 6.1.2.1 AT THE TIME OF THE ACCIDENT

According to SOLAS, liferafts should be stowed with an arrangement which will ensure that the liferaft is released and floats up to the surface (a float-free arrangement). The arrangement shall be in accordance with the LSA Code, see also the Marine Equipment Regulations. The arrangement shall ensure that each liferaft is released and floats free, and inflates automatically if it is an inflatable liferaft, when the ship is sinking.

If a weak link is used to secure the release mechanism, this shall fulfil the requirements with regard to the strains to be tolerated and under what strain it should tear. If a hydrostat releaser is used, this shall, among other things, ensure the automatic release of the liferafts at maximum four metres depth.

According to SOLAS, the liferafts now don't have to be placed along the sides and the required capacity on each side can be obtained by moving liferafts.

It is also possible for cargo ships to have one or more enclosed lifeboats on each side of the ship in addition to one or more liferafts placed so that these can easily be moved from one side to the other on a single open deck.

Vessels less than 85 metres may as an alternative only be equipped with liferafts. There is a requirement for 100% coverage on each side, if the liferafts under given conditions easily can be moved from side to side. Otherwise, it should be 150% liferaft capacity on each side.

#### 6.1.2.2 TODAY

No amendments beyond the introduction of a maximum weight of 185 kg for liferafts that are to be moved.

### 6.1.3 The NMD's evaluation

The NMD has reviewed the requirements that are made for the placement and release of liferafts. The NMD has film recordings of the "Bourbon Dolphin" and can, based on this evidence, state that the liferafts are no longer located in the cradles in which they were placed. This indicates that the liferafts may have been released during, or after the capsizing, but that they may have been entangled by railings or other constructions as the vessel capsized.

The NMD's perception is that the problem is mainly related to the release from the vessel during the capsizing and not to the actual release mechanism. During a capsize, the vessel will, the way the liferafts were placed on the "Bourbon Dolphin", "be placed over" the liferafts on the port side when they are released and thus catch these liferafts. The liferafts on the starboard side should, however, have a better chance of floating up because the float cradle ends near the side of the ship. Turbulence from water currents may still have dragged the liferafts into constructions behind the wheelhouse. Improvement of float cradles may reduce these problems.

### 6.1.4 The NMD's recommendation

It is a general problem that the current regulatory system is based on ships that are lost by sinking. The requirement for life-saving appliances is that they should endure 20° list and 10° trim and capsizing is not mentioned. The lessons learned from the "Bourbon Dolphin" accident and other capsize accidents indicate that the regulatory system should be updated.

It is therefore proposed that the regulatory system for free float of life-rafts be amended so that the functional requirement also applies to capsizing in addition to sinking.

When it comes to capsizing, the NMD does not think that the moving of liferafts should be included in the regulatory system. The NMD therefore also

proposes that the regulatory system is amended so that there in the future will be requirements for sufficient float capacity on each side of a vessel, irrespective of length.

- For vessels less that 85 m, without lifeboats, this will mean 150% float capacity on each side.
- For vessels less than 85 m, for which lifeboats are required, this will mean 100% float capacity on each side.

As a starting point, the amendment is proposed to apply to vessels exposed to significant external forces, of the type anchor handling vessels, towing vessels and crane vessels.

Improvement of the float cradle and integration of float stations needs to be focused on early in the design phase. This will increase the possibility of liferafts floating freely, regardless of the course of the casualty. There are currently no known solutions that are adequate to ensure free float or release both in the event of sinking and capsizing. The industry must therefore be given time to develop solutions that meet the functional requirements.

## 6.2 Survival suits (13.5.2)

### 6.2.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.5.2 p. 140)*
*The "Bourbon Dolphin" had survival suits placed in all crew cabins and at the various workstations. The vessel was thus equipped with more survival suits than the regulatory system demands. The Commission has since evaluated the functionality of equivalent suits and notes that the suits may be difficult to use in an evacuation situation, among other things because their footgear is not very user-friendly. Particularly when a vessel is listing, it may be difficult to move. The better the functionality, the lower the threshold will be for donning the suit in an emergency.*

*The Commission would request the Norwegian Maritime Directorate to take an initiative to improve the suits.*

* The NMD's commentary: In addition to the requirement for survival suits for all persons on board, there is a requirement for extra survival suits on the bridge, in the engine control room and on remote work stations.

### 6.2.2 Status of the regulatory system

#### 6.2.2.1 AT THE TIME OF THE ACCIDENT

The survival suit shall comply with the requirements of the LSA Code, which inter alia contains provisions of importance to mobility in general and the functionality of footwear, cf. SOLAS and the Marine Equipment Regulations. There are, however, no requirements for the footwear to have a given friction so that a person is able to walk on sloping and slippery surfaces.

Thermal suits on passenger ships, cf. the Rescue Regulations (passenger ships), shall be so designed that the person wearing it can walk on a wet and oily ship deck. This should be tested on a deck sloping 15°.

#### 6.2.2.2 TODAY

The LSA Code was amended as of 1 July 2008. The amendment means that the inflation time of any built-in buoyancy chamber should be included in the two minutes it takes to unpack the survival suit and put it on.

### 6.2.3 The NMD's evaluation

The NMD has discussed the problem regarding footwear with survival suit manufacturers and test institutions.

Functional requirements for survival suits do not contain requirements for friction and testing in order for persons to safely walk on sloping and slippery

surfaces. The functional requirements are limited to climbing the ladder, the ability to perform normal duties during evacuation, to swim in and to enter a float. It must be possible to open and put on the survival suit in less than two minutes on board the vessel.

In 2002, the NMD completed the project "Improved personal rescue equipment 2002". The project resulted in a long list of recommended functional requirements, but did not include footwear.

In general, there is reason to note that regulations and requirements for evacuation and rescue are based on accidents involving sinking and given limits for list of 20° and trim of 10°. Capsizing is not mentioned in SOLAS or the other IMO instruments. The fact that capsizing happens very quickly and there is little or no time to put on a survival suit is a major challenge.

The functional requirements must be balanced and provide the best possible effect in a critical situation where normal evacuation is not possible. For a capsizing that happens in a few seconds, dressing on board will not be realistic. At the same time, the introduction of improved fit and footwear could mean increased dressing time.

When quick evacuation is required, from a situation that was considered to be normal, there is a great danger that persons are neither given the time to put on life-jackets or survival suits. It is especially not very realistic to expect that crews will enter the cabins to fetch survival suits.

### 6.2.4 The NMD's recommendation

At this time, the NMD does not propose amendments to the regulations governing this field. To improve the availability, the NMD recommends that life-jackets and survival suits are kept readily available in well ventilated and marked lockers/cabinets close to mustering stations, or wherever the company deems most appropriate based on an evaluation of quick and safe evacuation. This is in addition to those that shall be placed on the bridge and at working stations.

For work on deck on anchor handling vessels, supply vessels and similar vessels where operations are carried out on the open deck, the NMD recommends the use of work clothes with buoyant and thermal properties.

When it comes to functional requirements for footwear, the NMD believes that this must be studied further and proposes that a project is established, in which the lessons learned from accidents and the knowledge from development, testing and production is assessed in relation to the advantages and disadvantages amendments to functional requirements may provide.

A new evaluation of the functional requirements may also be important in terms of the increasing offshore activity in arctic areas with lower

temperatures and demanding wind and wave conditions. Such a project will also be of importance to the fishing industry and a future arctic liner trade.

## 6.3 EPIRB (13.5.3)

### 6.3.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.5.3 p. 140)*
*The emergency transponder [EPIRB] was placed on the wheelhouse roof. As far as the Commission is aware, the emergency transponder failed to release*
*when the vessel capsized and float up to the surface as intended. Since there were many vessels in the vicinity, this was of no significance for the rescue operation. Without vessels in the immediate vicinity, signals from such a transponder would have been of crucial significance for rapid location of the casualty.*

*The Commission is aware of the problems related to release of emergency transponders, and would request the authorities to evaluate the placement and release mechanisms of such transponders.*

### 6.3.2 Status of the regulatory system

#### 6.3.2.1 AT THE TIME OF THE ACCIDENT

The Radio Regulations, which are based on SOLAS, make requirements for both float-free and manual satellite EPIRBs. The float-free satellite EPIRB shall be installed so that it will have the best possible chance of floating freely up to the surface without risk of being caught by obstructions such as railings, superstructures, etc., if the ship should sink. A manual satellite EPIRB shall be installed in the wheelhouse.

The manual satellite EPIRB can be left out if the float-free EPIRB may be activated by remote control from the wheelhouse and has been installed in such a way as to allow manual activation and a person to bring it to a survival craft, without exposing that person to danger. There are no requirements for remote activation in SOLAS.

The installed float-free satellite EPIRB should be designed to release itself and float free up to the ocean surface before reaching a depth of four metres at a list or trim of any angle. The installed EPIRB should be capable of operating properly over the range of shock, vibrations and other environmental conditions normally encountered in the ship's areas of operation.

The equipment shall be type-approved, cf. the Marine Equipment Regulations.

#### 6.3.2.2 TODAY

No amendments.

### 6.3.3 The NMD's evaluation

The NMD has reviewed video recordings of the "Bourbon Dolphin" after it sank. The NMD has not succeeded in identifying the EPIRB on these recordings. The NMD is therefore of the opinion that the EPIRB has been released, either during the capsizing or later when the vessel sank. It is certain that no signals were intercepted from the EPIRB after the accident.

If the EPIRB was released during the capsizing, it may, in the same way as for the liferafts, have been caught by edges on the roof of the wheelhouse or dragged into openings and therefore not emerged to the surface.

If it was released and floated up after the vessel sank three days later, it would no longer be sending signals. The transmission is activated upon contact with water and the lifetime for the EPIRB battery is at least 48 hours according to the test requirements.

EPIRBs were introduced to quickly locate vessels that are lost. The current Norwegian regulatory system requires one float-free EPIRB and one manual EPIRB which the officer of the watch shall bring to the survival craft.

Discussions indicate that in the case of evacuation priority is not given to bringing along the manual EPIRB. The reason for this is partly because the VHF radio and other equipment also should be brought to the survival craft at the same time as alarms are activated, life-jackets put on, etc.

The float-free satellite EPIRB is therefore of great importance.

Systems for ejection may ensure that the EPIRB is effectively separated from the vessel, but are not easy to release unless remote-mounted hydrostats with diagonal release or similar are arranged so that the EPIRB can be launched freely before it is submerged into the water.

At the same time, the release of the transponder should not happen unintentionally due to rainwater or sea spray.

### 6.3.4 The NMD's recommendation

The "Bourbon Dolphin" disaster shows that there is a need for improvements when it comes to the location and release functions of EPIRBs during capsizing.

The NMD proposes, through regulatory amendments, to require two EPIRBs, installed on the outer sides of either the roof of the bridge or on the bridge wings of vessels required to be equipped with float-free EPIRBs. This will increase the possibility of at least one of them floating up to the surface if the vessel should sink or capsize. It is of great importance that an EPIRB can easily be brought to a survival craft.

If this condition can not be satisfied, a third, manual EPIRB must be installed in the wheelhouse.

The NMD proposes new additional requirements so that the float-free function will cover both sinking and capsizing, as well as the introduction of at least two float-free EPIRBs, as outlined above.

The NMD has opened a dialogue with the Norwegian manufacturer Jotron AS about release mechanisms for float-free EPIRBs that can be released faster than existing mechanisms.

## 6.4 Voyage data recorder (VDR) (13.5.4)

### 6.4.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.5.4 p. 140)*
*The IMO has introduced requirements for voyage recorders for vessels over 3,000 tonnes, entering into force on 1 January 2008 for existing vessels. In the Commission's opinion such a requirement should be introduced also for rigs and smaller vessels. Sound recovery can secure important information, for example documentation of the instructions issued by the towmaster. It can also make important contributions to clarification of other situations that arise, for example delays, loss of equipment and so forth.*

### 6.4.2 Status of the regulatory system

#### 6.4.2.1 AT THE TIME OF THE ACCIDENT

The Navigation Regulations require that cargo ships of 3,000 gross tonnage and upwards shall be provided with a voyage data recorder (VDR).

This requirement also applies to Norwegian mobile offshore units of 3,000 gross tonnage and upwards.

#### 6.4.2.2 TODAY

SOLAS V/20 is amended so that cargo ships constructed prior to 1 July 2002 as an alternative to VDR may be provided with S-VDR (simplified voyage data recorder).

The amendment does not apply to ships constructed on 1 July 2002 or later.

### 6.4.3 The NMD's evaluation

The proposal for the introduction of VDR for ships of less than 3,000 gross tonnage has been discussed with the industry. It is deemed appropriate to introduce a requirement for S-VDR for such ships.

### 6.4.4 The NMD's recommendation

The NMD proposes to introduce a requirement for S-VDR for all supply vessels, anchor handling vessels, tugs, crane ships and offshore service vessels from 300 gross tonnage to 3,000 gross tonnage.

The NMD has evaluated the need for easy and fast access to data after an accident. It is proposed that data from the storage unit is copied to a storage unit in the float-free EPIRB.

# 7 REQUIREMENTS FOR THE COMPANYS' SAFETY MANAGEMENT (13.6)

## 7.1 Vessel-specific anchor handling procedure (13.6.1)

### 7.1.1 Problem as described by the commission

*(Cf. 4.7.3 p. 42)*
*An anchor-handling procedure can describe what is to be done, in what way the operation is to be done, what forces the vessel can handle and how they are to be handled, operational limitations, who is to do what, when the various operations are to take place and so on. The procedure, which is a necessary aid to identification and handling of the risks, should be vessel-specific.*
*In the Commission's opinion the company's general manual cannot replace an anchor-handling procedure, not even when supplemented by an RMP.*

### 7.1.2 Recommendation from the Commission

*(Cf. 13.6.1 p. 140)*
*Anchor-handling procedures ought to be prepared by the companies, and they ought to be vessel-specific.*
*Procedures should also include requirements for the crew's undertaking of assessments of expected mooring-line forces as described in the rig move procedure.*
*Companies should moreover ensure that the crews are competent to perform risk assessments.*

### 7.1.3 Status of the regulatory system

#### 7.1.3.1 AT THE TIME OF THE ACCIDENT

According to the ISM Code, cf. the ISM Regulations, procedures shall be established for the preparation of plans and instructions for key operations. The Code is also intended to ensure that the need for training is identified and that necessary training is given.

The Working Environment Regulations contain requirements for regular risk assessments to identify risks.

#### 7.1.3.2 TODAY

The identification of risks and risk control is emphasized in the Ship Safety and Security Act in connection with the safety management system requirement. The company shall ensure that a safety management system is established, implemented and developed. The master and other persons working on board have a duty to participate.

The immediate measures address the need for training on vessel capacity. The NIS/NOR Circular No. 7/2007 provides guidelines for ISM audits for anchor handling vessels.

### 7.1.4 The NMD's evaluation

Issues related to anchor handling procedures in a vessel's safety management system have been discussed with the industry and the classification societies which have carried out ISM audits on such vessels. The NMD has compared the practice for vessel-specific procedures in general.

To evaluate the practice of procedures in the industry, unscheduled inspections of anchor handling vessels have been conducted. Anchor handling procedures from three different companies have further been reviewed. These manuals are general and are distributed to all anchor handling vessels in the respective companies. The manuals were updated according to the immediate measures of 15 May 2007 from the NMD. None of these manuals could be accepted as the ships' own specific procedures for anchor handling, even though the descriptions are good.

The Anchor Handling & Towing Manual which formed the basis for the operations on the "Bourbon Dolphin" was part of the vessel's safety management system. The anchor handling manual which formed the basis for the operations is in part a good starting point, but it lacked a vessel-specific procedure. In the NMD's opinion, such a procedure should, among other things, include:

- Details about the vessel's capacity in relation to heeling moment from the forces of towing and lifting in relation to the vessel's stability.
- A description of how the forces for the launching and deployment of the anchor that are presented in an anchor handling plan should be assessed in relation to the vessel.
- Guidelines for the evaluation of the criteria for waves, wind and current that are the basis of the rig move plan.
- A description of how vessels can be manoeuvred safely in different weather conditions and ocean currents combined with anchor handling.
- Guidelines for utilization of engine power and requirements for suspension or alternative plans.
- Guidelines for the review of relevant suspension criteria and evaluation of alternative operations, as well as how this is to be communicated to the rig or other vessels in joint operations.
- References to the necessary expertise and details concerning risk assessment.

### 7.1.5 The NMD's recommendation

The NMD supports the recommendations from the Commission. The requirement is covered by the ISM Code, cf. the ISM Regulations, through requirements for procedures for key operations.

The NMD has, by providing information to the industry, cf. NIS/NOR Circular 7/2007 and RSV 04/2008, emphasized that the safety management for anchor handling and other special operations shall be in accordance with requirements and intentions of laws and regulations. The work will be continued in accordance with the recommendations in the report.

The NMD will intensify and increase the number of audits of classification societies, especially with a view to ISM.

Moreover, the NMD will initiate the establishment of a co-operative forum for parties delegated authority to approve and audit safety management systems.

## 7.2 Overlap/familiarisation/handover (13.6.2)

### 7.2.1 Problem as described by the Commission

*(Cf. 4.7.1 p. 41)*
*In the Commission's opinion, it is necessary that at least personnel in senior posts go overlap for a certain period. It is, moreover, common practice in the industry that officers go overlap, anything from a few days to a couple of weeks. The Commission would also emphasise that they were facing a demanding operation in deep water. The time used was clearly an insufficient familiarisation basis within the meaning of the Qualification Requirements. For subordinate crew such a timeframe may be sufficient, but particularly for a master, with paramount responsibility for the safety of the crew and vessels, overlap of a certain period will be necessary.*

### 7.2.2 Recommendation from the Commission

*(Cf. 13.6.2 p. 141)*
*Safety management systems should have barriers that mean that a master who has not previously been on board a vessel is given a certain form of overlap and familiarisation (induction). It is not sufficient that the master comes from another of the company's vessels.*

*In the same way, it is important that companies and operators facilitate the allocation of sufficient time for handover in a crew change. The crew changes must ensure that there is time for a sufficient review not only of the vessel's and the equipment's technical condition, but also for information about the operation with which the vessel is in progress.*

### 7.2.3 Status of the regulatory system

#### 7.2.3.1 AT THE TIME OF THE ACCIDENT

Requirements for safety management in accordance with the ISM Code, cf. the ISM Regulations, apply and the company is obliged to implement procedures to ensure that "new personnel and personnel transferred to new assignments related to safety and protection of the environment are given proper familiarization with their duties.". It further states that "Instructions which are essential to be provided prior to sailing should be identified, documented and given."

According to the Qualification Regulations, which refer to the STCW Convention and the STCW Code, the company and the master are responsible for ensuring that "seafarers, on being assigned to a ship, are familiarized with their specific duties and with all ship arrangements, installations, equipment, procedures and ship characteristics that are relevant to their routine or emergency duties".

According to the STCW Code, the company shall provide written instructions to the master of each ship, setting forth the policies and the procedures to be followed to ensure that all seafarers who are newly employed on board the ship are given a reasonable opportunity to become familiar with the shipboard equipment, operating procedures and other arrangements needed for the proper performance of their duties, before being assigned to those duties.

The Watchkeeping Regulations prescribe duties for the watch handover between the officer in charge of the navigational watch and the relieving officer.

#### 7.2.3.2 TODAY

According to the Ship Safety and Security Act, the master shall, among other things, ensure that necessary information about the ship, duties, basic environmental and safety provisions is given to other persons employed on board upon the commencement of work or assignment of work tasks. The immediate measures emphasize that all information about the vessel's capacity shall be communicated to the crew.

### 7.2.4 The NMD's evaluation

The Commission's proposal has been discussed with the industry and evaluated by the NMD.

### 7.2.5 The NMD's recommendation

The current regulatory system covers the problems pointed out by the Commission. As the problem is a part of the safety management system, the NMD will, in connection with the follow-up measures described under item 7.1.5, also bring attention to factors surrounding overlap, familiarisation and crew change. In future audits, cf. chapter 3.4, companies have to verify that they have fulfilled their obligations with respect to the above-mentioned.

## 7.3 Identify need for qualifications (13.6.3)

### 7.3.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.6.3 p. 141)*

*Anchor-handling is a demanding maritime operation and makes requirements for extended expertise in comparison with ordinary supply activity. An anchor-handling operation includes complicated winch operations, connection of heavy equipment and mastery of big external forces. When anchor-handling is to be done in great water depths under challenging sea, current, and wind conditions, it demands expertise far beyond the STCW Convention's minimum requirements. Of particular importance is a high level of expertise on the part of the senior officers of the watch on the bridge (the master and chief officer) to handle safe operation of the vessel. Any lack of experience must be compensated for by adding extra experienced personnel.*

*Safe anchor-handling also makes requirements for qualifications, among other things in the use of load calculator and other computer programs, including weight and power calculations. Such expertise and qualifications should be defined in a company's safety management system. Companies must also ensure that time and money are allocated to the implementation of sufficient training and expertise enhancement in these areas.*

### 7.3.2 Status of the regulatory system

#### 7.3.2.1 AT THE TIME OF THE ACCIDENT

According to the ISM Code, cf. the ISM Regulations, the company should "establish and maintain procedures for identifying any training which may be required in support of the safety management system and ensure that such training is provided for all personnel." The company should therefore, for each activity or operation, assess whether there is a need for specific expertise beyond the minimum requirements of the STCW Convention. The requirement applies specifically to the assessment of the need for qualifications.

The Working Environment Regulations prescribes requirements for training or information from the perspective of personal safety, health and working environment for the individual persons working on board ships.

#### 7.3.2.2 TODAY

According to the Ship Safety and Security Act, any person who is working on board must have the qualifications and certificates required for the relevant position or the work to be performed.

### 7.3.3 The NMD's evaluation

The company is responsible for ensuring that the personnel who are to serve on board possess the necessary qualifications. According to the ISM Code, the company is obliged to provide the necessary expertise, even beyond the requirements of the STCW Convention, so that the vessel operations can be performed safely.

Anchor handling is a demanding operation, involving combinations of lifting and towing of mooring lines and anchor, often together with running of the winches on a mobile offshore unit and in some cases also with several vessels on the same mooring line. In addition, a number of different loading options, combined with different weather conditions, ocean currents and wind are conditions that need to be assessed.

It is important to put the number of experienced seamen in connection with the rapid development of special marine operations. This will mean that the importance of special education and training is increasing.

#### 7.3.4 The NMD's recommendation

According to current regulations, the company is responsible for ensuring that the crew has adequate training and qualifications. Even though information in English is considered adequate, the NMD will consider requiring that safety critical information is made available in the crew's primary language.

# 8 POB LISTS (13.7)

## 8.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.7 p. 141)*
*During the rescue work after the accident it was discovered that duty-holder and the operator did not know how many people were on board the "Bourbon Dolphin" and who they were.*
*When a vessel is contracted, the companies must therefore ensure that the operator and duty-holder at all times have complete lists of the crews on the individual vessel. The lists must be continuously updated electronically.*

## 8.2 Status of the regulatory system

#### 8.2.1 At the time of the accident

As set out in the ISM Code, cf. the ISM Regulations, in connection with requirements for the company's emergency preparedness, the company should have an updated list of the crew and any other persons that may be on board. As a minimum, the list must contain the number and identity of

persons on board. The company shall ensure that such a list is available wherever deemed appropriate, that changes are approved and that old lists are immediately removed. The documentation shall have such a form as the company considers most effective. The ISM Regulations apply to both vessels and mobile offshore units.

In the Petroleum Safety Authority's Activities Regulations there is a requirement that the operator shall ensure that there exists at all times a complete list of all persons staying on or on their way to or from a facility or a vessel participating in petroleum activities.

#### 8.2.2 Today

No amendments.

### 8.3 The NMD's evaluation

The NMD states that the petroleum legislation makes a requirement that the operator must have information about personnel participating in operations. For vessels participating in operations on the Norwegian continental shelf, this issue is thus covered.

### 8.4 The NMD's recommendation

The NMD supports the Commission's recommendation and finds it natural that issues concerning POB lists and the distribution of these are agreed upon in connection with assignment reviews.

For activity outside the Norwegian shelf, it is considered appropriate that a practice in line with the petroleum legislation is incorporated in, for example, the NWEA guidelines.

## 9 PLANNING OF THE RIG MOVE (13.8)

### 9.1 Problem as described by the Commission

*(Cf. 12.3.3 p. 131)*
*In Chapter 6 the Commission evaluated the planning of the operation. The plan and the procedures contained weaknesses on a number of points and lacked reference to assessments of risk in planning and performance of the operation. This applied particularly to estimation of expected forces. The Commission has pointed out a failure to incorporate sufficient margins to take account of static and dynamic forces on the mooring lines (chains and wire) due to weather, wind and current during recovery and deployment of anchors. Nor was there sufficient reflection over the fact that the need to relieve the rig's winches by use of a two-boat method would cause increased risk for the vessels, which could have created greater problems than it actually did. The Commission has also demonstrated that the plan did not contain any clear weather criteria. The operator, the rig company and consultancy firm had allocated the various functions and*

*assignments in connection with the planning. The focus of the planning appears to have been directed particularly at the needs of the rig, its mooring and safety. Over and above specifying requirements for bollard pull, there was little attention paid to the vessels that were to be involved.*

## 9.2 Recommendation from the Commission

*(Cf. 13.8 p. 141)*
*The operator has the paramount responsibility for the safety of the entire operation. Rig moves must be planned and implemented pursuant to applicable requirements and guidelines. The procedure must reflect the realistic forces to which the vessels can be exposed. They must make sure that sufficient time is allocated to preparations before the operation commences, so that the vessels are guaranteed the necessary understanding of what it involves. All offshore operations are very expensive. Time is thus a critical factor. It is important that for example the weather requirements are clear and unambiguous, so that no disagreement arises as to when an operation can be initiated or suspended. The procedure must be operation-specific and easy for those who are to carry it out to understand. The Commission has discovered that no explicit risk assessments were prepared for the operation. Use of risk analyses in the planning phase establishes safety barriers. These may be of a technical, operational and expertise nature.*

## 9.3 Status of the regulatory system

### 9.3.1 At the time of the accident

For activities on the Norwegian continental shelf, anchor handling operations are regarded as petroleum activities, cf. the Act relating to petroleum activities. The responsibility for the operation is detailed in the petroleum legislation, where the operator has a paramount responsibility to ensure that anyone performing work for him complies with requirements prescribed by statute. This responsibility also includes the operator's own activity. Moreover, anyone participating in petroleum activities is responsible for ensuring compliance with the regulatory system by the implementation of systematic measures. According to the Petroleum Safety Authority's Activities Regulations, the responsible persons pursuant to the Framework Regulations are responsible for preparing a RMP.

According to the NMD's regulatory system, the Seaworthiness Act contained a requirement to keep the ship in a seaworthy condition. The NMD Anchoring Regulations had a requirement for interaction between the person in charge of the operation and operators of vessels when considering weather conditions and safety. Moreover, each vessel and unit had a requirement for risk assessments in relation to the safety management system.

There was an industry practice aimed at the operator and rig, which was meant to apply to the North West European Area (NWEA). The ISM Code

contains a requirement for the company to take into consideration standards prepared by, among others, organizations in the maritime industry.

### 9.3.2 Today

The Ship Safety and Security Act contains requirements for risk assessments. The industry standard NWEA is being revised. The immediate measures also address issues related to planning.

## 9.4 The NMD's evaluation

The accident in question occurred outside the Norwegian continental shelf. The installation that was to use the mooring system was not flying a Norwegian flag. Two of the hired anchor handling vessels were, however, Norwegian. The experience from the accident shows that weaknesses in planning and lack of compliance with plans, may lead to a lack of clarity when a situation occurs and when and why an operation should be suspended.

Requirements for planning criteria from the operator, internal for the installation, industry standards (NWEA) and for vessels were not complied with in areas that were important for the vessels. This means that the experience and expertise that these requirements and guidelines are based on are being neglected. The Commission has described this in its report.

The conclusion is that emphasis was put on the primary outcome, which is safe mooring, and on previously experienced accident conditions, such as anchor holding force, anchor equipment damage, collision with rig, fracture of auxiliary wire, as well as personal accidents on deck.

Although there was information about dynamic forces and guidelines for follow-up and collaboration during the process, these were not adequately aimed towards the safety of the anchor handling vessel.

## 9.5 The NMD's recommendation

The NMD believes that a requirement should be introduced that mooring plans take account of all relevant factors that may affect safety, both to the unit to be anchored and the anchor handling vessels that are engaged in the process. For the planning to be consistent, the characteristics of the anchor handling vessels to be used must be included in the planning, and all relevant criteria must be taken into account when a vessel is contracted.

The basis for the selection of anchor handling vessels must be changed to include information about:

- Calculated requirements for net bollard pull including dynamic additional forces
- Calculated requirements for manageable tensions included dynamic additional forces

- The different cargoes to be carried on the vessel in connection with the assignment

All operations as regards loads, bollard pull and manoeuvring shall be risk assessed. The results should be listed and relevant forces and suspension criteria limit values for single loads and combined loads should be indicated. The plans that are approved and form the basis for breakaway, relocation and mooring shall be made known to and discussed with key personnel on all involved vessels.

In the draft new Anchoring Regulations for mobile offshore units, the following is included:

- Anchor handling shall not commence if the platform manager or masters on anchor handling vessels decide that the weather conditions are, or may become, so poor that the safety of the crew, installation or anchor handling vessel is jeopardized.
- The planning of the anchor handling operation shall at least include a calculation and analysis of forces that may occur on mobile offshore units and anchor handling vessels, including environmental loads such as wind, waves and ocean currents. Risk assessments must be carried out in collaboration with relevant personnel from other organizations in order to reveal critical aspects of the mooring process, including coordination with anchor handling vessels. Clear procedures shall be prepared for the operation and the suspension criteria shall be defined.
- Those in charge of the anchor handling and positioning shall continuously check if the anchoring is done in accordance with the preconditions in the analysis. Furthermore, there must be a system documenting that the operation is safe and in compliance with the requirements of this Regulation and the preconditions of anchoring and positioning calculations.

Some of the proposed requirements should be reflected in the petroleum legislation, so that the paramount responsibility of the operator is exercised in the same way as the responsibility laid down in the NMD regulatory system.

# 10 EXECUTION OF THE RIG MOVE (13.9)

## 10.1 Start-up meeting and communication (13.9.1)

### 10.1.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.9 and 13.9.1 p. 140-142)*
*Demand for efficiency must never be at the expense of safety.*
*In the implementation, safety and coordination must be subject to continuous evaluation. It is important that the individual vessel and not*

*least the operator has insight and understanding of what tasks can be imposed on the individual player on the basis of the vessel's capacity and the crew's experience.*

*Under the NWEA guidelines a start-up meeting should be held in advance of the operation. The guidelines do not contain any further requirements as to who shall be present. In Section 61A of the Norwegian OLF guidelines, however, it is recommended that operational personnel from the rig, the operator and the vessels meet, but this practice is not always followed on the Norwegian Shelf. The Commission considers that it must be a mandatory requirement that the operator ensures that the necessary time is allocated for a joint meeting onshore before the operation commences. The RMP shall be submitted to the vessel and the company in advance of such a meeting.*

*Operators must ensure that risk analyses are prepared by the vessels before they start the operation, which was not done in this case, but which follows from the NWEA guidelines. The rig must also get access to the analyses.*

*Communication between the vessels and the rig is over an open VHF channel. All involved have access to this channel. The working language shall be common. It is important that communication be used actively and that what is said is understood by all. Communication is important for creating trust and a positive attitude, and can help everyone to feel secure during the operation. The towmaster has a key role in this, but the masters and officers on the vessels are also important contributors. According to a report from the Danish Commission of Inquiry (the Danish Maritime Authority), after the "Stevns Power" accident it was discovered inter alia that the routines for safety cooperation during the operation were defective.*

### 10.1.2 Status of the regulatory system

#### 10.1.2.1 AT THE TIME OF THE ACCIDENT

The Anchoring Regulations in force for Norwegian installations did not make any requirements for cooperation between those involved beyond requirements for a joint evaluation of the weather conditions. The maritime regulatory system has a requirement through the safety management system that cooperation during the operation shall be planned and followed up through the operation of the ship, cf. the ISM Code.

#### 10.1.2.2 TODAY

No regulatory amendments. However, the immediate measures address this problem.

### 10.1.3 The NMD's evaluation

The authorities should provide safety objectives and functional requirements that shall form the basis of planning and the execution of mooring. It is then

up to the individual responsible organization and the person in charge of the assignment to follow this up. The NMD considers it beneficial that the industry jointly develops and maintains standards relating to this, as for instance the NWEA guidelines.

In any case, all relevant factors shall be addressed explicitly in the planning, with clear suspension criteria for the operation in question. References to "best practice" documents will not be considered adequate in this connection, even if the criteria were the same.

#### 10.1.4 The NMD's recommendation

In the draft new Anchoring Regulations, the NMD has for its jurisdiction put focus on a clearer requirement for cooperation between the parties during the performance of the operation.

For operations on the Norwegian continental shelf, the petroleum legislation also applies, and it is left to the administrative authority to assess, in line with expressed political guidelines, the need for follow-up.

### 10.2 Tandem operations (13.9.2)

#### 10.2.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.9.2 s. 142)*
*When two or more vessels are working together during an operation, it is not sufficient to focus on the safety of the individual vessel alone. The vessels are facing different challenges and requirements. At the same time, they are dependent on one another to carry out the operation. In this form of operations the individual's area of responsibility cannot be restricted to his own vessel.*

#### 10.2.2 Status of the regulatory system

##### 10.2.2.1 AT THE TIME OF THE ACCIDENT

Under the ISM Code, the company's procedures should ensure that plans and procedures are prepared for key operations. A plan for tandem operations must also take account of the other vessel.

##### 10.2.2.2 TODAY

No amendments. The immediate measures also address this problem.

#### 10.2.3 The NMD's evaluation

Tandem operations or other multi-vessel operations take place in different circumstances, also during the recovery of anchors that have been set out in advance and in connection with ploughing/dredging. The safety of such operations is not covered in detail by the current regulatory system. The immediate measures address the problem, with reference to the ISM Code,

and take into account that the operations must be planned in such a way that each vessel is safe no matter what may happen with the other vessels. It is further in the nature of such an operation that the preparation of such a plan should be done jointly between the participants in the operation.

#### 10.2.4 The NMD's recommendation

The NMD will propose that the following is incorporated in the relevant regulations:

- Tandem operations and other multi-vessel operations should be planned and risk assessed based on the forces and manoeuvring challenges that may arise.
- An overview of the operations shall be prepared, indicating the maximum forces and weather-related restrictions that are taken into account for the operation and a plan for how the operation should be suspended if the criteria are exceeded.
- The plan shall contain information about vessels with managerial responsibility and how all the vessels should communicate.
- Arrangement related measures and conditions for safe operations.

## 10.3 Attention zones for running-out of anchors (13.9.3)

#### 10.3.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.9.3 p. 142)*

*An attention zone should be introduced along mooring lines that indicate a maximum distance that the vessel shall observe when running out anchors. If the zone is violated, the vessel must report to the rig and explain the cause. At the same time, the towmaster should be mandated to demand an explanation of the situation. If the vessel, with normal use of thrusters, is unable to keep inside the zone, measures shall be observed. The width of the zone and what measures are to be taken must be apparent from the RMP.*

#### 10.3.2 Status of the regulatory system

##### 10.3.2.1 AT THE TIME OF THE ACCIDENT

The Petroleum Safety Authority's regulations contain no requirements for attention zones in connection with anchor handling in the petroleum activity, except that the operation as a whole must be justifiable in terms of safety. There are no separate requirements for attention zones in the NMD regulations.

##### 10.3.2.2 TODAY

No amendments.

#### 10.3.3 The NMD's evaluation

The NMD finds it natural that the planning of maritime operations includes defined control limits that describe which margins the operation has been planned to deal with. If the control limit is exceeded, agreed procedures shall be made available to ensure that the operation can be brought under control or suspended.

The control limits shall be part of the overall operation plan. As for other limit criteria provided in the plan, routines for reporting and measures shall be made available to address safety.

### 10.3.4 The NMD's recommendation

In the draft new Anchoring Regulation, the NMD has incorporated supplementary provisions that attempt to focus on improved planning and execution of the operation, where deviations from planned and agreed criteria should lead to suspension of the operation. As an example, movement outside the specified attention zone can be a suspension criteria.

# 11 DUTY OF NOTIFICATION OF MARITIME ACCIDENTS OUTSIDE NORWEGIAN TERRITORY (13.10)

## 11.1 Problem to be addressed and recommendation from the Commission

*(Cf. 13.10 p. 142)*
*The Commission is aware that Norwegian authorities are looking more closely at requirements for a duty of notification in connection with contraventions of Chapter 18 of the Maritime Act. The Commission will leave it to the authorities to consider the scope of this duty further.*

## 11.2 Status of the regulatory system

### 11.2.1 At the time of the accident

At the time of the accident, the Norwegian Maritime Code as it read prior to 1 July 2008 regulated the notification and information on accidents. The implementation of the rules was further described in the Regulation.

In this Regulation, it was described that the owner or the master of the ship should contact the maritime investigator concerned as soon as possible after incidents necessitating a maritime inquiry. Furthermore, in the case of ″serious casualties of such extent that it may be assumed to be necessary to appoint a special commission of inquiry″ the owner or master of the ship should contact the Norwegian Maritime Directorate immediately.

### 11.2.2 Today

Today there is a new Regulation concerning the duty to notify and report in connection with incidents at sea.

This Regulation applies to Norwegian ships, as well as to foreign ships in Norwegian waters, and regulates the notification of accidents, near accidents and pollution.

Under this Regulation, the master or company shall, without delay, notify the Joint Rescue Coordination Centre (JRCC) about certain incidents. The JRCC will communicate notifications of incidents to the concerned agencies, such as the NMD, the Norwegian Coastal Administration and the Police.

The Regulation further requires the master or company to report the incident in writing to the NMD.

## 11.3 The NMD's evaluation

The new Regulation defines the duty to notify and report after incidents and makes it clear that near accidents of a certain character shall be reported to the NMD.

# 12 OTHER MEASURES

Chapter 12 deals with the NMD's handling of measures in addition to the recommendations that are published in the Commission's report.

## 12.1 Stability instruments

The Commission has not prepared definite proposals regarding stability instruments, but mentions training in the use of stability instruments:

> *(Cf. 13.6.3 p. 141)*
> *Safe anchor-handling also makes requirements for qualifications, among other things in the use of load calculator and other computer programs, including weight and power calculations. Such expertise and qualifications should be defined in a company's safety management system.*

### 12.1.1 Status of the regulatory system

#### 12.1.1.1 AT THE TIME OF THE ACCIDENT

The NMD regulations contain no requirements for stability instruments. If stability instruments are used on board, they shall, according to the Safety Measures Regulations, be presented to the NMD for approval.

If a classed ship has stability instruments, this will be approved by the classification society concerned.

The Qualification Regulations do not contain specific qualification requirements for the crew when it comes to expertise in the use of stability instruments. The STCW Code, in relation to stability, contains a requirement for deck officers on ships of 500 gross tonnage and upwards to have working knowledge of "stress-calculating equipment". At the management level, masters and mates shall have knowledge on the use of "stress-calculating equipment", including automatic data based equipment.

The safety management system shall ensure that necessary training is given in the use of the ship's equipment, cf. the ISM Code.

#### 12.1.1.2 TODAY

No amendments. The Ship Safety and Security Act contains general provisions regarding familiarisation and qualifications.

### 12.1.2 The NMD's evaluation

The NMD has held meetings with stability instrument manufacturers and discussed the issue with the industry.

### 12.1.3 The NMD's recommendation

The NMD recommends that, through regulatory amendments, requirements for installation and certification of stability instruments are introduced for all supply vessels, anchor handling vessels, crane vessels and offshore service vessels of 500 gross tonnage and upwards.

Stability instruments must be adapted to the new stability requirements that are proposed. The instrument shall, based on tank readings and input values for, among other things, deck cargo and weight of wire on the winches, as well as the angles α and β, be able to calculate maximum permissible tension in the mooring line. Stability instruments shall be used as a tool during planning of the operation, and to verify the planned operation.

Since stability instruments are not planning tools, they should not be linked to the measurement of tension in the mooring line.

The NMD will further recommend, through regulatory amendments, that crews who will be using stability instruments are given the necessary training.

# 13 OVERVIEW OF PROPOSALS FOR SAFETY MEASURES

Table 1 shows an overview of the fields that are dealt with in the report and appurtenant safety measures.

| Section | Field | Measure | National/international follow-up |
|---|---|---|---|
| 4.1<br>Stability calculations | Criteria and loading conditions for anchor handling | Regulatory amendment | Construction Regulations<br>Safety Measures Regulations<br>IMO-MSC/SLF |
| 4.2 Stability booklet | Information about vessel stability | Regulatory amendment | Construction Regulations<br>Safety Measures Regulations<br>IMO-MSC/SLF |
| 4.3<br>Training and operation | Competence in the field of stability and manoeuvring | Regulatory amendment | Qualification Regulations<br>Manning Regulations<br>IMO-MSC/STW |
| 5.1 The bollard pull certificate | Bollard pull in anchor handling | Regulatory amendment | Construction Regulations<br>IMO-MSC/DE |
| 5.2<br>Requirements for the winch package | Emergency release and testing | Regulatory amendment | Construction Regulations<br>IMO-MSC/DE |
| 5.3<br>Certification of winch operator | Competence on winches and equipment | Regulatory amendment | Qualification Regulations<br>Manning Regulations<br>IMO-MSC/STW |
| 5.4<br>Direct emergency exit from the engine-room | Emergency exit from the bottom of vessels | Recommendations | Navigare<br>(safety notice) |
| 6.1<br>Liferafts | Placement and functional requirements | Regulatory amendment | Rescue Regulations<br>IMO-MSC/DE |
| 6.2<br>Survival suits | Placement and functional requirements | Recommendations<br>Further consideration | Navigare<br>(safety notice) |
| 6.3<br>EPIRB | Placement and functional requirements | Regulatory amendment | Radio Regulation<br>IMO-MSC/COMSAR |
| 6.4<br>Voyage data recorder | Voyage data recorder for ships and mobile offshore units of less than 3,000 gross tonnage | Regulatory amendment | Navigation Regulation<br>IMO-MSC/NAV |

| Section | Field | Measure | National/international follow-up |
|---|---|---|---|
| 7.1<br>Vessel-specific anchor handling procedure | Contents of procedure for key operation | Recommendations, information, audits and establishment of co-operative fora | Instruction Circular (RSV)<br>NIS/NOR Circular |
| 7.2<br>Overlap/ familiarisation/ handover | Familiarisation with vessel and operation for new crews | Information, audits and co-operative fora | Instruction Circular (RSV)<br>NIS/NOR Circular |
| 7.3<br>Identify need for qualifications | Identify the need for training | Recommendation | Instruction Circular (RSV)<br>NIS/NOR Circular |
| 8<br>POB lists | Emergency preparedness | Recommendation | Navigare<br>(safety notice) |
| 9<br>Planning of the rig move | Relevant considerations, risk assessments and communication | Regulatory amendment | Anchoring Regulations<br>(and the petroleum legislation) |
| 10.1<br>Start-up meeting and communication | Cooperation between involved players | Regulatory amendment | Anchoring Regulations<br>(and the petroleum legislation) |
| 10.2<br>Tandem operations | Cooperation between involved players | Regulatory amendment | Safety Measures Regulations |
| 10.3<br>Attention zones for running-out of anchors | Planning | Regulatory amendment | Anchoring Regulations<br>(and the petroleum legislation) |
| 11<br>Duty of notification of maritime accidents outside Norwegian territory | Duty of notification | Covered by the Regulation concerning duty of notification and reporting | |
| 12.1<br>Stability instruments | Stability calculations, training | Regulatory amendment | Safety Measures Regulations<br>IMO-MSC/SLF<br>Qualification Regulations<br>IMO-MSC/STW |

# Annex 1 – Meeting overview

| Meeting overview | | |
|---|---|---|
| No. | Meetings with external parties | Commentaries |
| **1** | Rolls Royce. Winch manufacturer. | Technical working group/ DNV |
| **2** | ODIM. Winch manufacturer. | Technical working group/ DNV |
| **3** | Karm Winch. Winch manufacturer. | Technical working group/ DNV |
| **4** | National Oilwell. Winch manufacturer. | Technical working group/ DNV |
| **4** | Bourbon Offshore. | Management / technical working group |
| **5** | Coast Design. Stability instrument supplier. | Technical working group/ DNV |
| **6** | Health and Safety Executive (HSE) and Maritime and Coastguard Agency (MCA). British authorities. | Technical working group/ DNV |
| **7** | Ship designers. | Technical working group/ DNV |
| **8** | Rig and vessel companies via the Norwegian Shipowner's Association. | Technical working group/ DNV |
| **9** | Operator companies via OLF. | Technical working group/ DNV |
| **10** | The Petroleum Safety Authority. | Technical working group/ DNV |

# Annex 2 - Test calculations

## Design I:

| | | |
|---|---|---|
| Max continuous bollard pull: | **180** | tons |
| Length: | **64** | metres |
| Moulded depth: | **8** | metres |
| Breadth: | **16.4** | metres |

| **CONDITIONS WITH STERN PRESSURE** | **Tension** | **Δ** | **GM** | **Draught** | **Freeboard** | **Freeboard stern (AP)** | **Submersion of main deck (AP)** | **Angle 0.5 Gzmax** | **Trim** | **Max GZ** | **Residual area total** | **Residual area to peak point** | **Total area to peak point** | **Extension** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OPTIMAL**, 300 t stern pressure, max wire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| Empty secondary 100% | 269 | 4 163 | 1.6 | 5.6 | 2.4 | 1.87 | 12.8 | 12 | 0.98 a | 0.67/ 39° | 0.265 | 0.14 | 0.31 | 73 |
| Empty secondary 10% | 256 | 3 915 | 1.7 | 5.3 | 2.7 | 1.66 | 11.4 | 11.5 | 2.1 a | 0.68/ 37° | 0.275 | 0.13 | 0.297 | 70 |
| 2 x 50 t secondary 100% | 210 | 4 263 | 1.4 | 5.8 | 2.2 | 1.89 | 13.0 | 10.5 | 0.68 a | 0.51/ 34° | 0.21 | 0.083 | 0.203 | 65 |
| 2 x 50 t secondary 10% | 202 | 4 015 | 1.4 | 5.4 | 2.6 | 1.69 | 11.6 | 10.5 | 1.79 a | 0.52/ 32° | 0.198 | 0.081 | 0.197 | 65 |
| Chain lockers asymm 100% empty secondary | 270 | 4 298 | 1.6 | 5.8 | 2.2 | 1.88 | 12.9 | 12.5 | 0.64 a | 0.60/ 38° | 0.24 | 0.11 | 0.26 | 2/73 |
| Chain lockers asymm 10% empty secondary | 257 | 4 050 | 1.7 | 5.5 | 2.5 | 1.67 | 11.5 | 12 | 1.75 a | 0.60/ 37° | 0.23 | 0.11 | 0.252 | 3/73 |
| **OPTIMAL**, 300 t stern pressure, normal wire: | | | | | | | | | | | | | | |
| 100% | 231 | 4 204 | 1.5 | 5.7 | 2.3 | 1.88 | 12.9 | 11 | 0.86 a | 0.57/ 36° | 0.24 | 0.104 | 0.245 | 70 |
| 10 % | 221 | 3 957 | 1.5 | 5.3 | 2.7 | 1.67 | 11.5 | 11 | 1.97 a | 0.58/ 34° | 0.24 | 0.098 | 0.233 | 68 |
| Chain lockers asymm 100% | 233 | 4 339 | 1.5 | 5.9 | 2.1 | 1.89 | 13.0 | 11.5 | 0.51 a | 0.50/ 35° | 0.21 | 0.085 | 0.202 | 2/69 |
| Chain lockers asymm 10% | 222 | 4 092 | 1.5 | 5.5 | 2.5 | 1.68 | 11.6 | 11.5 | 1.62 a | 0.51/ 35° | 0.2 | 0.082 | 0.198 | 2/67 |
| **MARGINAL**, 300 t stern pressure, max wire: | | | | | | | | | | | | | | |
| Empty secondary 100% | 206 | 3 812 | 1.1 | 5.3 | 2.7 | 2.19 | 15.0 | 13.5 | 1.07 a | 0.56/ 37° | 0.207 | 0.095 | 0.228 | 68 |
| Empty secondary 10% | 180 | 3 492 | 1.2 | 4.8 | 3.2 | 1.93 | 13.2 | 12 | 2.49 a | 0.54/ 32° | 0.171 | 0.063 | 0.179 | 62 |
| 2 x 50 t secondary 100% | 155 | 3 912 | 0.9 | 5.4 | 2.6 | 2.21 | 15.1 | 12.5 | 0.76 a | 0.41/ 32° | 0.137 | 0.054 | 0.14 | 61 |
| 2 x 50 t secondary 10% | 132 | 3 592 | 0.9 | 5.0 | 3.0 | 1.96 | 13.4 | 11.5 | 2.17 a | 0.38/ 27° | 0.093 | 0.034 | 0.105 | 54 |
| Chain lockers asymm 100% | 210 | 3 947 | 1.2 | 5.5 | 2.6 | 2.2 | 15.0 | 14 | 0.72 a | 0.49/ 36° | 0.19 | 0.079 | 0.188 | 3/65 |
| Chain lockers asymm 10% | 182 | 3 626 | 1.2 | 5.0 | 3.0 | 1.94 | 13.3 | 13.5 | 2.13 a | 0.46/ 32° | 0.14 | 0.053 | 0.144 | 3/61 |

| |
|---|
| **MARGINAL**, 300 t stern pressure, normal wire: |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100% | 173 | 3 853 | 1.0 | 5.3 | 2.7 | 2.2 | 15.0 | 12.5 | 0.94 a | 0.47/ 34° | 0.164 | 0.068 | 0.175 | 63 |
| 10% | 151 | 3 533 | 1.0 | 4.9 | 3.1 | 1.94 | 13.3 | 12 | 2.36 a | 0.45/ 29° | 0.121 | 0.047 | 0.132 | 57 |
| Chain lockers asymm 100% | 176 | 3 988 | 1.0 | 5.5 | 2.5 | 2.21 | 15.1 | 14 | 0.59 a | 0.40/ 34° | 0.14 | 0.054 | 0.139 | 3/62 |
| Chain lockers asymm 10% | 152 | 3 668 | 1.0 | 5.1 | 3.0 | 1.95 | 13.4 | 13.5 | 1.99 a | 0.37/ 29° | 0.094 | 0.032 | 0.094 | 3/57 |
| **POOR**, 300 t stern pressure, max wire: | | | | | | | | | | | | | | |
| Empty secondary 100% | 119 | 3586 | 1.0 | 4.9 | 3.1 | 1.7 | 11.7 | 10.5 | 2.82 a | 0.35/ 25° | 0.078 | 0.03 | 0.088 | 50 |
| Empty secondary 10% | 115 | 3360 | 1.1 | 4.6 | 3.4 | 1.63 | 11.2 | 10 | 3.56 a | 0.35/ 26° | 0.073 | 0.032 | 0.093 | 48 |
| 2 x 50 t secondary 100% | 78 | 3686 | 0.7 | 5.0 | 3.0 | 1.73 | 11.9 | 10 | 2.5 a | 0.22/ 23° | 0.039 | 0.018 | 0.051 | 42 |
| 2 x 50 t secondary 10% | 74 | 3460 | 0.7 | 4.7 | 3.3 | 1.66 | 11.4 | 10 | 3.2 a | 0.22/ 23° | 0.037 | 0.019 | 0.053 | 40 |
| Chain lockers asymm 100% | 121 | 3721 | 1.0 | 5.1 | 2.9 | 1.71 | 11.8 | 12.5 | 2.45 a | 0.27/ 25° | 0.05 | 0.013 | 0.056 | 3/48 |
| Chain lockers asymm 10% | 116 | 3494 | 1.0 | 4.8 | 3.2 | 1.65 | 11.4 | 12.5 | 3.18 a | 0.28/ 25° | 0.051 | 0.016 | 0.061 | 3/47 |
| **POOR**, 300 t stern pressure, normal wire: | | | | | | | | | | | | | | |
| Normal wire 100% | 94 | 3628 | 0.8 | 4.9 | 3.1 | 1.71 | 11.8 | 10 | 2.68 a | 0.27/ 24° | 0.051 | 0.023 | 0.066 | 45 |
| Normal wire 10% | 90 | 3401 | 0.9 | 4.6 | 3.4 | 1.65 | 11.4 | 11 | 3.42 a | 0.28/ 25° | 0.049 | 0.025 | 0.071 | 43 |
| Normal wire Chain lockers asymm 100% | 96 | 3763 | 0.9 | 5.1 | 2.9 | 1.73 | 11.9 | 12 | 2.32 a | 0.20/ 23° | 0.032 | 0.012 | 0.037 | 3/43 |
| Normal wire Chain lockers asymm 10% | 91 | 3536 | 0.9 | 4.8 | 3.2 | 1.66 | 11.4 | 12.5 | 3.05 a | 0.20/ 24° | 0.026 | 0.011 | 0.037 | 3/42 |

| **CONDITIONS WITHOUT STERN PRESSURE** | **Tension** | **Δ** | **GM** | **Draught** | **Freeboard** | **Freeboard stern (AP)** | **Dekk i vann (AP)** | **Angle 0.5 Gzmax** | **Trim** | **Max GZ** | **Residual area total** | **Residual area to peak point** | **Total area to peak point** | **Extension** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OPTIMAL**, without stern pressure, max wire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| Empty secondary 100% | 368 | 3863 | 1.15 | 5.47 | 2.53 | 3.02 | 20.2 | 18 | 0.98 f | 0.99/ 47° | 0.32 | 0.2 | 0.483 | 80 |
| Empty secondary 10% | 338 | 3616 | 1.23 | 5.13 | 2.87 | 2.75 | 18.5 | 17.5 | 0.23 a | 0.98/ 44° | 0.33 | 0.18 | 0.452 | 80 |
| 2 x 50 t secondary 100% | 301 | 3963 | 0.91 | 5.59 | 2.41 | 3.05 | 20.4 | 18 | 1.29 f | 0.8/ 45° | 0.27 | 0.15 | 0.373 | 75 |
| 2 x 50 t secondary 10% | 280 | 3716 | 0.95 | 5.26 | 2.74 | 2.78 | 18.7 | 17.5 | 0.09 f | 0.79/ 43° | 0.27 | 0.136 | 0.345 | 75 |
| Chain lockers asymm 100% empty secondary | 379 | 3998 | 1.19 | 5.63 | 2.37 | 3.03 | 20.3 | 19 | 1.32 f | 0.93/ 47° | 0.29 | 0.18 | 0.441 | 3/78 |
| Chain lockers asymm 10% empty secondary | 347 | 3750 | 1.25 | 5.3 | 2.7 | 2.76 | 18.6 | 18 | 0.12 f | 0.9/ 45° | 0.3 | 0.168 | 0.409 | 2/75 |
| **MARGINAL**, without stern pressure, max wire: | | | | | | | | | | | | | | |
| Empty secondary 100% | 270 | 3512 | 0.58 | 5.08 | 2.92 | 3.49 | 23.1 | 20.5 | 1.13 f | 0.8/ 45° | 0.25 | 0.134 | 0.349 | 73 |
| Empty secondary 10% | 223 | 3192 | 0.54 | 4.65 | 3.35 | 3.12 | 20.8 | 19.5 | 0.45 a | 0.73/ 40° | 0.22 | 0.089 | 0.261 | 72 |
| 2 x 50 t secondary 100% | 214 | 3612 | 0.33 | 5.21 | 2.79 | 3.52 | 23.2 | 20.5 | 1.45 f | 0.62/ 43° | 0.193 | 0.092 | 0.246 | 70 |
| 2 x 50 t secondary 10% | 167 | 3292 | 0.24 | 4.78 | 3.22 | 3.16 | 21.1 | 20 | 0.11 a | 0.53/ 38° | 0.156 | 0.06 | 0.171 | 65 |

# Design II:

| | | |
|---|---|---|
| Max continuous bollard pull: | **110** | tons |
| Length: | **56** | metres |
| Moulded depth: | **7.1** | metres |
| Breadth: | **15** | metres |

| **CONDITIONS WITH STERN PRESSURE** | **Tension** | **Δ** | **GM** | **Draught** | **Freeboard** | **Freeboard stern (AP)** | **Submersion of main deck (AP)** | **Angle 0.5 Gzmax** | **Trim** | **Max GZ** | **Residual area total** | **Residual area to peak point** | **Total are to peak point** | **Extension** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPTIMAL, 250 t stern pressure max wire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| Full secondary 100% | 192 | 3 369 | 1.6 | 5.4 | 1.7 | 1.1 | 8.3 | 8.5 | 1.24 a | 0.44/ 34° | 0.176 | 0.078 | 0.183 | 66 |
| Full secondary 10% | 196 | 3 019 | 1.6 | 4.9 | 2.2 | 1.08 | 8.2 | 9.5 | 2.33 a | 0.51/ 33° | 0.18 | 0.082 | 0.199 | 65 |
| Chain lockers asymm 100% full secondary | 173 | 3 440 | 1.6 | 5.5 | 1.6 | 1.11 | 8.4 | 9 | 0.99 a | 0.38/ 34° | 0.134 | 0.06 | 0.149 | 2/65 |
| Chain lockers asymm 10% full secondary | 195 | 3 090 | 1.6 | 5.0 | 2.1 | 1.1 | 8.3 | 10 | 2.07 a | 0.44/ 34° | 0.146 | 0.069 | 0.165 | 2/63 |
| MARGINALE, 250 t hekktrykk, maxwire: | | | | | | | | | | | | | | |
| Full secondary 100% | 141 | 2 870 | 1.1 | 4.8 | 2.3 | 1.6 | 12.0 | 10.5 | 1.48 a | 0.38/ 32° | 0.118 | 0.054 | 0.137 | 57 |
| Full secondary 10% | 139 | 2 520 | 1.2 | 4.2 | 2.9 | 1.58 | 11.9 | 11.5 | 2.6 a | 0.43/ 29° | 0.103 | 0.047 | 0.132 | 53 |
| Chain lockers asymm 100% full secondary | 142 | 2 940 | 1.1 | 4.9 | 2.2 | 1.62 | 12.2 | 12.5 | 1.23 a | 0.32/ 34° | 0.086 | 0.044 | 0.111 | 3/56 |
| Chain lockers asymm 10% full secondary | 138 | 2 591 | 1.1 | 4.3 | 2.8 | 1.6 | 12.0 | 13 | 2.3 a | 0.35/ 29° | 0.079 | 0.032 | 0.094 | 3/53 |
| POOR, 250 t stern pressurre max wire: | | | | | | | | | | | | | | |
| Full secondary 100% | 105 | 3 099 | 1.2 | 5.0 | 2.1 | 1 | 7.6 | 7 | 2.27 a | 0.27/ 20° | 0.062 | 0.022 | 0.061 | 47 |
| Full secondary 10% | 109 | 2 750 | 1.2 | 4.4 | 2.7 | 0.98 | 7.4 | 8 | 3.4 a | 0.31/ 24° | 0.069 | 0.031 | 0.084 | 46 |
| Chain lockers asymm 100% full secondary | 104 | 3 170 | 1.1 | 5.1 | 2.0 | 1.02 | 7.7 | 8 | 2.02 a | 0.2/ 19° | 0.039 | 0.011 | 0.036 | 3/45 |
| Chain lockers asymm 10% full secondary | 107 | 2 821 | 1.2 | 4.5 | 2.6 | 1 | 7.6 | 8 | 3.14 a | 0.23/ 23° | 0.042 | 0.017 | 0.051 | 3/44 |

| **CONDITIONS WITHOUT STERN PRESSURE** | **Tension** | **Δ** | **GM** | **Draught** | **Freeboard** | **Freeboard stern (AP)** | **Submersion of main deck (AP)** | **Angle 0.5 Gzmax** | **Trim** | **Max GZ** | **Residual area total** | **Residual area to peak point** | **Total area to peak point** | **Extension** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OPTIMAL** without stern pressure, max wire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| Full secondary 100% | 294 | 3119 | 1.29 | 5.24 | 1.86 | 2.16 | 16.1 | 15.5 | 0.6 f | 0.73/ 45° | 0.27 | 0.152 | 0.364 | 78 |
| Full secondary 10% | 275 | 2769 | 1.28 | 4.72 | 2.38 | 2.14 | 15.9 | 16 | 0.47 a | 0.77/ 41° | 0.26 | 0.128 | 0.328 | 78 |
| Chain lockers asymm 100% full secondary | 298 | 3190 | 1.29 | 5.35 | 1.75 | 2.17 | 16.1 | 17 | 0.844 f | 0.67/ 46° | 0.213 | 0.136 | 0.323 | 2/76 |
| Chain lockers asymm 10% full secondary | 278 | 2840 | 1.26 | 4.83 | 2.27 | 2.16 | 16.1 | 17 | 0.21 a | 0.7/ 41° | 0.21 | 0.11 | 0.286 | 2/76 |
| **MARGINAL** without stern pressure, max wire: | | | | | | | | | | | | | | |
| Full secondary 100% | 270 | 3512 | 0.58 | 5.08 | 2.92 | 3.49 | 23.1 | 20.5 | 1.13 f | 0.8/ 45° | 0.25 | 0.134 | 0.349 | 73 |
| Full secondary 10% | 223 | 3192 | 0.54 | 4.65 | 3.35 | 3.12 | 20.8 | 19.5 | 0.45 a | 0.73/ 40° | 0.22 | 0.089 | 0.261 | 72 |

# Design III:

| | | |
|---|---|---|
| Max continuous bollard pull: | **200** | tons |
| Length: | **75** | metres |
| Moulded depth: | **8.5** | metres |
| Breadth: | **18** | metres |

| **CONDITIONS WITH STERN PRESSURE** | Tension | Δ | GM | Draught | Freeboard | Freeboard stern (AP) | Submersion of main deck (AP) | Angle 0.5 Gzmax | Trim | Max GZ | Residual area total | Residual area to peak point | Total area to peak point | Extension |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OPTIMAL**, 400 t stern pressure max wire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| Empty secondary 100% | 255 | 6 339 | 1.8 | 6.8 | 1.7 | 1.35 | 8.5 | 7.5 | 0.65 a | 0.48/ 25° | 0.13 | 0.064 | 0.144 | 57 |
| Empty secondary 10% | 264 | 6 068 | 1.7 | 6.6 | 1.9 | 1.44 | 9.1 | 7.5 | 0.94 a | 0.52/ 25° | 0.14 | 0.066 | 0.15 | 57 |
| 50 t secondary 100% | 235 | 6 390 | 1.7 | 6.9 | 1.6 | 1.35 | 8.5 | 7.5 | 0.56 a | 0.44/ 22° | 0.12 | 0.05 | 0.11 | 55 |
| 50 t secondary 10% | 243 | 6 118 | 1.6 | 6.6 | 1.9 | 1.44 | 9.1 | 7 | 0.84 a | 0.47/ 23° | 0.13 | 0.057 | 0.124 | 54 |
| 180 t secondary 100% | 193 | 6 519 | 1.5 | 7.0 | 1.5 | 1.34 | 8.5 | 7 | 0.34 a | 0.35/ 18° | 0.07 | 0.031 | 0.068 | 47 |
| 180 t secondary 10% | 197 | 6 248 | 1.4 | 6.8 | 1.7 | 1.43 | 9.0 | 7.5 | 0.61 a | 0.38/ 18° | 0.08 | 0.037 | 0.077 | 47 |
| Chain lockers asymm 100% empty secondary | 228 | 6 470 | 1.9 | 6.9 | 1.6 | 1.28 | 8.1 | 7.5 | 0.57 a | 0.42/ 23° | 0.12 | 0.044 | 0.108 | 2/55 |
| Chain lockers asymm 10% empty secondary | 239 | 6 200 | 1.8 | 6.7 | 1.8 | 1.38 | 8.7 | 8.5 | 0.85 a | 0.46/ 25° | 0.13 | 0.049 | 0.126 | 2/56 |
| **OPTIMAL**, 400 t stern pressure, normal wire: | | | | | | | | | | | | | | |
| Empty secondary 100% | 280 | 6 213 | 1.9 | 6.7 | 1.8 | 1.35 | 8.5 | 8 | 0.89 a | 0.54/ 26° | 0.18 | 0.07 | 0.16 | 60 |
| Empty secondary 10% | 290 | 5 939 | 1.8 | 6.5 | 2.0 | 1.44 | 9.1 | 8 | 1.19 a | 0.58/ 28° | 0.194 | 0.08 | 0.183 | 60 |
| 50 t secondary 100% | 247 | 6 263 | 1.8 | 6.8 | 1.7 | 1.34 | 8.5 | 8 | 0.8 a | 0.49/ 25° | 0.16 | 0.063 | 0.136 | 58 |
| 50 t secondary 10% | 267 | 5 989 | 1.7 | 6.5 | 2.0 | 1.44 | 9.1 | 8.5 | 1.09 a | 0.53/ 26° | 0.172 | 0.066 | 0.157 | 58 |
| 230 t secondary 100% | 194 | 6 443 | 1.5 | 6.9 | 1.6 | 1.33 | 8.4 | 7 | 0.49 a | 0.36/ 18° | 0.077 | 0.024 | 0.07 | 47 |
| 230 t secondary 10% | 200 | 6 169 | 1.4 | 6.7 | 1.8 | 1.43 | 9.0 | 7 | 0.76 a | 0.39/ 19° | 0.088 | 0.045 | 0.079 | 47 |
| Chain lockers asymm 100% empty secondary | 252 | 6 345 | 1.9 | 6.8 | 1.7 | 1.28 | 8.1 | 8 | 0.81 a | 0.47/ 25° | 0.145 | 0.054 | 0.134 | 2/58 |
| Chain lockers asymm 10% empty secondary | 264 | 6 070 | 1.9 | 6.6 | 1.9 | 1.38 | 8.7 | 8 | 1.1 a | 0.52/ 27° | 0.167 | 0.061 | 0.155 | 2/60 |
| **MARGINAL**, 400 t stern pressure, max wire: | | | | | | | | | | | | | | |
| Empty secondary 100% | 190 | 5 880 | 1.2 | 6.5 | 2.0 | 1.67 | 10.5 | 8 | 0.73 a | 0.38/ 21° | 0.088 | 0.031 | 0.082 | 48 |
| Empty secondary 10% | 185 | 5 560 | 1.2 | 6.2 | 2.3 | 1.71 | 10.8 | 9 | 1.24 a | 0.40/ 21° | 0.088 | 0.026 | 0.086 | 48 |
| 50 t secondary 100% | 173 | 5 930 | 1.2 | 6.5 | 2.0 | 1.66 | 10.5 | 8.5 | 0.65 a | 0.35/ 18° | 0.065 | 0.016 | 0.068 | 45 |
| 50 t secondary 10% | 168 | 5 610 | 1.1 | 6.2 | 2.3 | 1.72 | 10.8 | 8 | 1.14 a | 0.36/ 20° | 0.081 | 0.021 | 0.072 | 45 |
| Chain lockers asymm 100% | 167 | 6 012 | 1.3 | 6.6 | 1.9 | 1.61 | 10.1 | 8 | 0.65 a | 0.33/ 20° | 0.066 | 0.018 | 0.064 | 2/47 |
| Chain lockers asymm 10% | 164 | 5 692 | 1.2 | 6.3 | 2.2 | 1.66 | 10.5 | 8.5 | 1.14 a | 0.34/ 21° | 0.068 | 0.018 | 0.068 | 2/47 |
| **MARGINAL**, 400 t stern pressure, normal wire: | | | | | | | | | | | | | | |
| Empty secondary 100% | 210 | 5 745 | 1.4 | 6.3 | 2.2 | 1.69 | 10.6 | 9 | 0.95 a | 0.44/ 22° | 0.114 | 0.038 | 0.105 | 52 |
| Empty secondary 10% | 205 | 5 424 | 1.3 | 6.0 | 2.5 | 1.72 | 10.8 | 9 | 1.49 a | 0.45/ 23° | 0.107 | 0.039 | 0.11 | 50 |
| 50 t secondary 100% | 192 | 5 792 | 1.3 | 6.4 | 2.1 | 1.69 | 10.6 | 8 | 0.85 a | 0.40/ 21° | 0.087 | 0.027 | 0.086 | 49 |
| 50 t secondary 10% | 187 | 5 474 | 1.2 | 6.1 | 2.4 | 1.73 | 10.9 | 9 | 1.38 a | 0.41/ 22° | 0.089 | 0.032 | 0.091 | 48 |
| Chain lockers asymm 100% | 188 | 5 877 | 1.4 | 6.5 | 2.1 | 1.62 | 10.2 | 9 | 0.87 a | 0.38/ 22° | 0.103 | 0.027 | 0.086 | 2/50 |
| Chain lockers asymm 10% | 185 | 5 556 | 1.3 | 6.1 | 2.4 | 1.67 | 10.5 | 10 | 1.38 a | 0.4/ 23° | 0.089 | 0.028 | 0.09 | 2/50 |

| CONDITIONS WITHOUT STERN PRESSURE | Tension | Δ | GM | Draught | Freeboard | Freeboard stern (AP) | Submersion of main deck (AP) | Angle 0.5 Gzmax | Trim | Max GZ | Residual area total | Residual area to peak point | Total area to peak point | Extension |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OPTIMAL**, without stern pressure, max wire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| Empty secondary 100% | 408 | 5 939 | 1.8 | 6.7 | 1.8 | 2.49 | 15.5 | 12 | 1.35 f | 0.82/ 36° | 0.31 | 0.11 | 0.32 | 70 |
| Empty secondary 10% | 413 | 5 668 | 1.8 | 6.5 | 2.0 | 2.6 | 16.1 | 13 | 1.12 f | 0.87/ 36° | 0.31 | 0.13 | 0.33 | 70 |
| 50 t secondary 100% | 380 | 5 989 | 1.7 | 6.7 | 1.8 | 2.48 | 15.4 | 12 | 1.43 f | 0.76/ 35° | 0.27 | 0.12 | 0.3 | 68 |
| 50 t secondary 10% | 385 | 5 718 | 1.7 | 6.5 | 2.0 | 2.59 | 16.1 | 12.5 | 1.2 f | 0.80/ 35° | 0.29 | 0.11 | 0.31 | 67 |
| 180 t secondary 100% | 312 | 6 119 | 1.5 | 6.9 | 1.7 | 2.47 | 15.3 | 11 | 1.63 f | 0.61/ 30° | 0.21 | 0.077 | 0.196 | 60 |
| 180 t secondary 10% | 317 | 5 848 | 1.4 | 6.6 | 1.9 | 2.58 | 16.0 | 10.5 | 1.41 f | 0.64/ 32° | 0.23 | 0.087 | 0.202 | 62 |
| Chain lockers asymm 100% empty secondary | 387 | 6 070 | 1.9 | 6.8 | 1.7 | 2.41 | 15.0 | 12 | 1.4 f | 0.76/ 37° | 0.28 | 0.13 | 0.325 | 2/70 |
| Chain lockers asymm 10% empty secondary | 394 | 5 800 | 1.8 | 6.6 | 1.9 | 2.52 | 15.6 | 13 | 1.18 f | 0.81/ 37° | 0.29 | 0.14 | 0.328 | 2/68 |
| **MARGINAL**, without stern pressure, max wire: | | | | | | | | | | | | | | |
| Empty secondary 100% | 302 | 5 480 | 1.2 | 6.3 | 2.2 | 2.85 | 17.6 | 13 | 1.38 f | 0.65/ 33° | 0.21 | 0.069 | 0.22 | 62 |
| Empty secondary 10% | 292 | 5 160 | 1.1 | 6.1 | 2.5 | 2.93 | 18.0 | 13 | 0.95 f | 0.67/ 34° | 0.2 | 0.084 | 0.228 | 62 |
| 50 t secondary 100% | 275 | 5 530 | 1.1 | 6.4 | 2.1 | 2.85 | 17.6 | 13 | 1.47 f | 0.59/ 32° | 0.18 | 0.069 | 0.192 | 60 |
| 50 t secondary 10% | 265 | 5 210 | 1.0 | 6.1 | 2.4 | 2.92 | 18.0 | 14 | 1.04 f | 0.60/ 32.5 | 0.2 | 0.063 | 0.193 | 60 |

# Design IV:

| | | | | |
|---|---|---|---|---|
| Max continuous bollard pull: | **180** tons | | Max wire: | 172 t AH - 200 t secondary - 180 t work |
| Length: | **66** metres | | Normal wire: | 62 t AH - 40 t secondary - 62 t work |
| Moulded depth: | **8** metres | | | |
| Breadth: | **20.5** metres | | | |

| **CONDITIONS WITH STERN PRESSURE** | Tension | Δ | GM | Draught | Freeboard | Freeboard stern (AP) | Submersion of main deck (AP) | Angle 0.5 Gzmax | Trim | Max GZ | Residual area total | Residual area to peak point | Total area to peak point | Extension |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OPTIMAL**, 400 t stern pressure, max wire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| 100% | 208 | 5 377 | 2.0 | 5.3 | 2.8 | 1.44 | 8.0 | 7 | 2.62 a | 0.43/ 20° | 0.094 | 0.04 | 0.095 | 66 |
| 10% | | | | | | | | | | | | | | |
| Chain lockers asymm 100% | 126 | 6 353 | 2.1 | 6.0 | 2.0 | 0.82 | 4.6 | 8 | 2.34 a | 0.22/ 15° | 0.045 | 0.02 | 0.032 | 2/65 |
| Chain lockers asymm 10% | 116 | 5 764 | 2.0 | 5.6 | 2.5 | 1.2 | 6.7 | 8.5 | 2.49 a | 0.22/ 19° | 0.049 | 0.017 | 0.037 | 2/63 |
| **OPTIMAL**, 400 t stern pressure, normal wire: | | | | | | | | | | | | | | |
| 100% | 369 | 5 704 | 2.6 | 5.5 | 2.5 | 1.24 | 6.9 | 7.5 | 2.51 a | 0.73/ 28° | 0.183 | 0.1 | 0.247 | 55 |
| 10% | 336 | 5 104 | 2.6 | 5.0 | 3.0 | 1.64 | 9.1 | 9 | 2.64 a | 0.74/ 28° | 0.181 | 0.088 | 0.232 | 52 |
| Chain lockers asymm 100% | 257 | 6 090 | 2.6 | 5.8 | 2.2 | 1 | 5.6 | 9 | 2.38 a | 0.47/ 27° | 0.123 | 0.053 | 0.142 | 3/52 |
| Chain lockers asymm 10% | 246 | 5 490 | 2.6 | 5.3 | 2.7 | 1.4 | 7.8 | 11 | 2.51 a | 0.51/ 28 | 0.109 | 0.05 | 0.146 | 4/50 |
| **MARGINAL**, 400 t stern pressure, max wire: | | | | | | | | | | | | | | |
| 100% | 225 | 5 857 | 2.0 | 5.6 | 2.4 | 1.19 | 6.6 | 6 | 2.36 a | 0.43/ 19° | 0.094 | 0.043 | 0.096 | 43 |
| 10% | 208 | 5 361 | 2.0 | 5.2 | 2.8 | 1.48 | 8.2 | 7 | 2.56 a | 0.44/ 22° | 0.09 | 0.037 | 0.107 | 42 |
| Chain lockers asymm 100% | 123 | 6 243 | 2.0 | 5.9 | 2.1 | 0.94 | 5.2 | 7.5 | 2.24 a | 0.22/ 17° | 0.033 | 0.018 | 0.033 | 4/37 |
| Chain lockers asymm 10% | 117 | 5 743 | 2.0 | 5.5 | 2.5 | 1.24 | 6.9 | 8.5 | 2.42 a | 0.23/ 19° | 0.04 | 0.016 | 0.038 | 5/37 |
| **MARGINAL**, 400 t stern pressure, normal wire: | | | | | | | | | | | | | | |
| 100% | 346 | 5 469 | 2.7 | 5.3 | 2.7 | 1.18 | 6.6 | 8 | 3.12 a | 0.71/ 27° | 0.192 | 0.097 | 0.235 | 52 |
| 10% | 325 | 4 973 | 2.7 | 4.9 | 3.1 | 1.47 | 8.2 | 8 | 3.33 a | 0.74/ 27° | 0.178 | 0.083 | 0.221 | 50 |
| Chain lockers asymm 100% | 239 | 5 855 | 2.6 | 5.6 | 2.4 | 0.94 | 5.2 | 8 | 2.99 a | 0.46/ 27° | 0.089 | 0.049 | 0.136 | 4/50 |
| Chain lockers asymm 10% | 235 | 5 359 | 2.7 | 5.2 | 2.8 | 1.23 | 6.8 | 10 | 3.19 a | 0.49/ 27° | 0.091 | 0.046 | 0.139 | 4/48 |
| **POOR**, 400 t stern pressure, max wire: | | | | | | | | | | | | | | |
| 100% | 218 | 5 825 | 2.2 | 5.6 | 2.4 | 1.27 | 7.1 | 6 | 2.22 a | 0.42/ 19° | 0.095 | 0.036 | 0.093 | 43 |
| 10% | 206 | 5 367 | 2.2 | 5.3 | 2.8 | 1.48 | 8.2 | 8 | 2.55 a | 0.43/ 22° | 0.081 | 0.046 | 0.111 | 42 |
| Chain lockers asymm 100% | 118 | 6 210 | 2.2 | 5.9 | 2.1 | 1.03 | 5.7 | 8 | 2.1 a | 0.21/ 16° | 0.03 | 0.014 | 0.028 | 5/35 |
| Chain lockers asymm 10% | 60 | 5 859 | 1.7 | 5.6 | 2.4 | 1.02 | 5.7 | 8 | 2.76 a | 0.12/ 16° | 0.005 | 0.003 | 0.013 | 6/32 |
| **POOR**, 400 t stern pressure, normal wire: | | | | | | | | | | | | | | |
| 100% | 337 | 5 437 | 2.9 | 5.3 | 2.7 | 1.26 | 7.0 | 7.5 | 2.98 a | 0.69/ 27° | 0.192 | 0.097 | 0.228 | 52 |
| 10% | 326 | 4 979 | 2.9 | 4.9 | 3.1 | 1.47 | 8.2 | 8.5 | 3.32 a | 0.73/ 27° | 0.185 | 0.086 | 0.224 | 50 |
| Chain lockers asymm 100% | 232 | 5 822 | 2.8 | 5.6 | 2.4 | 1.02 | 5.7 | 8 | 2.85 a | 0.45/ 27° | 0.105 | 0.058 | 0.132 | 4/49 |
| Chain lockers asymm 10% | 288 | 5 365 | 2.9 | 5.2 | 2.8 | 1.23 | 6.8 | 8 | 3.18 a | 0.60/ 27° | 0.158 | 0.084 | 0.187 | 4/50 |

| CONDITIONS WITHOUT STERN PRESSURE | Tension | Δ | GM | Draught | Freeboard | Freeboard stern (AP) | Submersion of main deck (AP) | Angle 0.5 Gzmax | Trim | Max GZ | Residual area total | Residual area to peak point | Total area to peak point | Extension |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MARGINAL**, without stern pressure, max wire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| 100% | 371 | 5 457 | 1.3 | 5.5 | 2.5 | 2.31 | 12.7 | 12 | 0.32 a | 0.76/ 30° | 0.185 | 0.075 | 0.224 | 55 |
| 10% | 306 | 4 961 | 0.8 | 5.1 | 2.9 | 2.7 | 14.8 | 15 | 0.35 a | 0.70/ 30° | 0.146 | 0.064 | 0.184 | 52 |
| Chain lockers asymm 100% | 292 | 5 843 | 2.0 | 5.8 | 2.2 | 2.04 | 11.3 | 13 | 0.26 a | 0.56/ 30° | 0.125 | 0.058 | 0.149 | 5/55 |
| Chain lockers asymm 10% | 247 | 5 343 | 1.2 | 5.4 | 2.6 | 2.38 | 13.1 | 15 | 0.36 a | 0.53/ 30° | 0.091 | 0.042 | 0.12 | 8/50 |
| **POOR**, without stern pressure, max wire: | | | | | | | | | | | | | | |
| 100% | 355 | 5 425 | 1.4 | 5.5 | 2.5 | 2.41 | 13.2 | 13.5 | 0.15 a | 0.74/ 30° | 0.178 | 0.067 | 0.212 | 54 |
| 10% | 309 | 4 967 | 1.0 | 5.1 | 2.9 | 2.7 | 14.8 | 15 | 0.35 a | 0.70/ 30° | 0.14 | 0.049 | 0.186 | 52 |
| Chain lockers asymm 100% | 280 | 5 810 | 2.0 | 5.8 | 2.2 | 2.13 | 11.7 | 14.5 | 0.11 a | 0.54/ 30° | 0.109 | 0.038 | 0.14 | 6/52 |
| Chain lockers asymm 10% | 200 | 5 459 | 1.4 | 5.5 | 2.5 | 2.13 | 11.7 | 16 | 0.75 a | 0.41/ 30° | 0.062 | 0.035 | 0.092 | 9/48 |

# Design V:

| | | | | |
|---|---|---|---|---|
| Max continuous bollard pull: | **250** | tons | Maxwire: | 205 t AH - 100 t secondary - 134 t work |
| Length: | **71** | metres | Normalwire: | 67 t AH - 50 t secondary - 67 t work |
| Moulded depth: | **9.5** | metres | | |
| Breadth: | **20.5** | metres | | |

| **CONDITIONS WITH STERN PRESSURE** | Tension | Δ | GM | Draught | Freeboard | Freeboard stern (AP) | Submersion of main deck (AP) | Angle 0.5 Gzmax | Trim | Max GZ | Residual area total | Residual area to peak point | Total area to peak point | Extension |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OPTIMAL,** 500 t stern pressure maxwire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| 100% | 405 | 6 823 | 2.2 | 6.2 | 3.3 | 2.31 | 12.7 | 11.5 | 1.94 a | 0.77/ 31° | 0.28 | 0.111 | 0.248 | 65 |
| 10% | 300 | 6 232 | 1.9 | 5.8 | 3.7 | 2.48 | 13.6 | 11.5 | 2.52 a | 0.62/ 29° | 0.152 | 0.076 | 0.192 | 55 |
| Chain lockers asymm 100% | 369 | 7 072 | 2.2 | 6.4 | 3.1 | 2.2 | 12.1 | 12 | 1.79 a | 0.67/ 31 | 0.24 | 0.067 | 0.208 | 2/66 |
| Chain lockers asymm 10% | 272 | 6 470 | 1.9 | 5.9 | 3.6 | 2.36 | 13.0 | 13 | 2.42 a | 0.54/ 30° | 0.13 | 0.05 | 0.156 | 3/55 |
| **OPTIMAL,** 500 t stern pressure, normalwire: | | | | | | | | | | | | | | |
| 100% | 472 | 6 568 | 2.5 | 6.0 | 3.5 | 2.33 | 12.8 | 12 | 2.33 a | 0.93/ 32° | 0.35 | 0.087 | 0.289 | 68 |
| 10% | | | | | | | | | | | | | | |
| Chain lockers asymm 100% | 437 | 6 817 | 2.5 | 6.2 | 3.3 | 2.22 | 12.2 | 12 | 2.18 a | 0.83/ 32° | 0.31 | 0.072 | 0.246 | 2/68 |
| Chain lockers asymm 10% | | | | | | | | | | | | | | |
| **MARGINAL,** 500 t stern pressure, maxwire: | | | | | | | | | | | | | | |
| 100% | 320 | 6 782 | 2.0 | 6.1 | 3.4 | 2.12 | 11.7 | 10 | 2.5 a | 0.61/ 30° | 0.183 | 0.069 | 0.19 | 58 |
| 10 % | 293 | 6 257 | 1.9 | 5.8 | 3.7 | 2.45 | 13.4 | 11 | 2.55 a | 0.61/ 29° | 0.147 | 0.068 | 0.187 | 54 |
| Chain lockers asymm 100% | 282 | 7 031 | 2.0 | 6.3 | 3.2 | 2.01 | 11.1 | 10 | 2.35 a | 0.52/ 27° | 0.144 | 0.055 | 0.145 | 2/58 |
| Chain lockers asymm 10% | 261 | 6 506 | 1.9 | 6.0 | 3.5 | 2.34 | 12.9 | 12 | 2.4 a | 0.52/ 29° | 0.122 | 0.05 | 0.15 | 3/54 |
| **MARGINAL,** 500 t stern pressure, normalwire: | | | | | | | | | | | | | | |
| 100% | 389 | 6 527 | 2.3 | 5.9 | 3.6 | 2.14 | 11.8 | 10.5 | 2.89 a | 0.77/ 29° | 0.235 | 0.095 | 0.249 | 63 |
| 10% | | | | | | | | | | | | | | |
| Chain lockers asymm 100% | 351 | 6 776 | 2.3 | 6.1 | 3.4 | 2.03 | 11.2 | 12 | 2.74 a | 0.67/ 29° | 0.207 | 0.073 | 0.205 | 2/64 |
| Chain lockers asymm 10% | 324 | 6 243 | 2.2 | 5.7 | 3.8 | 2.36 | 13.0 | 13 | 2.82 a | 0.67/ 30 | 0.167 | 0.068 | 0.193 | 2/59 |
| **POOR,** 500 t stern pressure, maxwire: | | | | | | | | | | | | | | |
| 100 % | 283 | 7 078 | 1.7 | 6.4 | 3.1 | 2.04 | 11.3 | 10 | 2.18 a | 0.52/ 28° | 0.15 | 0.062 | 0.162 | 58 |
| 10% | 246 | 6 350 | 1.5 | 5.8 | 3.7 | 2.39 | 13.1 | 12.5 | 2.55 a | 0.50/ 29° | 0.111 | 0.053 | 0.149 | 52 |
| Chain lockers asymm 100% | 243 | 7 326 | 1.7 | 6.6 | 3.0 | 1.93 | 10.7 | 11 | 2.03 a | 0.43/ 27° | 0.078 | 0.039 | 0.117 | 3/59 |
| Chain lockers asymm 10% | 213 | 6 598 | 1.5 | 6.0 | 3.5 | 2.28 | 12.5 | 14 | 2.4 a | 0.42/ 29° | 0.079 | 0.036 | 0.114 | 3/52 |
| **POOR,** 500 t stern pressure, normalwire: | | | | | | | | | | | | | | |
| 100% | 353 | 6 823 | 1.9 | 6.2 | 3.4 | 2.06 | 11.4 | 12 | 2.57 a | 0.67/ 30° | 0.204 | 0.081 | 0.217 | 65 |
| 10% | 310 | 6 095 | 1.8 | 5.6 | 3.9 | 2.41 | 13.2 | 13 | 2.95 a | 0.66/ 30° | 0.157 | 0.066 | 0.195 | 58 |
| Chain lockers asymm 100% | 313 | 7 071 | 2.0 | 6.3 | 3.2 | 1.95 | 10.8 | 12 | 2.42 a | 0.57/ 30° | 0.184 | 0.061 | 0.176 | 2/64 |
| Chain lockers asymm 10% | 279 | 6 343 | 1.8 | 5.8 | 3.7 | 2.3 | 12.6 | 13.5 | 2.79 a | 0.57/ 30° | 0.127 | 0.048 | 0.155 | 3/58 |

| CONDITIONS WITHOUT STERN PRESSURE | Tension | Δ | GM | Draught | Freeboard | Freeboard stern (AP) | Dekk i vann (AP) | Angle 0.5 Gzmax | Trim | Max GZ | Residual area total | Residual area to peak point | Total are to peak point | Extension |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OPTIMAL,** without stern pressure, maxwire: | (t) | (t) | (m) | (m) | (m) | (m) | (°) | (°) | (m) | (m) | (mrad) | (mrad) | (mrad) | (°) |
| 100% | 505 | 6 323 | 1.2 | 6.1 | 3.4 | 3.61 | 19.4 | 16 | 0.35 f | 1.03/ 40° | 0.37 | 0.15 | 0.31 | 68 |
| 10% | 340 | 5 732 | 0.6 | 5.6 | 3.9 | 3.87 | 20.7 | 17 | 0.08 a | 0.77/ 35° | 0.24 | 0.09 | 0.227 | 69 |
| Chain lockers asymm 100% | 495 | 6 572 | 1.4 | 6.3 | 3.3 | 3.46 | 18.7 | 17 | 0.42 f | 0.98/ 41° | 0.43 | 0.14 | 0.36 | 4/73 |
| Chain lockers asymm 10% | 332 | 5 970 | 0.8 | 5.8 | 3.7 | 3.69 | 19.8 | 18 | 0.08 a | 0.72/ 36° | 0.21 | 0.076 | 0.19 | 6/68 |
| **POOR,** without stern pressure, maxwire: | | | | | | | | | | | | | | |
| 100% | 355 | 5 425 | 1.4 | 5.5 | 2.5 | 2.41 | 13.2 | 13.5 | 0.15 a | 0.74/ 30° | 0.178 | 0.067 | 0.212 | 54 |
| 10% | 309 | 4 967 | 1.0 | 5.1 | 2.9 | 2.7 | 14.8 | 15 | 0.35 a | 0.70/ 30° | 0.14 | 0.049 | 0.186 | 52 |
| Chain lockers asymm 100% | 280 | 5 810 | 2.0 | 5.8 | 2.2 | 2.13 | 11.7 | 14.5 | 0.11 a | 0.54/ 30° | 0.109 | 0.038 | 0.14 | 6/52 |
| Chain lockers asymm 10% | 200 | 5 459 | 1.4 | 5.5 | 2.5 | 2.13 | 11.7 | 16 | 0.75 a | 0.41/ 30° | 0.062 | 0.035 | 0.092 | 9/48 |

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