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SUPPLEMENT

TO

THE FINAL REPORT ON THE CAPSIZING ON 28 SEPTEMBER 1994 IN THE BALTIC SEA OF THE RO-RO PASSENGER VESSEL MV ESTONIA

Part I

The Joint Accident Investigation Commission
of
Estonia, Finland and Sweden

Preliminary version

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Preface

The Joint Accident Investigation Commission publishes in this Supplement the most important documents used in Commission's work. Large appendices of some research reports have been edited, but a list of appendices has been included.

This publication is a preliminary version. The final version will be published soon in one volume. Some documents will be added which due to editorial reasons had to be left out from this preliminary version.

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223	ENG	Protocol of MV ESTONIA's exercise Port State Control in Tallinn 27.9.1994.
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230	ENG	List of maintenance and repair works on MV ESTONIA. April 1993 - August 1994. Nordström & Thulin AB. Stockholm.
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4 VOYAGE CONDITIONS

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401	ENG	Weather Conditions on the Northern Baltic at September 28, 1994. Estonian Meteorological and Hydrological Institute. Tallinn 1995.
402	ENG	*Komulainen Marja-Leena*: The Baltic Sea Storm on 28.9.1994. An investigation into the weather situation which developed in the northern Baltic at the time of the accident to m/s Estonia. Helsinki 1994.
403	ENG	The m/s ESTONIA accident. Weather conditions on September 27 th and 28th 1994. Swedish Meteorological and Hydrological Institute. Norrköping 1995.

Wave conditions

405	ENG	*Kahma Kimmo - Pettersson Heidi - Myrberg Kai - Jokinen Hannu*: Estimated Wave Conditions and Currents during the last Voyage of M/S Estonia. Finnish Institute of Marine Research. Helsinki 1996.

406 FIN Merkitsevän aallonkorkeuden todennäköisyydet M/V ESTONIAn käyttämillä reiteillä. Merentutkimuslaitos. Helsinki 11.4.1997.

Significant wave height probabilities on the routes operated by MV ESTONIA. Finnish Institute of Marine Research. Helsinki 11.4.1997.

407 ENG *Kahma Kimmo - Pettersson Heidi*: Wave Height - Wave Period Distribution from the Northern Baltic Proper. Finnish Institute of Marine Research. Helsinki 1996.

Seakeeping

408 ENG *Karppinen Tuomo - Rintala Sakari - Rantanen Antti*: MV ESTONIA Accident Investigation. Numerical predictions of wave loads on the bow visor. Technical Report VALC106. VTT Manufacturing Technology. Espoo 1995.

409 ENG *Huss Mikael*: Wave loads on visor attachments. MV ESTONIA Accident Investigation. Internal report 1995 - 1997.

410 ENG *Trägårdh Peter*: Model test with M/S ESTONIA. Sea loads on bow visor and yawing behaviour due to heel. SSPA Maritime Consulting. Report 7524. Gothenburg 1995.

411 ENG *Sundell Tom*: MV ESTONIA Accident Investigation. Forces acting on the bow visor due to stationary flow. Technical Report VALC55. VTT Manufacturing Technology. Espoo 1995.

412 ENG *Karppinen Tuomo - Rantanen Antti*: MV ESTONIA Accident Investigation. Numerical predictions of wave-induced motions. Technical Report VALC53. VTT Manufacturing Technology. Espoo 1995.

413 ENG *Karppinen Tuomo*: MV ESTONIA Accident Investigation. Effect of speed on the visor loads. Working paper 29.10.1996.

PART II

5 OTHER INVESTIGATIONS

General observations after the accident

501 FIN M/S Estonian hylyn ympäristöstä laadittujen merenpohjakarttojen selitys. Merivoimien Tutkimuslaitos. Helsinki 28.3.1995.

502 SWE Rapport angående de tekniska och legala förutsättningarna att återfinna och omhänderta omkomna från färjan Estonia. Sjöfartsverket. 1994.

Report concerning technical and legal conditions to find and take care of victims from the ferry Estonia. Swedish Maritime Administration.

503 ENG *Rockwater A/S*: Condition Survey of the Vessel "Estonia" for the Swedish National Maritime Administration. Survey Report.

The vessel

504 ENG *Karppinen Tuomo - Rantanen Antti*: MV Estonia Accident Investigation. Stability calculations. Technical Report VALC177. VTT Manufacturing Technology. Espoo 1996.

505 ENG *Karppinen Tuomo - Rintala Sakari*: MV Estonia Accident Investigation. Stability calculations with water on the tank deck. Research Report VAL313-7331. VTT Manufacturing Technology. Espoo 1997.

506 ENG *Ingerma A. - Strizhak V.*: The Strength Studies for the Locking Devices of the Bow Visor of M/V ESTONIA. Estonian Maritime Academy & Tallinn Technical University. Tallinn 1997.

507 ENG *Metsaveer Jaan*: MV ESTONIA Accident Investigation. Calculation of Load-Carrying Capacity of the Bow Visor Locks. Tallinn Technical University. Tallinn 1996.

508 ENG *Katajamäki Kai*: MV Estonia Accident Investigation. Strenght investigation of the visor side locking device, numerical

calculations. Technical report VALC-246. VTT Manufacturing Technology. Espoo 1996.

509 ENG *Häkkä-Rönnholm Eeva*: Investigation of paint systems from MV Estonia Visor Bottom Lock. Research Report No. RTE57243/96. VTT Building Technology. Espoo 1996.

510 ENG *Ingerma A. - Strizhak V.*: An Analysis of the Reasons of the Failure of the Locking Devices of MV Estonia. Estonian Maritime Academy. Tallinn Technical University. Tallinn 1996.

511 ENG *Rahka Klaus*: MV Estonia. Visor Damage and Visor Attachment Strenght Investigations at VTT. Report VALB243. VTT Manufacturing Technology. Espoo 1997.

512 ENG *Airaksinen Jukka*: MV ESTONIA. Accident Investigation. Strength Investication of the Visor Hinge, Numerical Calculations. Technical Report VALC312. VTT Manufacturing Technology. Espoo 1997.

513 FIN *Kleimola Matti*: Laskelmat ESTONIAn keulavisiirin lukituslaitteiden kuormituksista. Espoo 1997.

Kleimola Matti: Calculations of the loadings on MV ESTONIA's bow visor locking devices. Espoo 1997

514 FIN *Kleimola Matti*: Laskelmat ESTONIAn keulavisiirin lukituslaitteiden kuormituksista (2. raportti). Espoo 1997.

Kleimola Matti: Calculations of the loadings on MV ESTONIA's bow visor locking devices. 2nd Report. Espoo 1997.

515 ENG *Niemi Erkki*: Upper Bound Estimation on the Ultimate Load Capacity of the Atlantic Lock. Lappeenranta University of Technology. Lappeenranta 1997.

516 ENG *Nilsson Fred - Öberg Hans*: Strength and failure assessments of parts from MV ESTONIA. Royal Institute of Technology. Stockholm 1996.

517 ENG *Pettersson Kjell - Söderholm P-O - Lange Nils*: Metallographic and fractographic examinations of samples from MV Estonia. Royal Institute of Technology. Stockholm 1995.

518 ENG *Pettersson Kjell - Söderholm P-O*: Notes from metallographic and fractographic examinations of samples from MV Estonia. Royal Institute of Technology. Stockholm 1996.

519 ENG *Öberg Hans*: Investigation of deformations and related loads, applied to the lug of the visor bottom lock of MV ESTONIA. Royal Institute of Technology. Stockholm 1996.

520 ENG MS ESTONIA Bow Visor. Inspection Report of PS-side Hydr. Lifting Cylinder. MacGREGOR (FIN) Oy. Piikkiö 1995.

Ship operations

521 ENG *Larjo Kari*: ESTONIA's shedule, ETA-PILOT and NaviSailor 2100. 15.10.1996.

522 ENG *Huss Mikael*: Simulation of the capsize. MV ESTONIA Accident Investigation. Internal report 1995 - 1997.

523 ENG *Rintala Sakari - Karppinen Tuomo*: MV ESTONIA Accident Investigation. Numerical predictions of the water inflow to the car deck. Technical Report VALC174. VTT Manufacturing Technology. Espoo 1996.

Operating history

524 ENG *Wermelin Hans*: M/S Estonia, a ship emanating from The Baltic Phenomenon. An historical overwiev made by *ADC Support AB*. Stockholm 1995.

Damages to bow of other vessels

525 ENG *Laur Uno*: Report. Damage to bow visor locking devices of passenger car ferry "DIANA II" in January, 1993, and preliminary conclusion i.r.o. the loss of the bow visor of m.v. "ESTONIA" on September 28th, 1994. Tallinn 1994.

526 ENG *Lehtola Kari*: Damage to the Bow of the SILJA EUROPA at the Time of the Accident Involving the ESTONIA 28.9.1994.

6 EVACUATION AND RESCUE

602	FIN	Suuronnettomuuden pelastussuunnitelma Saaristomeren meripelastusalueella. 18.6.1991. *Rescue Plan for Major Maritime Accident in the Archipelago Sea Maritime SRR. 18.6.1991.*
603	SWE	*ARCC Arlanda*: Bakgrund avtal enl Räddningstjänstlagen, larmtider och erfarenheter.
604	ENG	*Penttilä Antti - Ranta Helena*: Medicolegal Examination and Identification of Victims of M/S Estonia Mass Disaster. Department of Forensic Medicine, University of Helsinki - The Finnish DVI Team - Ministry of Justice. Helsinki 1996.

SUPPLEMENT No. 102

Suomen Valtioneuvoston päätös Suomen edustajien nimeämisestä MV ESTONIAn onnettomuuden kansainväliseen tutkintakomissioon.

Helsinki 29.9.1997

Decision of the Council of State of Finland on the appointment of the members to the Joint Accident Investigation Commission of MV ESTONIA.

Helsinki 29.9.1994.

OIKEUSMINISTERIÖ

Helsinki 29.9.1994

No 3498/062/94 OM

Viite

Jakelussa mainituille

Asia Suomen edustajien nimittäminen
Viron hallituksen asettamaan tutkintakomissioon

Valtioneuvosto on tänään oikeusministeriöstä tapahtuneessa esittelyssä, asian oltua ensin valtioneuvoston raha-asiainvaliokunnan käsittelyssä, nimennyt Viron hallituksen asettamaan, MS Estonian 28.9.1994 tapahtunutta uppoamista selvittävään tutkimuskomissioon Suomen edustajiksi varatuomari Kari Lehtolan, merikapteeni Heimo Iivosen ja tekniikan tohtori Tuomo Karppisen.

Tehtävän hoitamisesta aiheutuneet palkkiot ja korvaukset maksetaan momentilta 28.81.96 (muut ennalta arvaamattomat tarpeet).

Oikeusministeri Anneli Jäätteenmäki

Vanhempi hallitussihteeri Mirja Kurkinen

JAKELU varatuomari Kari Lehtola
merikapteeni Heimo Iivonen
tekniikan tohtori Tuomo Karppinen
suuronnettomuustutkinnan suunnittelukunta
oikeusministeriö/Helsingin maksukeskus

SUPPLEMENT No. 103

Regeringsbeslut K94/2393/2. Kommunikationsdepartementet. Uppdrag till Statens haverikommission att biträda i utredningsarbetet med anledning av passagerarfärjan Estonias förlisning.

Stockholm 1994 - 09 - 28

Government decision K 94/2393/2. Ministry of Transport and Communications. Direction to the Board of Accident Investigation to assist in the investigation of the capsize of the passenger ferry MV ESTONIA.

Stockholm 1994 - 09 - 28.

KOMMUNIKATIONS-
DEPARTEMENTET

REGERINGSBESLUT

1994-09-28 K94/2393/2

Statens haverikommission
Box 12538
102 29 STOCKHOLM

5 09/94
1

Uppdrag till Statens haverikommission att biträda i utredningsarbetet med anledning av passagerarfärjan Estonias förlisning

Den 28 september 1994 förliste passagerarfärjan Estonia sydväst om finska Utö.

Fartyget förde estnisk flagg.

Regeringen uppdrar - efter samråd med företrädare för Estlands regering - åt Statens haverikommission att biträda i utredningsarbetet med anledning av passagerarfärjans förlisning.

Det ankommer på Statens haverikommission att besluta om experter som skall delta i utredningsarbetet.

Regeringen kommer senare att föreskriva hur kostnaderna skall betalas.

På regeringens vägnar

Mats Odell

Jan-Olof Selén

Kopia till

Justitiedepartementet
Försvarsdepartementet
Finansdepartementet

Postadress
103 33 Stockholm

Besöksadress
Vasagatan 8-10

Telefon växel 08 - 763 10 00
Telefax 08 - 11 89 43
Telex 173 28 MINCOM S

SUPPLEMENT No. 201

Contract between Rederiaktiebolaget Sally, Mariehamn, Finland and Shipyard Jos. L. Meyer, Papenburg, Germany.

Mariehamn 11.09.1974.

CONTRACT

Pursuant to form adopted by the Swedish Shipbuilders' Association on the 30th January 1947 with amendments adopted on the 28th January 1964

This Contract is made between Rederiaktiebolaget Sally, Strandgatan 7, 22100 Mariehamn, Finland

as Purchaser, on the one part and Shipyard Jos. L. Meyer, W-Germany, 2990 Papenburg (EMS), Hauptkanal Rechts 2

as Builders, on the other part.

Whereby it is agreed as follows:

§ 1.

Subject to the conditions set out below the Builders will build for the Purchaser and ~~will deliver~~ at the Builders' yard at Papenburg (EMS)-Germany and will deliver a two compartment car- and passenger ferry at Emden/Germany *The vessel ordered*

(hereinafter called "the Vessel") having the Yard No. S.-590, substantially in accordance with the specification~~s~~ and drawing~~s~~ numbered

5675/79 dated 5th September, 1979

relating to this Contract, and intended to be taken as part hereof.

The Yard number shall be considered solely as the means of identifying the Vessel and the parts intended for her and does not imply any priority in regard to other vessels accepted for earlier delivery by the Builders.

In the event of any discrepancy between this Agreement and the said specifications ~~of~~ or drawings the provisions of this Agreement shall prevail and be adopted. In the event of any discrepancy between the specifications and the drawings the specifications shall prevail.

§ 2.

Leading dimensions and particulars

The dimensions of the Vessel shall be the following:

Length overall: .... approx.	155,40 m
Length between perpendiculars	137,40 m
Breadth, ~~moulded~~ max	24,60 m
moulded in waterline	23,60 m
Depth, moulded, to upper deck	13,40 m
Depth, moulded, to second deck	7,65 m
Number of passengers	2.000
Number of crew	188

The deadweight capacity of the Vessel including fuel, stores, provisions, fresh water, passengers (if any), crew and spare parts beyond the requirements of the Classification Society, etc., shall be about 2.800 tons (of ~~1,016~~ 1.000 kilos) on the international summer freeboard, corresponding to a mean draft in salt water (specific gravity 1.025) of about 5.55 m

The propelling machinery of the Vessel shall consist of four main engines of M.A.N., type 8L 40/45, each 4400 kw (5.984 HP) at 600 rpm

~~developing approx.~~ .... ~~I.H.P./B.H.P. (metric) at~~ approx. .... ~~r.p.m.~~

The mean speed of the Vessel on trials with clean bottom ~~when loaded to the said mean draft~~ with a draft corresponding to 1.460 tons deadweight and with her propelling machinery developing ~~the said power~~ /90% of the MCR at 188,5 rpm/ is estimated to be 21,2 knots in calm weather and smooth sea on opposite runs over a measured mile.

The warranties of deadweight and speed shall be deemed to have been complied with if the Purchaser shall dispense with the trials, ~~or shall not for the purpose of the trials provide and ship on board the deadweight required to submerge the Vessel down to the said mean draft.~~

The fuel consumption of the propelling machinery, ~~including all auxiliaries required for the propulsion of the Vessel~~, when developing approx. 17.600 kW ~~I.H.P./B.H.P. (metric)~~ and when running on 1.500 sec redwood I, 100°F with an effective thermal value of at least 10.000 kcal per kilo, is estimated not to exceed 209 ± 3 % grams per ~~I.H.P./B.H.P. (metric)~~ kw per hour.

The Vessel with her accomodation, equipment and machinery shall be built in accordance with the rules and requirements for class

Bureau Veritas

I 3/3 E + car- and passenger ferry deep sea, /Finnish/ ice class 1A + (Aut) and rules/regulations corresponding to specification

The Builders shall supply at their cost Builders' certificate, certificate of the Classification society, and certificates of tonnage for international measurement and ~~for~~ other certificates provided for in the specification

Unless otherwise agreed between the parties ~~Svensk Varvsstandard (Swedish Shipbuilding Standard)~~ Scandinavian standard for car/passenger ferries shall apply to all equipment, materials etc., ~~for which such standard is published.~~

If, during the period of building, alterations or additions are made to any rules, regulations or enactments in force before 11th September 1979 as far as the classification society is concerned and 1st April 1979 in all other respects and applicable to the Vessel the Builders shall inform the Purchaser thereof as soon as possible. The Purchaser must then decide whether and to what extent the alterations or additions which are not mandatory shall be incorporated in the Vessel. The amount of the additional expense or saving in cost arising from any alterations or additions shall be borne by or credited to the Purchaser, as the case may be.

§ 3.

Deficiency in deadweight and speed; excessive fuel consumption

If the estimated deadweight capacity mentioned in Clause 2 be not attained and if the deficiency exceeds ~~2%~~ 2,35% of the said deadweight capacity, the liability of the Builders shall be limited to the payment to the Purchaser, as liquidated damages, of DEM 15.000,- for every .... ton~~s~~ of deficiency beyond the said margin of ~~2%~~ 2,35%.

On the other hand, the Purchaser shall pay the same amount to the Builders for every .... ton~~s~~, by which the actual deadweight exceeds the said estimated deadweight increased by ~~2%~~ 4%.

Should the speed estimated in Clause 2 not be attained, the liability of the Builders shall be limited to the payment to the Purchaser, as liquidated damages, of the following percentages of the contract price stated in Clause 10:

For the first two tenth (2/10) of a knot deficiency .... Nil.
For each successive complete tenth (1/10) of a knot deficiency up to one half (½) of a knot .... 0,2 %
For each complete tenth (1/10) of a knot deficiency exceeding one half (½) of a knot .... 0.4 %

~~Should the fuel consumption exceed the consumption estimated in Clause 2 by more than 5%, the liability of the Builders shall be limited to the payment to the Purchaser, as liquidated damages, ... for each full five (5) grams per I.H.P./B.H.P. (metric) per hour by which the fuel consumption is increased beyond the said margin of 5 %.~~

The Builders guarantee that the deadweight capacity of the vessel determined in clause 2 shall not be less than 2500 tons, whereof no less than 1500 t. for cargo (lorries) on car deck and that the speed determined as stated in clause 2 shall not be less than 20,1 knots.

If the Builders cannot fulfill one or both of these two guarantees the Purchaser only has the right and option to refuse to take delivery of the vessel and to cancel the contract with an obligation for the Builders to refund immediately to the Purchaser 4 the instalments paid on account of the contract price plus interest.

§ 4.

Trial trip

When the Builders have notified the Purchaser that the Vessel is ready for delivery, a trial trip shall take place off .... EMDEN .... to ascertain whether the Vessel conforms with the terms of the contract. The trial trip, which shall be undertaken in the presence of representatives of the Purchaser and representatives of the c shall be ~~of approximately ... hours duration, and the propelling machinery shall be operating during two hours thereof at the normal working speed~~ according to the specification. The Builders at their discretion may extend the trial trip or hold further trial trips.

If, during the trial trip or within 6 hours after its completion the Purchaser makes no substantial complaint to the effect that the Vessel does not comply with the terms of the Contract, the Vessel shall be accepted by the Purchaser, who, if so required by the Builders, shall declare such acceptance in writing.

If, however, faults or defects arise during the trial trip, the Builders shall be entitled to remedy these and to ascertain by further trials whether the Vessel complies with the terms of this Contract.

If, in order to ascertain whether the Vessel complies with the terms of the contract, the Purchaser requires the Vessel to be loaded, the loading and discharge of the cargo shall be carried out by the Purchaser at his own risk and expense and the Builders shall not be held in any way responsible for delay or damage arising as a result of the loading and discharge.

§ 5.

Additional works

The Purchaser shall be entitled, subject to the approval of the Classification Society and to government regulation, to require alterations or additions to be made to the Vessel, provided such alterations or additions do not materially affect the general intention of the parties as embodied in the specifications and drawings relating to this Agreement and are notified in writing to the Builders at an appropriate time and a fair price adjustment shall have been agreed before the work thereon be put in hand.

If such alterations or additions cause delay x) the time of delivery of the Vessel shall be extended by the period of delay.

x) and the Builders notify the Purchaser that such delay will occur.

§ 6.

Increase in weight

Should any alterations or additions mentioned in Clauses 2 or 5 cause an increase in the weight of the Vessel and the Builders notify the Purchaser that such increase will result the deadweight capacity of the Vessel mentioned in Clause 2 shall be reduced by the actual increase in the weight. ~~accordingly.~~

§ 7.

Purchaser's supervision

The Purchaser or his representatives shall be entitled to supervise the construction of the Vessel according to the specification ~~and for that purpose shall have free access at their own risk during working hours to the berths and works of the Builders where the Vessel or the parts intended for her are being manufactured~~, and the Builders shall have due regard to any proper complaint or observations made by the Purchaser or his representatives concerning materials and workmanship. If the Builders so desire, the Purchaser or his representatives shall make such complaints or observations in writing. The Builders will in reasonable time notify the Purchaser or his representatives of dock trials and other such trials and tests.

§ 8.

Completion and delivery

The delivery date for the Vessel shall be

.... 30th June 1980 ....

Should delivery be delayed beyond the above mentioned date, the Builders shall only be liable to pay to the Purchaser, ~~as liquidated damages interest during the period of delay on~~ a compensation at the rate of DEM 20.000,- per day as from 1st July 1980. On the other hand, the Purchaser shall pay the Builders a compensation of DEM 5.000,- for every day the vessel is delivered earlier than 30th June 1980.

Should the Vessel not be delivered before 1st November 1980 the Purchaser has the option of cancelling this contract against being paid back the instalments paid on account of the contract price plus interest and also compensation due for payment as mentioned above. 5

the instalments already paid by the Purchaser in cash or by bills, at the highest rate charged from time to time by the Swedish private commercial banks on loans secured by mortgages on ships.

The Builders shall not be liable for damages or otherwise howsoever if the delay is due to force majeu
such as war or warlike operations, strike, lockout or other labour conflicts, whether approved or supported by trade unions or not, shorter working hours imposed on the Builders, shortage of manpower or materials, late delivery of materials or goods, defects in major forgings or castings, materials or goods supplied by sub-contractors, fire, accident, act of God, exceptionally bad weather unfavourable weather or any other circumstances outside the control of the Builders and whether affecting the Vessel or any other commitments of the Builders. And the time for delivery shall be extended by the number of working days lost to the Builders by reason of any of the above mentioned occurances, even if the cause of the delay arises after the date of delivery stated in this Contract.

The same sh apply to la delivery ca by late del of substant parts or se vices by su contractors providing t reason for delivery wo constitute force majeu for the Bui

If, during the period of building, the Vessel sustains damage which has been repaired to the satisfaction of the Classification Society and/or the government authorities concerned, the Purchaser is not thereby entitled to refuse delivery of the Vessel or to claim compensation.

If the Vessel is put into service by the Purchaser before it is entirely ready for delivery, the Purchaser's right to claim compensation for any delay in the delivery shall cease from the day the Vessel is put into such service.

If the Vessel is ready for delivery before the date mentioned in the first paragraph of this Clause and the Builders give to the Purchaser at least two weeks notice thereof the Purchaser
gladly shall/take delivery as soon as it has been ascertained that the Vessel has been built in accordance with the terms of the Contract. If such events occur, which in the Builders' judgement, may cause a delay, the Builders shall within two weeks notify the Purchaser of such event and, if possible, the estimated duration of the delay. If such written notice is not given within the stipulated two weeks, force majeure cannot be claimed for the period preceding such notice.

§ 9

(a). When the Vessel has been delivered to the Purchaser or the Purchaser has, at his request, *Liability* taken over the Vessel, the liability of the Builders shall cease, except that the Builders shall remedy at their own yard, free of charge and as speedily as possible any defect detailed in writing by the Purchaser to the Builders which may have developed in the propelling or auxiliary
and hull machinery during the ~~six~~ twelve months from the date the Vessel was delivered to or taken over by the Purchaser, or any longer period as may be granted by the sub-contractor, provided such defect is due to inferior workmanship or latent defects in material and is not due to overloading, incorrect fuel or lubrication, wear and tear, neglect, careless handling, external causes, accident or the like, or is due to putting the Vessel into service before it was entirely ready for delivery.

If the defect cannot be conveniently remedied at the Builders' yard, and if no other agreement can be arrived at between the parties, the Builders shall only be bound to pay in full and final settlement of their liability under this Clause to the Purchaser, such a sum as it would have cost the Builders had they done the work at their yard.

During the guarantee period ~~six months~~ twelve the Builders shall have the right to appoint a marine engineer, or mechanic fully conversant with the construction and running of the machinery as guarantee engineer, and the person so appointed shall receive from the Purchaser the customary salary and other remuneration due to a chief engineer on board a ~~Swedish~~ Finnish vessel of the same size, together, if so required, with a free passage and maintenance home as well as salary for the journey home. The Builders may accept the Purchaser's engineer as guarantee engineer.

The Builders' responsibility for the propelling and auxiliary machinery during the guarantee period shall cease if the guarantee engineer is dismissed without the Builders' approval. The Builders shall not be liable for any faults or omissions on the part of the guarantee engineer or on the part of any other member of the engineroom staff during the guarantee period.

(b). The Builders shall not in any circumstance be liable for loss of earnings or profits or for any other loss, or damage, whether direct or indirect, or for accidents or the consequences thereof which may arise after the delivery of the Vessel nor shall their liability extend further or otherwise than in the first paragraph of this Clause provided.

(c) The Builders shall upon request supply the Purchaser with copies of the relevant guarantee clauses regarding important goods installed in the Vessel.

§ 10.

The Purchaser undertakes to pay to the Builders as follows: *Payment*

	In Cash	By bills of exchange
On signing of this Contract	10 %	-
the 15th October 1979 On receipt of the bulk of rolled steel material .	-	15 %
the 15th December 1979	-	15 %
On laying of the keel or when construction the 2nd January 1980 on the berth commences	10 %	-
On launching ... (March 1980)	10 %	10 %
On delivery ... (June 1980)		
	30 %	40 %
On delivery to be covered by way of the loan	30 %	
Total	60 %	40 %

The Builders shall inform the Purchaser at least fourteen days in advance of the date on which each of the foregoing instalments is due for payment.

~~The Purchaser undertakes to hand over to the Builders at the signing of the contract the following securities in addition to the first instalment:~~

The total fixed price for the Vessel amounts to eightytwomillionsevenhundred-andfiftythousand (DEM 82.750.000,-) German marks. The Bills of exchange and and additional instalment of 30 %, equalling total of 70 % of the contract price will be covered by a loan.

~~The Purchaser shall pay to the Builders in advance, interest on the amount of outstanding bills together with any charges at the rate charged from time to time by the Swedish private commercial banks for bills of the kind delivered (the rate at present being .... %).~~

The cost of additional work done as well as allowances made, in accordance with Clauses 2, 3 and 5 hereof, shall be settled in cash on the delivery of the Vessel.

~~If for any reason the Purchaser cannot take delivery of the Vessel on the date the Builders have notified that the Vessel will be ready for delivery, the Purchaser shall nevertheless be liable to make full and final payment on that date.~~

~~The bills shall mature at six-monthly intervals and shall be redeemed by half-yearly instalments of~~

....

beginning six months after the date of delivery. The Purchaser shall, however, have the right to redeem the amount of the bills wholly or in part at any time prior to their maturity dates.

As security for the bills the Purchaser shall on the delivery of the Vessel hand over to the Builders a first priority mortgage in a form to be approved by the Builders registered on the Vessel for the full amount of the bills and interest thereon.

If the Builders so desire, the Purchaser shall apply to a credit institution approved by the Builders for the largest sum obtainable by way of loan on the security of a mortgage on the Vessel and in her charterparty (if any). The amount of such loan shall be paid to the Builders as soon as received and the Builders shall then hand to the Purchaser bills of the same amount as the loan as well as the mortgage required for the loan. If and when such loan is redeemed the mortgage thereby released shall be transferred to the Builders in exchange for any mortgage of lesser priority which the Purchaser may have created on the Vessel in favour of the Builders.

As long as any part of the bills remains unpaid the Purchaser shall keep the Vessel after delivery fully insured with such underwriters, insurance companies or institutions and on such terms as approved by the Builders, for all marine and other risks and protection and indemnity risks and war risks, with (if possible) mortgagee's protection insurance in addition. The policies shall provide (unless otherwise agreed) that all losses and claims shall be paid direct to the Builders who shall be entitled, out of the proceeds of the insurances, to retain an amount sufficient to meet what is owing by the Purchaser to the Builders.

If, at the time of delivery, there exists an abnormal international situation affecting currency and/or insurance conditions which may, in the Builders' opinion, prejudice the ready transfer of money to the Builders, the Purchaser shall at the request of the Builders redeem on delivery of the Vessel all outstanding bills or make available a guarantee acceptable to the Builders.

In addition to the foregoing the "General Loan conditions" annexed to this Contract shall apply.

§ 11.

Delay in payment

If payments in accordance with Clause 10 hereof are not made on due dates, the Builders shall be entitled to interest on the amount due, until payment made, at the highest rate charged by the ~~Swedish~~ German private commercial banks for short term loans on securities other than bonds or real estate mortgages, with a minimum of 6%.

If, during the period of building, any payment is more than thirty days in arrear, the Builders shall have the right to cancel this Contract and to claim damages according to law. If any delay in payment occurs after the delivery of the Vessel, the Builders shall be entitled to call for the immediate payment of all sums due from the Purchaser for the Vessel, with interest thereon.

§ 12.

Crisis Clause

If, by reason of circumstances of an exceptional nature, such as, for example, war, or the risk of war, or occurences or incidents which have a like effect or consequence as war or the risk of war, the rate of wages, and/or costs and/or prices for materials increase to such an extent that it would be unreasonable for the Builders to bear the increase occasioned as aforesaid, then the Builders shall be entitled to request an additional payment from the Purchaser of an amount which the parties hereto may agree on a basis reasonable to them both. If the parties are unable to reach an agreement, the amount of the payment shall be decided by arbitration in the manner laid down in Clause 14 hereof.

Such payment shall be made in cash on the delivery of the Vessel.

§ 13

Until delivery has been effected, the Builders shall keep the Vessel and all parts intended for use in her construction insured against the usual builder's risks, including war risk and sabotage as from the launching until the delivery of the vessel, for an amount not less than the instalments paid on account by the Purchaser. If considered necessary by the Purchaser the Vessel shall also be insured for an amount equaling the difference between the contract price and the present repurchase price and the additional cost of such insurance shall be borne by the Purchaser. Insurance

Should the Vessel be a total loss the parties may agree to cancel this contract and the Builders shall thereupon refund to the Purchaser the instalments paid on account of the contract price, plus interest and, in the event an additional insurance has been taken for the repurchase price, the difference between the contract price and the repurchase price.

§ 14

This contract shall be construed and the relations between the parties determined in accordance with German law. Disputes shall be settled by arbitration at the venue of the place of building according to the German law relating to arbitrations. Disputes

If the Builders so require the Purchaser shall lodge such security as is approved by the arbitrator(s) for costs and damages likely to arise from the arbitration proceedings. If the Purchaser does not meet this requirement, he shall be debarred from any further step in the proceeding.

§ 15

This contract cannot be assigned without the written consent of the Builders, which the Builders shall not unreasonably withhold. Assignment of contract

§ 16

The scope of supply for S. 592 is included in the specification for the Vessel. Scope of supply

§ 17

Defects in major forgings or castings can only be considered to constitute force majeure for the Builders provided the Builders have ordered the respective goods with utmost dispatch, have had the respective goods tested by X-ray or other available, effective method either at the sub-contractors works or at the yard at the earliest possible date, and have taken every reasonable step to avoid delay and provided such defects and the resulting delay in the construction affects the delivery date of the Vessel. Defects in forgings and castings

§ 18

This contract is subject the approval of Finlands Bank. Subject

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This contract with attached specifications and drawings has been drawn up and signed by or on behalf of the parties hereto in duplicate, one copy being retained by each party.

Mariehamn, 11th September, 1979.

REDERIAKTIEBOLAGET SALLY	JOS. L. MEYER
Sven-Erik Johansson	Joseph F. Meyer

Witnesses:

SUPPLEMENT No. 202

Extracts from specification for building.

Jos L. Meyer.

Papenburg-Ems.

1. GENERAL

General Regulations

The vessel shall be built in accordance with this specificatio and the General Arrangement drawings, equipped to comply with the specific regulations.

Inventories shall be delivered according to the included lists. Should any object be mentioned in more than one place, however it is only to be delivered once.
When two or more materials or methods of manufacture are mentioned, the Builders have the right to choose between these.

The design of subcontractors' equipment and recommendations for installation of the same equipment refer to their standard on the date of this specification.

If, as a result of increased experience or general technical development, other designs, materials or methods of manufacture than those stated in this specification are found equivalent but more practical, the Builders reserve the right to adopt these new designs etc. Such alterations, however, are always to be submitted to the Owners' surveyor for approval before being carried out.

The shipyard alone is responsible for the construction and quality of work of the ship. The fact that drawings or other documents, test results, etc. have been shown to the Owners or been approved by the Owners or an authority or that modifications have been carried out according to Owners' requirements does not relieve the shipyard from the above mentioned responsibility.

If drawings are submitted and any discrepancy should exist between this specification and the drawings, the specification shall prevail.

Details and equipment necessary for a ship of this type but not stated in this specification to be done according to yard's praxis approved by the Owners'.

General Description

The ship to be built in every respect as a modern car/passenger ferry, designed for short international voyage.

The ship has four medium speed main diesel engines, two CP propellers, two rudders, bulbous bow and two bow thrusters.

There is one trailer deck, breadth suitable for seven lanes, one hoistable car deck on SB and Port sides.

Two stern ramps and one bow ramp.
Each one passenger port C-and D-deck, pilot port on car deck, all on SB and Port sides.

All crew cabins are located on G- and F-deck in the deckhouse decks at sides, except of eight stewardess cabins in passenger accommodation at the sides.
All passenger's and crew's cabins to have shower and toilet.
Total passengers on board: 2000

Service activities will be rationalized by adopting a new land service catering system and effective store handling with provisions, shop stores, linen etc. in containers.

X Remark:

It is pointed out that the yard can take as much as possible from the "DIANA II" concept and that yard can choose the manufacturers for smaller things to assure the time schedule, to owner's approval.

11. MAIN DATA

111. DIMENSIONS, VOLUMES, DEADWEIGHT

1111. Dimensions

Length overall	abt.	155,40 m
Length between pp.		137,40 m
Breadth moulded, car deck		24,20 m
Breadth max.	abt.	24,60 m
Breadth moulded in w.l.		23,60 m
Depth to car deck		7,65 m
Depth to C-deck	abt.	13,40 m
Draft loaded		5,55 m
Max. scantlings draft		5,60 m
Height moulded betw. car and deck platforms		2,70 m
Free height on car deck below hoisted platform decks		4,70 m
Free height on platforms		2,10 m
Free entrance breadth x height fore		5,50 x 5,00
Free entrance breadth x height aft		5,50 x 5,00
Camber in car decks		0,00 m
Free height in saloons and halls (outside vent. ducts)		2,25 m
Free height in cabins		2,10 m
Free height in cabins on tween deck, min.		2,05 m

1112. Capacities

Passenger Accommodation

E-deck 4 cabins with 8 beds alt. 16 beds
98 cabins " 196 beds

D-deck 4 cabins with 8 beds alt. 16 beds
98 cabins " 196 beds

C-deck 4 cabins with 8 beds alt. 16 beds.
187 cabins " 374 beds
4 cabins with 16 beds
806 beds alt. 830 beds

On tween deck in the forward part couchettes for totally 350 persons with common toilet/wash room

Accommodation for Crew

G-deck	2 apartments for captain/chief engineer	2 beds
	1 owner cabin	1 bed
	18 twin cabins	36 beds
F-deck	25 cabins for officers	25 beds
	54 twin cabins	108 beds
E-deck	2 twin cabins	4 beds
D-deck	2 twin cabins	4 beds
C-deck	4 twin cabins	8 beds
		188 beds

Passenger seats

A la Carte room	abt.	120 seats	abt. 185 m2
Dining saloon	abt.	300 seats	abt. 450 m2
Cafeteria with grillroom	abt.	400 seats	abt. 610 m2
Dancing saloon	abt.	340 seats	abt. 545 m2
Night club + Conference r.	abt.	320 seats	abt. 410 m2
Lobby	abt.	50 seats	abt. 90 m2
Halls + Arcade	abt.	190 seats	
Conference room on tanktop	abt.	60 seats	abt. 90 m2
Milkshake room	abt.	30 seats	abt. 50 m2
Air seats	abt.	150 seats	abt. 300 m2
		1960 seats	

Mess and dayrooms

Officers' mess/dayroom Crew's mess/dayroom	abt.	200 seats	abt. 300 m2

Car Capacity

On car deck	abt.	290 cars or 47 lorries à 18 m length of 40 to. weight
On platforms	abt.	170 cars

Tank Capacities

Intermediate fuel oil (1500') Diesel oil	abt. }	850 m3
Lubricating oil/hydraulic oil	abt.	130 m3
Fresh water	abt.	650 m3
Ballast water	abt.	900 m3

1113. Tonnage

International and Suez tonnage measuring will be executed on the shipyard by Finnish Authorities. Gross register tonnage will be abt. 15.000 RT.

1114. Deadweight and Draught

The deadweight capacity of the vessel including fuel, stores, provisions, fresh water. Passengers, crew and spare parts beyond the requirements of the Classification Society etc. shall be not less than 2800 tons without fins, 2670 tons with fins corresponding to a mean draught in salt water (specific gravity 1,025) of 5,55m.

The actual deadweight capacity to be determined in the presence of the Owners' representative at the inclining test for the first ship only with the vessel in clean and practically completed condition (see para 14).

Lubricating oil and cooling water in the engine systems, refrigerant in refrigerating systems and water in boilers and piping systems are included in the light weight of the ship.

The contents of full deadweight to be designed as follows:

	without fins		with fins
Passenger with luggages	200 tons		100 tons
Crew	20 tons		20 tons
Provisions	80 tons		50 tons
Lorries	1760 tons		1760 tons
Fresh water	350 tons		350 tons
Thermal oil	15 tons		15 tons
Lubricating oil	50 tons)		50 tons
Diesel oil	80 tons)	=335 t	80 tons
Heavy fuel oil	205 tons)		205 tons
Water in swimming basin	40 tons		40 tons
total	2800 tons		2670 tons

112. SPEED AND POWER, MODEL TESTS

1121. Speed and Hull Form

- The mean speed of the vessel in trial condition with clean bottom when loaded to a draught corresponding to 1460 tdw without fins, 1330 tdw with fins with the propelling machinery developing 21600 hp = 90% MCR and with propeller rpm = 188 is to be abt. 21,2 knots in calm weather (wind force not over 4m/s and smooth deep water on opposite runs.)

1124. Model Test

Model test for streamline test will be carried out.

113. TRIM AND STABILITY

The stability shall fulfil the Solas requirements for "Two compartment division" for the following service conditions:

1. Ship fully loaded with full stores cargo and passengers
2. Ship loaded as in 1 but with 10% of stores
3. Ship loaded as in 1 but with 50% of stores
4. Ship loaded with full stores and full number of passengers but without cargo
5. Ship loaded as in 4 but with 10% of stores
6. Ship without cargo and passengers but with 100% of stores.
7. Ship without cargo and passengers but with 10% of stores.

Unsymetrical flooding shall be avoided as far as possible.

Preliminary stability and trim calculations to be made at an early stage of design work and to be forwarded to the Owners.

14. CLASSIFICATION, REGULATIONS, NOISE PREVENTING

The vessel with her accommodation, equipment and machinery shall be built under special survey to Bureau Veritas class, I 3/3 E + Car and Passenger ferry Deep sea Finnish Ice class I A +(AUT) = £0

The vessel with equipment shall comply with the following rules and regulations:

- The Finnish Board of Shipping.
- International Conference on Safety of Life at Sea 1974
- International Load Line Convention 1966 and admendments 1971 + 1975
- Convention for Tonnage Measurement of Ships, Oslo 1947
- Pollution Preventions 1973
- International Regulations for Preventing Collision at Sea 1972
- Finnish Authorities' recommendations for Safety Ship Labour 77 : 33
- US Regulations regarding sanitation (fresh water tank arrangement excluded) (as reasonable applicable)
- Convention on the Protection of the Marine Environment of the Baltic Sea Area 1974/232
- IMCO resolution A 325 (1x) 1975 concerning regulations for machinery and electric installations in passenger vessel and cargo ships
- USCG requirements for passenger vessels' safety to be followed, as reasonable applicable
- The Finnish Board of Shipping and Navigation Rules and Recommendations of Noise Level Criterium

116. MATERIAL AND WORKMANSHIP

All work subject to the supervision of the Classificatio Society shall be approved by its surveyor. Every piece of work shall with regard to design, material and workmanship, be of the same standard as is customarily found in Scandinavian shipbuilding.

High tensile steel to be used for weight minimising to choice of the yard. (except the flat bottom).

3. HULL AND DECK FITTINGS AND INVENTORY

31. HULL EQUIPMENT

312. .POORTS, RAMPS

Bow visor, bow ramp, stern ramps and side ports, complete with operation equipment, to be arranged to authorities' and Owerns' approval. The whole equipment, including pump aggregates, to be of von Tell's construction.

3121. Side Ports

3122. Pilot and Passenger Doors

Two hydraulically operated watertight pilot and provision doors midships on car deck, one on each side, in line wit the ships' side plating. Maximum 300 mm extension outside shell plating when operating. Height of doors about 2,0 m width about 1,2 m. The doors will be hydraulically secure around the frame and operated by means of hydraulic cylinder and seperate compact pump aggregates placed near Manual emergency pump to be arranged. One of the pump aggregates also to serve the hydraulic engine room hatch.

Opening time maximum 15-20 seconds.

Two hydraulically operated watertight paasenger doors C-and D-deck, one on each side in line with the shell plating.

The doors to be hinged on sides and opened outwards. Heig of doors about 2,0 m, width about 2,5 m. The doors will b hydraulically secured around the frame and operated by me of hydraulic cylinder and seperate compact pump aggregate placed nearby. Manual emergency pump to be arranged. Pump aggregate and control box to be recessed in bulkhead lockable doors.

Securing cleat for open position to be provided. The clea to be relased from the control box.

Opening time maximum 15-20 seconds.

3123. Bow Visor and Ramp

Outer Bow Visor

One strong bow visor (see also 212), hinged on forecastle deck and operated by two inside placed double-acting hydraulic cylinders.

Maximum time for opening 60 seconds.

Each main cylinder to be provided with an oil flow restriction device to prevent the visor from falling down in case of broken pipes or hoses.

Another restriction valve of adjustable type to be arranged for settling the closing speed.

Each cylinder to be privided with a directly connected overload relief valve.

In the common oil return line to be mounted a relief valve, adjusted to the pressure needed to hold the door in any position in case of broken pipes or hoses. In connection with this relief valve, an emergency by-pass valve to be installed.
In fully opened position the bow door to be mechanically secured by means of two hydraulically operated securing divices, which are automatically released at the normal closing operation.

The bow visor can not be operated if the bow ramp is not properly closed. Hydraulically operated securing device for closed position to be arranged.

The securings to release automatically at normal opening operation.

Two ice-breaking hydraulic cylinders to be installed and to work automatically at normal opening operation.

Electrically or thermal coils for heating purpose to be installed **in a cofferdam.**

The bow visor to be guided in right position when closing by at least four wedge-formed guides.

All bearings to be greased with spring loaded graese drums. Bearings of securing devices to be of self-lubricating materials.

Bow Ramp

One watertight bow ramp with longitudinal stiffeners arranged to give a free opening of 5,5 m width and 5,0 m height. In lowered position, the bow ramp to reach minimum 1,5 m forward of bulbuous bow's front. At the end of the ramp hinged flaps to be arranged.

The bow ramp cannot be operated if the bow door is not in open position.

Partial Collision Door

For the intended service not required by F.B.N.

3124. Stern Ramps and Doors

For loading through the stern, the vessel is equipped witl two hydraulically operated combined stern ramps and doors Clear opening 5,5 m width and 5,0 m height. Total length of the ramp abt. 6,5 m.

They are watertight and consist of part hinged to the hul: and flaps attached to outer end.

The ramps to be constructed for a charge of 10 degrees downwards/upwards from lowered horizontal position. All ramps to be designed for the same load as the main deck. Closing time maximum 60 seconds.

Also at the joints between ramps and deck, flaps to be arranged. The ramps to be opened and closed by means of hydraulic cylinders. Hydraulically operated securing devices for closed position, which shall be automatically released at normal opening operating. Restriction valves and relief valves to be provided as for the bow door.

The ramp sides to be provided with railings and with welded-on antislip profiles to Owners' approval.

Preventer to be provided.

3127. Hydraulic System

The hydraulic equipment for bow visor, bow ramp and stern ramps to consist of two double pump aggregates, one forward and one aft. each with two piston pumps driven by electric motors 380 Volts - 50 Hz. Working pressure of the hydraulic system up to 250 kp/cm 2.

The system is used also for car platforms.

The oil tanks to be placed above the pumps and oil level to be as high as possible above most of the hydraulic equipment to avoid air pockets in the pipes. The tanks to be provided with low level alarm and with minimum level switch of floating type for cutting out the electric circuit to the pumps.

Pipe system to be arranged in such a way that the piping circuit from one forward pump will operate platform sections Nos. 1 and 2 on port side and the other forward pump piping will operate platform sections Nos. 1 and 2 on starboard side. Both the pipe circuits to be connected thereafter to a common line to supply oil for bow visor and bow ramp. Similar system to be arranged for the aft pump aggregate. For emergency cases pressure and return lines to be arranged between forward pump aggregates and aft pump aggregates.

Pumps to be started and stopped at the following postions:

- At bow visor and bow ramp control box both forward pumps

- At stern ramp control box both aft pumps.

- At each platform sections control boxes pumps connected to pipe line in question.

Indication lamps for pumps running to be provided at each position. Control boxes for operation of doors, ramps and car platforms to be provided with clearly written signs indication the name and number of the actual door, ramp or platform together with valve positions.

Also warning signs at car platform control boxes indicating checking of platform top before hoisting. Signs for maximal shaft load on car deck and car platforms to be provided. All signs to be written in Finnish, English and Swedish language.

Arrange of the total plant as on "DIANA II".

SUPPLEMENT No. 203

Extracts from operation instructions for stern ramp, bow visor and bow ramp.

Von Tell Ab. Gothenburg.

Operation instructions for hydraulic and mechanical installations on board passenger ferry, yard No 590, built at Jos. L. Meyer, Papenburg, 1980.

The hydraulic and mechanical arrangements are constructed by VON TELL under manufacturing No 4911.1.

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For I - V in the operation instructions the position Nos in brackets ( ) correspond to the hydraulic scheme 49111-801.

For VI and VII in the operation instructions the position Nos in brackets ( ) correspond to the hydraulic scheme 49111-802.

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DRAWINGS

STERN RAMP, BOW VISOR AND BOW RAMP

49111-230, -260, -304, -330, -360, -361, -371, -372, -373

HANGING DECK, DRIVE-ON RAMPS

49111-101, -161, -162, -163, -164

PASSENGER BRIDGE, PASSENGER- AND PILOT DOORS

49111-761, -423, -426, -427, -428

HYDRAULIC

49111- 287, -387, -401, -785, -801, -802, -804, -805, -806, -821, -822, -823, -824, -825, -826, -827, -828, -830, -831, -871

+ all the hydraulic cylinders

+ 49111-502 Spare parts spec.

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I. STERN RAMP (SB and PS)

1) Construction

Dimensions: L = 6500 mm
B = 5500 mm between the tracks

Weight: abt 11,5 tons

The fore-end part of the ramp is provided with 9 sloping flaps of 1,5 m length. Any sloping flap can be moved independent from the others in order to level the incline of the ramp to the quay in case of heeling of the ship (2 degrees max.). The ramp is pivoted to the ship with 4 hinges. The two outer hinges are pivoted with spherical bearings and the inner ones with bronze bushes. The axles are of stainless material.

The ramps are provided with fastenings for preventer stays.

2) Maintenance

All bearings without zerk fittings and sloping flaps must be lubricated with engine oil in space of about two weeks.

The cylinder bearing bolts are provided with zerk fitting type DIN 3404 AM 10 x 1. The lubricating point should be lubricated with seawater consistent grease under use of the grease gun in space of every four weeks.

The axles of the ramp bearings are equipped with "automatic" grease filler. The lifetime for these is 5-6 months. Control at regular intervals that the grease fillers are intact and have lubricant.

All piston-rods and cylinders should be covered during painting. Dry paint spirts upon the surface of the piston-rod would spoil the cylinder packings within short time, what means undesirable leakages.

Check all hoses, hose connections and pipe connections to prevent leakages. Damaged components should be replaced if necessary in order to avoid interruption.

The hose connections should be painted, but not the hydraulic hoses.

The rubber packings should be treated with Tellin or similar mixture containing graphite and tallow in order to reduce the wear of the rubber. When a defect rubber packing is going to be replaced the packing channel has to be sufficiently cleaned before the new packing is fitted with glue. von Tell UK 2 glue or glue of the same quality has to be used.

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3) Load capacity

The ramp is constructed to carry an axle load of 18 tons at the distance between the axle of 1,3 m and the distance between the wheels of 2,0 m.

The star board ramp is provided with lugs for emergency operations, designed for normal load (axle load of 18 t)

4) Locking device

In closed position the ramp is locked by 3 wedges on each side and 2 hooks on the upper side. The wedges are operated by one hydraulic cylinder (11) on each side and each hook by one hydraulic cylinder (10).

The hooks on the upper side are first pressing the ramp into the rubber sealing frame and then the ramp is locked by the wedges.

The rubber packing is fixed with bolts.

The pressure reducing valves (32) (33) are reducing the pressure on the cleats, and the valves (28) and (29) are controlling the operating sequence of hooks and wedges.

5) Operation

For operation of the ramp, a hand-operated electric valve (17) is used which guides an operating valve (21) and a relief and by-pass valve (16). The operation itself of the ramp is carried out by two hydraulic cylinders (5) with spherical bearings. Two ice-breaking cylinders (8) assist the opening process. When the locking device of the ramp has been released the ice-breaking cylinders (8) are put under pressure to push the ramp outwardly. The ramp continues lowering by sole weight until it rests upon the quay. The control lever remains in lowering position all through the loading process in order to adjust the ramp inclining according to the actual depth of the quay. The lowering speed is adjustable by throttle non-return valves (40) at the cylinders (5). The throttles are to tune on parallel lowering of both sides. For closing the cylinder (5) is put under pressure and the ramp will close. Speed is adjusted by throttle valve (41). When the ramp is fully closed it is locked with hooks and wedges.

For the operation of the hydraulic cylinders for the hooks and the wedges a manual operating valve (24) is used. The speed is adjusted by the throttle valve (41).

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The relief and by-pass valve (16) is reducing the pressure if the ramp is not correctly operated and one forgets to set the operating valve on "floating position when the ramp rests upon the quay.

6) Control

Opening of the ramp

1) Start one of the pumps.

2) Close the ramp. The control lever will be in UPP position. (The pressure on the wedges is reduced.)

3) Open up the cleats. The control lever will be in position ÖPPNA until red lamp indicates ÖPPEN.

4) Lower the ramp. The control lever will be in position NER until the ramp is resting on the quay. The lever should remain on NER ("floating position") until the ramp will be closed.

5) Switch off the pump.

Closing of the ramp

1) Start one of the pumps.

2) Check that red lamp indicates ÖPPEN for the cleats. If not, open up the cleats.

3) Close the ramp. The control lever in position UPP until green lamp indicates UPPE.

4) Close the cleats. The control lever will be in position LÅSA until green lamp indicates LÅST.

5) Switch off the pump.

II. BOW VISOR

1) Construction

The visor has a weight of abt 54,5 tons and forms the W.T. front closure of the ship. The bow visor is pivoted at the upper deck. It opens in upward direction.

2) Maintenance

Under circumstances when temperature reaches 0° C or below check that the limit switches and other equipment on weather deck are not getting covered with ice. See also item I pos. 2).

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3) Locking device (25)

In closed position the visor is locked by two locking pins which are operated by one hydraulic cylinder (12) each. As a reserve the visor can also be locked by two manually operated locking devices. There is also one hydraulic operated "atlantic locking device" (12).

In open position the bow visor is locked by 2 locking pins which are hydraulic operated with one hydraulic cylinder (12) each.

In closed position the rubber packing is compressed by the sole weight of the bow visor. The rubber packing is fixed with bolts.

4) Operation

For the operation of the bow visor a hand-operated electrical valve (pos 17) is used which is guiding an operating valve (19). An electrical blocking is built in to prevent faulty operation between bow visor and bow ramp.

The very operation of the visor is performed by two hydraulic cylinder (2) with spherical bearings. Two ice-breaking cylinders (8) assist the opening process when the visor starts opening. When the locking devices of the bow visor are released the ice-breaking- and operatin cylinders are put under pressure and the visor will open. When the visor is fully opened it will be locked.

When lowering the bow visor the top of the cylinder will be put under pressure. In the bottom of the cylinder a valve (15) is fitted which is controlling the lowering when a pressure arises in the cylinder which is higher than the adjusting pressure of the valve. The lowering speed is adjustable by throttle non-return valves (39) and they should also bo so adjusted that the cylinders get the same timing.

5) Control

Opening of the bow visor

1) Start both of the pumps.

2) Open the atlantic locking device and the cleats. Put the control levers (one by one) in position ÖPPNA until red lamp indicates ÖPPEN.

   If the manual locking device has been used this has to be opened.

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3) Check that the lamp for the locking devices indicates ÖPPEN. If not, open up the locking devices which are locked.

4) Open the bow visor. The control lever will be in. position UPP until green lamp indicates UPPE.

5) Close the locking device. The control lever will be in position LÅSA until green lamp indicates LÅST.

6) Lower the bow visor and let it rest on the locking device in order to release the hydraulic pressure in the operating cylinder.

7) Switch off the pumps.

Closing of the bow visor

(Check that the bow ramp is closed and locked.)

1) Start the pumps.

2) Check that red lamp indicates ÖPPEN for cleats and the atlantic locking device. If not, open up the cleats and the atlantic locking device.

3) Open up the bow visor. (The load on the locking device is released.)

4) Open up the locking device. Put the control lever on ÖPPNA until red lamp indicates ÖPPEN.

5) Close the bow visor. The control lever will be in position NER until green lamp indicates NERE.

6) Lock the cleats. The control lever will be in position LÅSA until green lamp indicates LÅST.

7) If the atlantic locking device is going to be used this should also be locked.

8) Switch off the pumps.

III. BOW RAMP

1) Construction

Dimensions: L = 8225 mm
B = 5500 mm between the tracks

Weight: abt 12,1 tons

The fore-end part of the ramp is provided with 8 sloping flaps, which automaticly extend when the ramp is opening. Each sloping flap is working independently

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from the others in order to compensate for the heeling of the ship (2 degrees max.)

The ramp is pivoted to the ship with 4 hinges. The two outer hinges are provided with spherical bearings and the two inner with bronze bushes. The axles are of stainless steel.

The ramp is equipped with fastenings for preventer stays.

2) Maintenance

See item I. pos. 2).

3) Load capacity

See item I. pos. 4).

4) Locking device

The side cleats consists of 2 hydraulic operated locking pins on each side of the ramp in contrast to the stern ramp which has hydraulic operated wedges. See also the stern ramp (item I).

5) Operation

On the bow ramp an electrical blocking is built in which is preventing faulty operation between bow visor and bow ramp. The bow ramp has no ice-breaking cylinders similar to the stern ramp. In other respects see the stern ramp (item I).

Note: The bow ramp must not be operated until the bow visor is fully opened and in locked position.

6) Control

See item I pos. 6).

IV. HANGING DECK

1) Construction

The hanging decks are constructed for the transport of passenger cars. They are laid out as installation of raisable car decks. The area of decks consists of all together 8 sections, L = 6 x 20 m + 2 x 18,4 m. The sections at port are B = 5,5 m - those at star board B = 8,5 m. At star board side the lowered decks rest

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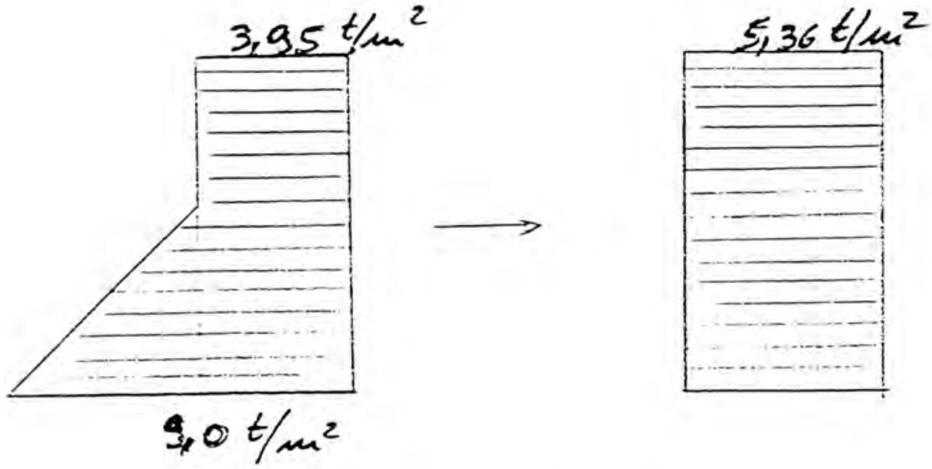
SUPPLEMENT No. 204

Handgeschriebene Festigkeitsberechnungen für die Bugvisier-Vesschlüsse der VIKING SALLY - ESTONIA

Hand-written strenght calculations for the VIKING SALLY - ESTONIA's bow visor locks

Angreifende Kräfte nach BV-RULES 1976



Kraftangriffspunkt im Flächenschwerpunkt der Projizierten Flächen:

$P_x = 381$ to

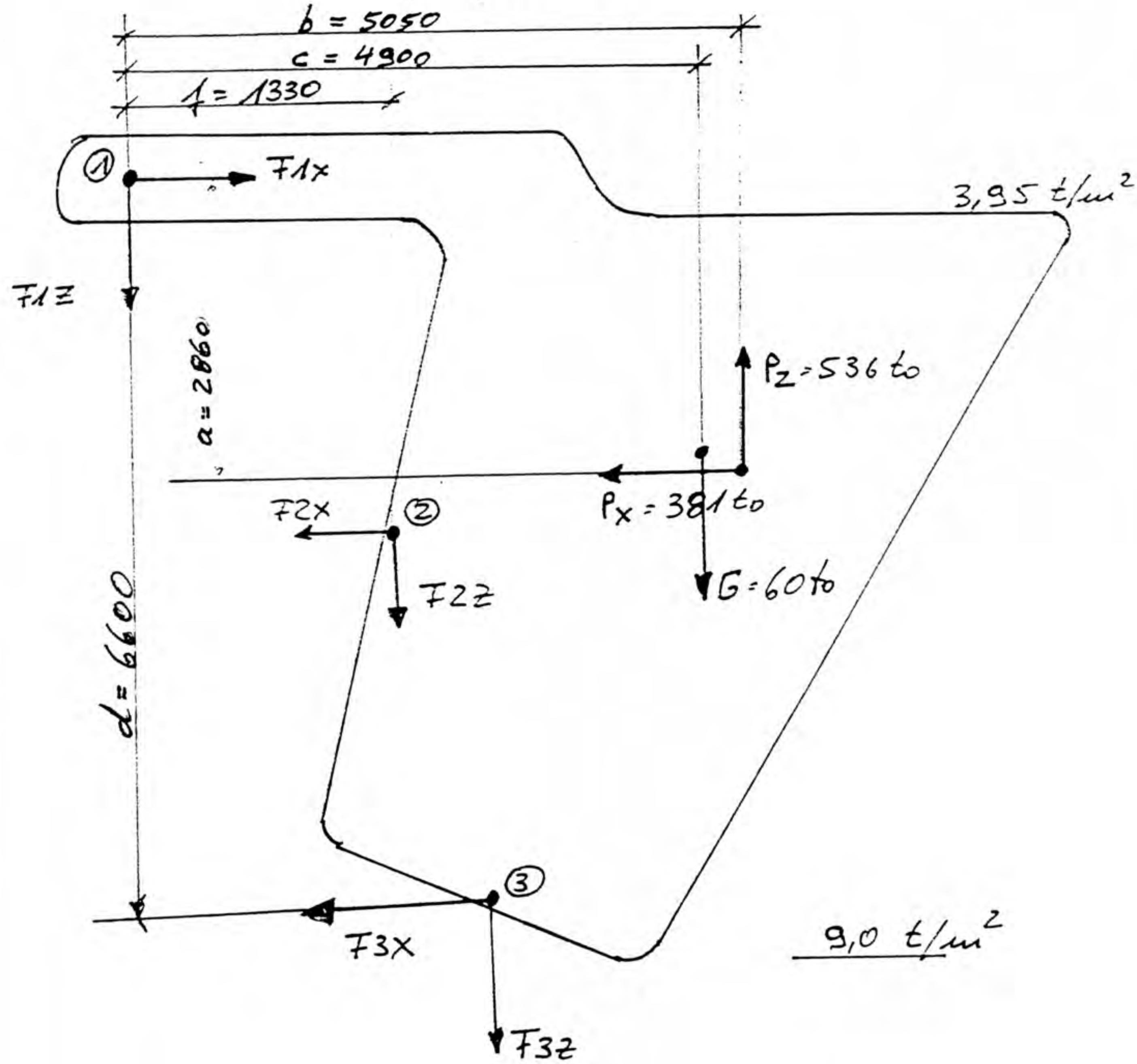
$P_z = 536$ to

$G = 60$ to

Bugklappe 590

②

Kräftesystem



Gesamt horizontalkraft:

$$R_x = \frac{P_z(b - f/2) - G(c - f/2) - P_x \cdot a}{d} = 152{,}5\ \text{to}$$

Gesamt vertikalkraft:

$$R_z = P_z - G = 476\ \text{to}$$

Insgesamt 5 Aufhängepunkte

$$F_{ix} = R_x/5 = 30{,}5\ \text{to}$$

$$F_{iz} = R_z/5 = 95{,}2\ \text{to}$$

$$F_R = \sqrt{F_{ix}^2 + F_{iz}^2} = 100\ \text{to}$$

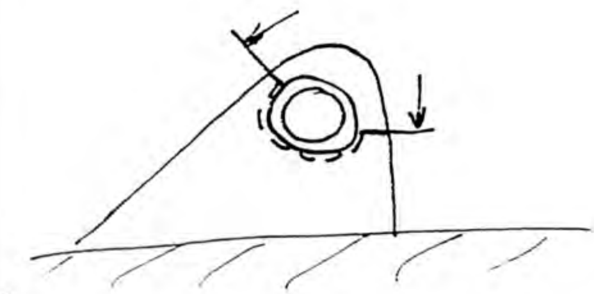
→ <u>100 to Belastung / Aufhängepunkt</u>

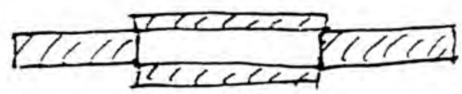
Mindestquerschnitte für Augen:

Material: St 52-2

$R_{eH} = 355\ N/mm^2 \Rightarrow k = 0{,}75$

$\sigma_{zul} = 123/k \Rightarrow 164\ N/mm^2$





$\sigma = \frac{F}{A} \quad A_{min} = \frac{F}{164}$

$A_{min} = \frac{100\ to}{164\ N/mm^2} = 6100\ mm^2$

SUPPLEMENT No. 205

Extracts from Bureau Veritas Rules and Regulations for the construction and classification of Steel Vessels 1977.

Paris.

Bureau Veritas

International Register
for the classification
of ships and aircrafts

Rules and Regulations

FOR THE CONSTRUCTION AND CLASSIFICATION OF

Steel Vessels

1977

31, rue Henri-Rochefort - Paris 17e

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Telex 290226 BVERITAS
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Section 6-6 | SUBDIVISION

Symbols

L, e, w defined in 6-12.11.

E: spacing, in metres, of bulkhead stiffeners,

other symbols used in this section are defined in the text.

6-61 General

1 - Application

11 - Requirements in this section provide scantlings and arrangement of watertight transverse bulkheads and bulkheads of ballast compartments, fuel oil bunkers, holds intended to carry liquids and shaft tunnel.

12 - On Owner's request, the Head Office will examine the watertight subdivision of:

- cargo ships, when intended for the mark ◯ or ◎.
- passenger ships, when intended for the mark ◇.

When assigning these marks, the requirements of 1-25.3 are to be complied with.

2 - Testing

21 - Hydraulic tests for bulkheads are to be carried out in accordance with section 3-7.

6-62 Watertight transverse bulkheads

1 - Disposition of watertight bulkheads

11 - Watertight transverse bulkheads are to be fitted as follows:

- a collision bulkhead located as stated in 12,
- an after peak bulkhead in way of the sterntube stuffing box, at a suitable distance from the sternpost,
- a bulkhead at each end of the machinery space.

Where special subdivision marks are not requested, it is recommended to provide a total number of watertight bulkheads not less than that given in the table hereafter, this number including the four preceding bulkheads that are mandatory. Bulkheads are so fitted as to form, as far as possible, watertight compartments of uniform length or with length decreasing slightly towards the ends.

L less than	Number of bulkheads	L less than	Number of bulkheads
87	4	144	7
102	5	165	8
123	6	186	9

12 - The collision bulkhead is to be provided at a distance d_c, in metres, aft of the fore perpendicular such as:

- passenger ships: $0{,}05 \leqslant d_c \leqslant 0{,}05L + 3$
- other ships:

$L \leqslant 90$m $\qquad 0{,}05L \leqslant d_c \leqslant 0{,}05L + 2{,}7$

$L > 90$m $\qquad 0{,}05L_1 \leqslant d_c \leqslant 0{,}08L$

where $L_1 = L$ without being taken greater than 200.

In the last condition, if a bulbous bow is fitted, the previous limit values may be altered as follows:

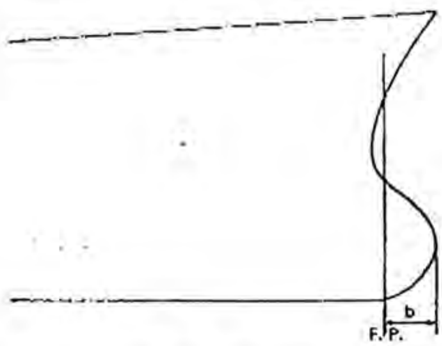
$$0{,}05L_1 - d \leqslant d_c \leqslant 0{,}08L - d$$

where d is the smaller of the values:

$0{,}015L_1$

$0{,}500b$

b being the distance, in metres, defined in the following sketch:



Steps or recesses may be permitted provided that the bulkhead shifted parts comply with the preceding limit values.

13 - Subject to Head Office's approval, the collision bulkhead may be provided at a distance, aft of the fore perpendicular, greater than the one defined in 12, on the condition that flooding calculations of the fore peak show that the buoyancy is not altered.

14 - The collision bulkhead is to extend, in all cases, to the freeboard deck. In ships fitted with a long forecastle, the Head Office may require a weathertight extension of this bulkhead to the forecastle deck; this extension may be shifted from the remainder of the bulkhead, on the condition that the deck part forming the step be also weathertight.

Scantlings of main stiffener and support repartition are to be determined in order that the platform deflection does not exceed 5mm/m.

55 - Scantlings of flexible supports and suspensions are to be determined taking account of a safety factor not being taken less than 5.

Rigid supports and locking devices are to be studied using direct calculations. In such a case, the maximum allowable stresses are:

- bending stress $\sigma \leqslant 85\ N/mm^2$
- shear stress $\tau \leqslant 42\ N/mm^2$
- combined stress $\sqrt{\sigma^2 + 3\tau^2} \leqslant 112\ N/mm^2$

11-44 Access

1 - Side openings and doors

11 - Where an opening is cut in side shell above freeboard deck for fitting a door, section compensations are to be provided above and below the opening.

Angles have to be rounded off.

12 - Compensed plates are to extent at least over two frames both sides of opening.

In determination of added section, horizontal edge reinforcement of opening may be included, provided they extent at least over the length required for compensed plates.

13 - The distance from upper edge of opening to strength deck has to be such than thickness of compensed plate does not exceed twice the normal thickness of shell plating in this area.

The distance of lower edge to freeboard deck has to be fixed in agreement with national authorities.

In some cases, it may be tolerated for a side door sill to be under load waterline, provided the ship's safety is not to decrease in any way. Particularly, watertightness is to be perfect and permanent. A drain system with easily accessible valve is to be fitted at bottom of compartment extending between door and door sill.

14 - Reinforced frames are to be fitted both sides of openings. Their scantlings are to be determined as for neighbouring frames, but replacing in formulae spacing E by 0,5(E + b) where b is, in m, the breadth of opening.

These frames are not required if height of opening is near from tweendeck height and door stiffeners are vertical.

15 - The closing of doors is to be watertight.

The thickness of plating is not to be less than for adjacent side shell.

The section modulus of stiffeners is to be at least equal to:

$$w = 7{,}7hE\ell^2$$

where h is the value calculated in 11-42.21 for side plating above freeboard deck.

16 - It is recommended to protect side doors against shocks which can result of cargo mistowage (for instance by use of a net or cables). To be efficient, protection devices are to be at some distance of the door.

2 - Bow and stern doors

21 - When the ship is equipped with a bow door, to allow access to garage, the collision bulkhead must have a removable part. This design is acceptable only above freeboard deck and only if the removable part has a watertightness and a strength equivalent to these of fixed rule bulkhead.

A movable access ramp may be used for this purpose.

22 - Scantlings of plating and stiffeners of a bow door are to be equivalent to those of adjacent shell structure.

23 - Thickness of a stern door plating is not to be less than:

$$e = 4{,}75E\sqrt{h}$$

Section modulus of stiffeners is not to be less than:

$$w = 7{,}7hE\ell^2$$

where value of h is calculated in 11-42.25.

24 - If stern door is used as access ramp for vehicles, it has also to be checked that scantlings of plating and stiffeners comply with rules of 11-43.

3 - Securing of doors

31 - Doors and screen-doors have to be firmly secured by use of cleats conveniently spaced or other similar devices.

Particularly, it has to be provided one of these devices at each corner of opening.

Structure reinforcements have to be realised on door and adjacent shell plating to attached points of cleats, hinges, jacks, etc.

32 - If door opens to inside of ship, securing devices have to be scantled in way to resist at a load height, in metres, equal to value calculated in 11-42.2.

SUPPLEMENT No. 206

Bureau Veritas Note Documentaire BM2.

Paris 5.4.1976.

B.BS970324

B117a

Bureau Veritas
Marine Division

Paris La Défense, 25 September 1995

FAX MESSAGE

RECEIVED GTB	1995-09-26
SEEN	HO
ACTION	HO ✓
C C	Haverikomm ✓
FILE	

to Mr Hans Olsson, BV Gothenburg

from P. Frey

M/V ESTONIA 35 P 387

Dear Mr Olsson,

I have your fax 3331 HO of today.

I enclose the Note documentaire BM2 dated 5 April 1976 Mr B. Stenström requested. I cannot find any English version of it.

I translate it quickly hereafter:

"Direct calculation of fore peak shell of large ships

Local loads

C1 (moulded) depth at upper deck in way of fore peak
p is the load in t/m2 derived from formulas for deck longitudinals of tankers.
One obtains:
p= ...
with h=...
then p= ... with 100<L<300
For such a calculation, the stress obtained according to the criterion defined in 5-72.11 is not to exceed 17.3 (kg/mm2)."

With best regards.

PFrey

P. Frey

encl. Note documentaire ND BM2 dated 5 Avril 1976 (1p.)

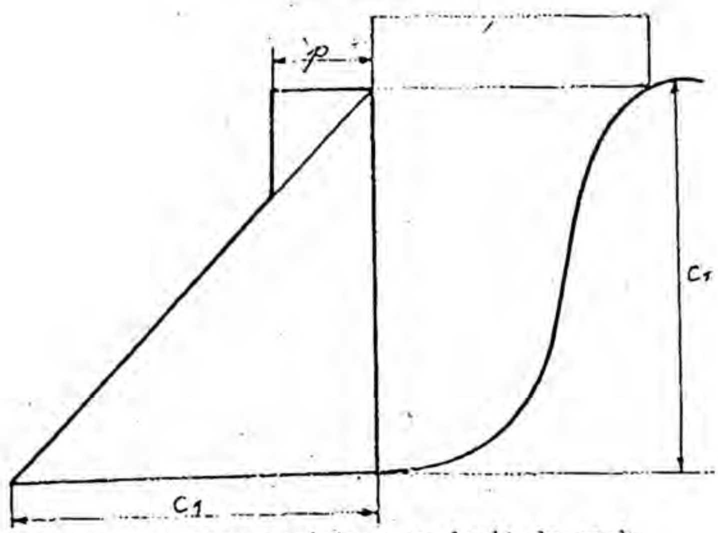
ADMINISTRATION BUREAU VERITAS le 5 Avril 1976

N.D. BM.2

NOTE DOCUMENTAIRE

CALCUL DIRECT DES MURAILLES DU PEAK AVANT DES GRANDS NAVIRES :

CHARGES LOCALES



C_1 : creux au pont supérieur au droit du peak

p est la charge en t/m2 déduite des formules de lisses de pont supérieur de pétroliers.

On obtient :

$$p = \frac{20,8}{4,2} \times 0,7 \times h$$

avec $h = 1,15 \left(\frac{L}{100} - 0,5\right)$ (voir 8-25-32)

d'où $\underset{t/m2}{p} = 4 \left(\frac{L}{100} - 0,5\right)$

avec $100 \leqslant L \leqslant 300$.

Pour un tel calcul, la contrainte obtenue par le critère défini en 5-72.11 ne devra pas être supérieure à 17,3.

SUPPLEMENT No. 207

Extrakt von Germanischer Lloyd Vorschriften für Klassifikation und Bau von stählernen Seeschiffen. Ausgabe 1978. Band 1.

Hamburg.

Extracts from Germanischer Lloyd Regulations for the classification and building of Steel Vessels. Version 1978. Part 1.

Hamburg

Germanischer Lloyd

Vorschriften
für
Klassifikation und Bau
von
stählernen Seeschiffen

Ausgabe 1978

Band I

Klassifikationsvorschriften · Schiffskörper

a) **Plattendicke:**

t = $\sqrt{k}$ (o,1 **L** + 5) **a/a$_o$** [mm]

Für **L** braucht kein größerer Wert als 2oo m eingesetzt zu werden.

a = Spantabstand (quer oder längs) auf o,2 **L** vom V.L.

a_o = Normalspantabstand (quer oder längs) gemäß Abschnitt 9, A. 1.1 (maximal 7oo mm)

Darüber hinaus muß bei Schiffen, deren Geschwindigkeiten die Werte der folgenden Tabelle, Spalte 2 überschreitet, die Plattendicke je Knoten Mehrgeschwindigkeit um o,5o mm verstärkt werden.
Dieser Zuschlag wegen erhöhter Geschwindigkeit soll mindestens 1 mm betragen, braucht jedoch nicht größer als 2 mm zu sein.

Länge L	Geschwindigkeit v*)	Interkostale Längsbänder
m	kn	
1	2	3
4o- 6o	1o	HP 14o x 7
61- 8o	11	HP 16o x 8
81-1oo	12	HP 18o x 9
1o1-13o	13	HP 2oo x 1o
131-16o	14	HP 22o x 11
161-18o	15	HP 24o x 11
über 18o	16	HP 26o x 12

*) v = die bei dem größten Tiefgang in glattem Wasser erwartete größte Schiffsgeschwindigkeit in Knoten.

b) **Aussteifungen:** Bei Querspantenbauweise sind der Flachkiel und die Bodenbeplattung durch zwischen den Seitenträgern anzuordnende interkostale Längsbänder nach Spalte 3 der Tabelle auszusteifen. Die Längsbänder sind so weit wie möglich nach vorn zu führen. Ausschnitte sind auf Durchschweißlöcher und den für Durchlauföffnungen erforderlichen Querschnitt zu beschränken.

4.3 Bei Längsspanten- bzw. Längsträgerbauweise sind die Längsspanten so weit wie möglich nach vorne zu führen.
Für die Bemessung von Längsspanten darf keine kleinere ununterstützte Länge als 1,8 m eingesetzt werden.

4.4 Durch Anordnung von interkostalen Steifen sollen möglichst quadratische Plattenfelder angestrebt werden.

F. Verstärkungen an Hintersteven, Wellenböcken und Schlingerkielen

1. Die Außenhautplatten, die am Hintersteven oder an den Wellenböcken angebracht werden, müssen verstärkt werden. Die Platten, die warm verformt werden, sind so dick zu wählen, daß sie nach der Bearbeitung mindestens die Mittschiffsdicke der Seitenplatten haben.

2. Im Bereich von Wellenböcken und Wellenhosen muß die Außenhaut die für o,4 **L** mittschiffs vorgeschriebene Dicke, im Bereich der Arme eine verstärkte Platte von 1,5facher Mittschiffsdicke erhalten.

3. Am Hintersteven sollen im Bereich der Einführung der Kräfte aus dem Rudersteven die Außenhautplatten die Dicke der mit ihnen zu verbindenden Platten des Ruderstevens, mindestens jedoch die 1,25fache Mittschiffsdicke der Seitenplatten erhalten.

4. Bei Propellerdrehzahlen über ca. 3oo Upm ist besonders bei flachen Böden über und vor den Propellern durch Anordnung interkostaler Schlingen die Größe der Plattenfelder zu verringern (siehe auch Abschnitt 8, A. 1.2.4 d).

5. Schlingerkiele sind so an der Außenhaut zu befestigen, daß z. B. bei Bodenberührung die Außenhaut nicht beschädigt werden kann. Die Schlingerkiele sollen daher an flach auf die Außenhaut aufgesetzten Flachstählen befestigt werden, welche rundherum wasserdicht mit der Außenhaut zu verschweißen sind.

G. Öffnungen in der Außenhaut

1. Allgemeines

1.1 Wenn in der Außenhaut Öffnungen für Fenster, Klüsen, Ausgüsse, Seeventile usw. eingeschnitten werden, müssen sie in den Ecken gut abgerundet und, wenn sie bei Schiffen bis **L** = 7o m größer als 5oo mm, bei Schiffen über **L** = 7o m größer als 7oo mm sind, durch einen Rahmen, eine verstärkte Platte oder eine Dopplung umfaßt werden.

1.2 Oberhalb von Öffnungen im Scheergang, die innerhalb von o,4 **L** mittschiffs liegen, ist im allgemeinen eine durchlaufende verstärkte Platte anzuordnen, durch die der fortfallende Plattenquerschnitt ersetzt wird. Bezüglich Außenhautpforten oder ähnliche große Öffnungen siehe 2.2. Besondere Verstärkungen sind im Bereich von Öffnungen im Scheergang an den Enden von Aufbauten erforderlich.

1.3 Bei den Ankerklüsen im Bug ist die Außenhaut zu verstärken.

1.4 Unter jedem Peilrohr ist die Bodenbeplattung mit einer verstärkten Platte oder Dopplung zu versehen.

2. Außenhautpforten

2.1 Außenhautpforten sollen im allgemeinen nicht unter die Tiefladelinie reichen. Bei Fahrgastschiffen muß die Unterkante von Außenhautpforten über der Tiefladelinie liegen. Bei Eisverstärkung siehe Abschnitt 15.

2.2 Die Außenhaut muß an Pforten die Ecken umfassende verstärkte Platten erhalten, die sich mindestens um je 1,5 Spantabstände über die

Pforten hinaus erstrecken. Die Konstruktion größerer Pforten (z. B. für Fahrzeuge) muß besonders behandelt werden.

2.3 Die Plattendicke der Pforten ist nach C. 3.1 zu bestimmen.
Die Versteifungen sind nach dem Druck p_s gemäß Abschnitt 4, B. 2. zu bestimmen, wobei folgende zulässige Spannungswerte zugrunde zu legen sind:

Biegespannung: $\sigma_b = 12o/k$ [N/mm²]

Schubspannung: $\tau = 7o/k$ [N/mm²]

Vergleichsspannung:

$$\sigma_v = \sqrt{\sigma^2 + 3\tau^2} = 14o/k \quad [N/mm^2]$$

2.4 Die Festigkeit der Pforten soll jedoch nicht geringer als die der umgebenden Schiffsverbände sein.

3. Rohranschlüsse an der Außenhaut

Die Befestigung von Speigattrohren und Armaturen an der Außenhaut soll mittels Schweißflanschen erfolgen. Statt der Schweißflansche können sachgemäß in die Außenhaut eingeschweißte kurze, dickwandige Rohrflanschstutzen vorgesehen werden.
Die Ausführung der Anschlüsse ist zur Genehmigung einzureichen, siehe auch Abschnitt 21, E.

H. Bugpforten

1. Allgemeines

1.1 Bugpforten sind oberhalb des Freiborddecks anzuordnen.

1.2 Werden Bugpforten des Visier-Typs oder geteilte Pforten angeordnet, ist eine wetterdichte innere Pforte vorzusehen. Eine Fahrzeugrampe kann für diesen Zweck dienen. Falls die Bugpforte zu einem langen Aufbau führt, muß die innere Pforte Teil des Kollisionsschottes sein (siehe hierzu auch Abschnitt 11, A. 2.1.6).

1.3 Bugpforten sind so anzuordnen, daß unter Berücksichtigung der Betriebsbedingungen ausreichende Dichtigkeit gewährleistet und ein ausreichender Schutz der inneren Pforten gegeben ist. Bugpforten, die zu Räumen in Aufbauten führen, müssen wetterdichte Verschlüsse erhalten.

1.4 Innere Türen müssen Vorreiber erhalten und wetterdicht sein.

1.5 Bugpforten sind für äußere und innere Drücke wie unter 2. angegeben zu bemessen.

2. Entwurfsdrücke

2.1 Der äußere Entwurfsdruck für den Bugbereich oberhalb der TWL (TWL = Tiefladelinie) ist nach folgender Formel zu berechnen:

$$p_{se} = (1,1 + o,75 \cdot \mathrm{tg}\,\alpha) \cdot v_R^2 \quad [kN/m^2]$$

v_R = Relativgeschwindigkeit zwischen Schiff und Welle in [kn]

v_R = $o,4 \cdot v \cdot \sin\Theta + o,6\sqrt{L}$, mit L_{max} = 25o m

v = Schiffsgeschwindigkeit in [kn] (siehe hierzu auch E. 4.2)

α = Seitlicher Ausfall der Oberfläche der Bugpforte gegenüber der Mittschiffsebene auf Mitte Pforte gemäß Abb. 6.2.

Θ = Winkel zwischen der Mittschiffsebene und der horizontalen Tangente an die Oberfläche der Bugpforte auf Mitte Pforte gemäß Abb. 6.2.

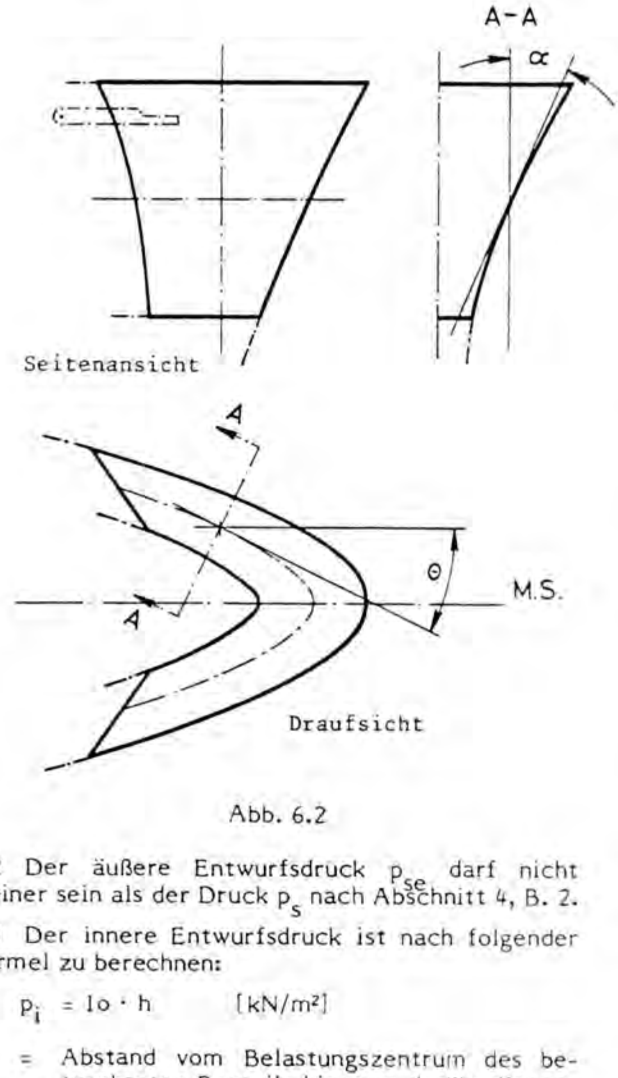


Abb. 6.2

2.2 Der äußere Entwurfsdruck p_{se} darf nicht kleiner sein als der Druck p_s nach Abschnitt 4, B. 2.

2.3 Der innere Entwurfsdruck ist nach folgender Formel zu berechnen:

$$p_i = 1o \cdot h \quad [kN/m^2]$$

h = Abstand vom Belastungszentrum des betrachteten Bauteils bis zum darüberliegenden Deck in [m]

h_{min} = 2,5 m.

3. Konstruktion, Abmessungen

3.1 Die Festigkeit der Bugpforten darf nicht geringer als die der umgebenden Schiffsverbände sein.

3.2 Bugpforten müssen so gebaut sein, daß horizontale oder vertikale Verschiebungen der Pforte im geschlossenen Zustand verhindert werden. Die Verbindungen zwischen den Hubarmen und der Pforte müssen von ausreichender Festigkeit sein.

4. Beplattung

4.1 Die Dicke der Beplattung von Bugpforten darf nicht kleiner sein als:

$$t = 1{,}26 \cdot a \cdot n \sqrt{p} \quad [mm]$$

$n = (1 - \frac{a}{2r})$ = Korrekturfaktor für gewölbte Platten, wobei r = Biegeradius

$n_{min} = 0{,}75$

$p = p_{se}$ gemäß 2.1 bis 2.3; der jeweils größere Wert ist zu nehmen

4.2 In keinem Falle darf die Plattendicke geringer als die Enddicke der Außenhaut gemäß C. 3 sein.

4.3 Werden innere Pforten als Fahrzeugrampen benutzt, darf die Beplattung nicht geringer sein als sich für Wagendecks nach Abschnitt 7, B. 3 ergibt.

5. Versteifungen

5.1 Die Abmessungen von Steifen sind nach folgenden Formeln zu bestimmen:

a) Widerstandsmoment:

$$W = \frac{M \cdot 10^3}{\sigma_p} \quad [cm^3]$$

$(W \approx 0{,}6 \cdot p \cdot a \cdot l^2 \quad [cm^3])$

b) Stegquerschnitt:

$$f = \frac{Q \cdot 10}{\tau_p} \quad [cm^2]$$

$(f \approx 0{,}05 \cdot p \cdot a \cdot l \quad [cm^2])$

M = größtes Biegemoment in [kN · m]

Q = größte Querkraft in [kN]

σ_p = 160/k [N/mm²]

τ_p = 100/k [N/mm²]

$p = 0{,}75 \cdot p_{se}$ (p_{se} siehe 2.1)
$p = 1{,}0 \cdot p_s$ (p_s siehe 2.2)
$p = 1{,}0 \cdot p_i$ (p_i siehe 2.3)
} der jeweils größere Wert ist zu nehmen

Die in runden Klammern angegebenen Formeln für W und f dienen nur zur Vordimensionierung.

5.2 Die Versteifungen von Türen, die auch als Fahrzeugrampe dienen, müssen auch den Vorschriften des Abschnittes 7, B. 3.2 entsprechen.

6. Träger

6.1 Träger und Stringer, die Steifen unterstützen, sind wie folgt zu bemessen:

a) **Entwurfsdruck:**

$p = 0{,}5 \cdot p_{se}$
$p = 1{,}0 \cdot p_s$
$p = 1{,}0 \cdot p_i$
} der jeweils größere Wert ist zu nehmen

b) **Zulässige Spannungen:**

Normalspannung: $\sigma \leq 120/k$ [N/mm²]

Schubspannung: $\tau \leq 80/k$ [N/mm²]

Vergleichsspannung:

$$\sigma_v = \sqrt{\sigma^2 + 3\tau^2} \leq 150/k \quad [N/mm^2]$$

7. Verschluß- und Sicherungseinrichtungen der Pforten

7.1 Allgemeines

Bugpforten müssen ausreichende Verschluß- und Sicherungseinrichtungen erhalten.

7.2 Anordnung

7.2.1 Verschlußeinrichtungen müssen einfach zu bedienen und leicht zugänglich sein.

7.2.2 Pforten mit einer lichten Öffnungsfläche von 12 m² und darüber müssen mit Verschlußeinrichtungen versehen werden, die von einer geeigneten Stelle aus fernbedient werden können. Anzeigevorrichtungen müssen für jede einzelne Verschlußvorrichtung anzeigen, ob sie geschlossen oder offen ist.

7.2.3 Das Bedienungspult darf nicht für Unbefugte zugänglich sein. Auf einer Anzeigetafel am Bedienungspult muß der Hinweis stehen, daß vor Verlassen des Hafens alle Verschlußeinrichtungen geschlossen werden müssen.

7.2.4 Werden kraft-hydraulisch betätigte Verschlüsse vorgesehen, muß für den Fall des Versagens des Antriebssystems die Verschlußvorrichtung auch manuell bedienbar sein.

7.3 Entwurfskräfte

7.3.1 Die Verschluß- und Sicherungseinrichtungen sowie die unterstützenden Bauteile sind nach dem jeweils größeren Wert der nach folgenden Formeln errechneten Entwurfskräfte zu bemessen:

a) **Äußere Kräfte:**

$$K_e = 0{,}5\, p_{se} \cdot A \quad [kN]$$

b) **Innere Kräfte:**

$$K_i = p_i \cdot A + K_p \quad [kN]$$

A = Fläche der Pforte in [m²]

K_p = gesamte Dichtungskraft in [kN] bei wasserdichter Abdichtung.

Die Dichtungskraft/Länge ist anzugeben. Normalerweise ist kein kleinerer Wert als 5 N/mm einzusetzen.

p_{se} siehe 2.1

p_i siehe 2.3

7.3.2 Für Bugpforten vom Visiertyp, die nach oben öffnen, sind die horizontalen und vertikalen Kräfte, die an den Verschluß- und Aufhängevorrichtungen angreifen, nach folgenden Formeln zu bestimmen (siehe hierzu auch Abb. 6.3):

a) **Kräfte in Längsrichtung an der Pfortenbasis** nach vorne wirkend:

$$R_{xf} = \frac{g \cdot G \cdot c + P_{xe} \cdot a - P_z \cdot b}{d} \quad [kN]$$

nach hinten wirkend: (falls $P_{xi} \cdot a > g \cdot G \cdot c$)

$$R_{xa} = \frac{g \cdot G \cdot c - P_{xi} \cdot a}{d} \quad [kN]$$

G = Masse der Bugpforte in [t]
a = vertikaler Abstand in [m] vom Drehpunkt der Bugpforte zum Schwerpunkt der vertikalen projizierten Fläche der Bugpforte.
b = horizontaler Abstand in [m] vom Drehpunkt der Bugpforte zum Schwerpunkt der horizontalen projizierten Fläche der Bugpforte.
c = horizontaler Abstand in [m] vom Drehpunkt der Bugpforte bis zum Massenschwerpunkt der Bugpforte.
d = vertikaler Abstand in [m] vom Drehpunkt der Bugpforte bis Unterkante Bugpforte (unterste Verschlußvorrichtung).

g = Erdbeschleunigung = 9,81 [m/s²]
P_{xe} = $p_e \cdot A_v$ [kN]
P_z = $p_e \cdot A_h$ [kN]
P_{xi} = $p_i \cdot A_v$ [kN]
p_e = $0,5 \cdot p_{se}$, p_{se} siehe 2.1
p_i = siehe 2.3
A_v = vertikale (auf die Spantebene) projizierte Fläche der Bugpforte in [m²]
A_h = horizontale projizierte Fläche der Bugpforte in [m²]

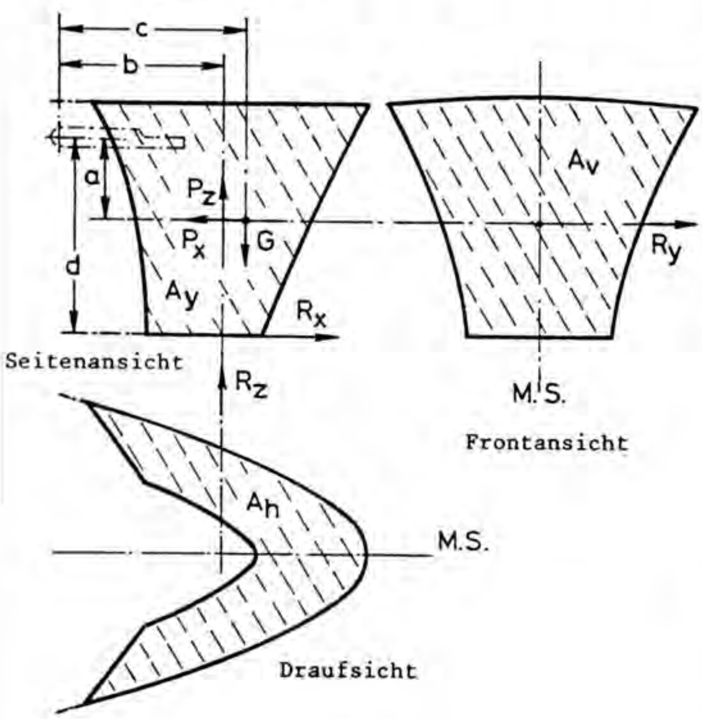


Abb. 6.3

b) **Kräfte in vertikaler Richtung**

$$R_{z1} = P_z - g \cdot G \quad [kN]$$

$$R_{z2} = 10 \cdot V - g \cdot G \quad [kN]$$

V = von der Bugpforte umschriebenes Volumen in [m³]

Der jeweils größere Wert ist zu nehmen

c) **Kraft in Querrichtung**

$$R_y = p_s \cdot A_y \quad [kN]$$

p_s siehe Abschnitt 4, B. 2.

A_y = projizierte Seitenfläche der Bugpforte in [m²]

7.3.3 Werden mehrere Verschluß- bzw. Unterstützungsvorrichtungen vorgesehen, so sind die Gesamtkräfte in horizontaler und vertikaler Richtung gleichmäßig auf die einzelnen Vorrichtungen zu verteilen.

7.4 Zulässige Spannungen

Normalspannung: $\sigma \leq 120/k$ [N/mm²]
Schubspannung: $\tau \leq 80/k$ [N/mm²]
Vergleichsspannung:

$$\sigma_v = \sqrt{\sigma^2 + 3\tau^2} \leq 150/k \quad [N/mm^2]$$

Zugspannung im Gewinde der Bolzen:

$$\sigma_z \leq 105/k \quad [N/mm^2]$$

7.5 Dichtungen

7.5.1 Das Dichtungsmaterial soll möglichst weich sein. Die Auflagerkräfte dürfen nur von der Stahlkonstruktion übertragen werden.

7.5.2 Bei der Bemessung der Halterungen der Dichtungen (Flachstähle) ist die während des Betriebes auftretende Abnutzung mit zu berücksichtigen.

J. Schanzkleid

1. Die Dicke des Schanzkleides darf nicht kleiner sein als:

$t = (0,75 - L/1000)\sqrt{L}$ [mm] für $L \leq 100$ m

$t = 0,65\sqrt{L}$ [mm] für $L > 100$ m

Für **L** braucht kein größerer Wert als 200 m eingesetzt zu werden. Das Schanzkleid, das im Vorschiffsbereich besonders dem Seeschlag von vorn ausgesetzt ist, soll die Dicke der Backseitenbeplattung gemäß Abschnitt 16, B. 1. erhalten.

Das Schanzkleid von Aufbauten über dem Freiborddeck darf hinter 0,25 **L** vom Vorsteven 0,5 mm dünner sein.

2. Die Höhe des Schanzkleides oder Schutzgeländers darf nicht weniger als 1,0 m betragen.

SUPPLEMENT No. 208

Extract from Lloyds Register of Shipping Rules and Regulations for the Construction and Classification of Steel Ships 1976.

London.

3514 Door openings in the side shell are to have well rounded corners, and adequate compensation is to be arranged (*see* D 514).

3515 The lower edge of door openings is not to be below a line drawn parallel to the freeboard deck at side which has, as its lowest point, the upper edge of the uppermost load line, unless otherwise permitted by the National Authority concerned.

BOW AND STERN DOORS

Definitions

3516

S = span of stiffeners, in metres,

s = spacing of stiffeners, in mm,

h = head, in metres, from mid-span of stiffener to top of door, but is not to be taken less than 2 m,

a = vertical distance, in metres, from the bow visor pivot to the centroid of the vertical projected area of bow visor,

b = horizontal distance, in metres, from the bow visor pivot to the centroid of the horizontal projected area of the bow visor,

c = horizontal distance, in metres, from bow visor pivot to centre of gravity of bow visor,

d = vertical distance, in metres, from bow visor pivot to lowest closing device or cleat,

W = weight of bow visor, in tonnes,

A_v = the area, in m^2, of the vertical projection of the bow visor (*see* Fig. D 35.1),

A_h = the area, in m^2, of the horizontal projection of the bow visor (*see* Fig. D 35.1),

V = the volume, in m^3, of the bow visor,

R_x = total horizontal force, in kN (tonne-f),

R_z = total vertical force, in kN (tonne-f),

τ = shear stress, in N/mm² (kgf/cm²),

σ = bending stress, in N/mm² (kgf/cm²),

σ_c = combined stress, in N/mm² (kgf/cm²),
$= \sqrt{\sigma^2 + 3\tau^2}$

Scantlings

3517 In general, the strength of bow and stern doors is to be equivalent to the surrounding structure.

Plating is not to be less than the minimum shell plating end thickness.

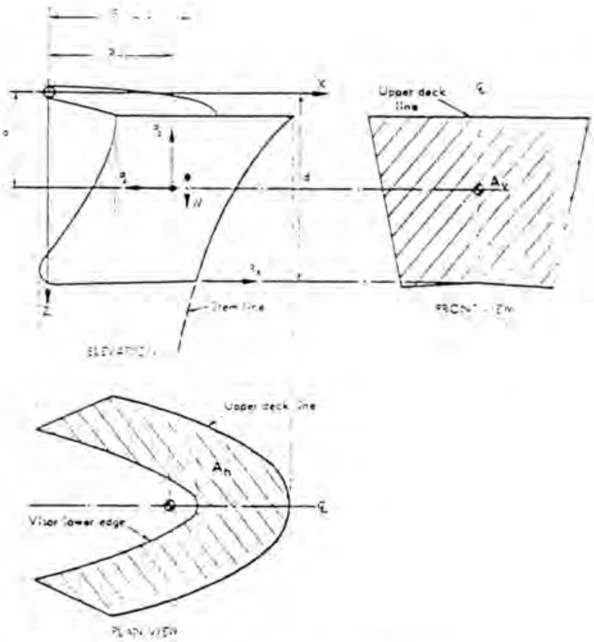


FIG. D 35.1 BOW VISOR

3518 The scantlings of stiffeners of stern doors, where not used for vehicle ramps, are not to be less than:—

$$\frac{I}{y} = \frac{S^2\,s\,h}{98.4}\ \text{cm}^3$$

Stiffeners are to be adequately supported by an efficient arrangement of webs and stringers.

3519 Bow doors of the visor or hinged opening type are to be adequately stiffened, and means provided to prevent lateral or vertical movement of the doors when closed.

In visor type doors care is to be taken to ensure that adequate strength is provided in the connections of the lifting arms to the door structure.

Additional Inner Bow Door

3520 Where bow doors are fitted, an inner door will also normally be required. The vehicle ramp may be used for this purpose.

Vehicle Ramps

3521 Where doors also serve as vehicle ramps, the scantlings are not to be less than would be required by 3504 and 3505.

Closing and Securing of Doors

3522 **All bow, stern and side shell doors are to be fitted with adequate means of closing and securing, commensurate with the strength of the surrounding structure.**

3523 For doors of the visor type (i.e. upward hinging) the horizontal and vertical forces acting on the cleats are to be calculated as follows:—

(a) Total horizontal force

$$R_x = \frac{9{,}81\ Wc + P_x a - P_z b}{d}\ \text{kN}$$

$$\left(R_x = \frac{Wc + P_x a - P_z b}{d}\ \text{tonne-f}\right)$$

where $P_x = 29{,}4\ A_v$ kN ($3\ A_v$ tonne-f) (*see* Fig. D 35.1)

$$P_z = 58{,}8\ A_h\ \text{kN}\quad (6A_h\ \text{tonne-f})$$

(b) Total vertical force

$R_z = P_z - 9{,}81\ W$ kN or $10{,}05V$ kN whichever is the greater.

($R_z = P_z - W$ tonne-f or $1{,}025V$ tonne-f, whichever is the greater.)

The cleats and surrounding structure are to be designed to withstand these forces, using the following permissible stresses:—

Shear stress τ = 83,4 N/mm² (850 kgf/cm²),

Bending stress σ = 122,6 N/mm² (1250 kgf/cm²),

Combined stress σ_c = 147,1 N/mm² (1500 kgf/cm²).

Where more than one cleat is fitted on each side, the total vertical and horizontal forces are, for the purpose of calculation, to be distributed equally between the cleats. However, d may still be measured to the lowest closing device or cleat when calculating R_x.

3524 **Bow and outer doors are to be so fitted as to permit tightness consistent with operational conditions and to give maximum protection to inner doors.**

Inner doors are to be gasketed and weathertight.

3525 **Stern doors are also to be gasketed and weathertight.**

Air Pipes

3526 Air pipes are to comply with the requirements of Chapter E and are to be of the height required by D 2911.

Air pipes are generally to be led to an exposed deck and fitted as required by D 2910 to D 2914 inclusive.

Alternative arrangements will be considered.

Ventilators

3527 Ventilator coamings and closing appliances are to be as required by D 29. Where the freeboard length of the vessel is 100 m or less, permanently attached weathertight steel closing appliances are to be provided.

If any such ventilators are led overboard in an enclosed 'tween deck space, the closing arrangements are to be submitted for approval. If such ventilators are led overboard more than 4,5 m above the main vehicle deck, closing appliances need not be fitted, but a satisfactory baffle arrangement should be provided, as in the case of air intakes or exhaust openings for machinery spaces which may be arranged in the sides of the ship.

Hatches

3528 Coamings of hatchways on weather decks, their closing and securing arrangements, are to be as required by D 26. Covers on small hatches are to be weathertight and preferably hinged. The spacing of securing devices is not to exceed 600 mm. Where toggles are fitted, their diameter is not to be less than 16 mm.

The height of hatch coamings may be reduced or these coamings omitted entirely, provided that the sealing arrangements are adequate and the safety of the ship is not thereby impaired in any sea condition. In such cases, the spacing of securing devices may require to be reduced. Each proposal for the reduction of hatch coaming height is to be specially considered in relation to hatch size and the height above the load waterline.

Companionways, Doors and Windows

3529 Companionways and doors therein are to be as required by D 2646 and D 2647.

In ferries which carry passengers, all openings in the main vehicle deck, being in an enclosed 'tween deck space closed by bow and stern doors, and leading to spaces below, are generally to be protected by steel doors or hatch covers which are substantially weathertight. These openings are generally to have sills or coamings not less than 230 mm above the main vehicle deck, with the exception of those leading to machinery spaces which are to have sills or coamings not less than 380 mm.

Exceptionally, where such openings are to be kept closed at sea, sills or coamings may be reduced in height, provided that the sealing arrangements are adequate. In such cases, the doors or hatch covers are to be secured weathertight by gaskets and a sufficient number of clamping devices.

SUPPLEMENT No. 209

Correspondence between Von Tell AB and the Finnish Maritime Administration about approval of the visor design in general.

Mölndal • Sweden 18/12 1979

von Tell

von Tell AB

Vårt datum Our date
1979-12-14
Ert datum Your date

Vår referens / Our reference
CB/IA
Er referens / Your reference

Sjöfartsstyrelsen
Bergmansgatan 1
HELSINGFORS
Finland

M

Att.: Fartygssektionen

Betr.: Godkännande av ritningar
vår ref. nr 4911.1

Rederi AB Sally, Mariehamn bygger vid Jos. L Meyer, Papenburg en passagerar- och bilfärja för trafik mellan Sverige och Finland. Denna färja skall byggas till Bureau Veritas och Ert godkännande.

Vi har av varvet i Tyskland erhållit i uppdrag att leverera höj- och sänkbara bildäck, ramper i för och akter, visir och sidoportar. Samma utrustning levererade vi till systerfartyget DIANA II, som byggts 1979 hos Meyer med godkännande av B.V. och Svenska Sjöfartsverket.

Vi önskar veta på vilka detaljer vi skall översända ritningar för Ert godkännande.

Vi avvaktar med intresse Er snabba behandling och svar.

Med vänliga hälsningar

von TELL AB

Conny Bryfors

1. [illegible]
2. [illegible]
3. [illegible]) ?
1979-12-20
CB.

[illegible] MKH

Postal address: P. O. Box 472 S-401 27 Göteborg 1 Sweden
Office address: Göteborgsvägen 97 S-431 37 Mölndal Sweden
Phone: 031-87 05 00
Telex: 20617 vontells
Telegram: telltrade
Bank: Skandinaviska Enskilda Banken, Göteborg
Bank Giro No 501-1838
Post Giro No 24 05 45-4

SJÖFARTSSTYRELSEN

Helsingfors 27.12.1979

Nr KD 3965/79/301
L 1296

Hänvisning CB/IA

von Tell AB
PB 472
S-40127 Göteborg 1
Sverige

Ärende Nybygge fos Jos.L.Meyer

Beträffande för-och akterramperna, sidoportarna och visiret förutsätter vi att ritningarna i första hand granskas av Bureau Veritas. Endast i det fall att klassen är osäker om hur någon punkt i lastlinje- eller SOLAS-konventionen tolkas av den finska administrationen, skall ritningar sändas till sjöfartsstyrelsen.
För snabb behandling bör i så fall problemet vara klart beskrivet. Sjöfartsstyrelsen saknar kapacitet för rutinmässig genomgång av allt det ritningsmaterial ett modärnt fartyg förutsätter.

Även beträffande de höj- och sänkbara bildäcken nöjer vi oss med att de godkänns av klassen om icke speciella problem uppstår. Om det dock är meningen att bildäcken skall kunna lyftas och sänkas i lastat tillstånd d.v.s. med bilar på, betraktas de som lastningsanordningar och skall godkännas av arbetarskyddsstyrelsen.

Med vänlig hälsning

Byråingenjör Gunnar Edelmann

GE/MS

Lom. 1.A4 ADRESS: Bergmansgatan 1 HELSINGFORS 14
POSTADRESS PB 158 00141 Helsingfors 14 Finland
TELEFON: 90-650 411
TELEX: 121471 mkh sf
POSTGIROKONTO 3801-4

SUPPLEMENT No. 210

Von Tell telex to Bureau Veritas 18.3.1980 about visor attachment design loads and stresses.

21542617934
20617 vontell s   80-03-18/868

good afternoon this is von tell ab gothenburg/sweden

att.: mr desoussa

re.: ferry in papenburg
bow visor
our ref 4911.1

---

we refer to phone conversation with mr desoussa.

in lack of bv rules we have used the lr rules and got

total horizontal force abt 230 tonne
total vertical force abt 470 tonne

we have calculated with the two side cleatings and the atlantic securing device and will then have a load of abt 80 tonne for each device.

calculated shear stress will be 800 kp/cm2 and bending stress 2400 kp/cm2.

we think we are slightly above the stress permitted by lr and we could change the present steel with min breaking strength of 50 kp/mm2 to a material with a breaking strength of 90 kp/mm2. 75 kp/mm2

please advise++

regards
von tell / a eriksson

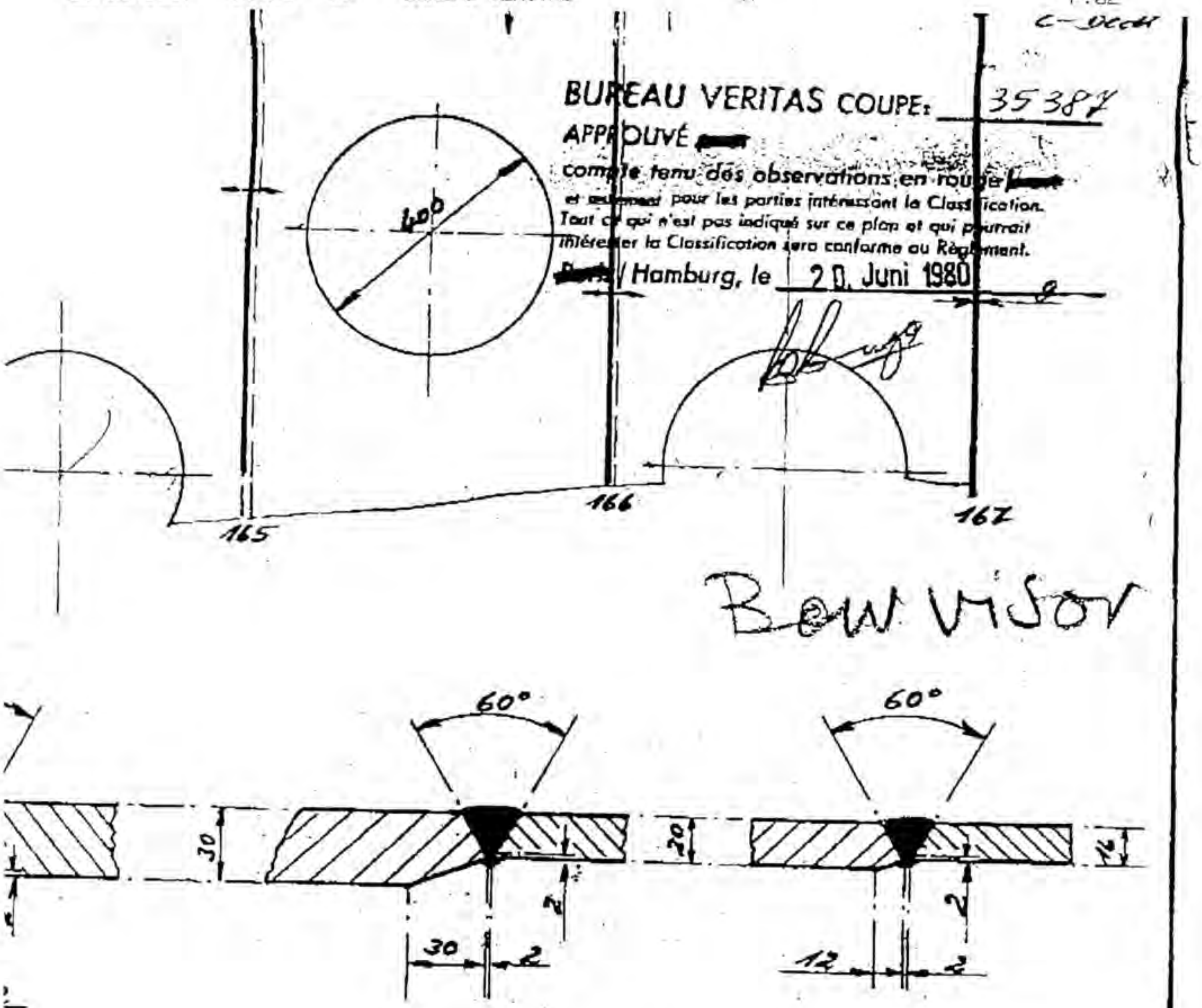
21542617934
20617 vontell s

SUPPLEMENT No. 211

Extracts from notes made by the Bureau Veritas surveyor on the visor assembly drawing 590/1103 rex 6.

C-Deck

BUREAU VERITAS COUPE: 35387
APPROUVÉ [redacted]
compte tenu des observations en rouge [redacted]
et seulement pour les parties intéressant la Classification.
Tout ce qui n'est pas indiqué sur ce plan et qui pourrait intéresser la Classification sera conforme au Règlement.
[redacted] / Hamburg, le 20. Juni 1980



- 3. 6. 1980

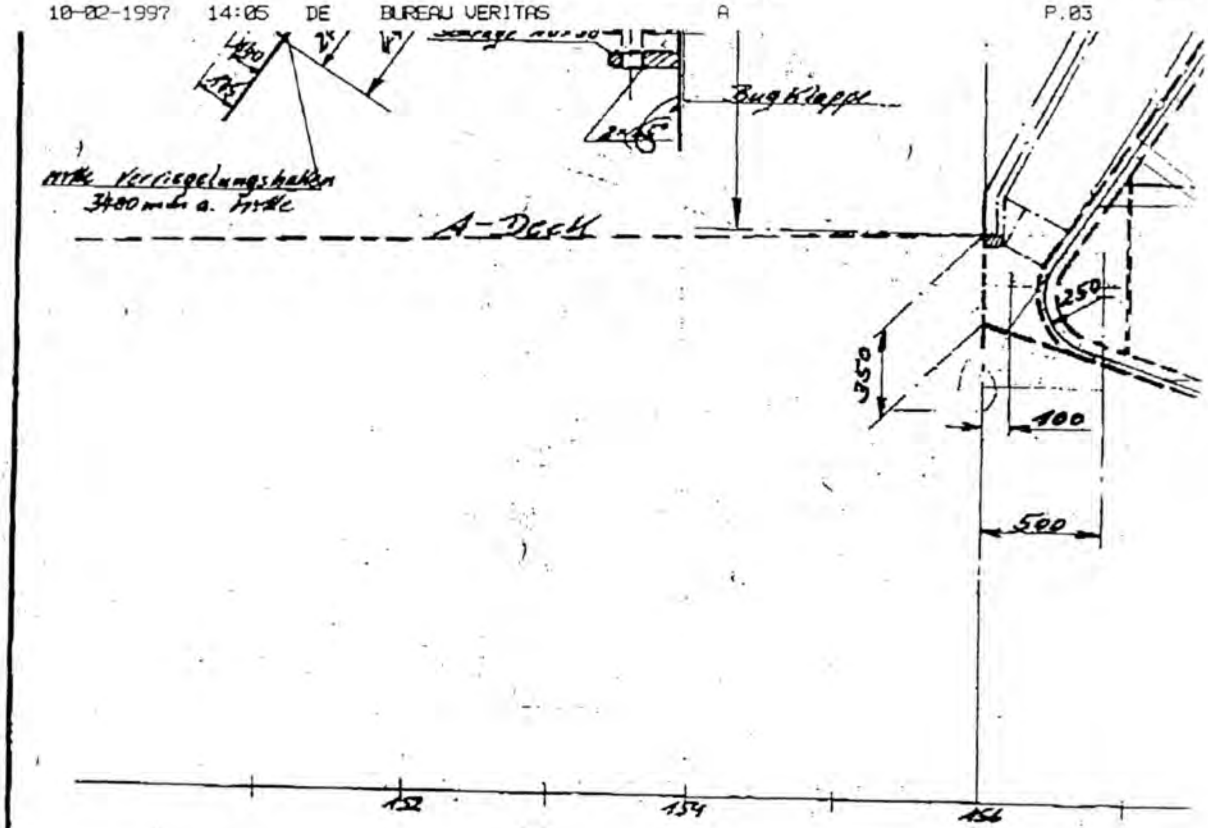
Nr.	Art der Änderung	Datum	Name
6	div. Änderungen	2.6.80	[illegible]
5	Schott Rz 17 / Schanzkleid / Scheinwerfer Kasten	26.2.80	[illegible]
4	Seitliche Führung der Bugklappe	2.1.80	[illegible]
3	geprüft: von Teil	22.11.79	[illegible]
2	Pos.-Nr. eingetragen	16.11.79	[illegible]
1	Zylinderaugen und den Scharnierarm geändert	6.11.79	[illegible]

Maßstab: 1:25, 1:5, 1:10, 1:25

Jos. L. Meyer Papenburg (Ems)
Schiffswerft Maschinenfabrik Dockbetrieb

Datum: 30.10.79

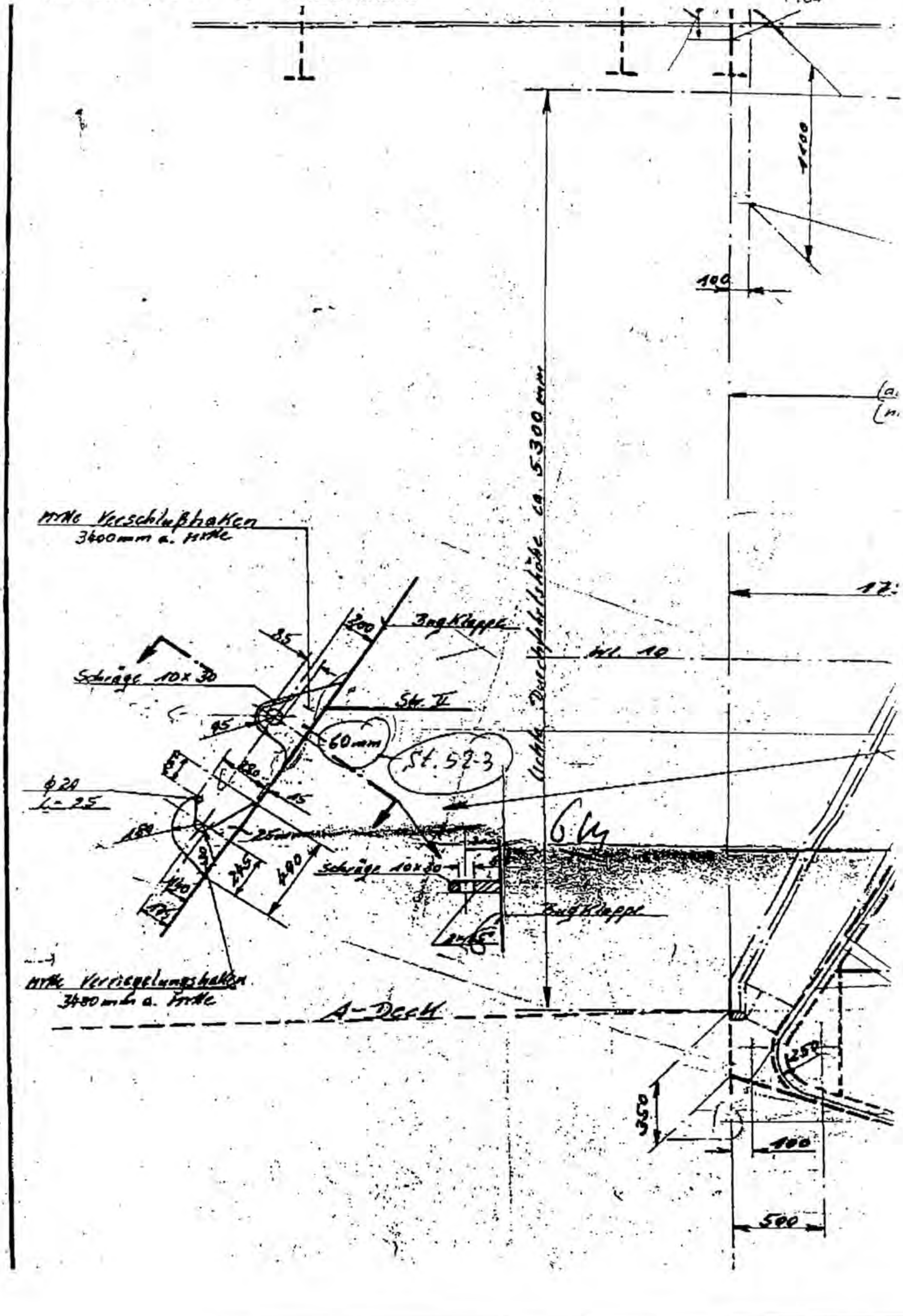
Gewerk



General remarks

1) Arrangement of locking devices subject to the approval of the national Authorities.

2) Watertightness of the ramp and local reinforcements of the ship's structure in way of locking devices, cylinders and hinges to Surveyor's satisfaction.



Mitte Verschlußhaken
3400mm a. Mitte
Schräge 10x30
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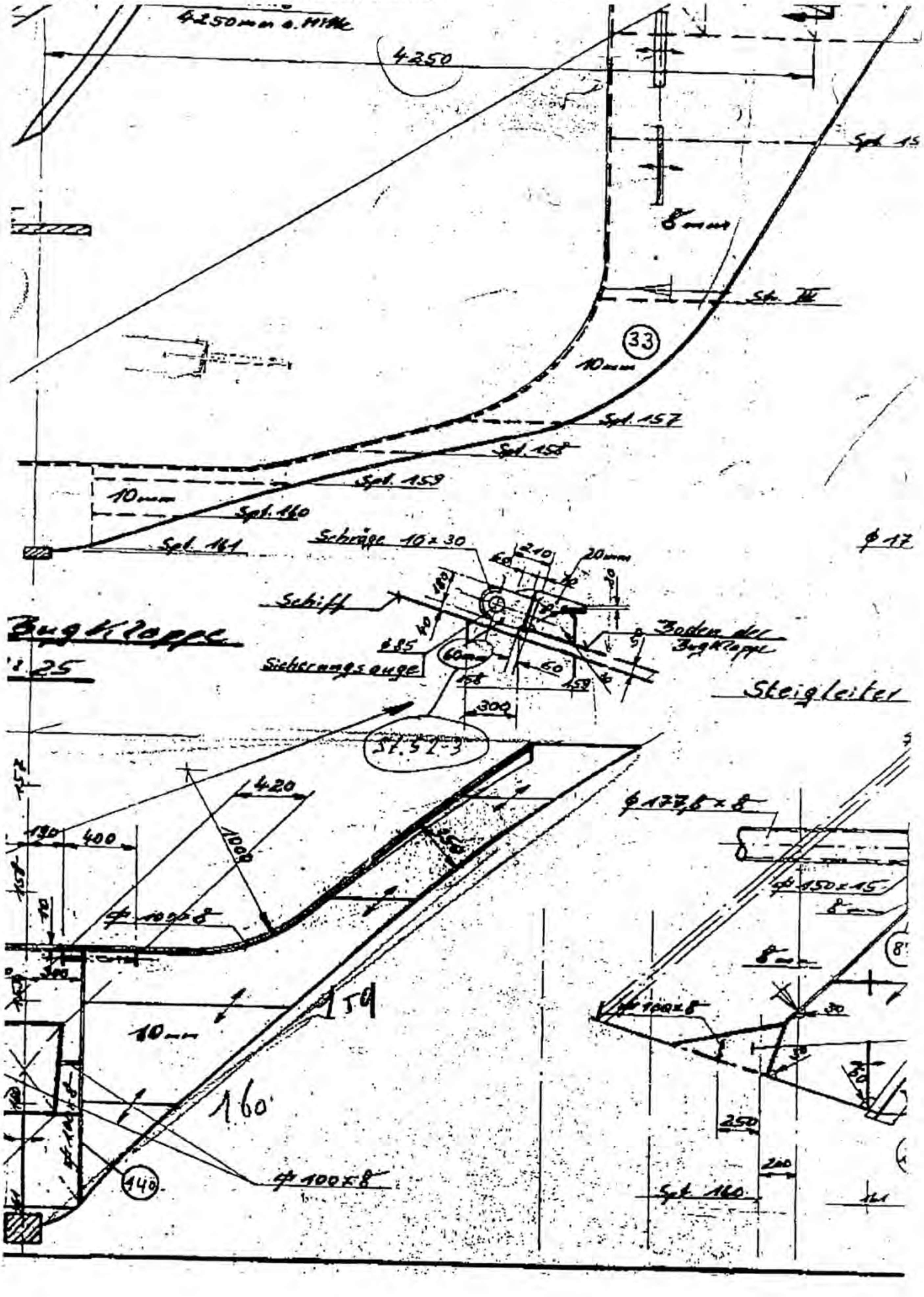
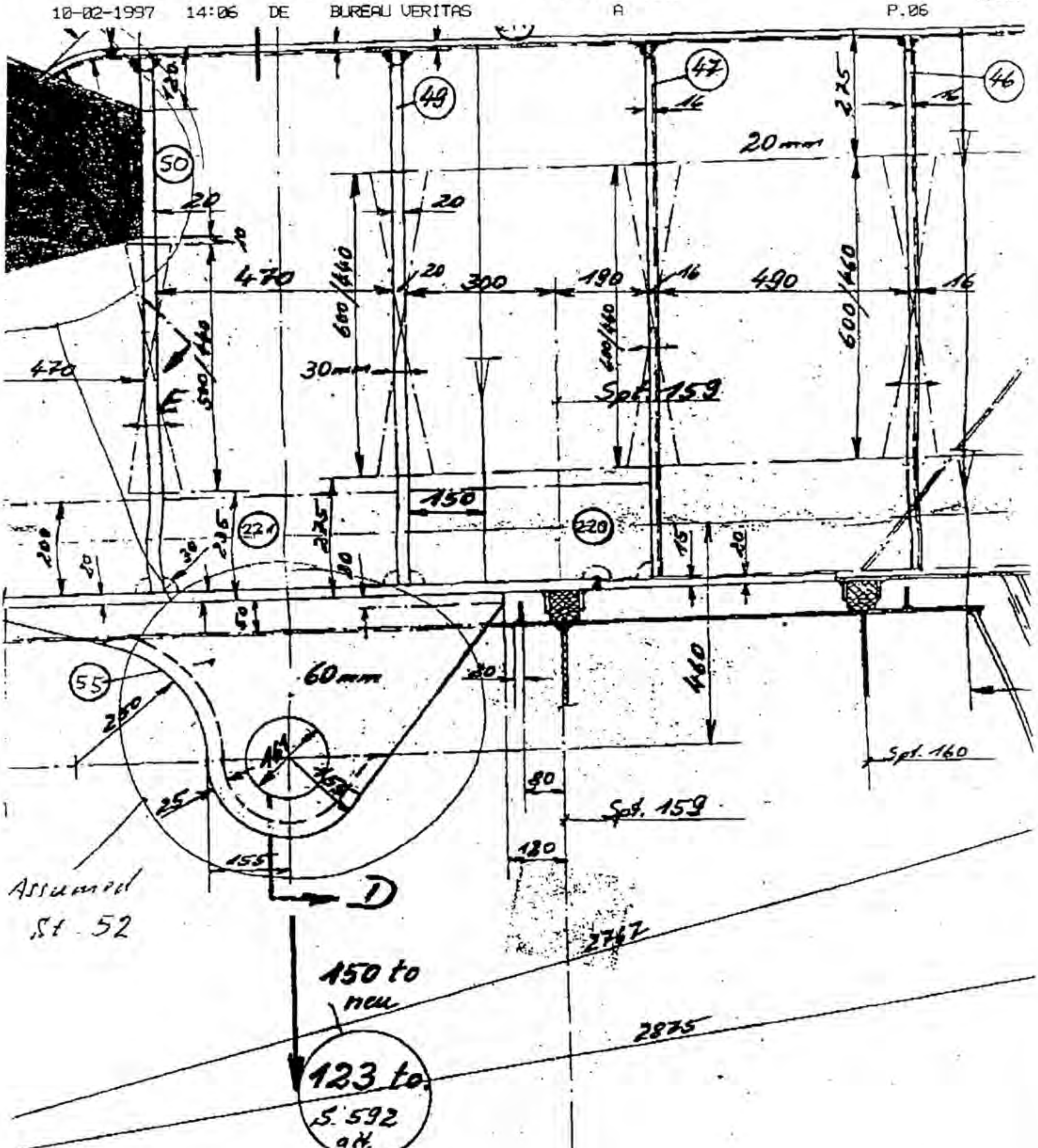
200
BugKlappe
Str. II
60mm
St. 52-3
φ20
L=25
25mm
schräge 10x30
BugKlappe
Mitte Verriegelungshaken
3480 mm a. Mitte
A-Deck
Lichte Durchfahrtshöhe ca. 5.300 mm
Kl. 10
1100
100
350
250
100
500


4250mm a. Mitte
4250
8mm
33
10mm
Spt. 157
Spt. 159
10mm
Spt. 160
Spt. 161
Schräge 10 x 30
Schiff
Bugklappe
1:25
Sicherungsauge
Boden der Bugklappe
Steigleiter
300
St. 52-3
420
400
1000
Φ 177,8 x 8
Φ 150 x 15
8mm
Φ 100x8
10mm
159
160
140
Φ 100 x 8
250
200
Spt. 160
30


47
49
46
50
16
275
20mm
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470
600/440
20
300
190
16
490
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16
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580/440
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150
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20
236
221
275
30
220
15
20
60
460
55
60mm
250
161
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Spt. 159
28
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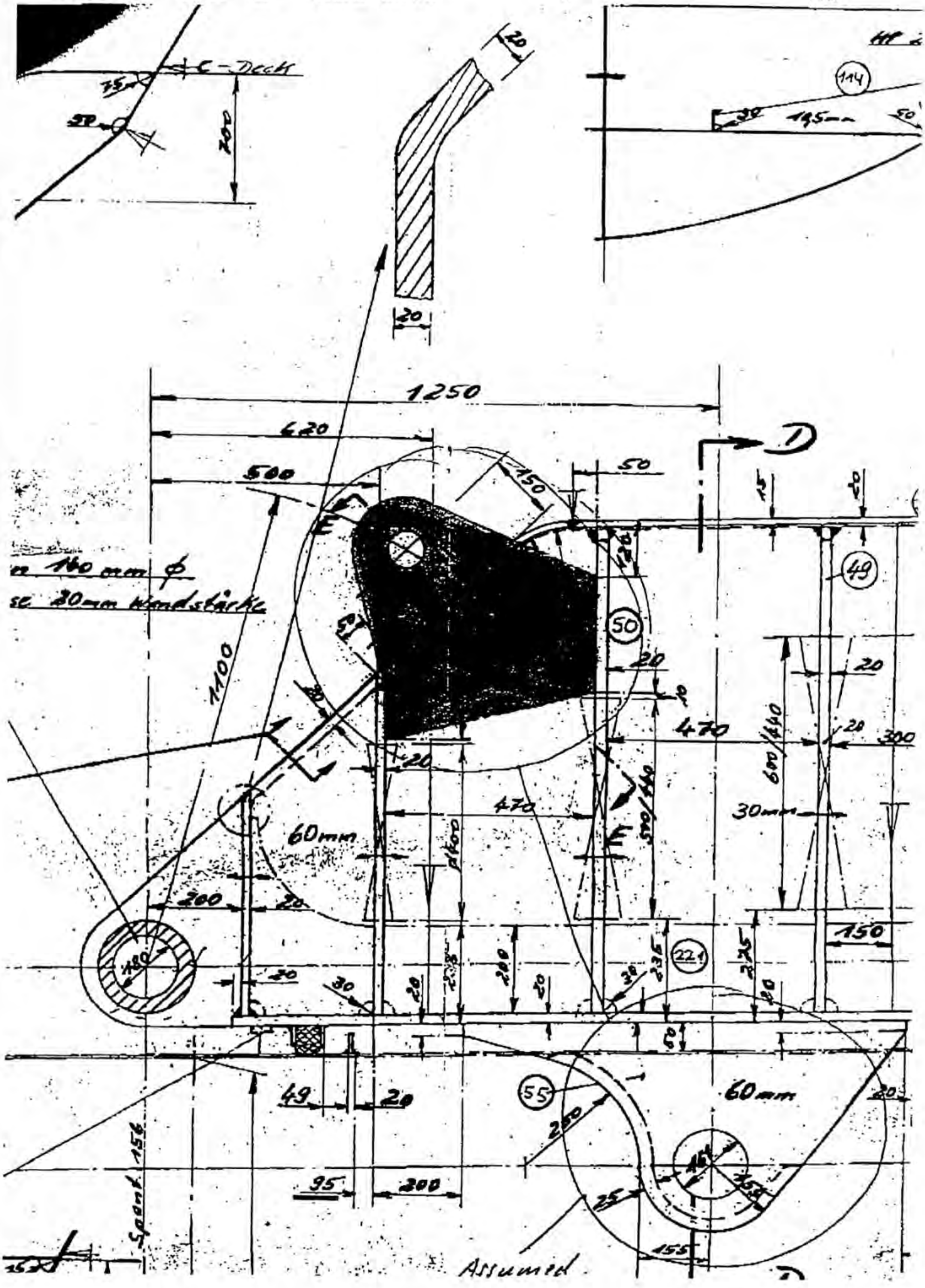
C-Deck
700
20
20
114
30
50
1250
620
500
150
50
D
140 mm ϕ
30mm Wandstärke
49
50
1100
20
470
600/440
300
30mm
60mm
470
200
150
221
180
30
55
60mm
49
20
250
95
200
Spant 156
155
25
Assumed

SUPPLEMENT No. 212

M/S ESTONIA & M/S MARE BALTICUM
Utredning beträffande placering av kollisionsskott/förlig ramp.

Nordström &Thulin.

Stockholm 1994.

M/S ESTONIA & M/S MARE BALTICUM
Investigation on placing of collision bulkhead/bow ramp

Nordström &Thulin.

Stockholm 1994.

ESTONIA
B 36

N&T Est. 1850

STATENS HAVERIKOMMISSION
Ink 1994 -12-
ESTONIA

Till: STATENS HAVERIKOMMISSION / Börje Stenström
Kopia: BUREAU VERITAS, Göteborg / Hans Olsson
N&T RedAvd / Ulf Hobro
Från: N&T RedAvd / Sten-Crister Forsberg
Datum: 08 december 1994[1]

Ang.: M/S ESTONIA & M/S MARE BALTICUM - UTREDNING BETRÄFFANDE PLACERING AV KOLLISIONSSKOTT/FÖRLIG RAMP.

INNEHÅLL:

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[1] Bilaga 2 reviderad 09 dec 1994

A. BAKGRUND

M/S Diana II byggdes av Jos. Meyer, Papenburg, V-Tyskland och levererades på försommaren 1979 till Rederi AB Slite, Sverige. Fartyget trafikerade i huvudsak Stockholm - Åbo för Viking Line fram till årsskiftet 1992/93 då hon hyrdes ut på bareboat-basis till TT-Line Gmbh, Hamburg för trafik Trelleborg - Rostock. I samband med Rederi AB Slites konkurs 7 april 1993 övertog Nordbanken Finans AB ägandet av fartyget inklusive bareboat-certepartiet med TT-Line. Den 5 oktober 1994 övertogs fartyget av Estonian Shipping Co Ltd (ESCO), Estland som disponerande ägare för insättande i EstLines trafik Stockholm - Tallinn under namnet M/S Mare Balticum.
Fartyget byggdes till och seglade under svensk flagg fram till den 5 oktober 1994 och har har under denna tid från och med byggnationen stått under svenska Sjöfartsverkets myndighetstillsyn som genom Sjöfartsinspektionen svarat för inspektion för och utfärdande av erforderliga certifikat enligt SOLAS.
Från och med den 5 oktober 1994 seglar fartyget under estnisk flagg och står därmed under tillsyn av den estniska sjöfartsmyndigheten som auktoriserat Bureau Veritas (BV) att svara för dess inspektion för och utfärdande av erforderliga certifikat enligt SOLAS.

M/S Viking Sally byggdes också av Jos. Meyer, Papenburg, V-Tyskland, i princip på samma linjeritningar som Diana II men med tillägg av en förlängning på 18,4 m midskepps. De båda fartygsskrovens förskepp och akterskepp var i det närmaste identiska. Viking Sally levererades 29 juni 1980 till Rederi AB Sally, Åland och insattes i Viking Lines trafik Stockholm - Mariehamn - Åbo. Efter Effjohn Oy, Finland förvärv av Rederi AB Sally insattes fartyget i april 1990 under namnet Silja Star i Silja Lines trafik Stockholm - Åbo och i januari 1991 under namnet Wasa King i Wasa Lines trafik Wasa -Umeå. Den 15 januari 1993 övertogs fartyget av E-Line Ltd, Estland som disponerande ägare för insättande i EstLines trafik Stockholm - Tallinn under namnet M/S Estonia.
Fartyget byggdes till och seglade under finsk flagg fram till den 15 januari 1993 och har har under denna tid från och med byggnationen stått under finska Sjöfartsstyrelsens myndighetstillsyn som svarat för inspektion för och utfärdande av erforderliga certifikat enligt SOLAS. Från och med den 15 januari 1993 fram till förlisningen den 28 september 1994 seglade fartyget under estnisk flagg och stod därmed under tillsyn av den estniska sjöfartsmyndigheten som hade auktoriserat BV att svara för dess inspektion för och utfärdande av erforderliga certifikat enligt SOLAS.

Båda fartygen byggdes till Bureau Veritas klassregler och har sedan dess upprätthållit BV klass med beteckningen + I 3/3 E, Deep Sea, Ice 1A, Car/Passenger Ferry + (AUT).

Nordström & Thulin AB:s Rederiavdelning (N&T) har varit Technical Managers för M/S Estonia på uppdrag av Estonian Shipping Co Ltd (ESCO) ända sedan fartygets övertagande från Effjohn den 14 januari 1993 och fram till dess förlisning den 28 september 1994. N&T har samma uppgift beträffande M/S Mare Balticum sedan dess övertagande från NordBanken Finans AB/TT-Line Gmbh den 5 oktober 1994. N&T gjorde också den tekniska besiktningen och certifikatkontrollen för köparnas räkning före förvärvet av respektive fartyg samt har också svarat för fartygens iordningställande före insättandet i EstLines trafik.

Genom finska och svenska massmedia har under veckorna 47 och 48 1994 framkommit uppgifter (se exempel i Bilaga 1) om att de vattentäta skotten/den förliga rampen bakom bogvisiret på M/S Estonia ej varit i enlighet med för fartyget gällande SOLAS regler och att dispens för detta medgivits av den finska Sjöfartsstyrelsen eftersom fartyget byggts enkom för trafik mellan Stockholm och Åbo, vilket man bedömt vara skyddade farvatten och att man därmed också ålagt fartyget restriktionen att ej färdas mer än 20 n.m. från närmaste land. Bl.a. citeras sjösäkerhetschefen i den finska Sjöfartsstyrelsen, sjöfartsrådet Heikki Valkonen, i en artikel i Hufvudstadsbladet den 1 december 1994 (se Bilaga 1) där Valkonen sägs bekräfta uppgifterna om rampens placering, seglationsrestriktionen men att särskilt certifikat för avvikelsen från SOLAS ej utfärdats av den finska myndigheten för M/S Viking Sally r.n. Silja Star r.n. Wasa King. Valkonen påstås vidare mena att rampens avvikande placering i förhållande till SOLAS var tillåten enligt SOLAS och att man därför ej behövt utfärda särskilt certifikat för detta. I samma artikel sägs också att den finska myndigheten har ej informerat den estniska myndigheten om avvikelsen därför att det är köparens och den mottagande flaggstatens sak att kontrollera säkerhet och eventuella begränsningar i trafikområde för ett fartyg.

De i föregående stycke anförda avvikelserna från SOLAS beträffande den förliga rampens placering samt de därav påstått ålagda seglationsrestriktionerna har undgått såväl N&T som BV vid övertagande/omflaggning/omcertifiering av M/S Estonia i januari 1993. Eftersom förskeppet på M/S Estonia byggdes i princip identiskt med M/S Diana II, torde samma förhållande beträffande rampplacering och seglationsrestriktion gälla även för M/S Mare Balticum som gällde för M/S Estonia. Även detta har i så fall undgått såväl N&T som BV vid övertagande /omflaggning/omcertifiering av M/S Mare Balticum i oktober 1994.

Med anledning av de påstådda seglationsrestriktionerna för M/S Estonia ex. Viking Sally under finsk flagg enligt ovan, har N&T skyndsamt utrett förhållandena för såväl M/S Estonia som för M/S Mare Balticum så långt N&T har kunnat vidimera fakta och vilket redovisas nedan:

B. GÄLLANDE SOLAS REGLER FÖR FARTYGS KONSTRUKTION (se Bilaga 2 och 3)

Relevanta regeltexter finns återgivna i Bilaga 3.

Som framgår av Bilaga 2 gällde SOLAS 60 för båda fartygen vid såväl kölsträckning som leverans. Det skulle möjligen kunnat ha ansetts framsynt och acceptabelt att i stället tillämpa den kommande SOLAS 74, vars text hade antagits av IMCO c:a 5 år före fartygens kölsträckning, men som inte sattes kraft i vare sig Sverige eller Finland förrän efter båda fartygens leverans. Detta hade emellertid inte haft någon betydydelse för placering av förligt kollisionskott eller ramp, eftersom reglerna i detta avseende var likalydande i SOLAS 60 och SOLAS 74. Dessa regler föreskriver min/max mått för kollisionsskottet placering i långskeppsled relativt förliga perpendikeln, utan hänsyn till om fartyget är försett med bulb eller ej, och dessutom att ett vädertätt skott skall anbringas som förlängning av kollisionsskottet mellan skottdäcket (bildäck) och närmast ovanförliggande däck. Detta senare skott behöver ej kontra direkt mot kollisionskottet men får till ingen del vara beläget för om förligaste tillåtna gräns för kollisionskottet. Ordet ramp finns ej omnämnt i regeln, men det finns heller inget i reglerna som förhindrar att det vädertäta skottet är öppningsbart så länge det är vädertätt stuvat under gång.

Först i 1981 års ändringar av SOLAS 74 införes möjlighet att ta hänsyn till ev. bulbstäv vid beräkning av kollisionsskottets min/max avstånd till förliga perpendikeln samt omnämnes ordet ramp och medges möjlighet till att den i sin egenskap av kollisionsskottsförlängning och till den del som är mer än 2,3 m över skottdäcket må utsträckas för om förligast tillåtna gräns för kollisionsskottet. Denna skrivning av reglerna har sedan hittills (december 1994) kvarstått oförändrad. Dessa regler torde ej ha kunnat tillämpas vid konstruktionen av Diana II eller Viking Sally eftersom de antogs av IMCO i november 1980, dvs efter båda fartygens leverans, och trädde ikraft först i september 1984.

C. FÖRESKRIVEN/FAKTISK PLACERING AV KOLLISIONSSKOTT/RAMP (se Bilaga 4)

Beräkningar för Diana II och Sally Viking av tillåten placering av kollisionsskott/ramp enligt SOLAS 60, SOLAS 74 samt 1981 års ändringar av SOLAS 74 jämfört med faktisk placering återfinns i Bilaga 4. Därav framgår att kollisionsskottet på Diana II är korrekt placerat från början, medan rampen till alla delar står avsevärt för långt förut för att kunna uppfylla kraven för förlängning av kollisionsskottet såväl i SOLAS 60 som i alla hittillsvarande (december 1994) versioner av SOLAS 74.

Förskeppslinjer och -arrangemang på Sally Viking är i allt väsentligt identiska med Diana II med undantag för att bulbens utsträckning förut ökats med 0,80 m. Enligt SOLAS 60 och SOLAS 74 står hennes kollisionskott, om än blott så dock, 7 cm för långt förut beroende på att perpendikellängden på Sally Viking ökats med 18,4 m midskepps jämfört med Diana II. Först från och med 1981 års ändringar av SOLAS 74 uppfylls kraven i detta avseende tack vare den förlängda bulben. Hade bulben varit identisk med den på Diana II hade kollisionsskottet stått 7 cm för långt förut också enligt reglerna i 1981 års ändringar av SOLAS 74. Sally Vikings ramp står till alla delar ännu längre för långt förut än på Diana II för att kunna uppfylla kraven för förlängning av kollisionsskottet såväl i SOLAS 60 som i alla hittillsvarande (december 1994) versioner av SOLAS 74.

D. MÖJLIGHETER TILL UNDANTAG FRÅN SOLAS KONSTRUKTIONSREGLER (Bilaga 5)

Som framgår av Bilaga 5 föreskrev SOLAS 60 en (1) möjlighet för flaggstatsmyndigheten att medge undantag för konstruktionsreglerna i kapitel II, där föreskrifterna för kollisionsskott återfinns. Samma lydelse i princip, endast redaktionellt ändrad, finns också i SOLAS 74 fortsatt gällande till dags dato (december 1994). Enligt denna paragraf (SOLAS 60; Ch II; Reg 1(c)) får myndigheten medge sådant undantag under förutsättning att myndigheten bedömer fartygets rutt som relativt skyddad. Om sådant undantag medgivits får fartyget ej avlägsna sig längre än 20 n.m. från land.

Från och med SOLAS 74 finns ytterligare en paragraf (Ch I; Reg 4(b)) som föreskriver möjlighet till att medge undantag från kapitlen II-1, II-2, III och IV om fartyget i fråga besitter någon form av nytänkande, vars vidare utveckling för tillämpning på framtida fartyg i internationell trafik allvarligt hämmas om gällande regler tillämpas. Myndigheten får därvid medge sådant undantag under förutsättning att myndigheten bedömer fartyget ha i alla avseenden tillräcklig säkerhet för dess avsedda trafik och att detta accepteras av myndigheterna i de land som fartyget kommer att anlöpa i sådan trafik. Om sådant undantag medges skall myndigheten meddela IMO specifikation på och bevekelsegrunder för sådant undantag samt skall IMO informera detsamma till konventionsstaterna.

Om undantag medgivits, oavsett vilken paragraf som åberopats, skall, enligt kapitel II, regel 12(a)(vi) i såväl SOLAS 60 som i till dags dato (december 1994) gällande versioner av SOLAS 74, ett särskilt undantagscertifikat härför utfärdas på föreskriven form i tillägg till övriga obligatoriska certifikat. Från denna regel har ej funnits och finns ej möjligheter till undantag. Se vidare nedan beträffande utfärdande, kontroll och varaktighet av certifikat enligt SOLAS.

E. UTFÄRDANDE OCH VARAKTIGHET AV SOLAS CERTIFIKAT FÖR PASSAGERARFARTYG (Bilaga 6)

Kapitel I i såväl SOLAS 60 som SOLAS 74 föreskriver bl. a. vilka certifikat som skall utfärdas, enligt vilken konvention de skall utfärdas samt utfärdande myndighets ansvar för utfärdade certifikat (Reg 12), utfärdade certifikats varaktighet (Reg 14), certifikatens utseende (Reg 15), hur utfärdade certifikat skall anslås (Reg. 16) samt hur de skall tydas av andra konventionsstater (Reg. 17). Med undantag för rent redaktionella ändringar, är dessa paragrafers lydelse oförändrad från SOLAS 60 till hittintills (december 1994) gällande versioner av SOLAS 74.

Till skillnad mot lastfartyg, utfärdas för passagerarfartyg ett samlande certifikat (Passenger Ship Safety Certificate (PSC)), vilket omfattar alla relevanta krav för fartyget i vid envar tid gällande SOLAS konvention (Reg 12(a)(i)). Därest ett undantag från för fartyget gällande SOLAS regler medgivits och sådant medgivande gjorts i enlighet med konventionens föreskrifter, skall ett särskilt certifikat, benämnt "Exemption Certificate", utfärdas för sådant undantag (Reg 12(a)(vi)). Av Reg 12 (a)(vii) framgår att flaggstatsmyndigheten har fullt ansvar för utfärdade certifikat oavsett om de utfärdats av myndigheten själv eller annan som därtill på föreskrivet sätt auktoriserats av myndigheten. Till dessa regler finns inga föreskrivna möjligheter till undantag, vilka skulle kunnat vara tillämpbara på Diana II/Viking Sally.

Reg 14 (a) föreskriver att PSC och ev. därtill hörande Exemption Certificates ej skall utfärdas för mer än 12 månader åt gången, d.v.s. att dessa certifikat efter föreskriven inspektion (se vidare avsnitt F nedan) skall förnyas var 12:e månad. Ej heller till denna regel finns några föreskriva möjligheter till undantag annat än mycket korta tidsdispenser för praktisk anpassning av inspektionstillfälle med anledning av aktuellt fartygs trafik.

Reg 15 staterar att utfärdade certifikat skall vara på det utfärdande landets officiella språk och att certifikatens disposition och förtryckta innehåll exakt reproducerar disposition och förtryckt innehåll på motsvarande angiven förlaga i vid var tid gällande SOLAS version . Det finns emellertid inget som hindrar att certifikattexten återgives på flera språk (t.ex. engelska) samtidigt.

Enligt Reg 16 skall samtliga för fartyget utfärdade och gällande SOLAS certifikat, eller vidimerade kopior därav anslås på en iögonenfallande och lätt tillgänglig plats i fartyget.

SOLAS certifikat som utfärdats för ett fartyg i dess flaggstatsmyndighets namn skall enligt Reg 17 till alla delar accepteras av övriga konventionsstater i samma omfattning som motsvarande certifikat utfärdade av sådan annan konventionsstat.

F. INSPEKTION FÖRE UTFÄRDANDE AV CERTIFIKAT ; KONTROLL AV UTFÄRDADE CERTIFIKAT (Bilaga 7)

I SOLAS 60, vilken gällde vid utfärdandet av de första PSC för såväl Diana II som Viking Sally, föreskrives i Kapitel I, Reg 6 vem/vilka som skall utföra föreskrivna inpektioner för att tillse att konventionens regler uppfylles samt att i vilket fall som helst garanterar flaggstatens regering de föreskrivna inspektionernas fullständighet och effektivitet. Regeln har i princip fortsatt samma mening i SOLAS 74, med undantag för redaktionella ändringar samt att flaggstatens regering ("Government") utbytts mot flaggstatens sjöfartsmyndighet ("Administration") från och med 1978 års protokoll till SOLAS 74, vilket trädde i kraft den 1 maj 1981 i såväl Finland som Sverige. Från och med då har Reg 6 också utökats med ett avsnitt som föreskriver skyldighet och möjlighet för av flaggstaten auktoriserad besiktningsman/-organisation (t.ex. klassen) som ådagalägger avikkelser mellan tillståndet på fartyget och dess utrustning och innebörden i utfärdade certifikat och vilka avvikelser bedömes äventyra säkerheten till sjöss för fartyget eller de ombordvarande, att tillse att avvikelserna omedelbart rättas till. Om så ej göres skall flaggstatens sjöfartsmyndighet omedelbart underrättas samt ifrågavarande certifikat omedelbart återkallas. Om fartyget befinner sig i ett annat konventionslands hamn, skall även detta lands sjöfartsmyndighet underrättas och skall denna lämna erforderlig assistans till flaggstatsmyndigheten eller den auktoriserade besiktningsmannen/-organisationen så att skyldigheterna enligt ovan kan fullgöras. Om så erfordras, skall den ifrågavarande hamnstatsmyndigheten förhindra att fartyget avseglar innan erforderliga åtgärder har vidtagits.

Kapitel I, Reg 7 i SOLAS 60 föreskriver när och hur besiktningar skall göras beträffande passagerarfartyg. Paragrafens mening är i princip fortsatt densamma i SOLAS 74 fram till dags dato (december 1994) med undantag för redaktionella ändringar och att den däri ingående specifikationen av fartygens utrustningar som skall vara föremål för besiktning har utökats/ändrats i takt med den under tiden utökade omfattningen av innehållet i SOLAS kapitel II-1, II-2, III och IV.
Avsnitt (a) i Reg 7 specificerar att inspektion skall vidtagas innan fartyget tages i drift, en gång var tolfte månad därefter samt i övrigt närhelst behov anses föreligga.

Innan fartyget tages i drift (Reg 7(b)(i) skall en komplett inspektion göras av fartygets skrov, dess strukturella delar, fartygets maskineri, pannor och utrustning. Inspektionen skall göras på ett sådant sätt att den tillförsäkrar att arrangemang, material, mått och prestanda av/i/på fartygets skrov, dess strukturella delar, fartygets maskineri, pannor och utrustning till alla delar och till fullo uppfyller tillämpbara delar av gällande SOLAS regler. Inspektionen skall också tillförsäkra att tillverkningsstandarden/arbetsutförandet ("workmanship") på alla delar av fartyget och dess utrustning är i alla avseenden tillfredställande.

Var 12:e månad efter fartygets idrifttagande (Reg 7(b)(ii)) skall inspektion vidtagas på ett sådant sätt att den tillförsäkrar att fartygets skrov, dess strukturella delar, fartygets maskineri, pannor och utrustning är i tillfredställande tillstånd och lämpat för avsett bruk samt uppfyller tillämpbara krav i gällande SOLAS regler.

Distinktionen i Reg 7(a) mellan avsnitten (i) - inspektion av arrangemang, material, mått och prestanda - och (ii) - inspektion av tillstånd = kondition - skall ses mot lydelsen av Reg 11 i samma kapitel som föreskriver att inga ändringar i sådana strukturella arrangemang, maskineri, utrustningar etc som omfattas av inspektionskrav enligt Reg 7 får vidtagas mellan inspektionstillfällena utan föregående tillstånd från flaggstatsmyndigheten. Samma regel uttrycker från och med 1978 års protokoll till SOLAS 74 explicit att tillståndet på fartyget och dess utrustning skall underhållas på ett sådant sätt att det är i överenstämmelse med föreskrifterna i gällande SOLAS reglemente för att tillförsäkra att fartyget i alla avseenden fortsatt är lämpat att gå till sjöss utan fara för fartyget eller ombordvarande.

I Kapitel I, Reg 19 i såväl SOLAS 60 som i SOLAS 74 fram till dags dato (december) föreskrives att varje fartyg är föremål för hamnstatsmyndighets kontroll av att fartyget innehar gällande SOLAS certifikat. Om fartyget företer sådana certifikat, skall hamnstatsmyndigheten låta sig nöja därmed, såvida man ej har grundad anledning att befara att tillståndet på fartyget eller dess utrustning i väsentlig grad avviker från de aktuella certifikatens innehåll eller på annat sätt strider mot gällande SOLAS krav. Om hamnstatsmyndigheten hyser sådan grundad anledning och medelst inspektion konstaterar avvikelse i väsentlig grad eller om fartyget ej kan förete erforderliga gällande certifikat, skall hamnstatsmyndigheten vidtaga erforderliga åtgärder för att förhindra att fartyget avseglar innan man bedömer att det kan gå till sjöss eller till lämpligt reparationsvarv utan fara för fartyget eller de ombordvarande.

Från och med 1978 års Protokoll till SOLAS 74 har i Kapitel I, Reg 14 lagts till ett avsnitt (g)(ii) som explicit behandlar certifikat i samband med flaggskifte. Häri stateras att tidigare utfärdat certifikat upphör att gälla då fartyget ifråga skiftar flagg. Fartygets nya flaggstatsmyndighet skall utfärda nytt certifikat först efter det man övertygat sig om att fartyget uppfyller kraven i Kapitel I, Reg 11 (a) och (b), dvs

- att tillståndet på fartyget och dess utrustning har underhållits på ett sådant sätt att det är i överenstämmelse med gällande SOLAS regler för att tillförsäkra att fartyget i alla avseenden fortsatt är lämpat att gå till sjöss utan fara för fartyget eller ombordvarande.

- att inga ändringar i sådana strukturella arrangemang, maskineri, utrustningar etc som omfattas av inspektionskrav enligt Reg 7 har vidtagits sedan närmast föregående inspektionstillfälle utan inhämtat tillstånd från aktuell flaggstatsmyndighet.

G. GÄLLANDE CERTIFIKAT WASA KING OCH DIANA II FÖRE FLAGGSKIFTE

Kopior av i detta sammanhang relevanta certifikat (PSC) som senast utfärdats av relevant myndighet före flaggskifte och såsom förevisats för köpare och BV av respektive säljare, återfinns i Bilaga 8 (Wasa King tbrn Estonia) och Bilaga 9 (Diana II tbrn Mare Balticum).

Enligt Solas 74 vid respektive utfärdande gällande form för PSC återfinns i Bilaga 10.
Enligt Solas 74 vid respektive utfärdande gällande form för Exemption Certificate återfinns i Bilaga

10.

I Bilaga 11 återfinns SOLAS definition av kort internationell resa. Därav framgår att rutten mellan Stockholm och Tallinn uppfyller vilkoren för kort internationell resa.

a) **Wasa King**

Fartyget skiftade från finsk till estnisk flagg den 15 januari 1993 vid Åbo reparationsvarv.

Fartygets sista finska PSC enligt kopia i Bilaga 8 är utfärdat av Sjöfartsstyrelsen/Sjöfartsinspektör Jan Jansson den 8 oktober 1992 och skulle gällt till den 22 maj 1993.
Därav framgår att certifikatet avser kort internationell resa. De enda dispenser/restriktioner som därpå finns antecknade avser fartygets radioutrustning.

Något undantagscertifikat i enlighet med SOLAS 74 Ch I;Reg 12(a)(vi),(vii) och Reg 14(a) för undantag från regler i SOLAS 60 Ch II/SOLAS 74 Ch II-1:

- har ej förevisats av säljare i samband med leverans till köparen (Krav i köpekontrakt)
- fanns ej anslaget på fartyget (SOLAS 74 Ch I; Reg 16) vid köparens inspektion före avtal om köp, ej heller vid leverans från säljare till köpare.

Att döma av tidningsartikel i Bilaga 1 finns anledning att förmoda att sådant undantagscertifikat aldrig har utfärdats.

Det förtjänar dessutom att påpeka att ovannämnda PSC ej utfärdats på föreskriven form i enlighet med SOLAS 74 Ch I; Reg 15(b) samt Appendix 1 (se Bilaga 11), vilken gällde (fr.o.m. 1 februari 1992) vid datum för certifikatet utställande den 8 oktober 1992. Om föreskriven form hade använts borde seglationsrestriktion med anledning av konstruktionsavvikelser funnits antecknad under rubriken "particulars of ship").

(b) **Diana II**

Fartyget skiftade från svensk till estnisk flagg den 7 oktober 1994 i Rostock.

Fartygets sista svenska PSC enligt kopia i Bilaga 9 är utfärdat av Sjöfartsverket/Överinspektör Åke Sjöblom den 10 juni 1994 och skulle gällt till den 1 feb 1995.
Därav framgår att certifikatet avser kort internationell resa. Exemption Certificate i enlighet med SOLAS 7 4 Ch I;Reg 12(a)(vi),(vii) och Reg 14(a) avseende undantag från Ch IV; Reg 3 i enlighet med Ch IV; Reg 5a finns utfärdat samma datum och avser fartygets radioutrustning.

Något undantagscertifikat i enlighet med SOLAS 74 Ch I;Reg 12(a)(vi),(vii) och Reg 14(a) samt för undantag från regler i SOLAS 60 Ch II/SOLAS 74 Ch II-1:

- har ej förevisats av säljare i samband med leverans till köparen (Krav i köpekontrakt)
- fanns ej anslaget på fartyget (SOLAS 74 Ch I; Reg 16) vid köparens inspektion före avtal om köp, ej heller vid leverans från säljare till köpare.

H. KOMMENTARER OCH SLUTSATSER

För såväl M/S Estonia som M/S Mare Balticum är det otvetydigt att förliga rampens placering ej uppfyller vare sig kraven i SOLAS 60 Ch II; Reg 9(a) eller SOLAS 74 Ch II-1; Reg 10,1-4.
Det förefaller också uppenbart att Exemption Certificate enligt SOLAS 74 Ch I; Reg 12(a)(iv),(vii)

för undantag från Ch II-1; Reg 10 i enlighet med Ch I; Reg 4(b) eller Ch II-1; Reg 1(c) ej har utfärdats tillsammans med senaste PSC i enlighet med Ch I; Reg 14(a) före omflaggning från finsk resp. svensk flagg till estnisk flagg.
Det förefaller sannolikt att Exemption Certificate enligt SOLAS 60 Ch I; Reg 12(a)(vi),(vii) för undantag från Ch II; Reg 9 i enlighet med Ch II; Reg 1(c) ej utfärdades före fartygens idrifttagande som nybyggen. Några andra regelföreskrivna möjligheter till undantag från Ch II; Reg 9(a) har ej återfunnits i SOLAS 60.
Om sådant Exemption Certificate trots allt har utfärdats vid idrifttagandet som nybyggen har fartygens finska respektive svenska myndighet uppenbarligen också gjort upprepade avsteg från SOLAS 60/74 Ch I; Reg 14, från vilken regler för undantag ej har återfunnits i någondera av konventionerna.

Vi kan därför inte finna annat än att den finska respektive svenska administrationen före fartygens idrifttagande som nybyggen antingen medgivit undantag från gällande konstruktionsregler i SOLAS enligt ovan och brustit i konventionens certifikatskrav enligt ovan eller allvarligt brustit i uppfyllandet av SOLAS 60 Ch I; Reg 6 och Reg 7(b)(i).

Från idrifttagandet som nybygge har

- Viking Sally/Silja Star/Wasa King från juli 1980 fram till januari 1993
- Diana II från försommaren 1979 fram till årsskiftet 1992/93

seglat under finsk respektive svensk flagg mellan Sverige och Finland, dvs den finska respektive svenska sjöfartsmyndigheten har varit hamnstatsmyndighet för varandras respektive fartyg under 13 år och det må därför finnas grundad anledning att förmoda att respektive myndighet känt till och accepterat den andra myndighetens medgivande av undantag från SOLAS reglerna beträffande den förliga rampens placering på det egna fartyget eller brustit i uppfyllandet av SOLAS 60/74 Ch I, Reg 19.

Om respektive myndighet från början medgivit undantag enligt SOLAS 60 Ch II; Reg 1 eller SOLAS 74 Ch II-1; Reg 1, dvs ålagt seglationsrestriktionen skyddade farvatten och 20 n.m. från närmaste land, finns anledning att ifrågasätta hur detta uppfyllts under Wasa Kings seglation Wasa - Umeå under tiden januari 1991 - januari 1993 och Diana II:s seglation Trelleborg - Rostock från årsskiftet 1992/93 till oktober 1994.

Efter skifte från svensk flagg till estnisk flagg seglade M/S Estonia från februari 1993 fram till sin förlisning 28 september 1994 enkom på rutten Stockholm - Tallinn. Om den svenska myndigheten känt till avsteget från SOLAS konstruktionsregler beträffande förrampens placering samt därmed påstådd ålagd seglationsrestriktion om skyddade farvatten högst 20 n.m. från närmaste land på M/S Viking Sally/Silja Star/Wasa King har man i så fall grovt brustit i uppfyllande av sina kontrollskyldigheter enligt SOLAS 74 Ch I; Reg 19 vad avser Estonia. Till yttermera visso inspekterades bl. a. just visir/port arrangemanget samt certifikaten på Estonia av Överinspektör Åke Sjöblom från Malmö inspektionsområde på eftermiddag/kväll den 27 september 1994 i Tallinn, d.v.s. omedelbart före fartygets påbörjande av den ödesdigra sista resan. M/S Diana II var då sedan årskiftet 1992/93 under Malmö inspektionsdistrikts domvärjo och det är inte osannolikt att man där var bekant med de båda fartygens nära släktskap i konstruktionen.

Om Diana II varit belagd med motsvarande seglationsrestriktioner, dvs skyddade farvatten högst 20 n.m. från land på grund av förrampens placering, av sin svenska myndighet har man i så fall också brustit i sitt uppfyllande av sin kontrollskyldighet enligt SOLAS 74 Ch I; Reg 19 vad avser M/S Mare

Balticum[1].

Trots inspektion av fartygens certifikat före avtal om köp och i samband med övertagande samt omfattande och noggranna inspektioner av fartygen såväl före köp som i samband med övertagande och under c:a en månad på varv för vardera fartyget därefter för iordningställande före idrifttagande i den nya trafiken, har N&T Rederiavdelning undgått att bemärka förrampernas felaktiga placering i förhållande till SOLAS. Ev. seglationsrestriktioner har ej återfunnits i någon form av tillgänglig dokumentation, ej heller i säljares och mäklares beskrivning av fartygen före, under eller i samband med avtal om köp. Ej heller har någon representant för säljare, tidigare befäl/besättning, eller inblandade myndigheter avgivit minsta indikation på att så skulle kunna vara fallet. N&T Rederiavdelning har i båda fallen förlitat sig på att av respektive föregående flaggstatsmyndighet, som varit tillsynsmyndighet för respektive fartyg alltsedan dess byggnation, utfärdade certifikat varit korrekta åtminstonde i vad avser respektive fartygs skrovkonstruktion.

Samma sak torde gälla för BV i egenskap av auktoriserat ombud för den estniska myndigheten såväl för Estonia som för Mare Balticum. Enligt N&T Rederiavdelnings förmenande har BV gått utomordentligt grannlaga tillväga i sina ansträngningar att uppfylla sina skyldigheter enligt SOLAS 74 Ch I; Reg 14(g)(ii), vilket avspeglats såväl i deras deras infordrande av ritningar och beräkningar med ty åtföljande kommentarer och krav på åtgärder samt deras engagemang och noggrannhet vid de omfattande inspektioner som gjorts före och i samband med respektive fartygs omflaggning och under c:a en månad på varv för vardera fartyget därefter för iordningställande före idrifttagande i den nya trafiken. Även dessa inspektioner har resulterat i en mängd krav på åtgärder (vilka samtliga vidtogs) på respektive fartyg. Dock ej vad beträffar de förliga rampernas placering där även BV i detta avseende förleddes att förlita sig på de av finsk respektive svensk myndighet utfärdade passagerarfartygscertifikaten.

Om trots allt våra ovan dragna slutsatser om allvarliga brister i finsk respektive svensk myndighets tillämpningar av vid var tidpunkt gällande SOLAS regler för respektive fartyg skulle visa sig vara helt felaktiga, torde en omprövning av ändamålsenligheten av SOLAS regler för certifiering och undantag från gällande reglementen vara lika angeläget som pågående omprövning av regler för bogporars styrka och ro-ro fartygs överlevnadsförmåga vid vatteninträngning på skottdäcket.

Därest BV och N&T Rederiavdelning hade varit medvetna om att respektive fartygs förliga rampers placering ej uppfyllde SOLAS föreskrivna krav och att fartygen därför var belagda med seglationsrestriktioner under tidigare administrationer, påstår vi att det ej kan hållas för osannolikt att sådana åtgärder påkallats och åtgärdats att det ej kan uteslutas att det tragiska skeendet efter det att Estonia förlorat sitt bogvisir fått ett annolrlunda förlopp.

Beträffande Mare Balticum hade det förmodligen bara betytt att man kunnat behålla det tidigare öppningsarrangemanget i bogen efter förstärkningar och modifikationer samt tillägg av lämpligt arrangemang för fullgott tillfredställande av SOLAS bestämmelser om kollisionsskottets vädertäta förlängning från skottdäcket till ovanförliggande däck och detta till ungefär samma kostnad som nyligen genomförd ombyggnad av bogpartiet med permanent förslutning av såväl visir som ramp.

[1] Omedelbart efter att N&T Rederiavdelning genom uppgifterna i massmedia v. 47/48 blivit varse och kontrollerat f.d. förrampens placering på M/S Mare Balticum i förhållande till SOLAS, anmäldes detta såväl muntligen och skriftligen till BV som varande auktoriserat ombud för fartygets estniska tillsynsmyndighet med begäran om omedelbara instruktioner om ev. åläggанden med anledning därav. BV huvudkontor i Paris meddelade kort därefter att vårt besked mottagits och att man med anledning av nyligen genomförd och godkänt ombyggnad av fartygets stävparti bedömde fartygets sjövärdighet och säkerhet som fullgod för fortsatt trafik Stockholm - Tallinn utan krav på omedelbara åtgärder eller restriktioner och att fartygets PSC fortsatt betraktades som gällande t.v. Man reserverade sig emellertid för att återkomma i frågan om ev. konstruktionsåtgärder efter vidare konsultationer med sina huvudmän i den estniska myndigheten.

SOLAS 60 till SOLAS 74 med ändringar till december 1994

Beträffande antagande, ratifiering, accepterande och ikraftträdande med avseende på regler för:

- **Placering av förliga kollisionsskottet**
- **Untantag från regler för fartygs konstruktion m.a.p. förliga kollisionsskottets placering**
- **Inspektion, certifiering och kontroll av regler för passagerarfartygs konstruktion**

SOLAS 60

IMCO	adopted	17jun 1960
	entered into force	25maj 1965
FINLAND	ratified without reservations	11maj 1965
	entered into force	26maj 1965
SWEDEN	ratified without reservations	23dec 1965
	entered into force	23mar 1966

SOLAS 74

IMCO	adopted	01nov 1974
	entered into force	25maj 1980
FINLAND	acceded without reservations	21nov 1980
	entered into force	21feb 1981
SWEDEN	ratified without reservations	07jul 1978
	entered into force	25maj 1980
ESTONIA	acceded without reservations	16dec 1991
	entered into force	16mar 1992

SOLAS PROTOCOL 1978

IMCO	adopted	17feb 1978
	entered into force	01maj 1981
FINLAND	acceded without reservations	30apr 1981
	entered into force	01maj 1981
SWEDEN	ratified without reservations	21dec 1979
	entered into force	01maj 1981
ESTONIA	acceded without reservations	16dec 1991
	entered into force	16mar 1992

1981 AMENDMENTS TO SOLAS 74/SOLAS PROTOCOLL 1978

IMCO	adopted	20nov 1981
IMO	entered into force	01sep 1984

FARTYGSSDATA:	**Diana II**	**Viking Sally**
Kölsträckt	16okt 1978	18okt 1979
Levererat/taget i drift	08jun 1979	29jun 1980
Administration, nybygge	SWEDEN	FINLAND
Gällande SOLAS, nybygge	SOLAS 60	SOLAS 60
Registrerad i ESTLAND	07okt 1994	15jan 1993

M/S MARE BALTICUM ex DIANA II as built - Placering av förligt kollisionsskott/ramp

A. Fartygets parametrar

Längd mellan perpendiklar	**lpp**	=	**119,00**	**m**	
Spantdistans #149-#160	spd	=	0,60	m	
Förliga perpendikelns position	FPP	=	0,20	m	för om #160
Position förkant bulb	BFK	=	3,85	m	för om #160
Distans från FPP till BFK	**b**	=	**3,65**	**m**	
Kollisionsskottets position	KSK	=	#149		
Distans från KSK till FPP	**k**	=	**6,80**	**m**	
Position ramp, bas	R1	=	#156		
Position ramp, 2,3m ö.dk.	R2	=	1,10	m	för om #156
Distans från R1 till FPP	**r1**	=	**2,60**	**m**	
Distans från R2 till FPP	**r2**	=	**1,50**	**m**	

B. **SOLAS 60, Ch.II, Reg. 9(a)**

(i)	**Krav 1**	k > 5% x lpp =	5,95	m
	Krav 2	k < 3,05m + 5% x lpp =	9,00	m

Kollisionsskottet står:	**rätt placerat**

(ii)	**Krav 1**	r1 > 5% x lpp =	5,95	m

Rampen står:	**3,35 m för långt förut**

C. **SOLAS 74, Ch. II-1, Reg. 9(a)**

Samma krav som SOLAS 60, d.v.s.

(i)	**Kollisionsskottet står:**	**rätt placerat**
(ii)	**Rampen står:**	**3,35 m för långt förut**

D. **SOLAS 74, 1981 AMENDMENTS, Ch. II-1, Reg. 10**

2	**.1**	0,5 x b =	1,83	m
	.2	1,5% x lpp =	1,79	m
	.3	=	3,00	m
		tillägg (t) = minimum (.1;.2;.3) =	1,79	m

1	**Krav 1**	k > 5% x lpp - t =	4,17	m
	Krav 2	k < 3,05m + 5% x lpp - t =	7,22	m

Kollisionsskottet står:	**rätt placerat**

3	**Krav 1**	r1 > 5% x lpp - t =	4,17	m
		r2 > 5% x lpp - t =	4,17	m

Rampens bas står:	**1,57 m för långt förut**
Rampen 2,3m ö. dk. står:	**2,67 m för långt förut**

M/S ESTONIA ex VIKING SALLY as built - Placering av förligt kollisionsskott/ramp

A. Fartygets parametrar

Längd mellan perpendiklar	**lpp**	=	**137,40 m**	
Spantdistans #149-#160	spd	=	0,60 m	
Förliga perpendikelns position	FPP	=	0,20 m	för om #160
Position förkant bulb	BFK	=	4,65 m	för om #160
Distans från FPP till BFK	**b**	=	**4,45 m**	
Kollisionsskottets position	KSK	=	#149	
Distans från KSK till FPP	**k**	=	**6,80 m**	
Position ramp, bas	R1	=	#156	
Position ramp, 2,3m ö.dk.	R2	=	1,10 m	för om #156
Distans från R1 till FPP	**r1**	=	**2,60 m**	
Distans från R2 till FPP	**r2**	=	**1,50 m**	

B. SOLAS 60, Ch.II, Reg. 9(a)

(i)	**Krav 1**	k > 5% x lpp =	6,87 m
	Krav 2	k < 3,05m + 5% x lpp =	9,92 m

Kollisionsskottet står: 0,07 m för långt förut

(ii)	**Krav 1**	r1 > 5% x lpp =	6,87 m

Rampen står: 4,27 m för långt förut

C. SOLAS 74, Ch. II-1, Reg. 9(a)

Samma krav som SOLAS 60, d.v.s.

(i)	**Kollisionsskottet står:**	**0,07 m för långt förut**
(ii)	**Rampen står:**	**4,27 m för långt förut**

D. SOLAS 74, 1981 AMENDMENTS, Ch. II-1, Reg. 10

2	**.1**	0,5 x b =	2,23 m
	.2	1,5% x lpp =	2,06 m
	.3	=	3,00 m
		tillägg (t) = minimum (.1;.2;.3) =	2,06 m

1	**Krav 1**	k > 5% x lpp - t =	4,81 m
	Krav 2	k < 3,05m + 5% x lpp - t =	7,86 m

Kollisionsskottet står: rätt placerat

3	**Krav 1**	r1 > 5% x lpp - t =	4,81 m
		r2 > 5% x lpp - t =	4,81 m

Rampens bas står:	**2,21 m för långt förut**
Rampen 2,3m ö. dk. står:	**3,31 m för långt förut**

SUPPLEMENT No. 213

Letter 20.4.1977 from the Finnish Maritime Administration to the Wärtsilä Turku Shipyard on the approval of the bow ramp as an upper extension of the collision bulkhead in MV TURELLA.

MERENKULKUHALLITUS

Helsinki 1977 04 20
KD 1591/77/301
No L 418

	AB/POT	
Saap. 1977 -04- 21		

Oy Wärtsilä Ab
Turun telakka
20810 Turku 81

Viite Kirjeenne 1977-04-15
AB/POT/mo

Asia Keularampin hyväksyminen yhteentörmäyslaipiona

SOLAS sopimus (luku II, sääntö 9) edellyttää että yhteentörmäyslaipiota jatketaan säätiiviinä (siis ei vesitiiviinä) laipiokannen yläpuolelle olevalle kannelle. Jatkeen ei tarvitse olla samassa linjassa yhteentörmäyslaipion kanssa mutta sen etäisyyden keulaperpendikelista tulee olla vähintään 0,05 L. Säätiivis keularamppi voidaan hyväksyä yhteentörmäyslaipion jatkeeksi mikäli viimemainittu ehto on hyväksytty. Merenkulkuhallitus on valmis hyväksymään Det norske Veritaksen periaatetta (II Sec 4 . 206) minkä mukaan ramppi hyväksytään jos se 2,3 metrin korkeuteen sijaitsee minimietäisyydellä keulaperpendikelistä.

Piirustuksenne 2.220.921.2000.14 mukaan keularamppi sijaitsee kokonaisuudessaan 0,05 L:n keulapuolella joten sitä ei voida hyväksyä yhteentörmäyslaipion jatkeeksi.

Toimistoinsinööri
G.Edelmann

OSOITE: Vuorimiehenkatu 1
HELSINKI 14
POSTIOSOITE: PL 158
00141 Helsinki 14
PUHELIN: 650 411
TELEX : 121471
POSTISIIRTOTILI: 3801-4

SUPPLEMENT No. 214

Correspondence between the Swedish Maritime Administration and the Götaverken Öresund Shipyard 8.1.1979 on the application of the SOLAS regulations for an upper extension of the collision bulkhead in two passenger ferries for the Gotland traffic.

FÖRSTA DOKUMENTET I SJÖFV
SOM BEHANDLAR RAMPENS PLACERING
OBS. FÖRFRÅGAN.

9 JAN 1979

SJÖFARTSVERKET

3112-130/F9

Sjöfartsverket
Fack

601 01 NORRKÖPING

Er ref. Your ref.	Ert brev Your letter	Vår ref. Our ref.	Datum Date
		G Andersson/MJ	1979-01-08

m.s. 278 och 279 - Gotlandsfärjor.

Refererande till samtal med herr Carsten Davidsson beträffande placering av ramp i förstäv ber vi Er snarast möjligt bekräfta att bestämmelserna i Solas 74, kapitel II-I, regel 9, inte kommer att tillämpas på rubricerade fartyg.

Med vänlig hälsning

GÖTAVERKEN ÖRESUNDSVARVET AB
Förkonstruktionsavdelningen

Ilmar Remmelgas

c.c. Sjöfartsinspektionen, Malmö.

Postadress Mailing address: Götaverken Öresundsvarvet AB S-261 20 LANDSKRONA
Telefon Telephone: 0418-188 50
Telegram Cables: OREYARD
Telex: 72257 OVYARD S
Postgiro Postal giro: 7 37 22-1
Bankgiro Bank transf serv: 660-1140
Bank: Skandinaviska Enskilda Banken

1979-02-02 Dnr 51.12 - 130/79

1979-01-08 G. Andersson/MJ

Sjöfartsinspektionen
Malmö sjöfartsinspektions-
distrikt
Inkom den 1979-02-05
Diarie nr

Götaverken Öresundsvarvet AB

261 20 LANDSKRONA

Datum

G. Andersson/MJ 1979-01-08

N/B 278 och 279 - Gotlandsfärjor

Med hänvisning till Ert ovannämnda brev meddelar sjöfartsverket att Regel 9 (a)(ii), kapitel II-1 i SOLAS-74 ej behöver uppfyllas helt på nybyggda färjor, beträffande rampens avstånd till F.P. Rampen skall göras vädertätt.

Med vänlig hälsning

Carsten Davidson

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SUPPLEMENT No. 215

Correspondence between the Swedish Maritime Administration and the Stena Line 20.3 - 26.3.1981 concerning MV KRONPRINSESSAN VICTORIA.

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64380+
NC
AO
10.56
64380+
64380 SHIPADM S
20752 NAVWEST S

1981-03-20

ATT: CARSTEN DAVIDSSON.

KRONPRINSESSAN VICTORIA - KOLLISIONSSKOTT.

PLACERINGEN KONTROLLERAD PÅ RITNING OCH OMBORD. SKOTT UNDER DÄCK 3 VID SPANT 138 VILKET ÄR OK. ÖVER DÄCK 3 TÄTAR BOGRAMPEN MOT LIST CA 65 MM FÖR OM SPANT 140, VILKET ÄR CA 1800 MM FÖR LÅNGT FÖRÖVER ENL. REGEL 9, SOLAS -74. OM BULBEN MEDRÄKNAS ENL. ALT. 2 I ÄNDRINGSFÖRSLAG LIGGER RAMPTÄTNINGEN CA 500 MM FÖR LÅNGT FÖRÖVER.

PETER HOFFSTEN
FÖRSTE FARTYGSINSPEKTÖR
I GÖTEBORGS DISTRIKTH

64380 SHIPADM S
20752 NAVWEST S
S

OF

20752 NAVWEST S
2559 STENA S 1981-03-25
ATT.. ÖVERINSPEKTÖREN

FÖLJANDE SÄNT TILL NORRKÖPING

SJÖFARTSINSPEKTIONEN
GÖTEBORG
INK. 1981 -03- 25
Dnr

ATT SJÖSÄKERHETSDIREKTÖREN

M/S 908 KRONPRINSESSAN VICTORIA

FRÅN ÖVERINSPEKTÖREN I GÖTEBORG FÖRSTÅR VI ATT NÅGRA FRÅGOR RÖRANDE RUBR FARTYG HAR HÄNSKJUTITS TILL CENTRALFÖRVALTNINGEN FÖR AVGÖRANDE. DETTA SKULLE AVSE FJÄRRSTYRDA VENTILER I LÄNSSYSTEMET, PLACERING AV BOGPORT OCH UTFÖRANDE AV KROKAR FÖR LIVFLOTTAR.

DÅ FARTYGET I DEN FÖRSTNÄMNDA FRÅGAN KLART AVVIKER FRÅN STIPULATIONERNA I SOLAS, BEFARAR VI ATT NYTTJANDEFÖRBUD KAN KOMMA ATT UTFÄRDAS. DÅ VI HAR ANLEDNING FÖRMODA ATT VARVET KOMMER ATT ERBJUDA FARTYGET FÖR ÖVERTAGANDE REDAN UNDER MORGONDAGEN, ÄR DET VÄSENTLIGT ATT VI OMEDELBART OCH I VARJE FALL FÖRE DAGENS SLUT FÅR ERT MEDDELANDE OM BESLUT I OVANNÄMNDA FRÅGOR.

MED VÄNLIG HÄLSNING
ENLIGT FULLMAKT
STENA LINE AB
A FLISING/LO

KOPIA: ÖVERINSPEKTÖREN, GÖTEBORG

2559 STENA SA
20752 NAVWEST SA

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SJÖFARTSINSPEKTIONEN
GÖTEBORG
INK. 1981 -03- 2 6
Dnr

T✠

20752 NAVWEST S
64380 SHIPADM S

KOPIA FÖR KÄNNEDOM:

NORRKOEPING 1981-03-26 VAAR REF: 31.12-2192/81
ERT DATUM: 1981-03-25

ANGAAENDE KRONPRINSESSAN VICTORIA, FJAERRSTYRDA VENTILER, PLACERING AV BOGPORT OCH UTFOERANDE AV KROKAR FOER LIVFLOTTAR, 2 TELEX FRAAN ER 1981-03-25

SJOEFARTSVERKET KOMMER ATT I SAERSKILD SKRIVELSE AALAEGGA GOETAVERKEN - ARENDAL ATT VID GARANTIDOCKNINGEN, DOCK SENAST OM ETT AAR FOERBAETTRA LAENSSYSTEMET PAA FARTYGET. PLACERINGEN AV INRE BOGPORT OEVERENSSTAEMMER MED INTERNATIONELL OCH SVENSK PRAXIS OCH GODKAENNS I BEFINTLIGT SKICK.

KROKARNA FOER LIVFLOTTARNA AER GODKAENDA AV DET NORSKE VERITAS OCH SJOEFARTSDIREKTORATET MEN EFTERSOM DET VID PROV VISAT SIG ATT ETT ANTAL KROKAR SOM NU AER UTBYTTA, FUNGERAT OTILLFREDSSTAELLANDE, HAR VERKET BEGAERT IN MATERIAL FOER GRANSKNING. OM DENNA GRANSKNING OCH VIDARE PROV INNEBAER ATT KROKARNA EJ KAN GODKAENNAS KOMMER VERKET ATT KRAEVA ATT KROKARNA BYTS UT.

FARTYGET HAR ERFORDERLIGA SVENSKA OCH INTERNATIONELLA CERTIFIKAT VILKET TORDE ACCEPTERAS AV SAAVAEL DANMARK SOM VAESTTYSKLAND PAA SAMMA SAETT SOM SVERIGE ACCEPTERAR DESSA NATIONERS CERTIFIKAT. SJOEFARTSVERKET HAR INTE FOER AVSIKT TA UPP HAER RELATERADE FRAAGOR MED DESSA LAENDERS SJOEFARTSADMINISTRATIONER.

AAKE SOEDERPALM

KOPIA: OEVERINSPEKTOEREN, GOETEBORG

TELEX SAENDT TILL STENA
✠
20752 NAVWEST S
64380 SHIPADM S

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SUPPLEMENT No. 216

Lehtola Kari:

VIKING SALLY - ESTONIA. SOLAS Passenger Ship Certificates and Inspection Certificates.

Working paper

31.3.1996

THE JOINT ACCIDENT INVESTIGATION
COMMISSION FOR THE MV ESTONIA

WORKING PAPER

VIKING SALLY - ESTONIA SOLAS PASSENGER CERTIFICATES AND INSPECTION CERTIFICATES

31.3.1996

Viking Sally - Estonia SOLAS Passenger Ship Safety Certificate and Inspection Certificates

1) Safety certificates

A review of the archives of the Finnish National Board of Navigation has shown that the vessel had a complete series of safety certificates from when the vessel was first taken into operation, to when it was transferred to sail under the Estonian flag.

The safety certificate has traditionally been prepared and signed by one official on the basis of the appropriate inspection certificates of experts in different fields.

The first safety certificate was valid from 27 June 1980 to 21 July 1980. This certificate gives the number of passengers as 1,100. When the vessel sailed from Papenburg to Finland, it arrived with dozens of German shipyard employees who continued to build cabins. Because the cabins were still under construction, it was not possible to certify the vessel as carrying more than 1,100 passengers. The period of validity of that first certificate was only one month.

In this first certificate, the vessel's trade area is defined in English, Finnish and Swedish as:

"for a short international voyage
lyhyillä kansainvälisillä matkoilla
för kort internationell resa"

The second safety certificate was valid from 16 July 1980 to 26 June 1981. This certificate gave the number of passengers as 2,000. The vessel had been made ready before this second certificate had been issued. This certificate gives the vessel's trade area as:

"for a short international voyage between Finland and Sweden
rannikkoliikenteessä Suomen ja Ruotsin välillä
i kustfart mellan Finland och Sverige"

(A direct translation of the Finnish and the Swedish is "for coastal traffic between Finland and Sweden".)

The same trade area was also mentioned in the two following certificates valid from 30 June 1981 to 24 June 1982 and from 17 November 1982 to 6 June 1983.

A search of the archives did not reveal any certificates valid from 7 June 1983 to 6 June 1985.

The next certificate found in the archives was valid from 7 June 1985 through 23 April 1986. It gave the trade area as

> "on a short international voyage between Finland and Sweden
> lyhyillä kansainvälisillä matkoilla Suomen ja Ruotsin välillä
> på korta internationalla resor mellan Finland och Sverige"

(Here, all three languages stipulate the same trade area.)

The following seven certificates, which cover the period from 3 June 1986 through 22 May 1993 stipulate the same trade area.

The trade area mentioned in the first safety certificate, "short international voyage", allows the vessel to trade in practice in the entire Baltic. The trade area mentioned in the safety certificates issued after 1985, "short international voyage between Finland and Sweden", apparently refers to the identical area.

The certificates valid between 30 June 1981 and 6 June 1983 also used the same English language definition of the trade area. On the other hand, the Finnish and Swedish language expressions, a direct translation of which is "for coastal traffic between Finland and Sweden", may refer to point 2c of SOLAS chapter II(A)(1), according to which a vessel may be prohibited from voyaging more than 20 nautical miles from land. While in traffic, the Viking Sally remained within this distance from land.

The officials who had participated in the granting of the certificates have noted that at the time there were no reasons connected with the structure of the vessel that would have required limiting its trade area to a smaller area than called for by "short international voyage". The "coastal traffic" notation apparently referred to the Commercial Vessel Officers Decree in force at the time. Section 2 of this Decree is attached (partly) in Finnish and Swedish.

2 §.

Tässä asetuksessa tarkoitetaan:

1) koneluksella — alusta, jonka pääkuljetuslaitteena on kone;

— — — — — — — —

7) sisäliikenteellä — liikennettä järvillä, joissa ja kanavissa sekä rannikon saaristoalueella, joka ei ole välittömästi alttiina aavalta mereltä tulevalle merenkäynnille;

8) rannikkoliikenteellä — liikennettä sisäliikennealueen ulkopuolella Suomenlahdella 23° itäiseen pituuteen, Pohjanlahdella ja Itämerellä 59°30' pohjoiseen leveyteen sekä Ruotsin saaristossa Söderköpingiin asti;

9) itämerenliikenteellä — liikennettä rannikkoliikennealueen ulkopuolella Itämerellä ja siihen liittyvillä vesillä aina Lindesnäsin ja Hanstholmin väliselle linjalle sekä Cuxhaveniin saakka;

10) euroopanliikenteellä — liikennettä itämerenliikennealueen ulkopuolella Vienanmeren satamiin pohjoisessa, 11° läntiseen pituuteen lännessä sekä Välimerelle ja siihen liittyville vesille, ei kuitenkaan Suezia kauemmaksi;

11) valtameriliikenteellä — liikennettä euroopanliikennealueen ulkopuolella; sekä

12) keskeytymättömällä kululla — kulkua, jonka kestäessä alus ei poikkea satamaan tai muutoin ole yhteydessä maihin pitempää aikaa kuin kaksi tuntia kerrallaan.

— — — — — —

2 §.

I denna förordning förstås med:

1) maskindrivet fartyg — fartyg med maskin såsom huvudframdrivningsmedel;

— — — — — — —

7) inre fart — fart på insjöar, floder och kanaler samt i skärgård vid kusten, som icke är omedelbart utsatt för sjögång från öppen sjö;

8) kustfart — fart utom området för inre fart på Finska viken till 23° ostlig longitud, på Bottniska viken och Östersjön till 59° 30' nordlig latitud samt i svenska skärgården till Söderköping;

9) östersjöfart — fart utom området för kustfart på Östersjön och därtill anslutna farvatten intill linjen Lindesnäs—Hanstholm samt till Cuxhaven;

10) europeisk fart — fart utom området för östersjöfart till hamnarna vid Vita havet i norr, till 11° västlig longitud i väster samt till Medelhavet och därtill anslutna farvatten, likväl icke längre än till Suez;

11) oceanfart — fart utom området för europeisk fart; samt

12) oavbruten gång — gång, under vilken fartyget icke anlöper hamn eller annorledes står i förbindelse med land under längre tid än två timmar åt gången

— — — — — — —

The officers in vessels intended for coastal traffic had less strict qualifications.

(5)

2 Surveys

When the Viking Sally - Estonia was under construction, the Commercial Vessel Decree issued in 1920 was in force in Finland. Section 45 of this Decree reads in Finnish and Swedish as follows:

45 §.

Rungonkatsastus toimitetaan ennen kuin alusta saadaan käyttää ja sen jälkeen merimatkustaja-aluksissa joka vuosi, muissa matkustaja-aluksissa joka toinen vuosi, merilastialuksissa joka kolmas vuosi sekä konevoimalla kulkevissa rannikkoaluksissa ja sisävesien koneilla kulkevissa lastialuksissa joka neljäs vuosi. Jos alus ylläpitää talviliikennettä, tulee se joka vuosi, ennenkuin tämä alkaa, katsastuttaa, jollei katsastusta sellaista liikennettä varten ole aikaisemmin vuoden kuluessa talvipurjehduksen päätyttyä toimitettu. Katsastus toimitetaan, kun alus on otettu tokkaan tai seisoo telakalla, sekä ennen kuin runko on kitattu tai maalattu.

Vastamainitussa toimituksessa on katsastettava myöskin kaikkien pelastusveneiden rungot.

Jos aluksella on luokka merenkulkuhallituksen hyväksymässä luokituslaitoksessa sitä liikennettä ja kulkuvettä varten, jossa alusta käytetään, olkoon se, niinkauan kuin luokitustodistus on voimassa, vapautettu edellä määrätystä katsastuksesta; kuitenkin, milloin alusta, jolla talviliikennettä ylläpidetään, ei ole laitoksen toimesta tässä suhteessa sitä vuotta varten katsastettu, toimitettakoon katsastus niin kuin yllä on sanottu.

Jos hyväksytyn luokituslaitoksen asiantuntija on toimittanut rungonkatsastuksen, olkoon siitä annettu todistus tässä maassa pätevä.

45 §.

Skrovbesiktning verkställes innan fartyget får användas och sedermera å sjögående passagerarfartyg varje år, å övriga passagerarfartyg vart annat år, å sjögående lastfartyg vart tredje år samt å kustgående maskindrivet lastfartyg och maskindrivet lastfartyg för inre farvatten vart fjärde år. Underhåller fartyget vintertrafik, bör detsamma varje år innan denna vidtager undergå besiktning, såframt besiktning för dylik trafik icke tidigare under året efter avslutad vinterseglation verkställts. Besiktning verkställes, medan fartyget är intaget i docka eller står på slip samt innan skrovet blivit spacklat och målat.

Vid nu nämnda förrättning bör besiktning verkställas jämväl å samtliga för livräddning avsedda båtars skrov.

Innehar fartyg klass i klassificeringsanstalt, som av sjöfartsstyrelsen godkänts, för den fart och det farvatten, vari fartyget användes, skall detsamma, så länge klassificeringscertifikatet är gällande, vara befriat från ovan föreskrivna besiktning; dock att, där fartyg, varmed vintertrafik underhålles, icke blivit i sådant avseende genom anstaltens försorg för året besiktigat, besiktning skall äga rum på sätt ovan är sagt.

Är skrovbesiktning verkställd av expert för godkänd klassificeringsanstalt, vare häröver utfärdat bevis här i landet giltigt.

Surveyors working for the Finnish National Board of Navigation have surveyed the vessel annually from 1980 to when the vessel was transferred to sail under the Estonian flag. However, the Finnish surveyors had not surveyed the hull, since according to section 45, paragraph 3 cited above, no surveys of the hull need be carried out on the vessel, since it had been classified by Bureau Veritas.

(6)

Annex 1 contained the records of the Finnish Survey of Seaworthiness, which also indicates that the survey of the hull is to be taken care of by the classification society.

Bureau Veritas, together with certain other older classification societies, received this approval under section 45 by a decision of the Finnish National Board of Navigation given already on 18 January 1921. A copy of this has already been distributed to the Joint Accident Investigation Commission.

M I V.

SJÖVÄRDIGHETSBESIKTNINGSBEVIS

passagerarfartyg i ~~ocean- nordsjö- östersjö- eller kustfart.~~ På korta internationella resor

Art, namn och l. d. namn: M/S Viking Sally	år 1980 material Stål Byggnadsort Papenburg	Antal huvudmaskiner 4 hk/bk Total 23.913 ~~17600~~ kW	Ångpanne/tryckkärlsbesiktningen gäller för perioden: / 19 — / 19	Skrovbesiktningen gäller för perioden / 19 — / 19	Fartyget är godkänt vid denna besiktning för perioden / 19 — / 19	
Reg. ort Mariehamn n:r	Största längd 155,~~44~~ 24 m. Största bredd 24,~~20~~ 32 m.	Lastlinjecertifikat gällande sjöfart:s 19 — / 19; klassen 23 6 1980 — 9 12 1980		²) fart på korta internationella resor	²) fa	
Igenkänningsbokstäver OIKW Is avgiftsklass I A	Dräktighet, brutto 15.566,89 netto 8.372,46 reg. ton	Klassificeringsanstalt BV I 3/3 E Passeng. Ferry Deep Sea	Klass	Klass		
Radio/telegrafi/telefoni/säkerhetscertifikat gällande ¹) Under anhakan / 19 — / 19	Säkerhetscertifikat gällande under anhakan / 19 — / 19	Klassificeringsperiod 3 7 1981 — 31 7 1985	När och var har fartyget senast dockats ~~Juni~~ April -80 Papenburg	Är fartyget godkänt för vintertrafik För vilken period		
Redare Rederi Ab Sally	Redarens postadress 22100 Mariehamn					

Befäl	Till- och förnamn	Kompetens
Befälhavare	Lars Mäki	Sjök. st. 5.7.72
Överstyrman	Stig Lindström	Öst. st. 16.12.66
II »	Karl-Gunnar Ekstrand	Sjök. st. 13.4.71
III »	Per B Häggblom	styrm. br. 21.4.65
IV »		
Maskinchef	Lars Karlsson	Öm. m. m. 26.2.70
I maskinmästare	Stig Strömberg	Öm. m. m. 1.2.59
II »	Lars Erik Eriksson	Öm. m. m. 16.9.75
III »	Reino Mäki	Im. m. br. 18.10.77
IV »		

Besättning	Antal
Befäl	8
Radiotelegrafister	1
Lotsar	2
Donkeymän Reparatörer	1
Timmermän	2
Båtsmän	1
Elektriker	1
Intendenter Pursers	1+1
Stuertar Kokssmästare	4
Föreståndarinnor	2
Kockar	5
Kokerskor	—
Manlig betjäning	26
Kvinnlig »	56
Matroser	6
Lättmatroser	2
Jungmän	1
Däckselever	—
Gossar	—
Smörjare	—
Eldare/Motormän	6
Trimmare/Maskinelever	1
Total	124

Nautisk utrustning 20.05.80

Finns tillräckliga sjökort	ja
» sjövägsreglerna	ja
» segelledsbeskrivningar	
» azimuth- och nautiska tabeller	
Fyrbok Nautical	
av år 1978 Almanac för år 1980	1
Kompasser, standard 1 Plath Kronometrar	1
» styr- 1 st Sextanter	
» gyro- Sperry	ja
När har kompasserna justerats	26.6.80
Är kompasserna försedda med certifikat	ja
Datum för certifikaten	3
Barometrar Kikare	
Lodningsapparater, trycklod ekolod	Simrad EH
Handlod	ja
Loggar: patent 1 Loggar: tryck	
Finns radar	3
» Decca navigator	
» automatstyrinrättning	Sperry Gyropilot

Radar Raytheon 1660/12SR
» » 1650/12XR
» Raycas 1660/12 SR
Kursskrivare Sperry
Loggar Raytheon DSN 450

Signalredskap

Topplanternor, elektr. 2+2 petrol.	
Sido- » 2+2	
Akter- » 1+1	
Ankar- » 2+2	2
Röda- » 2+2	
Finns certifikat för lanternorna	ja
» dagsignallampa	ja
Morselampor	ja
Blosslampor/Blåljus (blue lights)	
Fallskärmsraketer, röda	12
Stjärnraketer, röda	12
Röd ljus (red lights)	12
Svarta signalglober	
Svart dubbelkon	ja
Finns internationell signalbok	ja
» erforderliga signalflaggor	ja
» vissla ~~eller siren~~	ja
» mekanisk mistlur	ja
» skeppsklocka	ja
» fr. brygg. tel. ~~l. talrör~~ till maskinrummet	ja
» telefon för ut 4 Högtalare	ja
» » akter »	
Röksignaler	6

Ankare, kättingar och trossar

S. B. bogankare: vikt i kg	6.100
B.B. » » »	6.195
Första reservankare » » »	6155
Andra » » »	
S. B. kättings längd i meter	289,9
B. B. » » »	289,9
Minsta länkdiameter i mm.	60
Förtöjningslinor, stål-	
» , manilla-	
» , gräs-	
» , nylon-	Erforderligt antal

Kontroll av lastmärke

Överensstämma lastlinjerna å fartygssidorna med lastlinjecertifikatet	ja
Äro alla barriärerna i skick	ja
» stormportarna » »	ja
» in- och nedgångarna » »	
Kan fönsterventilerna i bordläggningen effektivt stängas	ja
Finns lock eller presenningar för alla ventilatorrör	Patent
» anordning för uppsättande av livlinor för att skydda besättningen på däck	
Äro skärstockarna och luckplankorna för alla luckor i skick	—
Äro presenningarna och skalkningsanordningarna för alla luckor i skick	—
Är fartygets djupgång uppmärkt i meter	ja

Livbåtar	N:r 1.	N:r 2.	N:r 3.	N:r 4.	N:r 5.	N:r 6.	N:r 7.	N:r 8. 9-10	Livflottar Märke Bb. N:r	Märke Stb. N:r
Art	Alla	I M								
Material	Glasfiber									
Längd m	x) 7,40	8,50		8 st	9,18				Viking	
Bredd m	2,44	2,90			3,41				25 K	
Djuplek m	0,99	1,20			1,48				25	26
Rymd m³	4,50	10,01			25,79				Viking	
Personantal	20	64		8 x	76				25 KF	
									6	6
x) Beredskapsbåt Åbo Båtvarv									31	32

Godkända livräddningsredskap	Antal	Pers.-antal
Livbåtar	10	692
Livflottar	63	1575
Flytredskap AR-66 = 6x20		—
Livbojar, vanliga	2	—
Livbojar med ljus	~~4~~ 3	—
Livbojar med 27.5 m lina	7	—
Livbojar med röksignal	2	—
Livvästar, godkända	2.298	—
Livvästar för barn	200	—
Livbåtarnas och -flottarnas sammanlagda personantal	2267	

Dävertarnas typ: Davit Company Delmenhorst "NT"

Uppgifter över livbåtar och -flottar

Finns erforderlig utrustning i livbåtarna	ja
Har å livbåtarna antecknats fartygets namn och hemort	ja
» livbåtarna dimensioner och personantal varaktigt utmärkts	ja
Finns lejdare vid varje dävertpar	ja
» belysningsanordning för livbåtarna	ja
» livlinor fästa vid mellangajarna till dävertparen	ja
» i livbåtarna under kölen löpande knopförsedda griplinor	ja
» » gliddanordningar för underlättande av sjösättning	ja
» livbåtars alarmlista	ja
Är motorbåtarna försedda med dieselmotor	ja
» » » pulver- eller ~~skum~~eldsläckningsapparat	ja
» » » bränsle för 24 timmars gång	ja
» livflottarna så placerade att de utan svårighet kan fällas i sjön	ja
» livflottarnas utlösningslina fäst vid fartyget	ja

Radioanläggningar

Finns godkänd radiotelegrafanläggn.	ja
» » radiotelefonläggning	ja
» » radiopejlapparat x)	ja
När har radiopejlapparaten kalibrerats	26.6.80
Finns portativ livbåtsradioapparat	ja
» fast »	

x) Debeg
VHF 4 ITT STR 4050

Noggrannare uppgifter om apparater, redskap mm.

Linkastningsapparatens märke	Comet 250 NR
Projektilernas antal till linkastningsapparaten	4
» datumstämpel	06.80
Antal linor till linkastningsapparaten	4
Finska livvästarnas märke	2298 st RT 63 P/200 st RT 10 P
Utländska »	—
Är livbojarna och -västarna försedda med fartygets namn	ja
Väger livbojarna med röksignal 4 kg	ja
Dagsignallampans märke	TRAK
Fallskärmsraketernas datumstämpel	06.80
Stjärnraketernas »	06.80
Rödljusens »	06.80
Portativa livbåtsradioapparatens märke	ITT Marine Solas III A Class X
Fasta livbåtsradiotelegrafinstallationens märke	
Kraftkällan för livbåtarnas belysningsanordning	Accumulatorer + Nödgenerator
Livbåtsmotorernas märke och vikt	9 st Saab 22 hp 1 st Saab 65 hp
Mekaniska roddanordningens märke	
Är livbåtstaljelöparna av vajer eller av manilla	Vajer
Finns anordningar till förhindrande av att livbåtsdävertarna ryckas ur sina skor	Patent
Avbryts kraftstillförseln automatiskt då livbåtarna lyfts maskinellt	Ja -»-
Har livbåtsutrustn. granskats i samband med livbåtsmanövr.	Ja
Har härom gjorts anteckningar i skeppsdagboken	ja
När har livflottarna senast översetts	6.6.80
» » senaste livbåtsmanöver ägt rum	25.6.80
» » livbåtsmotorn senast provstartats	25.6.80
Antal godkända livbåtmän	

Övriga uppgifter

Finns nationalflagga	ja
» fartygets sektionsritningar in duplo	ja
» pejlrör till slag Brunnar med automatlarm	
» belyst rodervisare	ja
» reservstyrinrättning	ja
» nödigt medicinförråd	ja
När har medicinförrådet senast förnyats	12.06.80
Finns nödig sjukvårdsutrustning	ja
» godkänd handbok för sjukvård	ja
» reservutgång från hytter	ja
» brandalarmlista	ja
Automatisk nödbelysning, beskaffenhet och ljuspunkternas antal Accum. + Nödgenerator 466/447	ja
Landgångar med erforderliga räcken; antal	från land
Konventionsenlig lotslejdare	+ Sidoportar
Äro eldsläckningsapparaterna väl placerade och lätt åtkomliga	ja
Äro livräddningsredskapen väl placerade och lätt åtkomliga	ja
Finns stabilitetsuppgifter	ja
» brandkontrollplan	ja
I vilket bolag är besättningen olycksfallsförsäkrad	Bof
Finns oljedagbok	ja

Antal presenningar för luckorna²)						
n:o 1	n:o 2	n:o 3	n:o 4	n:o 5	n:o 6	n:o 7
Bilfärja						

Antal presenningar för luckorna på mellandäck³)						
n:o 1	n:o 2	n:o 3	n:o 4	n:o 5	n:o 6	n:o 7
Bilfärja						

¹) Det nödiga överstrykes
²) Ocean-, nordsjö-, östersjö-, kust-
³) Är luckan försedd med metalltäckducka, antecknas detta med bokstaven »m»

Raft Davits Type SRR, R=3650 4 st

Maskineribesiktningsbevis

Fartygets art[1]) och namn passagerarfartyget Viking Sally
Redare Rederiaktiebolaget Sally Bruttodräktighet 15566,89 reg.ton
Framdrivningsmaskin: art [2]) dieselmotorer antal 4
Maskineffekt/17600 kW ~~HKi/HKe~~ enligt bevis den — 19 — Bevis ausfärdas från Sjöfartsstyrelsen av undertecknad.
Arbetstryck: lufttryck 30 kp/cm², ångtryck — kp/cm²

Var och när har föregående besiktning förrättats Ej tidigare, nybygge
Maskineriet godkändes då till den — 19 — /för seglationsperioden 19 —

Tillståndsbevis för pannan/pannorna har utfärdats den — 19 —
Är alla rörledningar författningsenliga Ja
Var är bränslebehållarena placerade i dubbelbotten, högtankar och dagtankar
Kan huvudpådragningsventilerna/bränsleventilerna avstängas på däck Ja
Hurudan är maskinrummets/pannrummets reservutgång 5/2 reservutgångar
Är säkerhetsventilerna justerade — Finns föreskrivna reservdelar ombord Ja, klass
Finns föreskrivna verktyg ombord Ja Finns föreskrivna reparationsförnödenheter ombord Ja
När har huvudmaskinen öppnats och besiktigats Kl. 07.80 Till vilken datum godkänd 07. 85
När har hjälpmaskinerna öppnats och besiktigats Kl. 07.80 Till vilken datum godkända 07. 85
När har propelleraxeln besiktigats SB & BB Kl. 04.80 Till vilken datum godkänd 04. 85
När har bottenventilerna och -kranarna öppnats och besiktigats Kl. 04.80 Till vilken datum godkända 04.85
När har tryckluftsbehållarena besiktigats Kl. 07. 80 Provtryck enl. klassfordr. kp/cm²

Länspumparna:

Huvudlänsledningens diameter 125

Kapacitet m³/h	300	110	110	110	30
Är pumpen självsugande	Ja	Ja	Ja	Ja	Ja
Art [3])	samtliga självständigt drivna				

Självständigt drivna brandpumpar: (för sprinkler-system)

Kapacitet m³/h	92	92	92	2 × 150
Tryck ~~kp/cm²~~ bar	9,0	9,0	9,0	7,5
Placering	Hm-rum	Hjm-rum	KAMEVA-rum	Verkstad & KAMEVA-rum

Är brandpumparna försedda med säkerhetsventiler Ja
Brandposter: På öppet däck 15 , ~~varav — är åtkomliga då fartyget har däckslast;~~
i passagerar~~e~~bostadsavdelningarna 68 ; i maskin- ~~och pannrummen~~ avd. 10
Vid brandposterna finns 92 st brandslangar à 15 m. Slangarnas diameter 52 mm
Storlek och typ [4]) av slangarnas munstycken Samtliga för alternativt sluten/spridd stråle

[1]) passagerar-, last-, isbrytar-, bogser-, fiske-, bärgningsfartyg
[2]) ång-, motor-, turbin-.
[3]) handpump, av huvudmaskineriet driven pump, självständigt driven pump
[4]) helstråle-, reglerbart, dimmunstycke

Flyttbara eldsläckningsapparater:

Typ [5])	Pulver	Pulver	Pulver	CO_2
Antal	1	2	160	3
Storlek	50 kg	12 kg	6 kg	12 kg
Senaste besiktning	samtliga	levererade	som nya	06,1980
Reservladdningar	1	2	160	3

Av flyttbara eldsläckningsapparater finns:

i maskin~~rummet~~ avdelningen: 1 st 50 kg pulv., 19 st 6 kg pulv. och 1 st 12 kg CO_2 [6])

» pannrummet: 2 » 12 -"- -"-, 2 » 6-"- -"- » — » — [6])

» övriga rummen: 2 » 12 -"- CO_2, 139 » 6-"- -"- » — » — [6])

I pannrummet finns 2 hetolje pannor, vilka är försedda med sammanlagt 2/2 eldstäder/brännare samt 8 st. avgaspannor (thermal fluid heaters) (gas heaters)

Finns vid varje panna en behållare med sand eller motsvarande —, volym — m³

Finns rökhjälm — Finns säkerhetslampor Ja, 10 st.

Finns ~~friskluft~~ tryck-luftsandningsapparater Ja, 6 st. Reservbehållarenas antal 12 satser = 12 st.

Finns brandyxor Ja, 10 st. Finns flyttbar borrmaskin Ja, 2 st., borrens diam 13 mm

Finns skumsläckningsanordning i utrymmet för olje-eldade pannor

Skumvätskemängd — l. Utrymmets golvyta — m², volym — m³

Finns i pannutrymmet någon annan anordning för eldsläckning Ja, CO_2 munstycken

Eldsläckningsanordningens kapacitet från centralt CO_2 batteri + handsläckare

Eldsläckning i maskinrum ~~i lastrum:~~ och i maskinavdeln. (~~anteckna ×~~)
- [x] Eldsläckande gas
- [ ] Ånga
- [ ] Skum
- [ ] ~~Annan, huruden~~

Största lastrummets bruttovolym — m³

Gasmängd 68 st. CO_2 behållare à 45 kg = 3060 kg CO_2. Landanslutn. för CO_2 finnes. I maskinrum och maskinavd. 35 st. CO_2 munst.

Finns i rum, dit CO_2 kan insläppas, alarmanordning för varnande av manskapet Ja.

Finns anordningar för förhindrande av oljeutflöde i bilgarna Ja

Finns separator eller annan anordning för avskiljande av olja från slagvattnet Separator + filter. ppm-skrivare

Anordningens typ och kapacitet 10 m³/h HDW Turbulo TE10FS + HDW TF10-S.

Anmärkningar: Brandsläckn. bildäck: 358 st. vattensprinklers, 2 st. 150 m³/h 75 MVP sprinklerpumpar. Brandmansutrustningar: 6 st. fullst. och 4 st. personl., fördelade på stationer. Klass: Bureau Veritas.

Å~~n~~gpannornas fullständiga/~~inre~~/klassbesiktning skall utföras den juli (07) 1985

Maskineriet godkännes vid denna besiktning till den 1 juli 1981 /för seglationsperioden 19—

på korta internationella resor ~~fart.~~

Antal besök ombord: 2 4 Mariehamn den 1 juli 1980

Besiktningsarvode: 1,750,-

Maskineribesiktningsman i Ålands distrikt

Rainer Mattsson

[5]) CO_2, pulver, skum, vatten.
[6]) Storlek och typ bör nämnas.

BUREAU VERITAS

INTERNATIONAL REGISTER FOR CLASSIFICATION OF SHIPS ESTABLISHED 1828

CERTIFICATE OF CLASSIFICATION

Certificate

" VIKING - SALLY "
==================

No. 35 P 387
in Register Book

N° 608862

MACHINERY

This is to certify that the machinery of the above named ship, has been surveyed during construction at Papenburg/Ems in 1979/1980 by surveyors to the Society, in accordance with the requirements of the Rules.

Main machinery Four Diesel engines, type MAN 8 L 40/45, 8 cyl., 4 cycle, single acting, supercharged, Nos. 1080005 and 008 - 010

total effective power 17600 kW (23913 hp) at 600 r.p.m. determined by testing

built at Augsburg by MAN Maschinenfabrik Augsburg-Nürnberg AG.

completed in April 1980

The machinery has been entered in the Register Book with the mark ✠

The present certificate is valid until JULY 1985

The next special survey will be the 1st **special survey No.** 1 CONTINUOUS SURVEY

When the requirements of the rules for maintenance of class and in particular those concerning surveys are not complied with, the validity of the certificate lapses and the class will be withdrawn from the Register.

The interventions of Bureau Veritas, carried out either in accordance with its own Regulations or according to standards, specifications or similar documents explicitly called for, or alternatively the opinions of the Society as expressed by the classification symbols or special marks, certificates, attestations, reports or similar documents, shall not, in any case, involve the responsibility of the Society.

Although the utmost care is taken in the drafting of Bureau Veritas publications, particularly with respect to the Register, the Society declines any responsibility for the errors or omissions which may be found therein or in the certificates, attestations or reports drawn up by its Services or its Surveyors, which may form the subject of observations by the Parties concerned. Furthermore, Bureau Veritas declines any responsibility for the errors of judgement, mistakes or negligence of its technical or administrative staff or Agents in drafting such documents and in carrying out the interventions which they cover, nor shall the responsibility of the staff be involved.

Propeller-shaft : Type, periodicity of Survey: two LB5

Last survey in: April 1980

At Hamburg , on July 1, 1980

For Bureau Veritas,

By order of the Secretary

W. BUHR

BUREAU VERITAS EXPERTEN HAMBURG gegründet 1828 INTERNATIONALES REGISTER

Form. Ad. M. E. 441

BUREAU VERITAS

INTERNATIONAL REGISTER FOR CLASSIFICATION OF SHIPS ESTABLISHED 1828

CERTIFICATE OF CLASSIFICATION

Certificate

№ 212788

" VIKING - SALLY "

No. 35 P 387
in Register Book

BOILERS

This is to certify that the undermentioned boilers has/have been surveyed for classification purpose at Papenburg/Ems in 1980
by Surveyors to the Society, in accordance with the requirements of the Rules.

Two thermal fluid heaters, type TO-80-II, Nos. 109 et 110

Total heating surface 250 m². Working pressure 7 kg/cm².
Superheated steam temperature 180 °C
Built at Alingsas by SANEA Verkstads AB in 1980

Four exhaust gas heaters, type S 1 - 200, Nos. 166 - 169
Four exhaust gas heaters, type S 1 - 65, Nos. 170 - 173

Total heating surface 1060 m². Working pressure 7 kg/cm².
Superheated steam temperature 180 °C
Built at Alingsas by SANEA Verkstads AB in 1980

The boiler is/are classed with the mark ✠

The present certificate is valid until JULY 1985

When the requirements of the rules for maintenance of class and in particular those concerning surveys are not complied with, the validity of the certificate lapses and the class will be withdrawn from the Register.

The interventions of Bureau Veritas, carried out, either in accordance with its own Regulations or according to standards, specifications or similar documents explicitly called for, or alternatively, the opinions of the Society as expressed by the symbols of Classification or special marks, certificates, attestations, reports or similar documents, shall not in any case, involve the responsibility of the Society.

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Stamp: BUREAU VERITAS · EXPERTEN IN HAMBURG · gegründet 1828 · INTERNATIONALES REGISTER

At Hamburg, on July 1, 1980

For Bureau Veritas:
By order of the Secretary

W. BUHR

Form Ad. M. E. 471 c

SUPPLEMENT No. 217

Selection of MV ESTONIA's certificates valid at the time of the accident.

PASSENGER SHIP SAFETY CERTIFICATE

No 2PA

This Certificate shall be supplemented by a Record of Equipment (Form P)

for xxx * international voyage
a short

Issued under the provisions of the
INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974,
as amended under the authority of the Government of

REPUBLIC OF ESTONIA

by BUREAU VERITAS

Name of Ship BV No : 35P387	Distinctive Number or Letters	Port of Registry	Gross Tonnage	IMO Number
ESTONIA	E S T E	TALLIN	15598	7921033

Sea areas in which ship is certified to operate (regulation IV/2) ...NA...
Date on which keel was laid or ship was at a similar stage of construction or, where applicable, date on which work for a conversion or an alteration or modification of a major character was commenced ....01/10/1979......

THIS IS TO CERTIFY :

1 That the ship has been surveyed in accordance with the requirements of regulation I/7 of the Convention.

2 That the survey showed that :

2.1 the ship complied with the requirements of the Convention as regards :

1 the structure, main and auxiliary machinery, boilers and other pressure vessels;

.2 the watertight subdivision arrangements and details;

.3 the following subdivision load lines :

Subdivision load lines assigned and marked on the ship's side at amidships (regulation II-1/13)	Freeboard	To apply when the spaces in which passengers are carried include the following alternative spaces
C.1	2062	
C.2	–	
C.3	–	

Ad. E 5426

2.2 the ship complied with the requirements of the Convention as regards structural fire protection, fire safety systems and appliances and fire control plans;

2.3 the life-saving appliances and the equipment of the lifeboats, liferafts and rescue boats were provided in accordance with the requirements of the Convention;

2.4 the ship was provided with a line-throwing appliance and radio installations used in life-saving appliances in accordance with the requirements of the Convention;

2.5 the ship complied with the requirements of the Convention as regards radio installations;

2.6 the functioning of the radio installations used in life-saving appliances complied with the requirements of the Convention;

2.7 the ship complied with the requirements of the Convention as regards shipborne navigational equipment, means of embarkation for pilots and nautical publications;

2.8 the ship was provided with lights, shapes, means of making sound signals and distress signals, in accordance with the requirements of the Convention and the International Regulations for Preventing Collisions at Sea in force;

2.9 in all other respects the ship complied with the relevant requirements of the Convention.

3 That an Exemption Certificate ~~has~~/has not* been issued.

This certificate is valid until 26 January 1995

Issued at COPENHAGEN, on the 23 June 1994

BUREAU VERITAS

KARSTEN BERTELSEN

Secretary

BUREAU VERITAS PARIS 1828 — COPENHAGEN — INTERNATIONAL REGISTER

KB /

* *Delete as appropriate.*

Ad. E 5426

~~CONDITIONALLY ISSUED * (See overleaf)~~

INTERIM PASSENGER SHIP SAFETY CERTIFICATE

This Certificate shall be supplemented by a Record of Equipment (Form P)

for ~~an~~ a short * international voyage

Issued under the provisions of the
INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974,
as amended under the authority of the Government of

..................the Republic of Estonia..................

by BUREAU VERITAS

Name of Ship BV No: 35 P 387	Distinctive Number or Letters	Port of Registry	Gross Tonnage	IMO Number
"ESTONIA"	E S T E	TALLINN	15598	7921033

Sea areas in which ship is certified to operate (regulation IV/2) .....N.A.....
Date on which keel was laid or ship was at a similar stage of construction or, where applicable, date on which work for a conversion or an alteration or modification of a major character was commenced .....12.79.....

THIS IS TO CERTIFY :

1 That the ship has been surveyed in accordance with the requirements of regulation I/7 of the Convention.

2 That the survey showed that :

2.1 the ship complied with the requirements of the Convention as regards :

.1 the structure, main and auxiliary machinery, boilers and other pressure vessels;

.2 the watertight subdivision arrangements and details;

.3 the following subdivision load lines :

Subdivision load lines assigned and marked on the ship's side at amidships (regulation II-1/13)	Freeboard	To apply when the spaces in which passengers are carried include the following alternative spaces
C.1	2062 mm	
C.2	–	
C.3	–	

* *Delete as appropriate.*
Conditionally issued maximum validity 2 months.
Interim maximum validity 5 months.

Ad. E 5426/1

RECORD OF EQUIPMENT FOR THE PASSENGER SHIP SAFETY CERTIFICATE

No

4 Methods used to ensure availability of radio facilities (regulations IV/15.6 and 15.7)

4.1 Duplication of equipment ........N.A.........

4.2 Shore-based maintenance ........N.A.........

4.3 At-sea maintenance capability ........N.A.........

5 Ships constructed before 1 February 1995 which do not comply with all the applicable requirements of chapter IV of the Convention as amended in 1988 *

	Requirements of regulations	Actual provision
Hours of listening by operator	8	8
Number of operators	1	1
Whether auto alarm fitted	Required	Fitted
Whether main installation fitted	Required	Fitted
Whether reserve installation fitted	Required	Fitted
Whether main and reserve transmitters electrically separated or combined	Separated	Separate installed

6 Ships constructed before 1 February 1992 which do not fully comply with the applicable requirements of chapter III of the Convention as amended in 1988 **

	Actual provision
Radiotelegraph installation for lifeboat	1
Portable radio apparatus for survival craft	1
Survival craft EPIRB (121.5 MHz and 243.0 MHz)	N.A.
Two-way radiotelephone apparatus	3

** This section need not be reproduced on the record attached to certificates issued after 1 February 1999.*

*** This section need not be reproduced on the record attached to certificates issued after 1 February 1995.*

THIS IS TO CERTIFY that this Record is correct in all respects.

Issued at ....Stockholm........ on the ....14 June 1993........

BUREAU VERITAS — REGISTRE INTERNATIONAL — EXPERT de STOCKHOLM — PARIS 1828

BUREAU VERITAS

Anders Wirstam

Secretary

Ad. E 5326

RECORD OF EQUIPMENT FOR COMPLIANCE WITH THE INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974, AS AMENDED IN 1988
(Form P)

No

This Record shall be permanently attached to the Passenger Ship Safety Certificate

1 Particulars of ship

Name of ship: "ESTONIA" BV Register: 35 P 387
Distinctive number or letters: E S T 6
Number of passengers for which certified: 2000
Minimum number of persons with required qualifications to operate the radio installations: 1

2 Details of life-saving appliances

1	Total number of persons for which life-saving appliances are provided	2188	
		Port side	Starboard side
2	*Total number of lifeboats*	5	5
2.1	Total number of persons accommodated by them	368	324
2.2	Number of partially enclosed lifeboats (regulation III/42)	–	–
2.3	Number of self-righting partially enclosed lifeboats (regulation III/43)	–	–
2.4	Number of totally enclosed lifeboats (regulation III/44)	–	–
2.5	Other lifeboats		
2.5.1	Number	5	5
2.5.2	Type	open	open
3	Number of motor lifeboats (included in the total lifeboats shown above)	10	
3.1	Number of lifeboats fitted with searchlights	2	
4	Number of rescue boats	1	
4.1	Number of boats which are included in the total lifeboats shown above	1	
5	Liferafts		
5.1	Those for which approved launching appliances are required		
5.1.1	Number of liferafts	12	
5.1.2	Number of persons accommodated by them	300	
5.2	Those for which approved launching appliances are not required		
5.2.1	Number of liferafts	51	
5.2.2	Number of persons accommodated by them	1275	
6	Buoyant apparatus		
6.1	Number of apparatus	6	
6.2	Number of persons capable of being supported	120	
7	Number of lifebuoys	18	
8	Number of lifejackets	2298 + 200 (children	

2 **Details of life-saving appliances (continued)**

9	Immersion suits	
9.1	Total number	30
9.2	Number of suits complying with the requirements for lifejackets	30
10	Number of thermal protective aids *	662
11	Radio installations used in life-saving appliances	
11.1	Number of radar transponders	1
11.2	Number of two-way VHF radiotelephone apparatus	3

3 **Details of radio facilities**

Item		Actual provision
1	Primary systems	
1.1	VHF radio installation :	
1.1.1	DSC encoder	N.A.
1.1.2	DSC watch receiver	N.A.
1.1.3	Radiotelephony	3
1.2	MF radio installation :	
1.2.1	DSC encoder	N.A.
1.2.2	DSC watch receiver	N.A.
1.2.3	Radiotelephony	N.A.
1.3	MF/HF radio installation :	
1.3.1	DSC encoder	N.A.
1.3.2	DSC watch receiver	N.A.
1.3.3	Radiotelephony	2
1.3.4	Direct-printing radiotelegraphy	N.A.
1.4	INMARSAT ship earth station	N.A.
2	Secondary means of alerting	N.A.
3	Facilities for reception of maritime safety information	
3.1	NAVTEX receiver	1
3.2	EGC receiver	N.A.
3.3	HF direct-printing radiotelegraph receiver	N.A.
4	Satellite EPIRB	
4.1	COSPAS-SARSAT	2
4.2	INMARSAT	N.A.
5	VHF EPIRB	N.A.
6	Ship's radar transponder	N.A.
7	Radiotelephone distress frequency watch receiver on 2,182 kHz **	1
8	Device for generating the radiotelephone alarm signal on 2,182 kHz ***	2

* *Excluding those required by regulations III/38.5.1.24, III/41.8.31 and III/47.2.2.13.*

** *Unless another date is determined by the Maritime Safety Committee, this item need not be reproduced on the record attached to certificates issued after*

2.2 the ship complied with the requirements of the Convention as regards structural fire protection, fire safety systems and appliances and fire control plans;

2.3 the life-saving appliances and the equipment of the lifeboats, liferafts and rescue boats were provided in accordance with the requirements of the Convention;

2.4 the ship was provided with a line-throwing appliance and radio installations used in life-saving appliances in accordance with the requirements of the Convention;

2.5 the ship complied with the requirements of the Convention as regards radio installations;

2.6 the functioning of the radio installations used in life-saving appliances complied with the requirements of the Convention;

2.7 the ship complied with the requirements of the Convention as regards shipborne navigational equipment, means of embarkation for pilots and nautical publications;

2.8 the ship was provided with lights, shapes, means of making sound signals and distress signals, in accordance with the requirements of the Convention and the International Regulations for Preventing Collisions at Sea in force;

2.9 in all other respects the ship complied with the relevant requirements of the Convention.

3 That an Exemption Certificate ~~has~~/has not* been issued.

This certificate is valid until 27 June 1994

Issued at Stockholm, on the 27 January 1994

BUREAU VERITAS PARIS 1828 EXPERT DE STOCKHOLM REGISTRE INTERNATIONAL

Anders Wirstam

BUREAU VERITAS

By order of the Secretary

* *Delete as appropriate.*

Ad. E 5426/1

| 1 B |

2839/57

INTERNATIONELLT MÄTBREV

INTERNATIONAL TONNAGE CERTIFICATE

Utfärdat enligt konvention om ett enhetligt skeppsmätningssystem avslutad i Oslo den 10 juni 1947.

Issued in accordance with the convention for a uniform system of tonnage measurement of ships concluded in Oslo on the tenth of June 1947.

FINLAND

Fartygets namn
Name of ship

~~V-I-K-I-N-G S-A-L-L-Y~~ */

Fartygets art / Description of ship	Nationalitet / Nationality	Hemort / Home port	Registerort / Port of registry	Registernummer / Official number	Signalbokstäver / Signal letters	Framdrivningssätt / Propelled by machinery or by sails
pass.färja pass.ferry	finsk Finnish	*/ Mariehamn	*/ Mariehamn	1265	C I K W	maskin machinery

Byggnadsår / When built	Byggnadsort / Where built	Byggnadsvarv (namn och adress) / Name and address of builders	Byggnadsnummer / Yard number	Byggnadsmaterial / Material
1980	Papenburg	Jos.L.Meyer Papenburg, Germany	590	stål steel

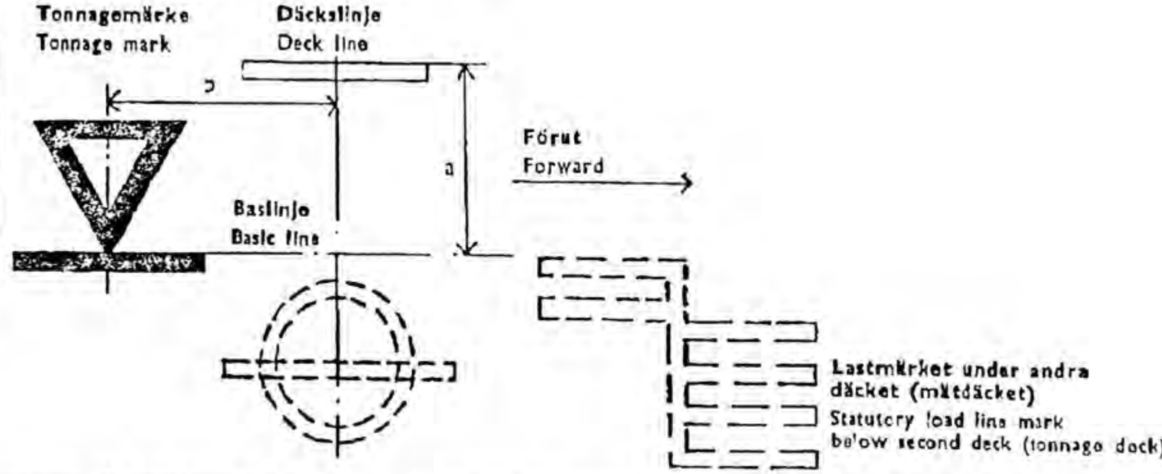
Framdrivningsmaskineri / Description of propelling machinery	Antal propellrar / Number of screws	Ägare (namn och adress) / Name and address of owners
diesel	två two (2)	*/ Rederiaktiebolaget Sally Mariehamn

Igenkänningsmått Identification dimensions	Fot Feet	Meter Metres
Längd från förkant av förstävens översta ända till akterkant av akterstävens översta ända Length from the fore side of the uppermost end of the stem to the aft side of the uppermost end of the stern post		148,82
Bredd, största yttre (avvisare ej inräknade) Breadth, extreme outside (rubbing pieces not included)		24,22
Djup i mittplanet vid mitten av igenkänningslängden från undersidan av övre däck till översidan av dubbelbottens tak eller överkanten av bottenstockar Depth in the middle plane at half length, from the under side of the upper deck to the upper side of the double-bottom plating or top of floors		6,50

Tonnagemärke
Tonnage mark

Detta tonnagemärke är märkt på fartygets båda sidor
i höjd med lastmärkets översta linje
On each side of the ship a tonnage mark is marked on level with the highest load-line grid as follows:

Avstånd (se figur) Distances (see figure)		Tum Inches	Millimeter Millimetres
Vertikalavstånd Vertical distance	a		1445
Horisontalavstånd Horizontal distance	b		1500



Härmed intygas att detta fartyg blivit mätt i enlighet med de till ovannämnda konvention fogade internationella skeppsmätningsreglerna och att dess dräktighet, mätt enligt regel I, är såsom i detalj framgår av sidan 2 i detta mätbrev, följande, förutsatt att tonnagemärkets baslinje icke ligger under vatten:
This is to certify that the above-named ship has been measured in conformity with the international regulations for tonnage measurement of ships annexed to the above mentioned convention and that her tonnage under Rule I of the said regulations is as stated in detail on page 2 of this tonnage certificate, provided the basic line of the tonnage mark as indicated above is not submerged:

bruttodräktigheten the gross tonnage being	15598,29	**registerton eller** register tons or	44187,80	**kubikmeter,** cubic metres,
nettodräktigheten the net tonnage being	8393,81	**registerton eller** register tons or	23778,53	**kubikmeter,** cubic metres.

Är fartyget nedlastat så djupt att tonnagemärkets baslinje ligger under vatten är detta mätbrev icke giltigt.
NB! When the basic line of the tonnage mark is submerged this tonnage certificate will not be valid.

Helsingfors, den 9 maj **19** 85

Lösen mk 6674,25
Mätningsarvode „ 3645,00
Summa mk 10319,25

MERENKULKUHALLITUS SJÖFARTSSTYRELSEN

På Sjöfartsstyrelsens vägnar:
For the National Board of Navigation:

Åke Wiberg
Skeppsmätningskontrollör
Chief tonnage surveyor

9227-67/21

Vänd
See overleaf

Fartygets namn VIKING SALLY
Name of ship

	Registerton Register tons	Kubikmeter Cubic metres
Underdäcksdräktighet Under-deck tonnage	5642,61	15984,74
Mellandäcksdräktighet Tween-deck tonnage		
Slutet rum i öppet sh.däcksrum Closed in space in open sh.deckspace	118,42	335,47
Överbyggnad Superstructure	9662,58	27372,75
Rum för framdrivningsmaskinerlet, belägna ovanför mätdäck Spaces above the tonnage deck included as part of the propelling-machinery space	174,68	494,84
Tillägg för luckor Excess of hatchways		
Bruttodräktighet Gross tonnage	15598,29	44187,80

	Registerton Register tons	Kubikmeter Cubic metres	Registerton Register tons	Kubikmeter Cubic metres
Bruttodräktighet Gross tonnage			15598,29	44187,80
Avdrag Deductions				
Befälhavare Master	34,71	98,32		
Besättning Crew	1808,59	5123,49		
Proviantrum Provision rooms				
Navigationsrum Navigation spaces	125,01	354,13		
Pumprum Pump rooms				
Verkstäder och förråd Workshops and store rooms	44,95	127,35		
Vattenbarlastrum * Water ballast spaces	199,76	565,88	2213,02	6269,17
Återstod Remainder			13385,27	37918,63
Drivkraftsavdraget Deduction for propelling-machinery spaces			4991,46	14140,10
Nettodräktighet Net tonnage			8393,81	23778,53

Rum ovanför mätdäck vilka icke inräknats i bruttodräktigheten.
Cubic capacity of spaces above the tonnage deck not included in the gross tonnage.

Lastrum Cargo spaces		Längd i meter Length	Registerton Register tons	Kubikmeter Cubic metres
Mellandäcksrum Tweendeck space		147,45	5905,50	16729,46
På däck 5 On deck 5	I II	11,84 6,97	70,27 41,36	199,06 117,19

Volymen av rum för framdrivningsmaskineriet, vilken ligger till grund för drivkraftsavdraget och vilken därför inräknats i bruttodräktigheten.
The cubic capacity of propelling-machinery spaces upon which the propelling-power allowance is based and which has therefore been included in the gross tonnage.

	Registerton Register tons	Kubikmeter Cubic metres
Under mätdäck Below the tonnage deck	1853,10	5249,57
Ovanför mätdäck Above the tonnage deck	174,68	494,84
Summa Total	2027,78	5744,41

No	Användning Available for	Registerton Register tons	Kubikmeter Cubic metres
6	Water ballast	30,53	86,5
8	Diesel oil	25,24	71,5
9	Heavy fuel oil	25,24	71,5
15	" " "	51,19	145,0
16	" " "	51,19	145,0
18	Diesel oil	24,71	70,0
19	Heavy fuel oil	25,77	73,0
20	Gas oil	7,59	21,5
17	Fresh water	6,35	18,0
24	Thermal oil	6,53	18,5
25	Lub oil	5,44	15,4
26	" "	5,44	15,4
27	" "	5,44	15,4
28	" "	5,44	15,4
29	Fresh water	5,82	16,5
30	Lub. oil	4,24	12,0
31	" "	1,84	5,2
32	" "	4,84	13,7
33	Bilge water	8,12	23,0
42	Dirty oil	4,91	13,9
40	HFO overflow	13,77	39,0
44	Sludge oil	9,25	26,2
45	DO. overflow	4,38	12,4
47	Diesel oil	16,59	47,0
48	" "	17,30	49,0
54	Water ballast	21,53	61,0
	Summa Total	388,69	1101,0

Av behörig myndighet gjorda anteckningar om ändring av fartygets namn, hemort, registerort, ägare o.s.v.
Statements made by competent authorities with regard to changes of ships name, home port, port of registry, owners etc.

*/ ALUKSEN NIMI
NAME OF SHIP : WASA KING

KOTIPAIKKA
HOME PORT : VAASA

REKISTERIPAIKKA
PORT OF REGISTRY : VAASA

OMISTAJAN NIMI JA OSOITE
NAME AND ADDRESS OF OWNERS : PARTREDERI FÖR WASA KING
MARIEHAMN

TURUSSA 7. 2. [illegible]91

MERENKULKULAITOS SJÖFARTSVERKET

...TARKASTAJA

(69)

INTERNATIONAL TONNAGE CERTIFICATE (1969) No. CPN0038

Issued under the provisions of the
INTERNATIONAL CONVENTION ON TONNAGE MEASUREMENT OF SHIPS, 1969,
under the authority of the Government of the

REPUBLIC OF ESTONIA

for which the Convention came into force on

by **BUREAU VERITAS**

Name of Ship	Distinctive Number or Letters	Port of Registry	Date*
ESTONIA BV Reg 35P387	ESTE 7921033	TALLINN	1980

* Date on which keel was laid or the ship was at a similar stage of construction, (Article 2(6)), or date on which the ship underwent alterations or modifications of a major character, (Article 3(2) (b)), as appropriate.

MAIN DIMENSIONS

Length (Article 2(8))	Breadth (Regulation 2(3))	Moulded Depth amidships to Upper Deck (Regulation 2(2))
138.88m	24.20m	13.40m

THE TONNAGES OF THE SHIP ARE :

GROSS TONNAGE 21794

NET TONNAGE 10428

THIS IS TO CERTIFY that the tonnages of this ship have been determined in accordance with the provisions of the International Convention on Tonnage Measurement of Ships 1969.

Issued at .... CCP - COPENHAGEN .... the .... 29 AUGUST 1994 ....

The undersigned declares that Bureau Veritas is duly authorized by the said Governement to issue this certificate.

BUREAU VERITAS

COPY

BUREAU VERITAS MARINE CENTER PARIS 1828 COPENHAGEN INTERNATIONAL REGISTER

JA / KB

KARSTEN BERTELSEN Secretary

BV Mod. Ad. E 1430

GROSS TONNAGE			NET TONNAGE		
Name of Space	**Location**	**Length (m)**	**Name of Space**	**Location**	**Length (m)**
UNDERDECK	-	-			
			CARGO COMPAREMENT	FORE-AFT	145.00
1st TIER					
ROUNDHOUSE NO. 1	(139-4)	121.20			
2nd TIER					
ROUNDHOUSE NO. 2	(139-4)	121.20			
DECK HOUSE	(-4- -15)	5.70			
3rd TIER					
ROUNDHOUSE NO. 3	(139-4)	121.20			
4th TIER					
ROUNDHOUSE NO. 4	(139-4)	121.20			
5th TIER					
ROUNDHOUSE NO.5	(127-4)	112.80			
6th TIER					
ROUNDHOUSE NO.6	(126-112)	11.30			
FUNNEL NO. 1	(120-108)	9.60			
7th TIER					
ROUNDHOUSE NO. 7	(79-45)	27.20			
FUNNEL NO. 2	(76-25)	19.20			

EXCLUDED SPACES (Regulation 2(5))

Less recess in roundhouse No. 4
Less recess in roundhouse No. 5

An asterisk (*) should be added of those spaces listed above which comprise both enclosed & excluded spaces

NUMBER OF PASSENGERS (Regulation 4(1)) 2000

Number of passengers in cabins with not more than 8 berths 1170

Number of other passengers 830

MOULDED DRAUGHT (Regulation 4(2)) **5.617m**

Date and place of last original measurement : /

Date and place of last previous remeasurement : /

REMARKS : The ship is remeasured according to articel 3(2)(d) of the 1969 Tonnage Convention.

The GROSS TONNAGE according to the measurement system previously in force to the measurement sytem of the International Convention on Tonnage Measurement of ships, 1969, is 15598 RT, according to the regulations of 1947 Oslo Convention. (Cf. IMO Resolution A. 758(18)).

BV Mod. Ad. E 1430

SUPPLEMENT No. 218

MV ESTONIA's classification certificates of 12.1.1993 for machinery and hull.

Bureau Veritas

INTERNATIONAL REGISTER FOR CLASSIFICATION OF SHIPS - ESTABLISHED 1828
REGISTRO INTERNACIONAL PARA LA CLASIFICACION DE BUQUES - FUNDADO EN 1828

Issued in lieu of certificate No 621418 followin change of name and Owners, flag and port for Registry.

CERTIFICATE OF CLASSIFICATION
CERTIFICADO DE CLASIFICACION

Certificate / *Certificado* No. 641994

No. 35 P 387
in Register Book
en el Registro

Annex to hull certificate No. 54222
Annexo al certificado casco

"ESTONIA"

MACHINERY / *MAQUINAS*

This is to certify that the machinery of the above named ship, has been surveyed for renewal
El abajo firmante certifica que las máquinas del buque han sido

of the certificate at/*en* Stockholm in/*en* June/July 1990

by surveyors to the Society, in accordance with the requirements of the Rules.
por el personal técnico de la Sociedad, de acuerdo con las prescripciones del Reglamento.

Main machinery/*Màquina principal* : Four Diesel engines, type MAN 8 L 40/45, 8 cyl., 4 cycle, single acting, supercharged, Nos 1080005 and 008-010

Total / *Potencia* effective power / *total* 17600 kW (/ *kW (* 23913 hp) at / *CV) a* 600 r.p.m. / *r.p.m.* determined by testing

Built at/*Construida en* : Augsburg by/*por* : MAN Maschinenfabrik Augsburg-Nürnberg AG

Completed in/*Acabada en* : April 1980

The machinery has been entered in the Register Book with the mark : ✠ MACH
Las máquinas han sido inscritas en el Registro con la marca :

This certificate, issued within the scope of the Bureau Veritas Marine Branch General Conditions, is valid
Este certificado, expedido con arreglo a las Condiciones Generales de la Rama Naval del Bureau Veritas, es valido

until / *hásta* JULY 15 1995

The installations covered by this certificate are surveyed under the continuous survey system
Las instalaciones cubiertas por este certificado están sometidas a la reclasificación

Propeller-shaft : Type, periodicity of survey : two LB 10
Eje de cola : Tipo, periodicidad de la visita :

Date of last complete survey/*Fecha de la última visita completa* : Dec 1988

Date of last partial survey/*Fecha de la última visita parcial* : Dec 1988

The validity of the assigned class is conditioned upon due compliance with the requirements of Chapter 2 of the Rules regarding maintenance of class.
La validez de la cota attribuida depende de la aplicación de las prescripciones del Capitulo 2 del Reglamento relativas al mantenimiento de la cota.

At/*Expedido en* Gothenburg , on/*el* 12 January 1993

For/*por el* Bureau Veritas,
(Signature and stamp)
Firma y sello
H Olsson

BUREAU VERITAS EXPERT de GOTEBORG PARIS 1828 REGISTRE INTERNATIONAL

Any person not a party to the contract pursuant to which this certificate is delivered may not assert a claim against Bureau Veritas for any liability arising out of errors or omissions which may be contained in said certificate, or for errors of judgment, fault or negligence committed by personnel of the Society or of its Agents in the establishment or issuance of this certificate, and in connection with any activities for which it may provide.

BV Mod. Ad. MEH 441 c

Bureau Veritas

(37)

INTERNATIONAL REGISTER FOR CLASSIFICATION OF SHIPS - ESTABLISHED 1828

REGISTRO INTERNACIONAL PARA LA CLASIFICACIÓN DE BUQUES - FUNDADO EN 1828

Issued in lieu of certificate No 037015 following change of name and Owners, flag and port of Registry

CERTIFICATE OF CLASSIFICATION

CERTIFICADO DE CLASIFICACIÓN

Certificate / *Certificado* No. 54222

No. 35 P 387 in Register Book / *en el Registro*

"ESTONIA"

HULL / *CASCO*

This is to certify that the above named / *El abajo firmante certifica que el buque* steel motor ship has been / *ha sido* surveyed for renewal of the certificate at/*en* Stockholm in/*en* June/July 1990 by Surveyors to the Society, in accordance with the requirements of the Rules.
por el personal técnico de la Sociedad, de acuerdo con las prescripciones de Reglamento.

Owners/*Armador* : ESTLINE A/S

Flag/*Bandera* : Estonian   Port of Registry/*Puerto de matrícula* : Tallin

Registered tonnage, Gross/*Arqueo bruto* : 15 566,89 RT   Net/*Neto* : 8 372,46 RT

Built at/*Construido en* : Papenburg   by/*por* : Jos. L. Meyer

Completed in/*Acabado en* : July 1980

The ship has been entered in the Register Book with the classification symbols :
El buque ha sido inscrito en el Registro con los símbolos de clasificación :

I 3/3 E

and the marks and notations : / *y las marcas y menciones*
✠ PASSENGER FERRY
DEEP SEA
ICE CLASS I A
✠ (AUT)

This certificate, issued within the scope of the Bureau Veritas Marine Branch General Conditions, is valid
Este certificado, expedido con arreglo a las Condiciones Generales de la Rama Naval del Bureau Veritas, es válido
until / *hasta* JULY 15, 1995

The hull of the ship is surveyed under the continuous survey system
El casco del buque está sometido a la reclasificacion

Date of the two last periodical bottom surveys/*Fecha de las dos ultimas visitas periodicas de la carena* :
in drydock/*en digue seco* : May 1990   in water/*submarina* : May 1989

The validity of the assigned class is conditioned upon due compliance with the requirements of Chapter 2 of the Rules regarding maintenance of class.
La validez de la cota attribuida depende de la aplicación de las prescripciones del Capitulo 2 del Reglamento relativas al mantenimiento de la cota.

At/*Expedido en* Gothenburg, on/*el* 12 January 1993

For/*por el* Bureau Veritas,

(Signature and stamp)
Firma y sello

H Olsson

BUREAU VERITAS — EXPERT de GÖTEBORG — PARIS 1828 — REGISTRE INTERNATIONAL

Any person not a party to the contract pursuant to which this certificate is delivered may not assert a claim against Bureau Veritas for any liability arising out of errors or omissions which may be contained in said cer[illegible]te, or for errors of judgment, fault or negligence com[illegible] by personnel of the Society or of its Agents in the [illegible]blishment or issuance of this certificate, and in connec[illegible] with any activities for which it may provide.

SUPPLEMENT No. 220

Extract from the Trim and Stability booklet of MV WASA KING.

Ship Consulting Ltd Oy

Turku 20.1.1991

WASA KING

TRIM AND STABILITY BOOKLET

SHIP CONSULTING LTD OY
KRESSUNKATU 31
20460 TURKU
F I N L A N D

TELEPHONE +358-21-471 281
TELEFAX +358-21-471 282
MOBILE +358-49-524 773
BANK OKOBANK FINLAND
ACCOUNT 571066-22441

SHIP CONSULTING

CONTENTS

GENERAL PARTICULARS

SHIP'S NAME :	WASA KING ex Silja Star ex Viking Sally
SIGNAL LETTERS :	OIKW
PORT OF REGISTRY :	
OWNERS NAME :	
BUILDERS NAME AND ADDRESS :	Jos. L. Meyer, Papenburg-Ems
SHIP'S NUMBER :	590
DATE OF KEEL LAID :	

MAIN DIMENSIONS :	Length over all	157.02 m
	Length between perp.	137.40 m
	Breadth mld	24.20 m
	Depth to A deck	7.65 m
	Draught	5.567 m
BLOCK COEFFICIENT :		0.681
DISPLACEMENT (1.025 t/m^3) :	T = 5.567 M	12708 T

GENERAL

This Trim and Stability Booklet is based on Maierform's Hydrostatic Particulars 6891.06-171.120, Cross Stability Curves Values 6891.01-171.200 and Damage Stability Diagram 6891.01-115.600 and Inclining experiment 11.01. 1991.

The difference of Light Ship Weight between the two inclining experiments was 313 t. The largest parts in additional weights were 'Duck tail' and additional insulation between passenger cabins.

The Duck tail's volume and effect to KM is not included in hydrostatic particulars. (Reduced trim and give more stability). During inclining experiment the Duck tail was over water surface all the time.

In loading cases 4 and 5 there has been shown stability curve and GM-values in various numbers of passengers. In loading cases 6, 7 and 8 there has been shown GM-values in various numbers of trailers.

The damage stability diagram has been calculated with the following criterions:

- GM at least 0.05 m
- Max. heel in unsymmetrical cases not more than 7°
- Margin line not immersed in the final stage of flooding.

The following tanks and spaces are connected with cross-flooding ducts:

- Heeling tanks (Tank 13 and 14)
- Sauna fr 110 - 120 from CL-side P & S
- Fresh water tanks fr 120 - 132 P & S

LOAD CASE 8

AS CASE 6 BUT 10 % OF BUNKERS AND STORES AT ARRIVAL

	Weight t	VCG from BL m	Mom tm	LCG from A_{PP} m	Mom tm	Free surf tm
Light ship weight	9733	11.56	112513	60.76	591377	
Crew + effects	20	22.00		55.00		
Provision + stores	60	10.00		46.00		
Heavy Fuel Oil						
Day tank 36	24	2.82		36.23		
Day tank 37	18	2.81		36.62		
Total of HFO	42	2.82		36.40		105
Diesel Oil						
Day tank 41	13	2.91		31.03		
Total of DO	13	2.91		31.03		39
Lubric. Oil						
Lubr oil tank 25	6	0.55		45.40		
Lubr oil tank 26	6	0.55		45.40		
Lubr oil tank 27	6	0.55		45.40		
Lubr oil tank 28	6	0.55		45.40		
Lubr oil supply t 30	5	0.55		50.15		
Kamewa tank 50	1	0.60		24.60		
Kamewa tank 51	1	0.60		23.40		
Kamewa tank 52	1	0.60		23.40		
Stern tube oil 55a	2	0.71		15.06		
Total of LO	34	0.56		42.41		
Fresh Water						
Tank 5	15	2.79		113.65		
Circulating tank 17	10	0.60		58.30		
Cool water tank 22	3	0.57		55.40		
Cool water tank 29	10	0.67		45.80		
Total of FW	38	1.48		76.63		166
Bilge water 33	22	0.55		35.83		

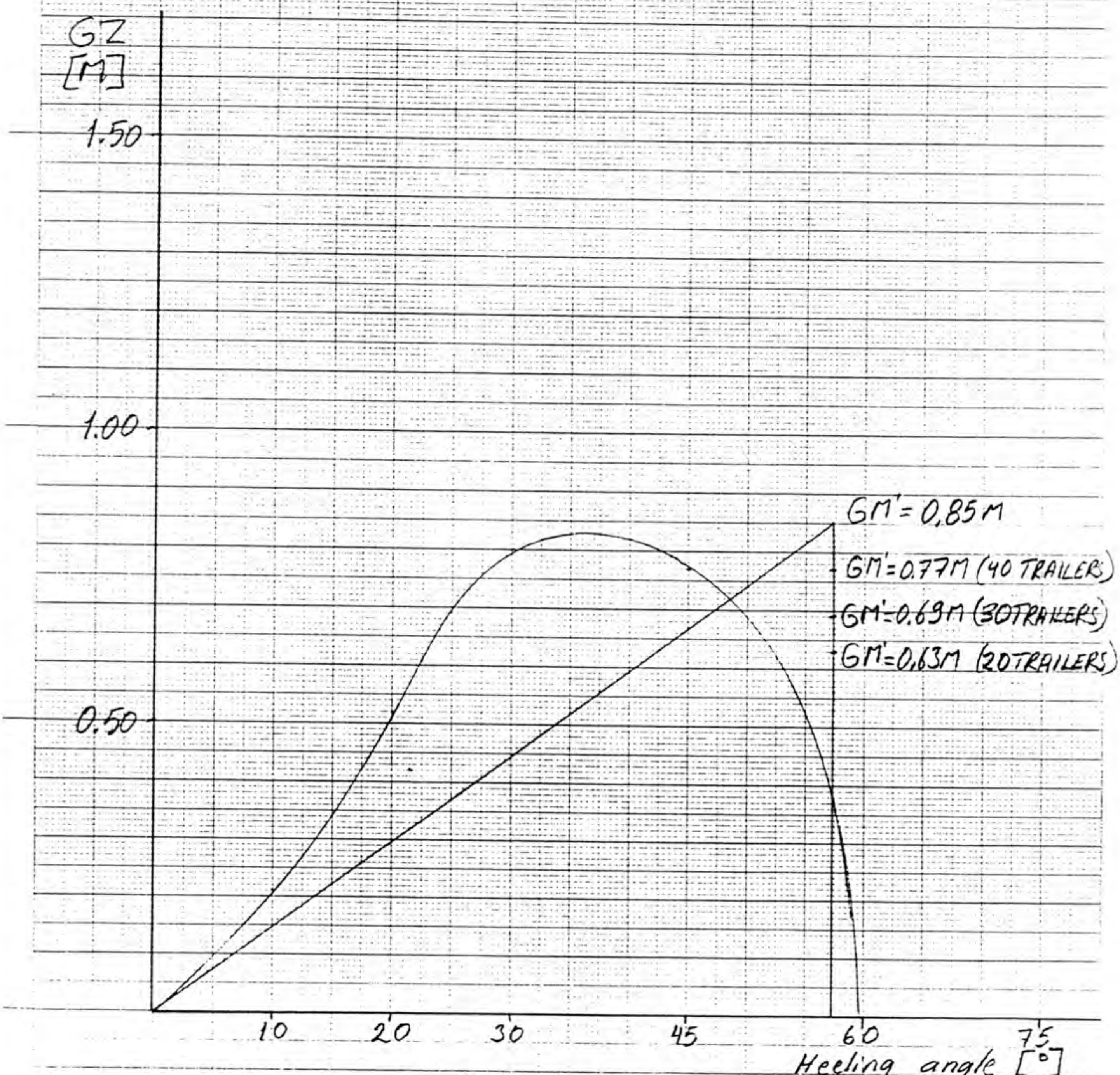
Water Ballast						
Fore peak tank 1	176	4.45		133.92		
Trim tank 2	303	4.69		121.40		
DB tank 6	88	0.64		104.84		
Total of WB	567	3.99		122.72		
2000 passenger+lugg	200	16.40		71.50		
Swimming pool	40	2.00		97.50		160
47 trailers a' 36 t	1692	9.50		66.50		
Dead weight	2694	8.52	22959	77.87	209790	470
Displacement	12427	10.90	135473	64.47	801167	470

Mean draught	5.47 m	KM	11.79 m
Trim	-0.12 m	KG	10.90 m
Draught aft	5.53 m	GM	0.89 m
Draught forw	4.41 m	MM'	0.04 m
		GM'	0.85 m

Calculation of curve of statical stability

Heeling	10°	20°	30°	45°	60°	75°
sin	0.1736	0.3420	0.5000	0.7071	0.8660	0.9659
KN	2.11	4.26	6.27	8.51	9.26	8.91
KG'*sin	1.90	3.74	5.47	7.74	9.47	10.57
GZ	0.21	0.52	0.80	0.77	-0.21	-1.66

Ship Consulting	LOAD CASE 8	WASA KING
Turku Finland	FULLY LOADED TO DRAUGHT	20.01 1991/VMJ
	5.567 M AT ARRIVAL	



SHIP CONSULTING

REPORT ON INCLINING EXPERIMENT

Ship :	M S W A S A K I N G	
Owner:	SALLY LINE AB MARIEHAMN	
Main dimensions:	LENGTH OVER ALL	155.40 m
	LENGTH BETWEEN PERP.	137.40 m
	BREADTH MOULDED	24.20 m
	DEPTH TO A DECK	7.65 m
	DEPTH TO C DECK	13.40 m
Date:	11.01 1991 betw. 16.00-19.00 o'clock	
Place:	MASA YARDS TURKU	
	- SPEC. GRAVITY OF SEAWATER 1.004 t/M^3	
	- TEMPERATURE	abt.-6 centigrade
	- TEMPERATURE OF WATER	abt. 0 centigrade
	- WIND	no wind
Present:	MR ALF ANDERSSON	MS WASA KING
	MR CARL GUNNAR EKSTRAND	MS WASA KING
	MR BO HENRIK STOLPE	MS WASA KING
	MR TIM R. E. AUTERO	Finnish Board of Navication
	MR VELI-MATTI JUNNILA	Ship Consulting

SHIP CONSULTING

READED DRAUGHTS

	DRAUGHT MARK		DISTANCE TO SEA-LEVEL		DRAUGHT	MEAN
d_{AP}				=		5.07
d_{ASB}				=		
d_{MP}	5.567	-	0.61	=	4.957	5.082
d_{MSB}	7.667	-	2.46	=	5.207	
d_{FP}	5.20	-	0.08	=	5.12	5.12
d_{FSB}	5.20	-	0.08	=	5.12	

TRIM $d_F - d_A = 5.12 - 5.07 = +0.05$ m

HOGGING CORRECTIONS
$Fo = d_M - \frac{1}{2}(d_F + d_A) =$
$= 5.082 - \frac{1}{2}(5.12 + 5.07) = 0.013$ m

CORRECTED MEAN DRAUGHT $= d_M + Cb \times Fo$
$= 5.082 + 0.667 \times 0.013 = 5.091$ m
Cb = block coefficient at draught of 5.10 m

Displacement at draught 5.091 m is 11132 t and LCG -3.657 m

TANKS TO BE SUBTRACTED

TK8	DB-TANK 8	53,55	86,60	0,00	0,55	236
TK41	DO DAY TANK	11,56	31,03	0,00	2,85	4
TK 45	OVERFLOW TANK 45	1,19	35,78	0,00	0,10	8
TK20	DB-TANK 20	3,49	59,87	0,00	0,25	27
TK10	H-TANK 10	42,75	74,20	0,00	1,30	150
TK11	H- TANK 11	27,55	74,20	0,00	1,28	150
TK38	SETTLING TANK 38	21,38	32,20	0,00	2,30	10
TK39	SETTLING TANK 39	13,59	33,84	0,00	1,85	7
TK36	HFO DAY TANK 36	17,29	36,23	0,00	2,20	8
TK37	HFO DAY TANK 37	19,79	36,62	0,00	2,81	6
TK40	OVERFLOW TANK	3,04	34,38	0,00	0,11	74
TK4A	TANK 4A	70,00	114,25	0,00	2,72	48
TK4B	TANK 4B	65,00	114,25	0,00	2,65	48
TK5	TANK 5	135,00	113,65	0,00	2,70	138
TK44	SLUDGE OIL	5,50	32,20	0,00	0,11	123
TK33	BILGE WATER	21,00	35,83	0,00	0,53	50
TK42	DIRTY OIL	6,20	33,85	0,00	0,35	12
TK17	FRESH WATER CIRCUL.	13,70	58,30	0,00	0,52	14
TK22	COOLING WATER	1,00	55,40	0,00	0,35	3
TK29	COOLING WATER	7,00	59,82	0,00	0,32	11
TK6	DB-TANK 6	87,95	104,84	0,00	0,64	0
TK2	TRIM TANK 2	303,06	121,40	0,00	4,69	0
TK1	FORE PEAK TANK 1	175,98	133,92	0,00	4,45	0
TK24	THERMAL OIL TANK 24	5,13	45,78	0,00	0,25	13
TK25	LUBR OIL TANK 25	11,88	45,40	0,00	0,45	3
TK26	LUBR OIL TANK 26	9,00	45,40	0,00	0,40	3
TK27	LUBR OIL TANK 27	9,90	45,40	0,00	0,42	3
TK28	LUBR OIL TANK 28	9,72	45,40	0,00	0,41	3
TK30	LUBR OIL SUPPLY TANK 30	5,85	50,15	0,00	0,32	7
TK32	LUBR OIL TANK 32	7,74	47,40	0,00	0,55	3
TK50	KAMEWA TANK 50	0,88	24,60	0,00	0,25	2
TK51	KAMEWA TANK 51	1,71	23,40	0,00	0,50	0
TK52	KAMEWA TANK 52	1,71	23,40	0,00	0,50	0
TK55A	STERN TUBE OIL	0,99	15,06	0,00	0,20	5
TK55	STERN TUBE TANK	0,59	15,10	0,00	0,30	1
	GEAR OIL STORAGE	1,35	39,40	0,00	3,50	0
TK13	HEELING TANK SB	28,60	78,10	0,00	0,52	193
TK14	HEELING TANK P	129,90	77,60	0,00	1,91	73
	TOTAL OF TANKS	1331,52	98,42	0,00	2,73	1436

SHIP CONSULTING

SUBTRACTED WEIGHT

CODE NUM.	WEIGHT T	NAME	FRAME NO	FROM DECK	FROM CL	DECK NO
	0.3	FORK LIFT PLATFORMS	5	0.2	0	2
	1.3	FORK LIFT	10	0.7	0	2
	0.5	VENEER	59	0.6	0	2
	16.0	WASTE CONTAINERS	53	0.8	0	2
	1.5	EMPTY CONTAINER	122	2.4	0	2
	0.1	CLEANING EQUIPMENTS	105	0.2	0	0
	0.1	CLEANING EQUIP.	100	0.2	0	1
	0.8	INSULATION MATERIALS	45	0.5	0	8
	1.5	FUEL FOR EMER. GENER.	76	0.9	0	8
	1.9	STEEL PLATES	57	0.6	0	8
	1.75	CARPETS	8	1.0	0	1
	1.0	GLASS	8	0.3	0	1
	0.5	MATERIALS	7	0.2	0	1
	2.8	MATERIALS	13	1.2	0	1
	1.0	FORK LIFT	25	0.5	0	1
	0.25	TOOLS	26	0.2	0	1
	1.5	PROVISIONS	35	0.8	0	1
	3.5	PROVISIONS	37	0.8	0	1
	0.05	CLEANING EQUIP.	118	0.2	0	9
	0.1	COPY MACHINE	110	0.7	0	7
	0.15	LINEN STORE	117	1.0	0	7
	0.1	OFFICERS DAY ROOM	110	0.8	0	7
	0.4	MISCELLANEOUS	95	0.5	0	7
	0.05	HOSPITAL	90	0.6	0	7
	1.3	MATERIALS	81	0.3	0	7
	2.0	MISCELLANEOUS	80	0.7	0	7
	0.15	MATERIALS	54	0.3	0	7
	0.3	MESS ROOMS	25	0.5	0	7
	0.15	SPORT ROOM	10	0.8	0	8
	0.4	MATERIALS	73	0.3	0	7
	0.2	LINEN STORE	28	0.7	0	6
	0.4	GALLEY	47	1	0	6
	0.24	CARPETS	81	0.4	0	6
	2.9	CARPETS	80	0.5	0	5
	0.15	WELDING MACHINE	40	0.5	0	5
	1.3	CARPETS	81	0.6	0	4
	0.6	INSULATION MATERIALS	82	0.8	0	4
	0.42	CARPETS	82	0.6	0	4
	0.1	STORES	42	0.6	0	4
	0.6	WASTE	75	0.3	0	4
	0.1	REFRIGERATOR	122	0.6	0	4
	5.6	PROPELLER SPARE PLADES	15	0.4	0	2
	0.2	U-PROFILES	25	0.2	0	2
	0.8	I-PROFILES	25	0.2	0	2
	0.3	WASTE	24	0.2	0	2
	0.9	WASTE	70	0.4	0	2
	1.1	ICE AND SNOW	80	0.0	0	7
	0.9	ICE AND SNOW	85	0.0	0	8
	0.1	ICE AND SNOW	120	0.0	0	10

SHIP CONSULTING

SUBTRACTED WEIGHT

CODE NUM.	WEIGHT T	NAME	FRAME NO	FROM DECK	FROM CL	DECK NO
	3.2	MATERIALS IN ENG ROOM	60	0.2	0	1
	1.65	22 PERSONS IN SHIP	80	1.1	0	5
	3.75	CREW'S PERS. GOODS	70	1.0	0	7
	66.96	TOTAL OF SUBTRACTED WEIGHT		40.12	12.22	

SHIP CONSULTING

PENDEL NUMBER 1 LENGTH OF PENDEL 4455 MM

NAME OF OBSERVERS: TOMI JUNNILA

LOCATION OF PENDEL: ON CARDECK AFTER

CASE NO	NUMB. OF OBS.	1	2	3	4	5	6	7	8	9	10	SUM	MEAN VALUE	LIST
I	1	2330											2330	0.00
II	1	2252											2252	1.00
III	1	2226											2226	1.34
IV	1	2324											2324	0.08
V	1	2388											2388	0.75
VI	1	2454											2454	1.59
VII	1	2511											2511	2.33
VIII	1	2415											2415	1.09
IX	1	2343											2343	0.17

SHIP CONSULTING

PENDEL NUMBER 2 LENGTH OF PENDEL 4470 MM

NAME OF OBSERVERS: BO HENRIK STOLPE

LOCATION OF PENDEL: ON CARDECK AFTER

CASE NO	NUMB. OF OBS.	1	2	3	4	5	6	7	8	9	10	SUM	MEAN VALUE	LIST
I	1	728											728	0.00
II	1	650											650	1.00
III	1	622											622	1.36
IV	1	723											723	0.06
V	1	788											788	0.77
VI	1	853											853	1.60
VII	1	910											910	2.33
VIII	1	813											813	1.09
IX	1	742											742	0.18

HEELING TANK SOUNDINGS AND VOLUMES

CASE NO	LIST	PORT SIDE SOUN cm	CORR cm	VOL m^3	WEIG t	TCG m	SB-SIDE SOUN cm	COR cm	VOL. m^3	WEIG. t	TCG m
I	.6°SB	450	452	129.7	129.9	-8.69	121	119	28.5	28.6	7.57
II	.4°P	485	483	141.8	142.3	-8.74	68	70	16.4	16.5	7.34
III	.7°P	491	494	146.1	146.8	-8.75	47	50	11.8	11.8	7.20
IV	.5°SB	453	455	130.9	131.4	-8.70	116	114	27.2	27.3	7.54
V	1.3°SB	422	427	120.0	120.5	-8.67	161	155	38.1	38.3	7.69
VI	2.2°SB	391	399	109.3	109.7	-8.59	206	199	48.6	48.8	7.95
VII	2.8°SB	365	375	100.2	100.6	-8.54	246	235	57.9	58.1	8.13
VIII	1.7°SB	411	417	116.2	116.7	-8.63	179	171	41.7	41.9	7.79
IX	.8°SB	446	449	128.5	129.0	-8.72	126	123	29.6	29.6	7.59

SHIP CONSULTING

D U R I N G   E X P E R I M E N T

MEAN MOULDED DRAUGHT	5.091	m
TRIM	+0.05	m
SEAWATER DENSITY	1.004	ton/m^3
DISPLACEMENT	11132	t
HEIGHT OF METACENTER ABOVE BL	11.69	m

CASE NO	WEIGHT (TON)	INCLINING MOMENT (TONM)	TOTAL MOM (TONM)	INCLINING ANGLE DIFFER. (DEG)	TOTAL (DEG)	METACENTRIC HEIGHT GMI (M)
II	12.14	196.30	196.30	1.00	1.00	1.011
III	4.47	71.55	267.86	0.35	1.35	1.021
IV	15.36	-247.24	20.62	-1.28	0.07	0.994
V	10.94	-178.38	-157.76	-0.83	-0.76	1.068
VI	10.64	-174.96	-332.72	-0.84	-1.595	1.073
VII	9.24	-153.38	-486.10	-0.73	-2.33	1.073
VIII	16.16	267.44	-218.66	1.24	-1.09	1.032
IX	12.24	200.45	-18.21	0.92	0.17	1.127

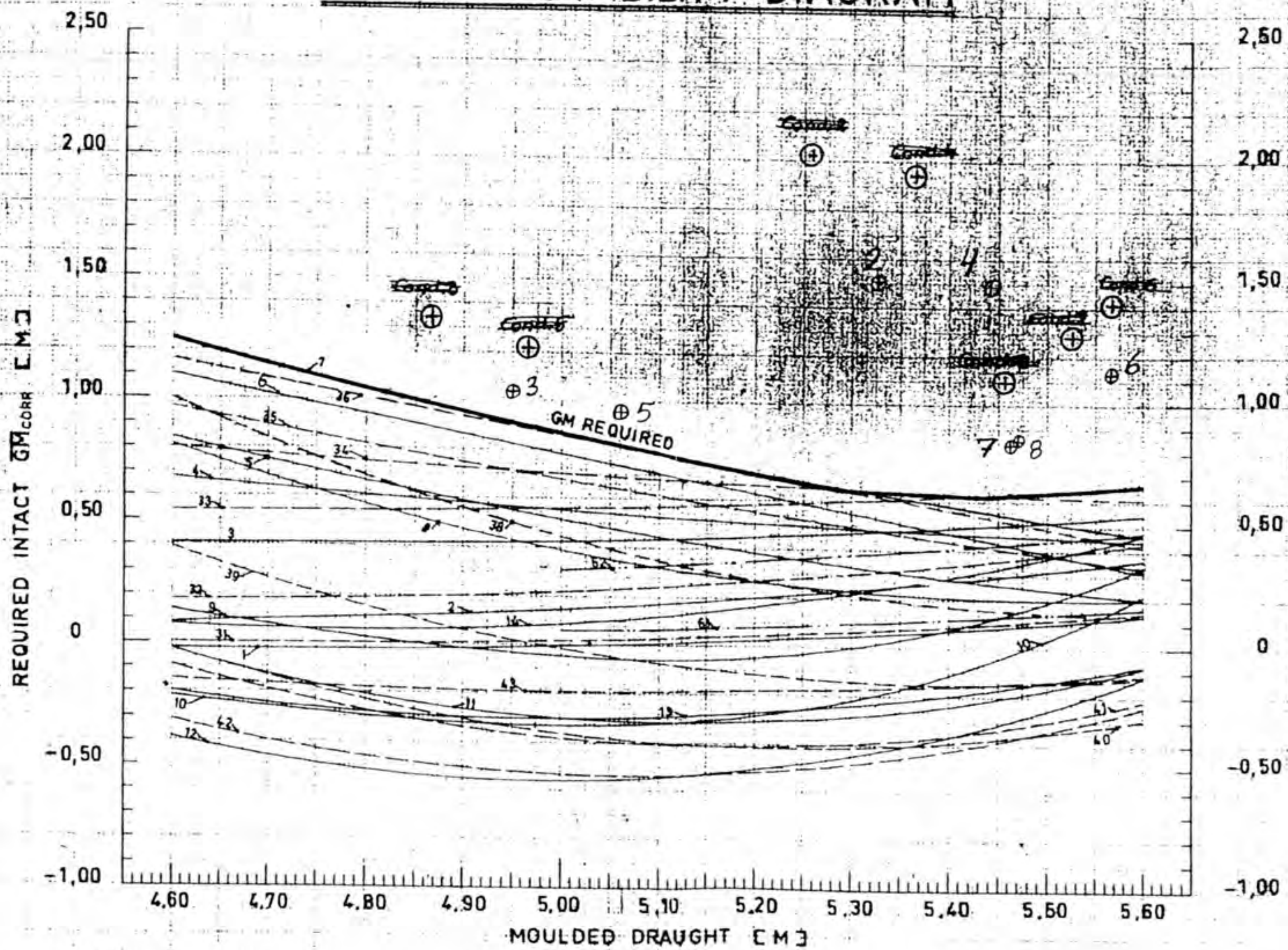
METACENTRIC HEIGHT DURING EXPERIMENT	GM = 1.050 M
FREE SURFACE CORRECTION	GMC = 0.129 M
CORRECTED METACENTRIC HEIGHT	GMO = 1.179 M
HEIGHT OF METACENTER ABOVE BL	KM =11.690 M
CENTRE OF GRAVITY ABOVE BL	KG =10.511 M

L I G H T   S H I P

	WEIGHT (TON)	CENTRE OF GRAVITY FROM LPP/2 (M)	CL (M)	BL (M)
DURING EXPERIMENT	11132	-3.553	0.00	10.511
WEIGHTS TO BE ADDED	0	-0.000	0.00	0.00
WEIGHTS TO BE SUBTRACTED	67	-28.58	0.00	12.22
TANKS TO BE SUBTRACTED	1332	+29.72	0.00	2.73
LIGHT SHIP	9733	-7.934	0.00	11.564
INCLINING TEST 21.6 1980	9420	-7.02	0.00	11.31
DIFFERENCE	313	-0.914	0	+0.254

JOS.L.MEYER PAPENBURG EMS	BUILDING № 590	MAIERFORM 6891.01-115.600

DAMAGE STABILITY DIAGRAM



NOTES:

THE VESSEL'S CALCULATED AVAILABLE GM_{CORR} MUST ALWAYS BE ABOVE OF THE CURVE OF "GM-REQUIRED"

⊕ = GM VALUES AVAILABLE FOR INTACT VESSEL OF REPORT.

SUPPLEMENT No. 221

Section 45 of the Commercial Vessel Degree no. 261/1920.

12.12.1920.

45 §.

Rungonkatsastus toimitetaan ennen kuin alusta saadaan käyttää ja sen jälkeen merimatkustaja-aluksissa joka vuosi, muissa matkustaja-aluksissa joka toinen vuosi, merilastialuksissa joka kolmas vuosi sekä konevoimalla kulkevissa rannikkoaluksissa ja sisävesien koneilla kulkevissa lastialuksissa joka neljäs vuosi. Jos alus ylläpitää talviliikennettä, tulee se joka vuosi, ennenkuin tämä alkaa, katsastuttaa, jollei katsastusta sellaista liikennettä varten ole aikaisemmin vuoden kuluessa talvipurjehduksen päätyttyä toimitettu. Katsastus toimitetaan, kun alus on otettu tokkaan tai seisoo telakalla, sekä ennen kuin runko on kitattu tai maalattu.

Vastamainitussa toimituksessa on katsastettava myöskin kaikkien pelastusveneiden rungot.

Jos aluksella on luokka merenkulkuhallituksen hyväksymässä luokituslaitoksessa sitä liikennettä ja kulkuvettä varten, jossa alusta käytetään, olkoon se, niinkauan kuin luokitustodistus on voimassa, vapautettu edellä määrätystä katsastuksesta; kuitenkin, milloin alusta, jolla talviliikennettä ylläpidetään, ei ole laitoksen toimesta tässä suhteessa sitä vuotta varten katsastettu, toimitettakoon katsastus niin kuin yllä on sanottu.

Jos hyväksytyn luokituslaitoksen asiantuntija on toimittanut rungonkatsastuksen, olkoon siitä annettu todistus tässä maassa pätevä.

45 §.

Skrovbesiktning verkställes innan fartyget får användas och sedermera å sjögående passagerarfartyg varje år, å övriga passagerarfartyg vart annat år, å sjögående lastfartyg vart tredje år samt å kustgående maskindrivet lastfartyg och maskindrivet lastfartyg för inre farvatten vart fjärde år. Underhåller fartyget vintertrafik, bör detsamma varje år innan denna vidtager undergå besiktning, såframt besiktning för dylik trafik icke tidigare under året efter avslutad vinterseglation verkställts. Besiktning verkställes, medan fartyget är intaget i docka eller står på slip samt innan skrovet blivit spacklat och målat.

Vid nu nämnda förrättning bör besiktning verkställas jämväl å samtliga för livräddning avsedda båtars skrov.

Innehar fartyg klass i klassificeringsanstalt, som av sjöfartsstyrelsen godkänts, för den fart och det farvatten, vari fartyget användes, skall detsamma, så länge klassificeringscertifikatet är gällande, vara befriat från ovan föreskrivna besiktning; dock att, där fartyg, varmed vintertrafik underhålles, icke blivit i sådant avseende genom anstaltens försorg för året besiktigat, besiktning skall äga rum på sätt ovan är sagt.

Är skrovbesiktning verkställd av expert för godkänd klassificeringsanstalt, vare häröver utfärdat bevis här i landet giltigt.

SUPPLEMENT No. 222

Decision of the Finnish Maritime Administration 1921 to approve certain classification societies for carrying out hull surveys.

kennettu 1865 ja
tettiin ehdottaa
4 år gammalt
t, att detsamma
olämpligt, be-
g å den gjorda
yä ulkoasiainmi-
en pidettämiseks
llystöä hankitta
yä hakija kompas-
a tehtyyn anomuk
n iråkadt haveri
förluster, besl

Jefim Sonkins anhållan om tillstånd att till utlandet försälja motorskonerten "Venus" om 70,97 nott. registerton.

18/1 1921 B. P. N:o 12/2 A.

N:o 10.

Chefens för Sjöfartsafdelningen på grund af Sjöfartsbyråns förslag gjorda framställning att fartyg som innehava klass i någon av klassificeringsanstalterna Lloyds Register of British and Foreign Shipping, Bureau Veritas, Germanischer Lloyd, British Corporation eller det Norske Veritas för den fart och det farvatten, vari fartyget användes, skola tills vidare och så länge klassificeringscertifikatet är gällande vara befriade från skrovmaskin- och pannbesiktning;

att utländska fartyg, med undantag af passagerarefartyg, som innehafva intyg öfver att de undergått besiktning utomlands af vederbörlig myndighet och blifvit godkända för färder, i hvilka äfven Finland inbegripes, skola tillsvidare och tills dess Sjöfartsstyrelsen närmare bestämmer, hvilka utländska myndigheter och af dem utfärdade besiktningsintyg skola här i landet godkännas, vara befriade från besiktning. För isgående fartyg gäller vad därom stadgats; samt

att fartyg som innehafva högsta klass i Register of British and Foreign Shipping och British Corporation samt fartyg med isförstärkning och högsta klass enligt Bureau Veritas, Germanischer Lloyd eller Det Norske Veritas för det farvatten det an-

att förorda bifall till den gjorda ansökan.

Beslöts att med stöd af stadgandet i §: 45 i förordningen angående handelsfartyg af den 18 Oktober 1920 godkänna nämnda klassificeringsanstalter samt att i cirkulär delgifva Sjöfartsinspektörerna detta beslut äfvensom intaga detsamma i Styrelsens meddelanden,

Däremot och då Sjöfartsstyrelsen allaredan den 7 innevarande januari gjort hänvändning till Statsrådet i det afseende andra stycket innehåller och Sjöfartsstyrelsen icke eger ändra förordningens bestämningar angående fartygs isförstärkning, lämnades framställningen till denna del utan afseende.

Merenkulkuhallitus
Pöytäkirjat
1921 Tammikuu
24.1 (?)

SUPPLEMENT No. 223

Protocol of MV ESTONIA's exercise Port State Control in Tallinn
27.9.1994.

Translation from Estonian

Director General of the Estonian National Maritime Board
Mr Kalle Pedak

Report

It is hereby reported that a Port State (PSC) training inspection was carried out by the inspectors of the Estonian National Maritime Board`s Ship Inspection Department (with assistance of the Swedish Maritime Administration inspectors) on m.v. "Estonia" on 27.09.94. The purpose of this inspection was to obtain experience for the Estonian inspectors in respect of large passenger ships and also to carry out a Port State Control (PSC) of this vessel.

As a result of this inspection all shortcomings noted by the inspectors and instructors were fixed in the "Report of Inspection in Accordance with the Memorandum of Understanding on Port State Control". This Report was signed by the Head of National Ship Inspection Department A. Valgma. Later on this Report was used as a teaching aid on training of inspectors.

The aim of this inspection was not to find out the knowlege and training of the officers or crewmembers because it is the task of other authorities. In course of discussings with the ship`s officers the theoretical problems of stability were not touched since the inspectors were interested in technical condition and organizational level of the vessel.

Ship Control Inspectors /signature/ Valgma

/signature/ Buddell

31.05.96

For true translation Uno Laur

Eesti Veeteede Ameti peadirektorile hr. Kalle Pedak

Raport

Käesolevaga tetame Teile, et 27.09.94.a. Eesti Veeteede Ameti laevakontrolli inspektorite poolt teostati m/l "Estonia " lipuriigi (PSC) kontrollõppus (Rootsi Mereadministratsiooni spetsialistide - instruktorite kaasabil), et anda Eesti laevakontrolli inspektoritele kogemusi suurte reisilaevade kontrolliks ja ühtalasi teostada laeva lipuriigi kontroll (PSC). Ülevaatuse tulemusena koostati kõikide inspektorite ja instruktorite poolt avastatud mittevastavuste koondakt - " Report of inspection in accordance with the Memorandum of Understanding on Port State Control", millele kirjutas alla laevakontrolliteenistuse juhataja A. Valgma. Nimetatud akti kasutati hiljem õppematerjalina inspektorite väljaõppe kursustel. M/l "Estonia" ülevaatuse ülesandeks ei olnud välja selgitada , ega uurida laevapere ja ohvitseride teadmiste- oskuste taset sest selleks on teised instantsid. Vestlustes laeva ohvitseridega ei käsitletud laeva püstivuse ega stabiilsuse teoreetilisi küsimusi, kuna ispektoreid huvitas laeva tehniline ja organisatsiooniline tase.

Laevakontrolli inspektorid: /Valgma/

/. Buddell /

31.05.96.a.

31/05 '96 13:56 ☎372 6 312303 E N M B →→→ CMM TALLINN EST. ☑002

FORM B

REPORT OF INSPECTION IN ACCORDANCE WITH THE MEMORANDUM OF UNDERSTANDING ON PORT STATE CONTROL

1 name of issuing authority [redacted]
2 name of ship ESTONIA 5 call sign ESTE
9 date of inspection 27.09.1994 10 place of inspection TALLINN.

15 nature of deficiency code	text	Convention[1] references	16 action taken[2]
1284	Bow door, packing damage		99
1280	Sounding pipe Aux Eng. room		17
0720	2 portable fire exting. missing Eng-room		17
0920	SAFETY PLAN		99
2010	MUSTER LIST		99
2030	DAMAGE CONTROL PLAN		99
2045	CARGO OPERATION MANUAL		99
0710	FIRE PREVENTION NAV. BRIDGE DOOR,		
	BOILER ROOM CLOSING DEVICE MISSING		
	FIRE DOOR IN GALLEY NOT WORKING		
	PROPERLY		17
1520	'OFF-COURSE' ALARM NOT INSTALLED		99
0745	MEANS OF CONTROL: MIMIC PANEL		99
2055	MANUALS AND INSTRUCTIONS		
	(EM.GEN, BRIDGE ROUTINES, EM. HANDLING		
	STEERING GEAR, MANOEUVRE CHARACTERISTICS		99
1260	WINDOWS IN GALLEY NOT POSSIBLE		
	TO CLOSE		17
1250	COVERS ON BULKHEAD DECK		
	TO BE CLOSED		17
1199	CARGO SECURING DEVICES		99
	(A FEW PIECES OF SEC. DEV. WORNED		
	OUT).		

Continuing page ☒ no ☐ yes

name Head of National Ship Inspection Department
duly authorized surveyor

A. Valgma
Valgma

To completed in the event of ...

... State informed, classification ...

31/05 '96 14:01 LBH/VAST NR09882 S.002

SUPPLEMENT No. 224

List of surveys carried out by Bureau Veritas on
VIKING SALLY - ESTONIA.

Bureau Veritas
Marine Division

15.06.1995

SURVEYS CARRIED OUT BY BUREAU VERITAS ON M/S "ESTONIA"

Place	Intervention dates	Class surveys	Statutory surveys	Observations
Papenburg	1980 07 01		ISLL	Issuance of Class and Load Line certificates to
				Messrs Meyerwerft Newbuilding S 590 VIKING SALLY
Hamburg	1981 02 12	OS AUT		Issuance of definitive AUT certificate
Stockholm	1981 04 13	CSH CSM		
Turku	1981 05 04 - 08	AS DOK CSH CSM	ASLL	
Stockholm	1981 4 23	CSM		
Turku	1981 9 3	OSAB		
Turku	1981 09 21 - 22	CSM ASAUT		
Turku	1981 10 20	OSH		Survey after minor collision
Turku	1982 5 13	ASM CSM		
Turku	1982 5 17	CSM		
Stockholm	1982 05 24 - 25	ASH CSH CSM		
Stockholm	1982 05 25 - 06 07	CSH AB	ASLL	
Turku	1982 11 8	ASAUT		
Turku	1982 12 9	OSAB		
Stockholm	1983 01 07	CSM		
Stockholm	1983 03 04	CSH		
Turku	1983 04 25 - 29	AS DOK CSH CSM	ASLL	CSH item Bow Door credited
Stockholm	1983 05 02 - 16	OSM		
Turku	1983 05 25	OSM CSM		
Stockholm	1983 10 24 - 1984 01 02	ASAUT		
Turku	1984 04 02	CSM		
Stockholm	1984 05 07	CSM		
Stockholm	1984 05 18	AS UWS CSH CSM ASAB	ASLL	
Mariehamn	1984 05 25	OSH		Survey after grounding ,voyage to Helsinki for repairs
Helsinki	1984 05 25 - 26	OSH		Temporary repairs of grounding damages
Turku	1984 11 23	OSM		Extension of tailshaft survey periodicity
Turku	1984 12 10	ASAUT		

Place	Intervention dates	Class surveys	Statutory surveys	Observations
Stockholm	1984 12 17	OSH		Diver survey,postponement of grounding repairs
Turku	1985 02 15	OSM		
Stockholm	1985 03 25	OSH		Diver survey, postponement of grounding repairs
Helsinki	1985 04 22 - 05 06	DOK CSH TS CSM		Permanent repairs, stern modification
Stockholm	1985 05 24 - 07 15	AS CSH CSM ASAB ASAUT	PSLL	Renewal of class term and load line certificate
Turku	1986 04 10	CSM		
Stockholm	1986 04 25	CSH CSM		
Stockholm	1986 05 27		ASLL	
Stockholm	1986 08 18	CSM		
Stockholm	1986 09 01	CSM		
Stockholm	1986 09 24	AS UWS		
Stockholm	1986 09 24 - 12 08	ASAUT		
Turku	1987 01 13 - 21	DOK CSH		Repairs of cracks in rudder plating
Turku	1987 04 06 - 08	OSH OSM OSAB CSH		Bottom of bow door repaired/strengthened (ice
				damage)
Turku	1987 04 23 - 05 08	OSM		Repairs to main engine n°1
Stockholm	1987 06 10	CSM		
Stockholm	1987 07 23	AS ASAUT ASAB	ASLL	
Stockholm	1988 02 08	CSH ASAB		
Turku	1988 03 14	CSM		
Turku	1988 03 28	CSM		
Stockholm	1988 05 10	AS CSH CSM	ASLL	CSH item Bow Door credited
Stockholm	1988 05 25	CSH CSM		
Turku	1988 09 15	DOK CSM		
Turku	1988 09 26	ASAUT		
Stockholm	1988 11 06 - 12 09	DOK TS		Surveys after grounding and periodical surveys
Turku	1989 05 02 - 03	DOK ASAUT CSH CSM		
Turku	1989 05 29 - 30	AS CSH CSM	ASLL	
Turku	1990 04 30 - 05 07	DOK CSH CSM		Change of name to "SILJA STAR"

Place	Intervention dates	Class surveys	Statutory surveys	Observations
Stockholm	1990 06 14 - 07 03	AS CSH CSM ASAB AUT	PSLL	Renewal of class term and load line certificate
Turku	1990 11 21 - 12 14	DOK		
Turku	1991 02 04	OS		Change of name to "WASA KING"
Holmsund	1991 04 13 - 15	AS CSH CSM	ASLL	
Holmsund	1991 09 23	ASAUT CSM		
Holmsund	1992 06 17 - 18	AS ASAUT CSH CSM	ASLL	
Holmsund	1992 11 28	ASAB CSM		
Abo	1993 01 04 - 14	DOK TS CSH	PSLL IOPP PSCONS	Change of name to "ESTONIA" and of Owners/Flag
			PSEQ PSRAD	Issuance of: interim LL certif.; interim cargoship
				safety certificates.
Tallinn	1993 01 16 - 28		PSPS	Issuance of interim PSSC certificate (passenger ship)
Stockholm	1993 03 15	CSH CSM	OSIOPP	Issuance of interim IOPP certif.(definitive certificate
				issued on 07/04/1993)
Abo	1993 03 22 - 04 03	OSM		Change of outboard tailshaft sealings
Stockholm	1993 05 22 - 24	CSH CSM		Postponement of CSH/CSM items
Stockholm	1993 06 14		OSLL OSPS	Renewal of interim LL & PSSC certificates
Stockholm	1993 08 12 - 13	AS ASAUT	ASIOPP	
Stockholm	1993 10 18	CSH CSM		CSH item Bow Door credited
Stockholm	1993 11 11		OSLL OSPS	Renewal of interim LL & PSSC certificates
Stockholm	1993 11 16	ASAB		
Nadendal	1994 01 10 - 14	DOK		Installation of Stabiliser units
Stockholm	1994 01 27		PSPS	Periodical survey and renewal of interim PSSC certif.
Stockholm	1994 03 16	CSH CSM		
Stockholm	1994 04 11		OSLL	Renewal of interim LL certificate
Stockholm	1994 05 09 - 11	CSH CSM		
			Issuance of definitive PSSC (clerical mishandling) 23 june 1994	
Stockholm	1994 06 26		OSPS	Renewal of interim PSSC certificate
Stockholm	1994 08 23 - 25	AS ASAUT ASAB CSM	ASLL ASIOPP	
Stockholm	1994 09 09		OSLL	Renewal of interim LL certificate

SURVEY CODES USED IN THE TABLE				
	CLASS SURVEY CODES			STATUTORY SURVEY CODES
AS	Annual survey (Hull & Machinery)		ISLL	Initial survey Load Line
ASAB	Annual survey Boilers		ASLL	Annual survey Load Line
ASAUT	Annual survey Automated installation		PSLL	Periodical survey Load Line
CSH	Continuous survey Hull		ASIOPP	Annual survey Marpol
CSM	Continuous survey Machinery		IOPP	Periodical survey Marpol
DOK	Periodical bottom survey in drydock		PSPS	Periodical survey Passenger ship
UWS	Underwater survey		PSCONS	Periodical survey Saf. construction
TS	Tailshaft survey		PSEQ	Periodical survey Saf. equipment
OSH	Occasional survey Hull		PSRAD	Periodical survey Saf. radio
OSM	Occasional survey Machinery		OSLL	Occasional survey Load Line
OSAB	Occasional survey Boilers		OSIOPP	Occasional survey Marpol
OSAUT	Occasional survey AUT installation		OSPS	Occasional survey Passenger ship

SUPPLEMENT No. 225

VIKING SALLY - SILJA STAR - WASA KING.

Dockings and recorded damages to the bow 1981 - 1993.

Memorandum 16.8.1995/FIN.

THE JOINT ACCIDENT INVESTIGATION
COMMISSION FOR THE MV ESTONIA

PROMEMORIA
16.8.1995/FIN

VIKING SALLY - SILJA STAR - WASA KING

DOCKINGS AND RECORDED DAMAGES TO THE BOW 1981 - 1993

1 DOCKINGS

Time	*Yard*	*Reason for docking*
Viking Sally		
04 - 08.05.1981	Wärtsilä, Turku	Warranty & annual docking
25 - 29.04.1983	Wärtsilä, Turku	Annual docking
24 - 26.05.1984	Valmet, Vuosaari	Bottom contact at Apotekarfaret 23.5.1984
02 - 03.04.1985	Finnboda	Stern tube leakage
22.04 - 06.05.1985	Valmet, Vuosaari	Ice damage repairs, damage repairs, shipping company works
12 - 23.01.1987	Wärtsilä, Turku	Annual docking
06 - 08.04.1987	Wärtsilä, Turku	Ice damages
12 - 16.9.1988	Wärtsilä, Turku	Stern tube leakage, annual docking
11.06 - 12.08.1988	Finnboda	Bottom contact damage repairs
02.05.1989	Wärtsilä, Turku	Propeller flange exchange
Silja Star		
21.11.1990	Turun Korjaustelakka, Naantali	
Wasa King		
04.01.1993	Turun Korjaustelakka, Naantali	Transfer docking

2 RECORDED DAMAGES TO THE BOW

2.1 Winter 1982

Ice damages to the bow were recorded during the winter of 1982. Dents on both sides of bow visor. Size 1.5 m x 1 m and ~ 50 mm deep. Also sternwise on visor denting between each rib from ice reinforcement and up ~ 1.5 m and ~ 50 mm deep. Aft from bow visor on hull denting between ribs above ice reinforcement ~ 1,5 m high but narrowing toward aft and ending at rib nr 147. Dents also here are up to 30 mm deep.

2.2 Winter 1987

The winter of 1987 was a very bad ice winter. On 1 - 2.3.1987 on scheduled voyage from Turku to Stockholm Viking Sally got some damages to bow. During the inspection a crack was observed low in the visor between the thicker ice reinforcement plating and the upper thinner plate together with denting of the thinner plate. The crack extends from the bow as far as 1 m on port and 0.5 m on starboard.

Provisional repairs were made on 2.3.1987. The crack was welded and a doubling plate was welded on the outside. Later on 26.3.1987 the provisonal welding was noted to be cracked. A number of smaller cracks were observed also. The final repair was done during docking on 6 - 8.4.1987.

APPENDICES:

Nr	*Language*	*Document*
1	SWE	Viking Sallyn laivapäiväkirjan ote n:o 2/82 *(Logbook note nr 2/82)*
2	SWE	Viking Sallyn laivapäiväkirjan ote n:o 2/87
3	SWE	Viking Sallyn laivapäiväkirjan ote n:o 4/87
4	SWE & ENG	Haveribesiktningar Ab: Survey report LK 39/87. 13.3.1987
5	SWE & ENG	Autero Tim R.: Besiktningsrapport n:o 3715/87/TRA. 21.4.1987. (*Inspection report nr 3715/87/TRA. 21.4.1987*)

Erinlämnat till Höffs

UITE N:O

Journalutdrag

Nr och år	Fartygets namn
2/82	Viking Sally

Hamn där eller resan under vilken händelsen inträffade	Datum för händelsen
Under vinterns körning i is	1982

Last	Befälhavare
Passagerare och Bilar	Håkan Karlsson / Lars Mäki

Under vintern 1982 har följande isskador uppstått.
På bogporten i stäven påvardera sida en intryckning 1,5 x 1 meter och ca 50 mm intryckt, där akterom på bogporten intryckningar mellan varje spant från isförstärkningen och uppåt ca 1,5 m och ca 50 mm intryckt. Akterom bogporten på skrovet intryckningar mellan spanterna ovanför isförstärkningen ca 1,5 meter högt men avsmalnande akteröver för att sluta vid spant Nr 147. Intryckningarna är även här upp till 30 mm.

....
Håkan Karlsson befälhavare

Obs. Ny numrering vid början av varje år.

Journalutdragets ricktighet intyga:

....
Stig Lindstrom överstyrman

....
Per Häggblom 1:sta styrman

A.R. 100x50 8 78 mt

JOURNALUTDRAG

LIITE N:O 2

Journalutdrag

Nr och år	Fartygets namn
2/87	VIKING SALLY

Hamn där eller resan under vilken händelsen inträffade	Datum för händelsen
Under vecka 9 1987	Vecka 9

Last	Befälhavare
Passagerare och bilar	Håkan Karlsson

Måndagen den 02.03-87

Vid inspektion upptäcktes att bogvisiret hade fått en spricka i nedre kanten mellan den grövre isförstärkta plåten och den tunnare ovanför samt intryckningar i den tunna plåten.
Spricka går från stäven och ca en meter akteröver på Bb sida och en halv meter på Sb sida.
Finnboda varv tillkallades för att provisoriskt reparera sprickan.
Sprickan svetsades och på Bb sida lades en dubbling utanpå.

Håkan Karlsson befälhavare

Journalutdragets ricktighet intyga:

T. Sundqvist

Ture Sundqvist överstyrman

P. Sjögren

Per Sjögren lots

Obs. Ny numrering vid början av varje år

7-061/86
VIKING SALLY
Ank. den 1987-03-09

HAVERI 7-061/86

LIITE N:O 3

Journalutdrag

Nr och år	Fartygets namn
4/87	m.s. Viking Sally

Hamn där eller resan under vilken händelsen inträffade	Datum för händelsen
Under vecka 13	Vecka 13

Last	Befälhavare
Passagerare och fordon	Rune Wiklund

Torsdagen den 26.03.87

Konstaterades att svetsningen som gjordes på bogvisiret den 02.03.87 hade gått upp. Ett antal mindre sprickor konstaterades också.
Se journalutdrag 2/87.

Ombord den 27.03.87

Rune Wiklund/Befälhavare

Utdragets riktighet intyga:

S.Lindström/Överstyrman

J-E. Eriksson/Linjelots

Ous. Ny numrering vid början av varje år

LIITE NO 4 SWE

HAVERIBESIKTNINGAR AB

Survey Report Vår ref: LK 39/87

"VIKING SALLY" - sprickor och intryckningar i nedre del av bogport efter gång i is Stockholm - Åbo 1 - 2 mars 1987.

Rederi:	Rederi AB Sally Mariehamn
Hemmahamn:	Mariehamn
Befälhavare:	Håkan Karlsson
Byggd:	1980, Jos E Mayor, Papenburg
Klass:	B.V.

På uppdrag av Redarnas Ömsesidiga Försäkringsbolag, Mariehamn, har undertecknad besiktigat rubricerade skada med fartyget liggande vid Tegelvikshamnen i Stockholm den 2 mars 1987.

Närvarande var också maskinchef L Jansson och senare under dagen Lars-Olof Ålander, Bureau Veritas.

Journalutdrag utskrives senare och sändes via rederiet till Redarnas Ömsesidiga Försäkringsbolag.

<u>Nedre delen av bogporten:</u>

Babord sida spricka cirka 800 mm lång, intryckningar
./. och skadade internals, se bifogade foton. Styrbord sida
spricka cirka 200 mm lång, mindre intryckningar och
./. skadade internals, se bifogade foton.

Skadorna reparerades temporärt av personal från AB Finnboda Varf med fartyget liggande vid ordinarie kajplats i Stockholm.

Hyra av skylift.

Två formade dubblingsplåtar beställdes för att svetsas över skadorna, vardera cirka 1000 x 700 x 20 mm.

Svetsning av sprickor i internals.

forts.

Address
Grevgatan 24
S-114 53 Stockholm
Sweden

Telephone
Office 46-8-60 79 20
Private 46-8-764 400 13
Car 46-10-71 46 69

MBS-CALL
0047-87366
Await answering tone and dial your number without the area code.

Telex
12442 Fotex S
Att: Haveri-besiktningar

HAVERIBESIKTNINGAR AB

Permenent reparation

Nedre del av bogport kapas och förnyas styrbord och babord vardera cirka 1200x900x20 mm bockad.

Internals kapas och förnyas som erforderligt.
Justering av bogport.

Ställning
Målning av berört och förnyat material
Brandvakt.

En grov uppskattning av reparationskostnaden är SEK 50 000:- och tiden separat afloat till tre dagar.

Stockholm den 16 mars 1987

Lars-O.Jansson

LIITE N:O 5 SWE

Kopia till rederiet

Nr 3715/87/TRA 1987.04.21

TZEN

B E S I K T N I N G S R A P O R T :

m/s VIKING SALLY , Cod: OIKW, Hemort: Mariehamn

Rederi: Sally Rederi Ab,Sally Färjor
Mariehamn,Åland
Klass: Bureau Veritas,Finsk Isklass IA
BRT:15598, NRT: 8393, DWT: 2740
Byggd: 1980, Jos.L.Meyer,Papenburg,BRD
Maskineri: MAN-dieslar 4x4400kW

På uppdrag och för räkning RÖF,Redarnas Ömsesidiga Försäkringsbolag, Mariehamn, utförde undertecknad haveribesiktning av skrov och maskiner isamband med dockning vid Oy Wärtsilä Ab,Åbovarvet 6-8/4-87 samt övervakning och uppföljning av reparationer som utfördes isamband med dockningen 6-8/4-87. Dockningen skedde efter det fartyget anlänt till Åbo och lossats 6/4-87.Fartyget var torrsatt och klart för bottenbesiktning 6/4-87 klo. ca. 16,oo då klass- och försäkringsbesiktningen påbörjades jointly.
Vid dockningen och reparationerna var olika instanser repressenterade enligt följande:

Fartyget: befälhavaren,kapt. Håkan Karlsson,Maskin-chief Lars Kalsson
Rederiet: Inspektör Yngve Röblom
BV-klassen: Ing. Risto Kajatsalo
Oy Wärtsilä Ab,Åbovarvet: Ing. Ilkka Salminen, Ing. Ilkka Suupohja
RÖF-försäkringen av konsult.Ing.Tim R. Autero, Åbo

Vid besiktningarna och reparationerna kunde följande noteras:

Intryckningar och skador av isar på förbogvisirets nedre del.Journalutdrag på skadornas uppkomst fanns ej men dessa härrör sig från isgång under denna vinter i svåra isförhållanden.
Skadorna åtgärdade nu på följande sätt:
Intryckt plåt i visirets nedre del på SB- och BB-sidan utskurits 6 spantfack= ca. 4000mm x 1100-900mm på vardera sidan och förnyats.
I visirets nedre center-område=Soft-nose-del utskurits plåt ca. 2000mm brett x ca. 1100mm högt samt ovanför detta ca. 2000-2500mm brett x ca. 1500mm högt och förnyats. Se bifogade fotos Nr 1....5. Skadorna befann sig till största delen i visirets torrtank.
2 st.spant på SB- och BB-sidan kapade och förnyade i visirets främre centerparti. De övriga spanterna av bottenstockslika/veb-spant-plåtar riktade delvis och reparerade.
Reparationerna och svetsningarna ufördes som tvåskiftesarbete och delvis även med övertidsforcering och kunde slutföras=svetsningarna strax före utdockningen 8/4-87 på kvällen ca. klo. 20,oo.
Reparationen av visirets nedre del skulle ej nödvändigtvis ha fordrat dockning utan kunde ha utförts vid kaj från arbetsponton och ställningar

Vid dockningen konstaterades is-skador på slingerkölarna som åtgärdades enligt följande:

På SB-slingerköl fattades från förändan räknat 25 spantfack= ca.21 meter (Spt. 80M-95) se fotos 9 och 10, Vid Spt. 80M var slingerkölen tillknycklad illa och på övriga ställen helt bortsliten. Slingerkölsdelarna har vid lossnandet=lösbräckningen skadat bordläggningen delvis och

PåBB-slingerköl fattades ca. 8 m = spt. 85-95, se foto 11. ca. 3 m från förändan räknat, vid spt.90-91 noterades ett hål ca. 60x40mm i bordläggningsplåten vid slingerkölsinfästningen, se foto Nr 12. Då slingerkölen slitits loss har denna skadat något bordläggningsplåten under denna och även Inerta-160 bottenfärgen ovanför och under slingerkölinfästningen.

Skadorna reparerade nu delvis:
På BB-sidan utskurits bordläggningsplåt vid ovannämnda hål ca. 500x 500mm och förnyats. 8 m ny slingerköl av V-formad balk-konstruktion av plåtar med ca. Ø 40mm rundjärnskant. Den förnyade delen av slingerkölen blev endast grundmålad och målningarna inne i ballastvattentanken i skrovet bakom slingerkölsinfästningen blev omålad tillsvidare.

På SB-sidan förnyades ca. 21 meter slingerköl som ovan och även här blev målningen av kölen och tankarna och delvis även inne i maskinrummet vid slingerkölsinfästningarna omålade tillsvidare. x/

Följande intryckningar och målfärgs-skador som förorsakats av bortslitna slingerkölsdelar kvarstå oreparerade tillsvidare för senare åtgärdning isamband med kommande dockningar:

På BB-sida 1 st. lokal intryckning under sligerkölen spt. 86-87,dim. ca. 500x500xdjup. ca. 35mm, 1 st. bågformad skråma i målfärgen spt. 88-92 och skador i målfärgen under slingerkölen spt.85-91,se foto 11 och även foto Nr 12.

På SB-sidan 1 st.skarp intryckning under slingerkölen spt. 90-91 dim. ca.500x600xdjup=50mm samt ca. 3m akterut vid spt.84-88 intryckninger under slingerkölen dim. ca. 400x1000mm x djup. ca. 35 max. samt härtill intryckning under och runt slingerkölsinfästningen vid spt.80N-80-0 500x600x30mm.Vid ovannämnda intryckningar samt ovanför slingerkölen är Inerta-160 specialfärgen bortsliten och skadad, Se fotos 9 och 10. Dessa intryckningar kvarstå oreparerade och även målfärgs-skadorna för senare åtgärdning isamband med kommande dockningar.Noteras bör att dessa är belägna vid ballastvattentankar och delvis även in i maskinrumsutrymmena. x/

Tillägg till tidigarenämnda förbogvisir-reparation:
De förnyade och riktade,svetsade områdena i visiret blev endast grundmålade från utsidan och inne i visir-torrtanken på grund av tidsbrist. Målningen kommer att utföras senare och bör påskrivas samma is-skadehaveri som nu reparerats.

----

x/ De senare målningarna berör på BB-sidan torrtank 8A och ballastvattentank Nr 14.
På SB-sidan beröres följande tankar: Torrtank 8A,Trimtank 13,torrtank Nr 15 och nedre svets-sömmen går på vardera sidan delvis även in i maskinrummets utrymmen.

På SB-sidan i bottnet noterades att 1 st. galler för sjöintag och dess raminfästning skadats emedan det andra gallret var oskadat.
Reparation utförd nu av gallerinfästningen med bultar som förnyats ca. 1-1,2 m och ca. 1/3-del av gallret som skadats utbränts och förnya av stålplåt med utbrända sjövattenintags-skåror tills. ca. 0,5-0,6m^2

Skador noterade på propellerbladen och som troligtvis delvis förorsakats av att bortslitna slingerkölsdelar hamnat i beröring med dessa.

(translation 16.8.1995 for international ESTONIA-commission)

HAVERIBESIKTNINGAR AB

Survey report

"Viking Sally" - cracks and dents in the lower sections of bow-door after voyage in ice Stockholm - Turku 1 - 2 March, 1987

Shipping Company: Sally-Shipping Co Mariehamn

Home Port: Mariehamn

Master Mariner: Håkan Karlsson

Built: 1980

Class. BV

Under assignment from Shipping Co Mutual Insurance Company, Mariehamn, the undersigned has inspected the damage of the headline when the ship was in port at Tegelvikshamnen in Stockholm on the 2nd March, 1987.

Present was also Chief engineer L Jansson and later in the day Lars-Olof Ålander, Bureau Veritas.

Journal excerpt will be taken later and shall be sent via the Shipping Company to the Shipping Co Murtual Insurance Co.

Lower part of bow-visor:

Port side crack 800 mm long, dents and damaged internals, see photographs attached. Starboard side crack 200 mm long, smaller dents and damaged internals, see photos attatched.

The damages have been repaired temporarily by personnel from Finnboda Wharf while ship was in port at its ordinary quay place in Stockholm.

Skylift rented.

Two formed doubling plates were ordered for welding over the damages, both were approximately 1000 by 700 by 20 mm.

Welding of cracks in internals.

<u>Permanent repair:</u>

Lower part of bowdoor to be cut and renewed on starboard and port both approximately 1200 by 900 by 20 mm bent.

Internals to be cut and renewed as required.
Adjustment of bow-door.

Scaffold (??? by translator)
Painting of affected and renewed material.
Fire guard.

A rough estimate of repair cost is SKR 50000.- and of time separate afloat (???) is three days.

Stockholm 16 March, 1987

Lars-O.Jansson
(translation of inspection report for international ESTONIA-commission, 16.8.1995)

Nr 3715/87/TRA

INSPECTION REPORT

m/s VIKING SALLY, Cod: OIKW, home port: Mariehamn

Shipping Co: Sally Shipping Co, Sally Ferries, Mariehamn, Åland
Class: Bureau Veritas, Finnish ice class IA
GRT: 15598, NRT: 8393, DWT: 2740
Built: 1980, Jos.L.Meyer, Papenburg, BRD
Engines: MAN Diesels 4x4400 kW

Assigned and to be reimbursed by Shipping Co Mutual Insurance Co, Mariehamn, the undersigned performed damage inspection of hull and engines during docking at Oy Wärtsilä Ab, Turku dockyards on the 6 - 8/4-87 and supervision and follow-up of repair work done during the docking 6 - 8/4-87. Docking occurred after arrival in

Åbo and the release of passangers and cargo on 6/4-87 at 16:00 hours approximately when class and insurance inspection were commenced jointly.

During the docking and the repairs various parties were represented as follows:

The ship: master mariner, captain Håkan Karlsson, chief engineer Lars Karlsson
Shipping Co: Inspector Yngve Röblom
Cl-society: Mr Risto Kajatsalo, Bureau Veritas
Oy Wärtsilä Ab, Turku dockyard: Mr Ilkka Salminen, Mr Ilkka Suupohja
InsuranceCo: Consultant Tim R. Autero, Åbo /representing Shipping Co Mutual

The following notes were taken during inspection and repair.

Dents and damages by ice on lower parts of bow-visor. Log-book excerpts on origins of the damages were not available but they were obtained during this winter in difficult ice conditions.

The damages have been attended to in the following way:

Dented plate in lower part of visor starboard and port sides cut and removed in 6 ribspacings= ca 4000 by 1100 to 900 mm on both sides and replaced.

In visor lower centre-part=Soft-nose-part cut and removed as large as 2000 mm wide by 1100 mm high and above that ca 2000 to 2500 mm wide by 1500 mm high and replaced. See attached photos Nr 1 . . .5. The damages occurred mostly in the dry-tank of the visor.
2 ribs on starboard and port side cut and replaced in the foremost centre part of the visor. The other ribs of the keel/webplates straightened partly and repaired.

The repairs and welding work were realised during two shifts and partly also as over-time work and were completed=the welding just before outdocking (???) on 8/4-87 at night at ca 20:00 hours. Docking was not necessary for repair of visor lower front and it could have been done at quay-side using working pontones and scaffolding.

Ice-damages to the bilge-keels were observed during the docking and they were repaired as follows:

A section having a length of 25 ribspacings of the starboard bilge-keel was missing=21 metres (Rib 80M-95) see photos 9 and 10. At rib 80M the bilge-keel was badly buckled and from other locations completely torn off. The parts of the bilge-keel have during tearing off damaged the sideplatings of the vessel partly and ....

/side 2/
From the port-side bilge-keel was missing ca 8 metres = between ribs 85 - 95, see photo 11. Ca 3 m counting from the bow-end, at rib 90 - 91, a hole was noted ca 60 x 40 mm in the side-plating at the attachment location of the bilge-keel, see photo Nr 12. When the bilge-keel had been torn off it had damaged the side-plating somewhat under itself and also the INERTA-160 painting above and under the attachment location of the bilge-keel.

The damages were now repaired partly:
On port-side removal of side-plating ca 500x500 mm and replaced. 8metres new bilge-keel having a V-shaped beam-construction of plating with ca Φ=40mm round-bar-edge. The new part of the bilge-keel was only primer-painted and the inside of the ballast-tank behind the bilge-keel attachment was left unpainted for the time being.

On starboard ca 21 metres of bilge-keel was replaced as above and also here the painting of the bilge-keel and the tanks and partly also in the engine room at the bilge-keel attachment locations was not completed for the time being.

The following dents and damages to the paint that had been caused by torn-off bilge-keel sections remain unrepaired for the time being for later attention in connection with later dockings:

On port-side 1 dent under the bilge-keel rib 86 -87, size 500 x 500 mm, deopth ca 35 mm, 1 bow-shaped scratch in the painting at ribs 88 - 92 and damages to the painting under the bilge-keel at ribs 85 - 91, see photo 11 and also 12.

On starboard 1 sharp dent under the bilge-keel at ribs 90 -91 measuring 500 x 600 mm depth 50 mm and ca 3 m stern-wise at ribs 84 - 88 dents under the bilge-keel measuring 400 x 1000 mm depth ca 35 mm and additionally dents under and around the bilge-keel attatchment at rib 80N-80-O measuring 500 x 600 mm depth 30 mm. At these dents and above the bilge-keel the INERTA 160 special paint had been worn off and damaged, see photos 9 and 10. These dents and paint damages remain unrepaired for later attention during future dockings. It is to be noted that these are located at the ballast tanks and partly also at the engine rooms.*)

Addition to above mentioned bow-visor repair:
The renewed and straightened, welded areas inj the visor were only primer-ointed on the outside and inside the visor dry-tank due to lack of time. The painting will be

done later and shall be considered due to tha same ice created damages that have now been repaired.

---

*) The subsequent paint-work will cover dry-tank 8A and ballast-water-tank Nr 14. On starboard side the following tanks are involved: Dry-tank 8A, Trimtank 13, Drytank Nr 15 and the lower weldments extend on both sides partly also into the engine-room spaces.

On starboard side was noted that 1 grid for sea-water intake and its fixture frame had been damaged but the other grid was undamaged. The grid-fixture was repaired using bolt replacements ca 1 - 1,2 m and ca 1/3 of the damaged grid was cut and replaced with steel plate with cut sea-water intake slots sized ca 0.5 - 0.6 m^2.

Damages were noted on the propeller-blades and they had probably been caused by torn off bilge-keel parts that had hit the propeller-blades.

SUPPLEMENT No. 226

Extract from M/S ESTONIA Safety Manual

M/S ESTONIA

Safety Manual

FOLLOWING PERSONS ARE CONNECTED TO THE PERSONAL CALLING SYSTEM, PROGRAMMED FOR THE 333-ALARM

Cabin Tel	Rank	Action
800	Master	To bridge - bring VHF
801	Chief Engineer	To bridge - bring VHF
700	Chief Officer	To bridge - bring VHF
701	2:nd Officer	To bridge - bring VHF
702	2:nd Officer	To bridge - bring VHF
711	Chief Purser	To bridge - bring VHF
705	Purser	To Information
713	1:st Engineer	To engine control room
716	Electrician	To lifeboat 1
719	Engine Repairman	To lifeboat 1
721	Boatswain	To lifeboat 1 - bring VHF
727	Doctor	To lifeboat 1 - bring VHF
724	Deck Repairman	To lifeboat 1 - bring VHF

MAN OVER BOARD BOAT (MOB).
MOB CREW.

Officer on duty
Watch on duty
716 Electrician
719 Engine Repairman
724 Deck Repairman
727 Doctor

STANDBY - ON DECK

721 Boatswain
727 Doctor

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2. ORGANISATION

2.1 Introduction

The most important aspect is that all crew members are aware of the importance of safety onboard, and are motivated to ensure the passenger's and crew's safety in the event of an emergency. Every member of the crew has a crew number, based upon their duties within the safety organisation. The duties are evident from the alarm list 2.5.

2.2 Alarm number

The alarm number states the position in the vessel's safety organisation in the event of lifeboat- and fire alarm - the Alarm List. You are assigned an alarm number upon commencing your duty onboard. The deck crew receive their alarm number from the chief officer, the machine crew from the chief engineer and the catering crew from the chief purser. All alarm numbers refer to a certain duty and a certain bed onboard. Sometimes an alarm number can be assigned for a optional duty and bed. If an alarm number is changed, the departmental chief will issue you a new personal instruction, which summarizes the alarm list with containing only the parts that concerns you. The new personal instruction will take effect until further notice. (See alarm list 2.5)

The first number in your alarm number states the department you belong to:

1 = Deck
2 = Machine
3 = Catering
4 = Bar and dining room
5 = Kitchen
6 = Cateteria, Pub
7 = Purser
8 = Tax free shop

2.3 Alarm

All crew members belong to a certain group in the safety organisation. In case of alarm, everyone has their own assembly point and a group leader to report to. All groups are directed from the command centre on the bridge. The command centre will consist of the master, chief officer, chief purser, chief engineer and assistant purser 711.

All activity is carried out in accordance with the prearranged alarm list or by direct orders. Only in the event of personal danger can a deviation be made. If you don't complete your duty, a "gap" will appear in the organisation which can lead to mortal danger for the persons you are responsible for.

2.5 Equipment

Security- and rescue equipment onboard consists among other things of the following:

- The fire stations with equipment;
oxygen apparatus, boiler suits, helmets, boots, lamps, spare oxygen tubes. Cleaning equipment for chemical damage is placed in a separate station.

- Fire fighting equipment is placed in different places onboad. Fxed equipment is for example sprinklers and Co2 systems, water posts and firedoors. The mobile fire fighting equipment consists of fire houses, portable fire extinguisher, foam apparatus and fire blankets.

- First aid equipment and stretchers.

- Protective clothing, survival suits, safety belts and harnesses, breathing apparatus and thermal protection (hypothermal sacks), portable pumps and building material.

- Alarm device; automatic fire alarms, alarm buttons, alarm and warning bells, loud speakers and personal call system.

- Emergency lights, distress signals and emergency signs.

- Telephones, portable radios and radio stations.

- Life-boats and life-rafts with equipment.

- Life-jackets, life-buoys and man-over board buoys.

- Pyrotechnical equipment.

- Warm clothing, blankets.

- Helicopter deck

- Watertight doors and sections

SAFETY AND RESCUE EQUIPMENT IS TO NO USE IF YOU DON'T KNOW WHERE IT IS OR HOW TO USE IT.

3. Responsibilities of the safety groups

3.1 Command centre

The safety organisation directs from the command centre, which consists of; master, chief officer, chief engineer and chief purser.

Master leads the work in the command centre.

The chief officer leads:

- The boat groups, wich are responsible for all activity on deck.

- First aid group, wich takes care of injured and ill, and handle the transport of those.

- Helicopter group.

The chief engineer leads:

- Fire group 1 and 2, who handles the fire fighting, damage control, access and cleaning of chemicals and leakage tightening.

- The machine group, which handles machinery, electrical support, pumps and tanks.

The chief purser leads:

- Zone leaders, which in their turn leads the evacuation groups.

- The guard group, which carry out limited evacuation, blocking and guarding arround the accidental area.

In case of helicopter assistance, the guard group is placed under the officer which leads the helicopter group

The chief officer leads the radio traffic.

A.B.s on duty serve as helmsman and lookout as well as courier.

Assistant purser makes the calls from the command centre and keeps the records over the group's measures.

3.2 Other security groups

Each group has a leader, who is responsible for the group's activity.

The leader handles the contact with the command centre. In case of problems that takes measures, the command centre shall always be informed immediately.

Every group leader shall choose a person of the group as vice group leader. The group members shall in case of alarm or exercise go to the assembly point. The group leader reports to the command centre when the group is assembled.

3.3 Communication

The command centre takes care of all external communications.

Most safety groups have a portable VHF, which is used for traffic between the group and the command centre. The radio must not be used between the groups.

3.4 Training

The group leaders leads the group's training according to a schedule made in advance. They are responsible that all group members participate the training and of the group's equipment. A report regarding the training is given to responsible officer in the command centre.

4. ALARM SIGNALS

4.1 Introduction

Alarm signals are used to mobilize the safety organisation onboard and to start their actions.

Two completely different types of alarms are used on our vessels:

- The loudspeakers call "MR SKYLIGHT" + additional code, which is only for the crew. The call is made everywhere in the vessel.

- The passengers are alarmed by lifeboat alarm and/or fire alarm.

4.2 Alarm signal only for the crew

All "MR SKYLIGHT" alarms are loudspeakers alarms.

In case of fire:

"MR SKYLIGHT TO NUMBER ONE": signal to the fire groups to immediately go to fire station number one.

"MR SKYLIGHT TO NUMBER TWO": signal to the fire groups to immediately go to fire station number two.

"MR SKYLIGTH TO NUMBER ONE AND TWO": signal to fire group 1 to immediately go to fire station number 1, and fire group 2 to fire station number 2.

<u>At these alarms gathers also the boat group at boat deck.</u>

In case of collision or grounding:

"MR SKYLIGHT DAMAGE CONTROL": signal to everybody in fire organisation to go to their fire stations.

The fire groups prepare themselves to access and damage control.

Alarm number 121 automatically sound all tanks. Alarm number 130 and 132 are automatically closing the scuppers on cardeck and all openings in the plating.

Calling first aid group togehter:

"MR SKYLIGHT 727": the first aid group gathers at the nurse cabine.

If the first aid group are wished to be gathered to a certain place, a supplementary code can be attached to the ordinary call.

5.81 Instructions for the bridge in case of:

COLLISION, GROUNDING OR LEAKAGE

1. Close the watertight doors.

2. Announce "MR SKYLIGHT one and two DAMAGE CONTROL" through the loud speakers.

3. A.B.s on duty, equipped with VHF, flashlight, searching schedule and fire keys, search through the watertight section from the stem towards the stern according to the prearranged control routine. (See point 5.804.) When they meet the firegroup crew, which has searched the vessel from the stern, they must report to the command centre. After that they must immediately return to the bridge.

4. Inform master, chief engineer, and information.

5. Deck repairmen sound tank according to check list without specific orders.

6. A.B. 130, 132 and machine repairman 220 close the scuppers, valves, and hatches on car deck as per the check list without specific orders.

7. Take out current safety plans.

8. When all groups are gathered, give order of suitable action until the command centre group takes over.

9. When the master has arrived on the bridge, the officer on duty gives a report of the situation and after that, if the situation requires, he goes to his boat group, equiped with megaphone and VHF.

10. Chief officer makes stability calculations and is responsible for ballasting the vessel.

11. Follow the special instructions for operations and actions.

5.84 Evacuation

1. Evacuation starts with a lifeboat alarm. The master decides when to start the alarm.

2. Chief purser leads the evacuation from the command leading cetral according to the alarmlist.

3. The evacuation shall be documented and followed-up on the emergency plan.

4. Following announcement is made to the passengers:

LOUD SPEAKERS CALL UPON EVACUATION

Swedish: Allmänt meddelande. Befälhavaren uppmanar samtliga passagerare att omedelbart bege sig till räddningsstationerna. Hissarna får inte användas. När ni kommit till er räddningsstation, handla enligt personalens direktiv.

Estonian:

English: Attention all passengers. The Captain informs that all passengers immediately are requested to go to the rescue stations. Do not use the elevators. At your rescue station, please act according to the instructions given by the crew.

6. FIRE GROUP 1

6.1 Meeting place

Fire station 1 which is forward at deck 8.

6.2 Composition

Alarm numbers: 130, 131, 211, 216, 220, 221, 222, 230, 231, 522, 540, 716.

6.2 Equipment

Keys
Portable radios with chanel 15
Smoke diving apparatus with spare air
Fireman's suits, protection boots
Fireman helmets with wiser
Fireman belts with fireaxe and lifeline
Heating protection suits, protection gloves
Special nozzle, portable fire estinguisher
Lamps, bolt clipper, crewbar, iron-bar leaver,
jack, securing material
first aid material

6.4 Calling together

Fire group alarmed by the call "MR SKYLIGHT" and fire alarm. The number after "MR SKYLIGHT" announcement is the number of the fire station where the group has to meet. If no station number is given, is the meeting point fire station 1. Addition "DAMAGE CONTROL" to the alarm announcement tells the group the equipment for the alarm.

ATOMATICALLY FIRE ALARM

At the atomatically fire alarm shall the people that belongs to the fire groups immediately go to fire station number one without any particular order, and stay there await additional order.

TASK

The group that is leaded by the second engineer shall as soon as possible contact the fire chief in the leading cenral on VHF, chanel 15 for reciving a state control and the catastrophe place. When arriving to the fire station the group shall get dressed in their equipment. The group leader has to tell the leading central when the group is ready for action. And then, when they have recieved order they go to the accidental area. The group leader has to keep continues with the smoke divers and the leading central for information and order. Firegroup 1 is special educated for fighting accomodation fires. Alarm number 220 and 221 is also ready for helicopter landing.

6.6 Clothes

The members of the firegroup shall if possible get dressed in warm and isolating clothes. Clothes made of synthetic fibres that can take fire or melt down by heating shall be removed before fire protection suits is taken on. When abandon the ship shall firefighting suits be broght to the saving stations.

6.7 Exercises

Firegroup is exersising every second week under the leading of the group leader. The exercise has to be done and followed by an exercise program. The group leader has to make up a written report regarding the exercise to the ships fire cheif. Three times a year shall the fire group take part in a special exercise under the leading of a independant proffesional firestaff.

6.8 Special instructions for the group members

At the alarm "MR SKYLIGHT DAMAGE CONTORL" shall A.B. 130 and repairman 220 directly go to the car deck and close the scuppers accordingly to a ready made special instruction. When this has been done they should let the leading central know and thereafter go to the firegroup.

7. FIRE GROUP 2

7.1 Meeting place

Fire station 1 which is aft on car deck.

7.2 Composition

Alarm numbers: 132, 133, 135, 212, 215, 232, 233, 234, 511, 513, 523, 717

7.2 Equipment

Keys
Portable radios with chanel 15
Smoke diving apparatus with spare air
Fireman's suits, protection boots
Fireman helmets with wiser
Fireman belts with fireaxe and lifeline
Heating protection suits, protection gloves
Special nozzle, portable fire estinguisher
Lamps, bolt clipper, crewbar, iron-bar leaver, jack, securing material
first aid material

Equipment chemical station

Chemical protection suits, chemical apron, special gloves, boots, protection glases, lifellines, lamps, gas-meter, absorption dryer and tightening material.

7.4 Calling together

Fire group alarmed by the call "MR SKYLIGHT" and fire alarm. The number after "MR SKYLIGHT" announcement is the number of the fire station where the group has to meet. If no station number is given, is the meeting point fire station 2. Addition "DAMAGE CONTROL" to the alarm announcement tells the group the equipment for the alarm.

ATOMATICALLY FIRE ALARM

At the atomatically fire alarm shall the people that belongs to the fire groups immediately go to fire station number two without any particular order, and stay there await additional order.

TASK

The group that is leaded by the second engineer shall as soon as possible contact the fire chief in the leading cenral on VHF, chanel 15 for reciving a state control and the catastrophe place. When arriving to the fire station the group shall get dressed in their equipment. The group leader has to tell the leading central when the group is ready for action. And then, when they have recieved order they go to the accidental area. The group leader has to keep continues with the smoke divers and the leading central for information and order. Firegroup 1 is special educated for car decks fire and chemical protection.

7.6 Clothes

The members of the firegroup shall if possible get dressed in warm and isolating clothes. Clothes made of synthetic fibres that can take fire or melt down by heating shall be removed before fire protection suits is taken on. When abandon the ship shall firefighting suits be broght to the saving stations.

7.7 Exercises

Firegroup is exersising every second week under the leading of the group leader. The exercise has to be done and followed by an exercise program. The group leader has to make up a written report regarding the exercise to the ships fire cheif. Three times a year shall the fire group take part in a special exercise under the leading of a independant proffesional firestaff.

7.8 Special instructions for the group members

At the alarm "MR SKYLIGHT DAMAGE CONTORL" shall A.B. 132 and directly go to the car deck and close the scuppers accordingly to a ready made special instruction. When this has been done they should let the leading central know and thereafter go to the firegroup.

SUPPLEMENT No. 228

Safety round on board MV ESTONIA of the AB seaman on watch.

Safety Round of the Watchkeeping Seaman on M/V ESTONIA

Descending from the bridge along the corridor on Deck 8

1. Bow, Deck 7 (X, cabins), along portside bow through the lounge

2. Port side central Deck 7 (repairman's cabin), through the aft lounge

3. Deck 7, next to the Mess door (opposite the seamans' cabin), up and to the deck

4. On Deck 8, opposite the cabins of the Swedes to starboard through the resting lounges

5. Starboard side aft (near the sauna) through the aft lounge to Deck 7

6. Deck 7 starboard aft opposite the lift door through the officers' mess down the open stairs to Deck 5

7. On the open deck of Deck 5 aft (behind the café) down the open stairs port side X bar to the car deck

8. On deck 2 portside aft along the portside up to the aft lifts

9. On Deck 2 port side between the aft lifts along port side towards the bow up to the passageand to starboard bow

10. On deck 2 near the bow ramp starboard between the opening swtchboard and the ramp along starboard aftwards up to the 1st door to the stairs, down to Deck 1 to the bow

11. On Deck 1 first cross passage left at the bow mowing aftwards

12. On Deck 1 the second right-side cross-passage starboard at the end to the sauna and through the locked sauna door to Deck 0

13. Deck 0 in the sauna between the lift doors and the conference sauna door starboard; along the sauna staircase to Deck 1, moving aftwards

14. Mid-Deck 1 in the corner of the starboard side side crossing, moving aftwards

15. Engine room on Deck 1, the last crossing to the right, starboard side along the corridor towards the bow up to the bow lift. Taking the lift to Deck 7, officers' section starboard side, thence to the bridge.

The duration of the round is about 20 - 25 minutes

Extract from the log book at the Stockholm Pilot Station

During a passage in the routes from Söderarm or Sandhamn to Stockholm, the ferries report times at a number of check points to the Pilot Station. These times are noted in a log book At very few occasions some times may be missing.

The following table contains arrival times at the entrance of the archepelago at Sandhamn (Sa) or Söderarm (Sö) and berthing in Stockholm for the Estonia (E) and the Silja Line ferries Silja Symphony (SY), Silja Europa (SE) and the Viking Line ferries Olympia (O), Cinderella (CIN), Mariella (M)

	Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
1993	02.03	SY	0358 Sö	—	03.07	SY	0452 Sa	0830
		O	0420 Sö	0856		O	0519 Sa	0857
		E	0539 Sa	0932		E	0540 Sa	—
	02.05	SY	0353 Sö	—	03.09	SY	0458 Sa	—
		O	0419 Sö	0855		O	0520 Sa	0853
		E	0559 Sa	0937		E	0540 Sa	0926
	02.07	SY	0451 Sa	0830	03.11	SY	0451 Sa	0829
		E	0454 Sö	—		O	0520 Sa	0857
		O	0514 Sa	0856		E	? Sö	0930
	02-09	SY	0455 Sa	—	03.13	SY	0455 Sa	0828
		O	0515 Sa	0857		O	0521 Sa	0900
		E	0547 Sa	0930		E	0539 Sa	0918
	02.11	SY	0455 Sa	0826	03.15	SE	0340 Sö	0843
		O	0517 Sa	0856		O	0518 Sa	0855
		E	0545 Sa	0938		E	0537 Sa	—
	02.13	SY	0452 Sa	0830	03.17	SE	0344 Sö	0831
		O	0519 Sa	0856		E	0435 Sö	[illegible]
		E	0546 Sa	0935		O	0524 Sa	0855
	02.15	SY	0453 Sa	0828	03.19	O	0440 Sö	0853
		O	0520 Sa	—		E	0445 Sö	0910
		E	0535 Sa	0935		SE	0900 Sö	1316
	02.17	SY	0453 Sa	0829	03.21	SE	0438 Sa	0832
		O	0517 Sa	0855		E	0445 Sa	0800
		E	0540 Sa	0930		O	0518 Sa	—
	02.19	SY	0453 Sa	0829	03.23	SE	0345 Sö	0830
		O	0524 Sa	0856		O	0517 Sa	0900
		E	0548 Sa	0936		E	0756 Sa	1110
	02.21	SY	0400 Sö	0829	03.25	SE	0338 Sö	0829
		O	0420 Sö	0857		O	0519 Sa	—
		E	0505 Sö	0939		E	0540 Sa	0920
	02.23	SY	0450 Sa	0830	03.27	SE	0343 Sö	0829
		O	0519 Sa	0855		O	0519 Sa	0855
		E	0538 Sa	—		E	0544 Sa	0921
	02.25	SY	0454 Sa	0830	03.29	SE	0346 Sö	0830
		O	0519 Sa	0857		O	0520 Sa	0852
		E	0540 Sa	0940		E	0545 Sa	0921
	02.27	SY	0449 Sa	0827	03.31	SE	0437 Sa	—
		O	0515 Sa	0854		O	0520 Sa	0852
		E	0540 Sa	0925		E	0544 Sa	0928
03.01	~~02.29~~	SY	0453 Sa	0832	04.02	E	0408 Sa	0755
		O	0517 Sa	0854		SE	0438 Sa	—
		E	0539 Sa	0924		O	0521 Sa	0856
	03.03	SY	0452 Sa	—	04.04	SE	0448 Sa	0829
		O	0516 Sa	0856		O	0518 Sa	0852
		E	0545 Sa	0921		E	0654 Sa	1036
	03.05	SY	0500 Sa	0828	04.06	SE	0445 Sa	0837
		O	0518 Sa	0900		O	0518 Sa	0840
		E	0539 Sa	0933		E	0540 Sa	0927

1993

Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
04.08	SE	0338 Sö	0851	05.10	SE	0436 Sa	0839
	CIN	0428 Sö	0859		CIN	0526 Sa	—
	E	0535 Sa	0925		E	0546 Sa	0927
04.10	SE	0440 Sa	0834	05.12	SE	0440 Sa	0828
	CIN	0524 Sa	0853		CIN	0529 Sa	—
	E	0542 Sa	0925		E	0542 Sa	0919
04.12	SE	0443 Sa	0840	05.14	SE	0440 Sa	0825
	CIN	0524 Sa	0853		CIN	0525 Sa	0856
	E	0535 Sa	—		E	0543 Sa	0921
04.14	SE	0443 Sa	0838	05.16	SE	0437 Sa	0826
	CIN	0525 Sa	0855		CIN	0523 Sa	0857
	E	0537 Sa	0923		E	0540 Sa	0923
04.16	SE	0442 Sa	0835	05.18	SE	0439 Sa	0826
	CIN	0525 Sa	0855		CIN	0521 Sa	—
	E	0545 Sa	0925		E	0540 Sa	0920
04.18	SE	0345 Sö	0835	05.20	SE	0439 Sa	0842
	CIN	0432 Sö	0859		CIN	0523 Sa	0854
	E	0531 Sö	0930		E	0540 Sa	0922
04.20	SE	0336 Sö	0830	05.22	SE	0439 Sa	0830
	CIN	0423 Sö	0856		CIN	0525 Sa	—
	E	0540 Sa	0924		E	0535 Sa	0920
04.22	SE	0343 Sö	0833	05.24	SE	0440 Sa	0828
	CIN	0421 Sö	0902		CIN	0526 Sa	0854
	E	0458 Sö	0930		E	0537 Sa	—
04.24	SE	0439 Sa	0832	05.26	SE	0420 Sa	0833
	CIN	0520 Sa	0858		CIN	0523 Sa	0855
	E	0549 Sa	—		E	0540 Sa	0921
04.26	SE	0449 Sa	0831	05.28	S.E	0443 Sa	0830
	CIN	0520 Sa	0856		CIN	0525 Sa	—
	E	0543 Sa	0912		E	0546 Sa	0925
04.28	S.E	0438 Sa	0836	05.30	SE	0443 Sa	0830
	CIN	0519 Sa	0900		CIN	0523 Sa	0900
	E	0540 Sa	0917		E	0546 Sa	0930
04.30	SE	0440 Sa	0828	06.01	SE	0441 Sa	0833
	CIN	0520 Sa	0857		CIN	0520 Sa	—
	E	0544 Sa	0926		E	0535 Sa	0911
05.02	SE	0445 Sa	0827	06.03	SE	0438 Sa	0835
	CIN	0521 Sa	0902		CIN	0519 Sa	0858
	E	0538 Sa	0930		E	0537 Sa	0917
05.04	SE	0442 Sa	0831	06.05	SE	0437 Sa	0832
	CIN	0526 Sa	0902		CIN	0521 Sa	—
	E	0542 Sa	0920		E	0543 Sa	0925
05.06	SE	0440 Sa	0832	06.07	SE	0439 Sa	0831
	CIN	0525 Sa	0858		CIN	0519 Sa	0857
	E	0542 Sa	—		E	0530 Sa	0920
05.08	SE	0433 Sa	0827	06.09	SE	0450 Sa	0830
	CIN	0524 Sa	0902		CIN	0527 Sa	0855
	E	0541 Sa	0923		E	0540 Sa	—

1993

Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
06.11	SE	0441 Sa	0826	07.13	SE	0456 Sa	0835
	CIN	0523 Sa	0857		CIN	0527 Sa	0854
	E	0541 Sa	0925		E	0539 Sa	0930
06.13	SE	0443 Sa	0834	07.15	SE	0450 Sa	0838
	CIN	0525 Sa	0854		CIN	0524 Sa	—
	E	0542 Sa	0921		E	0542 Sa	0926
06.15	SE	0444 Sa	0835	07.17	SE	0450 Sa	0830
	CIN	0523 Sa	0851		CIN	0526 Sa	0856
	E	0540 Sa	0921		E	0540 Sa	0921
06.17	SE	0445 Sa	0835	07.19	SE	0449 Sa	0830
	CIN	0522 Sa	0859		CIN	0524 Sa	0855
	E	0539 Sa	0917		E	0544 Sa	—
06.19	SE	0447 Sa	0837	07.21	SE	0449 Sa	0832
	CIN	0527 Sa	0859		CIN	0521 Sa	—
	E	0541 Sa	0924		E	0540 Sa	0930
06.21	SE	0450 Sa	0830	07.23	SE	0448 Sa	0833
	CIN	0525 Sa	0852		CIN	0524 Sa	?
	E	0543 Sa	0930		E	0537 Sa	0921
06.23	SE	0448 Sa	0851	07.25	SE	0451 Sa	0833
	CIN	0525 Sa	0854		CIN	0526 Sa	?
	E	0542 Sa	0923		E	0537 Sa	0908
06.25	SE	0448 Sa	0829	07.27	SE	0351 Sö	0833
	CIN	0520 Sa	0906		CIN	0421 Sö	0855
	E	0541 Sa	0916		E	0500 Sö	0923
06.27	SE	0448 Sa	0827	07.29	SE	0452 Sa	0839
	CIN	0520 Sa	0859		CIN	0530 Sa	0859
	E	0538 Sa	0921		E	0534 Sa	—
06.29	SE	0449 Sa	0830	07.31	SE	0342 Sö	0831
	CIN	0521 Sa	0859		CIN	0530 Sa	0858
	E	0543 Sa	0921		E	0537 Sa	0922
07.01	SE	0452 Sa	0834	08.02	SE	0448 Sa	0833
	CIN	0520 Sa	0858		CIN	0530 Sa	0900
	E	0535 Sa	0922		E	0537 Sa	0917
07.03	SE	0456 Sa	0838	08.04	SE	0457 Sa	0829
	CIN	0521 Sa	0902		CIN	0524 Sa	0858
	E	0548 Sa	—		E	0533 Sa	0910
07.05	SE	0349 Sö	0848	08.06	SE	0447 Sa	0829
	E	0508 Sö	0920		CIN	0524 Sa	0856
	CIN	0521 Sa	0859		E	0538 Sa	—
07.07	SE	0506 Sa	0839	08.08	SE	0450 Sa	0830
	CIN	0520 Sa	0901		CIN	0525 Sa	0853
	E	0538 Sa	0849		E	0540 Sa	0930
07.09	SE	0455 Sa	0832	08.10	SE	0342 Sö	0834
	CIN	0525 Sa	0855		CIN	0525 Sa	0857
	E	0540 Sa	—		E	0538 Sa	0915
07.11	SE	0454 Sa	0834	08.12	SE	0453 Sa	0835
	CIN	0526 Sa	0853		CIN	0524 Sa	0857
	E	0542 Sa	0920		E	0539 Sa	0930

1993

Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
08.14	SE	0340 Sö	0842	09.15	SE	0342 Sö	0832
	CIN	0525 Sa	0857		CIN	0427 Sö	0855
	E	0537 Sa	0921		E	0455 Sö	0920
08.16	SE	0445 Sa	0829	09.17	E	0445 Sö	0924
	CIN	0525 Sa	0856		SE	0453 Sa	0930
	E	0540 Sa	0931		CIN	0524 Sa	0857
08.18	SE	0338 Sö	0838	09.19	SE	0453 Sa	0829
	CIN	0417 Sö	0855		CIN	0525 Sa	0900
	E	*) — Sö	—		E	0543 Sa	—
08.20	SE	0442 Sa	0830	09.21	SE	0448 Sa	0825
	CIN	0525 Sa	0859		CIN	0523 Sa	0852
	E	0538 Sa	0921		E	0538 Sa	0924
08.22	SE	0445 Sa	0837	09.23	SE	0448 Sa	0826
	CIN	0525 Sa	—		CIN	0524 Sa	—
	E	0540 Sa	0938		E	0537 Sa	0924
08.24	SE	0447 Sa	0828	09.25	SE	0450 Sa	0827
	~~CIN~~ E	0540 Sa	0920		CIN	0524 Sa	?
	CIN	*) — Sa	—		E	0542 Sa	0922
08.26	SE	0450 Sa	0839	09.27	SE	0449 Sa	0829
	CIN	0527 Sa	0857		CIN	0526 Sa	0857
	E	0539 Sa	0920		E	0543 Sa	0922
08.28	SE	0449 Sa	0830	09.29	SE	0450 Sa	0839
	CIN	0526 Sa	0857		CIN	0525 Sa	—
	E	0538 Sa	0923		E	0538 Sa	0923
08.30	SE	0452 Sa	0827	10.01	SE	0449 Sa	0829
	CIN	0521 Sa	0900		CIN	0526 Sa	—
	E	0537 Sa	0925		E	0537 Sa	0930
09.01	SY	0454 Sa	0839	10.03	CIN	0432 Sö	—
	CIN	0522 Sa	0857		SE	0447 Sa	0832
	E	0535 Sa	0924		E	0535 Sa	0930
09.03	SY	0456 Sa	0830	10.05.	CIN	0425 Sö	0901
	CIN	0523 Sa	0858		SE	0455 Sa	—
	E	0538 Sa	0930		E	0541 Sa	0930
09.05	SY	0456 Sa	0828	10.07	SE	0455 Sa	0832
	CIN	0525 Sa	0858		CIN	0525 Sa	0855
	E	0540 Sa	0917		E	0536 Sa	0918
09.07	SY	0346 Sö	0829	10.09.	SE	0451 Sa	0828
	E	0455 Sö	—		CIN	0526 Sa	0857
	CIN	0525 Sa	0857		E	0537 Sa	0927
09.09	SE	0450 Sa	0830	10.11	SE	0450 Sa	0824
	CIN	0524 Sa	0856		CIN	0525 Sa	0854
	E	0539 Sa	0916		E	0537 Sa	0920
09.11	SE	0449 Sa	0835	10.13	SE	0341 Sö	0837
	CIN	0524 Sa	0855		CIN	0430 Sö	0858
	E	0538 Sa	0925		E	0500 Sö	0925
09.13	SE	0457 Sa	0833	10.15	SE	0455 Sa	0830
	CIN	0524 Sa	0856		CIN	0525 Sa	0855
	E	0538 Sa	0925		E	0540 Sa	0920

x Normal pass. time for the other check-points

1993

Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
10.17	SE	0455 Sa	0828	11.18	SE	0453 Sa	0827
	CIN	0525 Sa	0856		CIN	0524 Sa	0858
	E	0540 Sa	0929		E	0540 Sa	0927
10.19	SE	0347 Sö	0823	11.20	SE	0356 Sö	0829
	CIN	0423 Sö	0855		CIN	0435 Sö	0859
	E	0516 Sö	0923		E	0539 Sa	0934
10.21	SE	0452 Sa	0830	11.22	SE	0357 Sö	0822
	CIN	0523 Sa	0823*)		CIN	0422 Sö	0854
	E	0540 Sa	?		E	0455 Sö	0927
10.23	SE	0452 Sa	–	11.24	SE	0354 Sö	0835
	CIN	0523 Sa	0854		CIN	0443 Sö	0858
	E	0538 Sa	0930		E	0456 Sö	0925
10.25	SE	0343 Sö	0828	11.26	SE	0403 Sö	0826
	CIN	0430 Sö	–		CIN	0525 Sa	0905
	E	0449 Sö	0927		E	0535 Sa	0930
10.27	SE	0453 Sa	0833	11.28	SE	0451 Sa	0828
	CIN	0525 Sa	0858		CIN	0525 Sa	0855
	E	0552 Sa	0925		E	0538 Sa	0918
10.29	SE	0453 Sa	0831	11.30	SE	0453 Sa	0828
	E	0502 Sö	0922		CIN	0525 Sa	0853
	CIN	0529 Sa	0856		E	0537 Sa	–
10.31	SE	0449 Sa	0826	12.02	SE	0357 Sö	0830
	E	0457 Sö	0921		CIN	0428 Sö	0855
	CIN	0524 Sa	0854		E	0459 Sö	–
11.02	SE	0449 Sa	0829	12.04	SE	0455 Sa	0827
	CIN	0525 Sa	0855		E	0459 Sö	0930
	E	0540 Sa	–		CIN	0524 Sa	0854
11.04	SE	0450 Sa	0825	12.06	SE	0356 Sö	0820
	CIN	0525 Sa	0855		E	0508 Sö	–
	E	0536 Sa	0957		CIN	0525 Sa	0900
11.06	SE	0448 Sa	0829	12.08	SE	0354 Sö	0828
	CIN	0524 Sa	0906		CIN	0419 Sö	0855
	E	0542 Sa	0917		E	0506 Sö	0930
11.08	SE	0450 Sa	–	12.10	SE	0452 Sa	0824
	CIN	0525 Sa	–		CIN	0527 Sa	0855
	E	0540 Sa	0930		E	0539 Sa	0930
11.10	SE	0356 Sö	0838	12.12.	SE	0448 Sa	0823
	CIN	0430 Sö	0906		E	0457 Sö	0924
	E	0451 Sö	0930		CIN	0525 Sa	0858
11.12	SE	0356 Sö	0825	12.14	SE	0450 Sa	0825
	CIN	0434 Sö	0858		CIN	0525 Sa	0855
	E	0449 Sö	0930		E	0541 Sa	0928
11.14	SE	0352 Sö	0827	12.16	SE	0358 Sö	0827
	CIN	0417 Sö	0853		CIN	0423 Sö	0855
	E	0451 Sö	0918		E	0454 Sö	0922
11.16	SE	0450 Sa	0826	12.18	SE	0452 Sa	0822
	CIN	0525 Sa	0859		CIN	0523 Sa	0857
	E	0546 Sa	0930		E	0540 Sa	–

*) Misprinting?

	Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
1993	12.20	SE	0358 Sö	0825	01.25	SE	0455 Sa	0827
		C/N	0421 Sö	0855		M	0515 Sa	0856
		E	0453 Sö	0930		E	0525 Sa	0857 x)
	12.22	SE	0349 Sö	0836	01.27	SE	0457 Sa	0828
		E	0454 Sö	0922		M	0512 Sa	0854
		C/N	0522 Sa	0856		E	0522 Sa	0854
	12.24	SE	0452 Sa	0830	01.29	SE	0401 Sö	0827
		C/N	0525 Sa	0857		M	0423 Sö	0851
		E	0538 Sa	0921		E	0517 Sa	0856
	12.26	SE	0404 Sö	0831	01.31	SE	0405 Sö	0826
		M	0424 Sö	–		M	0429 Sö	–
		E	0500 Sö	0930		E	0513 Sa	0858
	12.28	SE	0450 Sa	0830	02.02	SE	0453 Sa	0826
		M	0518 Sa	0854		M	0520 Sa	0855
		E	0540 Sa	0917		E	0523 Sa	0900
	12.30	SE	0357 Sö	0828	02.04	SE	0450 Sa	0830
		M	0414 Sö	0855		M	0517 Sa	0857
		E	0507 Sö	0930		E	0520 Sa	0904
					02.06	SE	0451 Sa	0829
.794	01.01	M	0519 Sa	0900		M	0519 Sa	0900
		E	0641 Sa	0954		E	0521 Sa	–
		SE	0716 Sa	1056	02.08	SE	0451 Sa	0825
	01.03	SE	0452 Sa	0829		M	0519 Sa	?
		M	0519 Sa	–		E	0521 Sa	?
		E	0535 Sa	0924	02.10	SE	0508 Sa	0910
	01.05	SE	0455 Sa	0820		M	0519 Sa	0854
		M	0517 Sa	0853		E	0520 Sa	–
		E	0535 Sa	0914	02.12	SE	0504 Sa	0910
	01.07	SE	0456 Sa	–		M	0519 Sa	0907
		M	0519 Sa	0857		E	0520 Sa	0857
		E	0536 Sa	0922	02.14	SE	0455 Sa	0832
	01.09.	SE	0454 Sa	0828		M	0518 Sa	0830
		M	0519 Sa	0903		E	0523 Sa	0900
		E	0525 Sa	0855	02.16	SE	0458 Sa	0852
NOTE	01.15	SE	0408 Sö	0827		M	0514 Sa	0858
		E	0452 Sö	0925		E	0518 Sa	0919
		M	0520 Sa	0857	02.18	SE	0507 Sa	0859
	01.17	SE	0451 Sa	0824		M	0513 Sa	0855
		M	0520 Sa	0855		E	0518 Sa	0900
		E	0539 Sa	–	02.20	SE	0451 Sa	0827
	01.19	SE	? Sa	0834		M	0511 Sa	?
		M	0519 Sa	0835		E	0517 Sa	0901
		E	0538 Sa	?	02.22	SE	0451 Sa	0823
	01.21	SE	0400 Sö	0828		M	0514 Sa	0859
		M	0414 Sö	–		E	0518 Sa	0855
		E	0507 Sö	0927	02.24	SE	0452 Sa	0826
	01.23	SE	0406 Sö	0828		M	0511 Sa	0853
		M	0420 Sö	0855		E	0515 Sa	0852
		E	Sö	0926				

x) NEW TIME TABLE : 09-00

1994

Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
02.26	SE	0451 Sa	0843	03.30	SE	0417 Sö	0912
	M	0508 Sa	0857		E	0425 Sö	0900
	E	0514 Sa	0850		M	0429 Sö	0858
02.28	SE	0448 Sa	0825	04.01	SE	0454 Sa	0828
	M	0508 Sa	0854		M	0513 Sa	0853
	E	0513 Sa	—		E	0515 Sa	?
03.02	SE	0512 Sa	0920	04.03	SE	0457 Sa	0829
	M	0407 Sö	0856		M	0518 Sa	0853
	E	0518 Sa	0849		E	0520 Sa	0859
03.04	SE	0450 Sa	0827	04.05	SE	0400 Sö	0827
	M	0511 Sa	0855		M	0425 Sö	0849
	E	0518 Sa	0853		E	0517 Sa	0900
03.06	SE	0502 Sa	0824	04.07	SE	0455 Sa	0830
	M	0521 Sa	0849		M	0514 Sa	0857
	E	0525 Sa	—		E	0519 Sa	0856
03.08	SE	0453 Sa	0827	04.09	SE	0506 Sa	-
	M	0516 Sa	0853		M	0518 Sa	0856
	E	0517 Sa	0900		E	0520 Sa	0905
03.10	SE	0459 Sa	0826	04.11	SE	0451 Sa	0827
	M	0511 Sa	0853		M	0514 Sa	0855
	E	0515 Sa	—		E	0517 Sa	0854
03.12	SE	0500 Sa	0833	04.13	SE	0453 Sa	—
	M	0517 Sa	0857		M	0510 Sa	0855
	E	0520 Sa	0855		E	0515 Sa	0855
03.14	SE	0451 Sa	0825	04.15	SE	0456 Sa	0827
	M	0512 Sa	0854		M	0518 Sa	0900
	E	0515 Sa	?		E	0521 Sa	0858
03.16	SE	0454 Sa	0833	04.17	SE	0454 Sa	0827
	M	0512 Sa	0855		M	0517 Sa	0902
	E	0526 Sa	0900		E	0520 Sa	0855
03.18	SE	0454 Sa	0825	04.19	SE	0453 Sa	0823
	M	0510 Sa	0858		M	0515 Sa	0906
	E	0519 Sa	0900		E	0518 Sa	0859
03.20	SE	0453 Sa	0827	04.21	SE	0454 Sa	0837
	M	0512 Sa	0855		M	0516 Sa	0854
	E	0523 Sa	—		E	0521 Sa	0859
03.22	SE	0450 Sa	0825	04.23	SE	0454 Sa	0827
	M	0514 Sa	0903		M	0512 Sa	0854
	E	0518 Sa	0857		E	0518 Sa	0901
03.24	SE	0455 Sa	0826	04.25	SE	0454 Sa	0827
	M	0513 Sa	0854		M	0511 Sa	0854
	E	0517 Sa	—		E	0515 Sa	0854
03.26	SE	0451 Sa	0826	0427	SE	0455 Sa	0830
	M	0508 Sa	0821		M	0515 Sa	0854
	E	0515 Sa	0848		E	0520 Sa	0856
03.28	SE	0454 Sa	0825	04.29	SE	0454 Sa	?
	M	0516 Sa	0858		M	0520 Sa	0858
	E	0523 Sa	0856		E	0520 Sa	0858

1994

Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
05.01	SE	0403 Sö	0828	06.02	SE	0500 Sa	0835
	M	0520 Sa	0853		M	0515 Sa	0852
	E	0522 Sa	0900		E	0517 Sa	0852
05.03	SE	0453 Sa	0830	06.04	SE	0451 Sa	0828
	M	0519 Sa	0852		M	0519 Sa	0851
	E	0523 Sa	–		E	0521 Sa	0854
05.05	SE	0453 Sa	0835	06.06	SE	0453 Sa	0831
	M	0514 Sa	0855		M	0515 Sa	0858
	E	0519 Sa	0901		E	0517 Sa	0851
05.07	SE	0453 Sa	0830	06.08	SE	0453 Sa	0831
	M	0514 Sa	0854		M	0515 Sa	0854
	E	0515 Sa	0859		E	0517 Sa	0852
05.09	SE	0455 Sa	0827	06.10	SE	0452 Sa	–
	M	0514 Sa	0855		M	0514 Sa	0857
	E	0518 Sa	0858		E	0517 Sa	0857
05.11	SE	0455 Sa	0833	06.12	SE	0454 Sa	0832
	M	0515 Sa	0855		M	0515 Sa	0858
	E	0525 Sa	0900		E	0516 Sa	0857
05.13	SE	0455 Sa	0827	06.14	SE	0453 Sa	0825
	M	0515 Sa	0857		M	0515 Sa	0855
	E	0520 Sa	0859		E	0518 Sa	0907
05.15	SE	0455 Sa	0828	06.16	SE	0452 Sa	0834
	M	0516 Sa	0855		M	0514 Sa	0851
	E	0519 Sa	0905		E	0517 Sa	0855
05.17	SE	0451 Sa	0830	06.18	E	0420 Sö	0856
	M	0516 Sa	0856		SE	0456 Sa	0831
	E	0518 Sa	0858		M	0515 Sa	0852
05.19	SE	0455 Sa	0828	06.20	E	0418 Sö	0858
	M	0515 Sa	0853		SE	0454 Sa	0830
	E	0517 Sa	0858		M	0515 Sa	0853
05.21	SE	0455 Sa	0839	06.22	M	0420 Sö	0855
	M	0514 Sa	0853		E	0425 Sö	–
	E	0516 Sa	0854		SE	0454 Sa	0839
05.23	SE	0454 Sa	0830	06.24	SE	0402 Sö	0840
	M	0513 Sa	0850		M	0428 Sö	0854
	E	0517 Sa	0859		E	0429 Sö	0850
05.25	M	0417 Sö	0853	06.26	E	0424 Sö	0855
	SE	0454 Sa	0824		SE	0453 Sa	0830
	E	0516 Sa	0858		M	0514 Sa	0849
05.27	SE	0451 Sa	0830	06.28	E	0425 Sö	0849
	M	0518 Sa	0855		SE	0454 Sa	–
	E	0519 Sa	0858		M	0513 Sa	0849
05.29	SE	0452 Sa	0838	06.30	SE	0402 Sö	0831
	M	0516 Sa	0858		E	0430 Sö	0850
	E	0520 Sa	0853		M	0515 Sa	0850
05.31	SE	0453 Sa	0826	07.02	E	0429 Sö	0900
	M	0515 Sa	0859		SE	0453 Sa	0830
	E	– Sa	0855		M	0513 Sa	0852

1994

07.04	EST	0430 Sö	?	08.07	E	0418 Sö	0855
	SE	0453 Sa	0830		SE	0454 Sa	0826
	M	0514 Sa	0847		M	0516 Sa	0904
07.06	SE	0454 Sa	0829	08.09	M	0417 Sö	0858
	M	0515 Sa	—		SE	0456 Sa	0824
	E	0519 Sa	0856		E	0515 Sa	0854
07.08	SE	0453 Sa	0828	08.11	E	0418 Sö	0852
	M	0515 Sa	0900		SE	0454 Sa	0826
	E	0519 Sa	0856		M	0513 Sa	0852
07.10	SE	0449 Sa	0830	08.13	E	0417 Sö	0858
	M	0515 Sa	0909		SE	0456 Sa	0825
	E	0518 Sa	0856		M	0513 Sa	0855
07.12	SE	0453 Sa	0831	08.15	E	0419 Sö	—
	M	0517 Sa	0901		SE	0500 Sa	0825
	E	0519 Sa	0856		M	0512 Sa	0856
07.14	E	0415 Sö	—	08.17	SE	0458 Sa	0827
	SE	0454 Sa	0831		M	0514 Sa	0858
	M	0514 Sa	0855		E	0523 Sa	0857
07.16	E	0416 Sö	0855	08.19	SE	0401 Sö	0825
	SE	0452 Sa	0832		M	0523 Sa	0853
	M	0515 Sa	0857		E	0527 Sa	0853
07.18	E	0411 Sö	0851	08.21	SE	0500 Sa	0826
	SE	0457 Sa	0831		M	0521 Sa	0854
	M	0515 Sa	0855		E	0523 Sa	0902
07.20	E	0413 Sö	0856	08.23	E	— Sö	0850
	SE	0454 Sa	0829		SE	0455 Sa	0826
	M	0511 Sa	0854		M	0530 Sa	0857
07.22	E	0430 Sö	0848	08.25	E	0425 Sö	0853
	SE	0454 Sa	0829		SE	0452 Sa	0822
	M	0517 Sa	0902		M	0528 Sa	0857
07.24	E	0427 Sö	0852	08.27	E	0425 Sö	0849
	SE	0453 Sa	0826		SE	0456 Sa	0824
	M	0511 Sa	0857		M	0528 Sa	0852
07.26	E	0426 Sö	0858	08.29	E	0427 Sö	—
	SE	0453 Sa	0827		SE	0454 Sa	0824
	M	0511 Sa	0902		M	0525 Sa	0849
07.28	M	0412 Sö	0855	08.31	SE	0455 Sa	0827
	SE	0453 Sa	0827		M	0521 Sa	0855
	E	0520 Sa	0855		E	0524 Sa	0855
07.30	SE	0455 Sa	0826	09.02	SE	0457 Sa	0826
	M	0513 Sa	0854		M	0513 Sa	—
	E	0518 Sa	0858		E	0515 Sa	-
08.01	SE	0456 Sa	—	09.04	SE	0457 Sa	0825
	M	0514 Sa	0850		M	0515 Sa	0857
	E	0516 Sa	0854		E	0518 Sa	0857
08.03	E	0430 Sö	0900	09.06	SE	0457 Sa	0828
	SE	0455 Sa	—		M	0513 Sa	0856
	M	0514 Sa	0854		E	0518 Sa	0855
08.05	E	0418 Sö	0853	09.08	SE	0457 Sa	0824
	M	0428 Sö	-		M	0515 Sa	0857
	SE	0458 Sa	0826		E	0517 Sa	0854

1994

Date	Ship	Entrance	Berthing	Date	Ship	Entrance	Berthing
09.10	SE	0406 Sö	0833				
	M	0522 Sa	0858				
	E	0523 Sa	0902				
09.12	SE	0403 Sö	0825				
	M	0518 Sa	0857				
	E	0520 Sa	0900				
09.14	M	0407 Sö	0857				
	E	0416 Sö	0905				
	SE	0459 Sa	0831				
09.16	M	0417 Sö	0855				
	E	0421 Sö	0902				
	SE	0457 Sa	0835				
09.18	M	0424 Sö	0856				
	E	0429 Sö	–				
	SE	0459 Sa	0828				
09.20	E	0432 Sö	–				
	SE	0455 Sa	0827				
	M	0525 Sa	0854				
09.22	E	0425 Sö	0853				
	SE	0456 Sa	0831				
	M	0525 Sa	0855				
09.24	E	0421 Sö	0858				
	SE	0457 Sa	0830				
	M	0525 Sa	0851				
09.26	E	0423 Sö	0900				
	SE	0457 Sa	0833				
	M	0526 Sa	0857				

SUPPLEMENT No. 229

Arrival times of MV ESTONIA and some other passenger ferries at the entrance of Stockholm Archipelago and in Stockholm 3.2.1993 - 26.9.1994.

Extract from the log book at the Stockholm Pilot Station.

SUPPLEMENT No. 230

List of maintenance and repair works on MV ESTONIA
April 1993 - August 1994.

Nordström & Thulin AB

Stockholm

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month AUG. **Year** 1994

MAIN ENGINE
1. ME2 -overhaul of cyl.7,new piston rings,new O-rings,over- cyl.cover.Changed fuel injector valve of cyl.3. 2. ME3 -change of exhaust valves cyl.2 and 6. 3. Overhauling of spare ME cyl.cover. 4. Cleaning,grinding of spare ME exhaust valves.
AUXILIARE ENGINE
1.AE1 -measure and record crankweb deflections,checking and adjusting clearences of inl.and exh.valves. 2.AE3 -change of fuel injector valves,oil in turbocharger, rocker arm bearing and pin,checking and adjusting clearences of inl.and exh.valves. 3.AE4 -measure and record crankweb deflections
PUMPS
1.AE seawater pump nr.2 -changed shaft seal. 2.Repairing of AE seawater pump nr.1 -changed coupling, shaft seal,impeller,rings,bearing. 3.Repairing of gear hydrofor pump nr.2.
COMPRESSORS
1.Air compr.1 -cleaned and changed 1.and 2-stage blow- through valves. 2.Air compr.2 -changed non-return valve,crankbearings, cleaned and repaired 1.and 2-stage blow- valves.
PIPE SYSTEM
1.Repairing of pipelines in ME room and AE room. 2.Change of sewage system pipelines in sewage room. 3.Repairing of vater system pipes for oil purifier.
1.Cleaning oil purifiers nr.2 and 3.Changed paring disk in oil purif.nr.3. 2.Change of exhaust gas boilørs nr.1,2 and 3 flaps air cylinders seals. 3.Checking and adjusting of cardeck platform nr.3.
MISCELLANEOUS
1.Cleaning of all bilges in eng.rooms. 2.Washing of AE room.

L. LEIGER [signature]
CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month AUG. **Year** 1994

AIRCONDITIONING
1.Repairing of chilled liquid aut. valves in AC-5,AC-14,AC-17. 2.Repairing of thermostats and air mixers in cabins -26 pcs. 3.Cleaning up AC rooms on deck 7.
ACCOMMODATIONFANS
1.Change and washing air filters. 2.Change of belts E-28. 3.Service works of AC fans.
KITCHEN
1.Repairing of refr.equipment in kitchen. 2.Repairing of dish washing machine. 3.Cleaning of clogged scuppers in kitchen.
HOTEL
1.Repairing of doors,beds,locks in pass.cabins. 2.Repairing of floor in "Night Club". 3.Repairing of pass.cabins water mixers. 4.Service and repairing works of refr.equipment in "Seaside", "Taxfree",Sauna,"Poseidon" and "Night Club".
SEWAGESYSTEM
1.Cleaning of clogged sewage pipes. 2.Repairing and change of Evac-equipment. 3.Repairing of pipes in vaacuum system.
MISCELLANEOUS

L. LEIGER [signature]

CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month Aug **Year** 1994

ELECTRICAL PART.

1.Replacement of el.motor bearings - thermal oil pump,compressor of prov.refr.plant,AE nozzle cooling pumps,trim pump.
2.Repairing of smoke detectors.
3.Repairing of bow thruster nr.1 aut.swicth.
4.Drawing of cable on deck 8 in dayroom.
5.Cleaning of bow thrusters nr.1,2 contactors contacts.
6.Replacement of cables in control box elevator nr.1.
7.Checking & cleaning connection terminals,cables of telephone input lines.
8.Drawing of cable for central office computer.
9.Service works of ventilation boards K3a and K3b,boiler board K5.
10.Drawing of cable to boatswain workshop.
11.Cleaning and checking of copy machine "Canon".
12.Replacement of rudder angle indicator.
13.Replacement of temp.sensor of exh.gas boiler AE nr.2.
14.Service and adjusting of ME nr.1,2,3,4 "Graviners".
15.Repairing of AE nr.1 lub.oil level sensor.
16.Dismantlimg for painting,installing painted overboard searchlights.
17.Cleaning of rudder machines contactors contacts.
18.Repairing of washing machine in sauna.
19.Repairing of elevators nr.1,2,3,4 (end switches,locks etc).
20.Repairing of frying pan in galley.
21.Repairing of coffee machines in mess,in "Baltic Bar".
22.Repairing of washing machine nr.2 on deck 7.
23.Repairing of heating table in galley.
24.Repairing of meat slicing machine.
25.Repairing of ice generator in "Night Club".
26.Replacement of lamps and tubes in accodation.

L. LEIGER [signature]
CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month 07. **Year** 1994

MAIN ENGINE

1.Overhaul of cyl.5 ME4.New piston rings new O-rings,overhauled cover.
2.Change of exhaust valves on cyl.5 & 8 ME2.
3.Overhauling of spare ME cyl.cover.
4.Cleaning and montage of spare exhaust gas turbine for ME.

AUXILIARE ENGINE

1.Cleaning of oil coolers of AE 3 & 4.
2.Change of oil in turbochargers of AE 1 & 4.
3.Change of oil filter cartridges,cleaning of centrifuges on AE 1&3

PUMPS

1.Repairing of dirty water tanks pump.

COMPRESSORS

1.Repairing of compressor No 2 - change of connecting rods,cylinders,piston rings,bearings.

PIPE SYSTEM

1.Repairing of pipelines in aux.eng.room,separ.room.

1.Making container for oily rags.
2.Repairing of ME autom.oil filters.Change of seals.
3.Inspection of main shaft bearing No3 Ps.Cleaning of cooling system,installation of ventilations pipe.
4.Change of seals on ramps hydr.oil system.

MISCELLANEOUS

1.Cleaning of bilges in all engine rooms.
2.Painting works in engine rooms.
3.Inspection of draft stops on decks No 4,5;6,7 ,installation new draft stops.
4.Repairing of spare fuel injector valves for ME.

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AIRCONDITIONING

1.Inspection of compressor No 2 for AC.Elimination of failures.
2.Repairing and adjusting AC for navig.bridge.
3.Cleaning of ventilation channels.
4.Repairing of room thermostates.

ACCOMMODATIONFANS

1.Change of AC filtres,washing of filtres.
2.Change of fans belts,adjusting of belts.
3.Greasing of fan bearings.

KITCHEN

1.Repairing of kitchen refrigerator.
2.Repairing of paper press,change of belts.
3.Cleaning of clogged scuppers in kitchen.

HOTEL

1.Repairing of doors,locks,beds,ceilings in pass.cabines.
2.Repairing of coffee maker in "Poseidon","Baltic Bar".
3.Repairing of dish washing machine in rest.
4.Rebuilding of beer cooling system in "Night Club"
5.Repairing of pass.cabines water mixers.

SEWAGESYSTEM

1.Inspections and repairing of sewage plants pumps and compressors.
2.Cleaning of clogged sewage pipes.
3.Repairing and change of EVAC-equipment.
4.Adjustment of chlorine dosators in sewage plants.

1.Installation works for new carbidge container.
2.Repairing of fresh and waste water pipelines.
3.Change of water in swimming pool.
4.

MISCELLANEOUS

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JOBS MADE IN JULY (ELECTRICAL PART).

1. Replacement of OPF level pump S180 bearings.
2. Adjusting, [illegible] installing of shaft bearings temperature sensors.
3. Replacement of [illegible] prelubrication pump on aux. engine [illegible], replacement of bearings.
4. Replacement "Fire in exhaust box" [illegible] temperature sensor.
5. Replacement of faulty autom. fuse of emergency [illegible]
6. Installing of lamp under the [illegible].
7. Making of cover for [illegible] lock deck [illegible] outside.
8. [illegible]
9. Cable drawings on bridge [illegible] of bow searchlight and steering gear [illegible], installing of extra [illegible] & [illegible] searchlights switches [illegible]
10. Installing of [illegible]
11. Repairing of [illegible] in [illegible]
12. Repairing of [illegible] cutting machine [illegible] galley.
13. Repairing of engine room ventilation board [illegible] contactor coils [illegible]
14. [illegible] installation of new garbage container.
15. [illegible]
16. Repairing of [illegible] of [illegible]
17. Repairing of [illegible]
18. [illegible] of [illegible] in [illegible]
19. [illegible]
20. [illegible], washing of [illegible]
21. Checking of [illegible] of generator.
22. Replacement of [illegible] refrigerator [illegible]
23. Cable drawing & [illegible]
24. Checking of [illegible] functions of boiler circulating pumps, replacement [illegible] relays.
25. [illegible]
26. [illegible]
27. [illegible]
28. [illegible]
29. [illegible]
30. [illegible]
31. [illegible]
32. Repairing of [illegible]
33. Repairing of [illegible] machine [illegible]
34. Checking, [illegible]
35. Cable drawings [illegible]
36. [illegible]
37. Checking, [illegible] equipment.
38. Repairing of [illegible]
39. Checking of [illegible] of computer, [illegible] on to UPS mains.
40. Repairing of [illegible] cable.

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JOBS MADE IN JULY (EL. PART, continuation)

41. Dismantling for painting, installing of painted overboard searchlights
42. Maintenance, cleaning of hand-driers.
43. Checking, testing of cardeck tracktor el. equipment.
44. Repairing of fore mooring winches board.
45. Repairing of aft. mooring winch components.
46. Replacement of turning part of anemometer.
47. Repairing of [illegible] machine "Darka" in [illegible]
48. Repairing of [illegible] valve of Poseidon [illegible]
49. Checking of refrigerator in Ole Carta.
50. Repairing of Bilge valve N 17 position [illegible]
51. Replacement of safety lock magnet of lift [illegible]
52. Drawing of [illegible]
53. Planned [illegible]

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WORKS MS ESTONIA Month JUNE **Year** 1994

MAIN ENGINE

1.Change of fuel injection valves on ME4.
2.Cleaning of water cooler ME1 change of defective seals.
3.Change of oil filters cartridges on ME 2 & 3.Cleaning of elements
4.Change of exhaust gases temperature sensors cyl.1 & 2 ME1.
5.Elimination of control air leakages in ME 3 & 4 control panels.

AUXILIARE ENGINE

1.Change of fuel injection valves on AE2.
2.Change of oil filtres on AE1 & AE4.

PUMPS

1.Repairing of dirty water tank No 12 pump.
2.Change of shaft seal on AE1 pre-lubricating pump.
3.Change of bearings and seals on fuel oil booster pump for AE.

COMPRESSORS

1.Change of oil in compressor No 3,test of safety systems.
2.Change of oil and oil filtres in working air compressor.

PIPE SYSTEM

1.Change of fire system pipelines on deck No 7.
2.Cleaning of cooling water system for main shaft bearings.
3.Repairing of ME2 sea cooling water pipe.
4.Repairing of bilge water pipe in Ka Me Wa -room.

1.Survey of Ps main shaft bearing No3.
2.Cleaning of lub oil and fuel oil separators.
3.Repairing of water-tight door No 12.Change of rolls liner.
4.Cleaning of thermal oil boiler No 2.
5.Repairing of door of elevator No1.

MISCELLANEOUS

1.Cleaning bilges in all engine rooms.
2.Painting of floor plates in engine rooms.
3.Painting of ME exhaust gas collectors.

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WORKS MS ESTONIA Month JUNE **Year** 1994

AIRCONDITIONING

1. Repairing of thermostates and air mixers in 27 pass.cabines.
2. Change of thermostatin cabine No 1046.
3. Cleaning of air conditioning agregates VSM-57 condensator, installed new zinc protectors. Pressure test of oil system.
4. Repairing of chilled liquid autom.valve in AC 13 & 14.

ACCOMMODATIONFANS

1. Change of filters in all AC .Washing the filtres.
2. Greasing and test of all fire dampers.
3. Cleaqning of condensator of eng.control room AC.
4. In 4.deck WC installed ventilation valve.

KITCHEN

1. Repairing of refrigerator in cold kitchen.
2. Repairing of refrigerators door in hot kitchen.
3. Change of kitchens paper press belts. Repairing of press.
4. Repairing of chees cutter, and dish washing machine.

HOTEL

1. Repairing of "A La Carte's" juice chiller.
2. Rebuilding of beer chiller system in "Night Club"
3. Maintenance of ice generators in "Baltic Bar" and Night Club"
4. Repairing of coffee maker in "Baltic Bar".

SEWAGESYSTEM

1. Repairing of vaacuum pump of sewage plant No 2.
2. Chemical cleaning of sewage system.
3. Cleaning of clogged pipes.
4. Change and repairing of EVAC equipment.

1. Repairing of garbage container.
2. Repairing of washing machine for crew.
3. Repairing of coffee maker in mess-room.
4. Cleaning of clogged scuppers on deck No 1 & 6.

MISCELLANEOUS

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WORKS MS ESTONIA Month JUNE **Year** 1994

JOBS MADE IN JUNE (ELECTRICAL PART)

1. Repairing, drying of lifeboat N1 winch limit switch.
2. Drawing of cable for separate socket for MW oven in galley.
3. Cleaning, service of ME & emerg. light accumulator batteries.
4. Cable drawing in A'la Carte for new equipment.
5. Replacement of bearings on luboil purifier N1 el. motor.
6. Repairing of lift N1 (inner door contacts).
7. Adjusting of hydraulic door deck 5 StBd sensor.
8. Drawing of phone cable on deck 8.
9. Replacement, repairing, replacement of aux.eng.4 prelub. pump.
10. Repairing of Coffee machine lock in Poseidon.
11. Painting of bow hydraulic and ventilation boards.
12. Replacement of CPU on fin system LCU StBd.
13. Replacement of aux. engines 1,2,4 prelub. pump motors.
14. Checking of Ps intermediate shaft bearing N3 temperature sensor, adjusting of measuring sircuit.
15. Repairing of coffee mashines in mess, Baltic bar, Poseidon.
16. Replacement of sauna heating range. contactor. cable.
17. Repairing of carbage container.
18. Replacement of contactor coil,limit switch on boat winch N2.
19. Replacement of overcurrent relais of boiler supply Fan N 1,2.
20. Repairing of elevator N 1.
21. Checking , adjusting of fireproof doors indication.
22. Checking, replasement of faulty sensors of gas detection .
23. Repairing of frying pan in galley.
24. Repairing of lighting in cardeck.
25. Adjusting of bilge level sensors.
26. Cleaning, greasing of StB gyrorepeater on bridge.
27. Replacement of "fire in exhaust boiler" N2,3 sensors.
28. Replacement of CPP level pump bearings StB.
29. Cable drawing on bridge,reinstalling of steering gear,bow search light joysticks and switch,installing of extra switches.
30. Repairing of cheese cutting machine in galley.
31. Repairing of hair dryer in family sauna.
32. Replacement of aux. eng. prelub.oil pressostats and cables.
33. Replacement of shaft turning devices control cables coatings.

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WORKS MS ESTONIA Month 05 **Year** 1994

A-2

MAIN ENGINE
1.Inspection of main bearing No 3 ME2. 2.Change of exhaust gas turbine on ME1. 3.Change of high pressure fuel oil pump cyl.No5 ME1. 4.Change of fuel pump non returne valve on cyl1 ME3.cyl7 ME4. 5.Change of seal rings on ME crankcase safety valves.
AUXILIARE ENGINE
1.Change of cylinder covers on AE3. 2.Overhauling AE spare cyl. covers. 3.Cleaning of AE4 turbine,change of bearings. 4.Change of fuel injector valves on AE4. 5.Cleaning of oil cooler and thermostate on AE1.
PUMPS
COMPRESSORS
1.Change of oil in compressors No 1 & 2.Safety test.
PIPE SYSTEM
1.Repairing of sea water and fresh water cooling systems for main and aux engines,boilers. 2.Repairing of waste water system in separ.room. 3.Elimination of leakage in thermal oil system in sewage-room.
1.Repairing of cargo lift door on car-deck. 2.Mounting pipes for car-deck signalisation cables. 3.Change of vertical spindle bearings of separators No 1 & 2. 4.Change of bearing and seals on lift No4 gear. 5.Cleaning and painting of sea water strainrs in eng.rooms.
MISCELLANEOUS
1.Washing and painting in engine rooms,cleaning bilges. 2.Cleaning of thermal oil boiler No1. 3.Washing of exhaust gas boilers.

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WORKS MS ESTONIA Month 05 **Year** 1994

AIRCONDITIONING

1.Change of thermostates in cabines No 7015,4330,7001,6032,756, 5227,1047.
2.Repairing of cabine thermostates and air mixers in cabines No 829,831,1010,1063,1077,1118,4106,4416,4420,5129,6317,7001,6329,1035 1037,1006,6335,1009,1025,1027,1030,1049,1050.

ACCOMMODATIONFANS

1.Change of AC filtres,washing filtres.
2.Cleaning up the AC-rooms.
3.Change of belts in AC-3
4.Repairing of thermostate-valve in AC-6 & 17.

KITCHEN

1.Repairing of refrigerators door in cold kitchen.
2.Service works on hot kitchen refrigerators.
3.Repairing of shells in kitchen.
4.Repairing of sliceing machine and paper-press.

HOTEL

1.Repairing of hot water pipelines and water armature.
2.Repairing of cabine refrigerators.

SEWAGESYSTEM

1.Emptying and cleaning of sewage plant No2.
2.Repairing of compressor on sewage plant No1.
3.Repairing and adjusting of chlorine dosators.
4.Repairing of ejector pump No 4 on plant No 2.
5.Repairing of pipes in vaacuum system.

1.Repairing of hot water circulation pump.
2.Cleaning of grease tank in grey water system.
3.Repairing of 2 grey water pumps.
4.Repairing of ice generator in "Baltic Bar".

MISCELLANEOUS

1.Service works on provision plant refrigerator equipment .

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WORKS MS ESTONIA Month 05 **Year** 1994

JOBS MADE IN MAY (ELECTRICAL PART)

1. Cleaning, painting of bow hydraulik station board.
2. Restauration of gyro repeater on bridge
3. Replacement of RPM relais of ME 2 in control panel.
4. Replacement and repairing of printed circuit H8R7 in ME safety system.
5. Replacement of lower bearing cover and bearings of hot water circulating pump.
6. Cable drawing for 3 advertising lamps in pub and night club.
7. Repairing of control pushbuttons of life boats NN 1,2,3.
8. Repairing, adjusting of bilge water valve of Ka-Me-Wa room.
9. Replacement of fire detector in cardeck.
10. Repairing of limit switches of life boats NN 3,5.
11. Repairing of minus pole switches of boats NN3,5,9.
12. Replacement of separator room supply fan 1 contactor coil.
13. Installing of switch for welding socket in fore vent. board.
14. Replacement of Graywater pump N 1,2 bearings.
15. Replacement of ER-30 bearings.
16. Replacement of Seawater pump AUX.EN. N1 bearings.
17. Replacement of Flushwater pump SEWAGE PLANT N2 bearings.
18. Repairing of lift N1 safety lock contacts.
19. Replacement of ER-41 contactor coil.
20. Repairing of mess dishwashing machine thermostat.
21. Repairing of STL BCU-card,replacement of sensors.
22. Replacement of swimming pool light.
23. Repairing of paper press in kitchen.
24. Repairing of cardeck supply fan N 14.
25. Drawing of cable in "Balticbar".
26. Cleaning of coffee machine in mess.
27. Checking and replacement of AVACO system sensors.
28. Adjusting of lift N4 brakes.
29. Repairing of engine room lighting equipment.
30. Repairing of lift NN3,4 signal card.
32. Making of EXH.FAN CRANK alarm.
33. Replacement of "fire in exhaust gas boiler" aux.eng. N3 sensor.
34. Cable drawing,installing of sensor, indication lamps of board cover position.
35. Replacement of shaft turning device control cables covers.
36. Replacement of fuel oil separator 1 el.motor bearings.
37. Replacement of "oil pressure before turbine" transmitter.
38. Repairing of hydraulic elevator in store.

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WORKS MS ESTONIA Month 04 **Year** 1994

MAIN ENGINE

1.Change of cylinder cover No 1 ME 3.
2.Change of starting air distributor shaft and bearings on ME 4.
3.Change of high pressure fuel oil pump cyl.6 ME 1.
4.Change of fuel injector valves No 1-8 ME 3.
5.Elimination of control air leakages on ME 3 & 4.

AUXILIARE ENGINE

1.Overhaul of AE 1:installed overhauled cyl.covers,overhauled pistons,new piston rings,overhauled connecting rods,new big end bearings,change of all fuel injector valves,change of lubricating oil.
2.Change of low pressure fuel oil pump on AE 2.

PUMPS

1.Repairing of ME Ps cooling water double pump No 2 : change of shaft and bearing.

COMPRESSORS

PIPE SYSTEM

1.Repairing of gray water pipelines on car deck.
2.Repairing of hot water and cold water pipelines on car deck.
3.Repairing of trim pump suction pipe.

1.Washing of exhaust gas boilers ME and AE.
2.Testing and greasing of elevators No 1,2,3,4.
3.Change of breakers shoes on elevator No 4,adjusting.

MISCELLANEOUS

1.Cleaning and painting the weldings in dry tank No 16A St.B & Ps.
2.Overhauling AE spare cyl.covers.
3.Cleaning of ME fuel injector valves cooling water circ.tanks.
4.Washing engine rooms and cleaning bilges.

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WORKS MS ESTONIA Month 04 **Year** 1994

AIRCONDITIONING
1.Change of AC filtres,washing of filtres. 2.Repairing of thermostatic valve of AC 2. 3.Adding freon to AC systems.
ACCOMMODATIONFANS
1.Repairing of cabine thermostates and air mixers. 2.Change of 5 cabine thermostates. 3.Repairing fans E49 and AC-13,adjusting belts.
KITCHEN
1.Repairing refrigerators door and lock. 2.Repairing of kitchens furniture. 3.Repairing of paper press. 4.Repairing of dish-washing machine.
HOTEL
1.Repairing of water mixers in cabines. 2.Repairing of one section of refrigerator lockers. 3.Repairing of cabine refrigerator.
SEWAGESYSTEM
1.Emptying of sewage plant No 1.Cleaning. 2.Change and repairing of vaacuum equipment. 3.Cleaning vaacuum pipes,change of damaged pipes.
1.Repairing of coffee machine in "Poseidon",refrigerators and ice generators in "Baltic bar",juice cooler.
MISCELLANEOUS
1.Repairing of garbage container. 2.Cleaning of swimming pool filtres.

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WORKS MS ESTONIA Month 04 **Year** 1994

JOBS MADE IN APRIL (EL. PART)

1. Installing of safety swithes & contactors on grinding machines.
2. Adjusting of ME 1 turning gear limit switch.
3. Replacement of bearings of luboil purifier 3 pump.
4. Repairing of ME 3 load indicating instrument
5. Repairing of firetight door magnet.
6. Repairing of terminal connection on Fan AC3? motor.
7. Installing of extra socket on bridge.
8. Adjusting of rudder angle indication potentiometer.
9. Repairing of air cond. temperature regulator TA control
10. Changing vice versa of window wiper park and [illegible].
11. Replacement of temperature after aux exhaust boiler 3 sensor.
12. Replacement of sea cooling water temperature [illegible] MEs [illegible].
13. Replacement of contactor contacts ME sea water double cooling pumps(4 pcs).
14. Repairing of Sauna washing machine water pump [illegible].
15. Adjusting of analog pressure sensors of STL alarm system
16. Repairing of elevator N 4.
17. Replacement of ER 41 fan el motor bearings.
18. Replacement of AC 18 fan el motor bearings.
19. Replacement of cardeck heating fan N 17 el motor bearings.
20. Repairing of cooling compressor in Night [illegible].
21. Installing of water pool projectors.
22. Repairing of passengers men sauna heating [illegible].
23. Checking adjusting of bow ramp position sensor.
24. Repairing of paper press in store.
25. Cleaning of bow truster N 1 breaker bow trusters boards adjusting of starting time relays.
26. Repairing of refrig. trucks connecting [illegible] in cardeck.
27. Repairing of coffee machine in [illegible].
28. Reinstalling of gyrocompass repeater [illegible].
29. Replacement of RPM relais of ME 2.
30. Repairing of [illegible] sea water double cooling pump starter.

H. MOOSAAR [signature]

CHIEF ENGINEER

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WORKS MS ESTONIA Month 03 **Year** 94

MAIN ENGINE

1. ME4 cyl.3 and 4 - overhaul
2. ME3 cyl.7 - change of high pressure fuel oil pump.
3. Elimination of control air leakage in St.b. speed contr. syst.
4. Overhaul of spare cyl.covers grinding of valves.
5. Check of crankshafts counter-weights bolts.on ME 1,2,3,4.

AUXILIARE ENGINE

1. Measurement and adjustment of cyl. top pressure AE 1 & 3.
2. Change of fuel injector valves AE 3.
3. Change of oil in AE 4 turbine.
4. Elimination of fuel oil leakages on AE systems.

PUMPS

1. Repairing of Fs. ME preheating pump.
2. Repairing of vaacuum sewage pump.
3. Repairing of Fs. ME cooling sea-water pump No 2.

COMPRESSORS

1. Change of valves on starting air compressor No 2.
2. Repairing of solenoid valve,change of decompression valves on working air compressor.

PIPE SYSTEM

1. Repairing of ME sea cooling water pipelines.
2. Change pipes in ME fresh cooling water system.
3. Overhaul of ME 1 & 2 fresh cooling water thermostatic valves.
4. Repairing exhaust gas boilers cooling syst.

1. Overhaul and cleaning of lub.oil separators No 1,3,4.
2. Cleaning of ME 1,2,3,4 oil coolers.
3. Cleaning of fresh cooling water tank No 17.

MISCELLANEOUS

1. Cleaning of bilges in all eng.rooms.
2. Repairing of high pressure washing machine.
3. Change of damaged pressure gauges.

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WORKS MS ESTONIA Month 03 **Year** 94

AIRCONDITIONING

1. Change and washing of all AC filtres.
2. Repairing of AC 3 thermal oil valve.

ACCOMMODATIONFANS

1. Straining of AC fans belts.
2. Repairing of cabine thermostats and air mixers.
3. Testing AC equipment, adding freon.
4. Greasing and checking fire flaps on vent.channels.

KITCHEN

1. Repairing of refr.equipment in kitchen.
2. Repairing of dish washing machine.
3. Repairing of slicing machines.

HOTEL

1. Repairing of water mixers in cabines.
2. Repairing of doors and locks.

SEWAGESYSTEM

1. Change and repairing of vaacuum-equipment.
2. Washing of sewage plants.
3. Change of vaacuum pump on sewage plant.

1. Repairing of coffee machines and ice generators.

MISCELLANEOUS

1. Repairing of carbage container.
2. Repairing of hot water heater.
3. Repairing of washing machines for crew.

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WORKS MS ESTONIA Month 03 **Year** 94

JOBS MADE IN MARCH (EL. PART).

1. Installing of Pub stage dimmers.
2. Installing of alarm pushbuttons in casino.
3. Replacement of container socket on cardeck.
4. Repairing of heater timer in mess refrigerator table.
5. Installing of spotlights in tax-free.
6. Making an order of el. equipment of tax-free office. (cable trays, telephone, talk-back system, wall sockets.
7. Repairing of men's sauna heater, replacement of two elements.
8. Replacement of sewage flushwater pump el.motor bearings.
9. Replacement of aux. fresh cooling water double pump el motor bearings.
10. Installing of window wiper on bridge.
11. Restauration of working ability of fire detection station 1.1 loop.
12. Installing of telephone to security officer's cabin.
13. Repairing of coffee machine in conference.
14. Rewinding of Tamrok work air compressor el. motor, [illegible] of unit's working ability.
15. Replacement of prov. cooling water pump el motor bearings.
16. Cleaning of nightclub ice machine and greesing water pumps el. motors.
17. Replacement of containers sockets in cardeck.
18. Replacement of galley range heaters.
19. Cleaning of ME fuel flow sensors.
20. Replacement of ice machine fan in Baltic Ba
21. Repairing of cofee machine in Baltic Bar.
22. Replacement of two smoke detectors in cardeck.
23. Installing of air valve and overcurrent relay in Tamrok.
24. Adjusting of ME temp. sensors.
25. Replacement of program el.motor of ice machine in cafeteria.
26. Cleaning of MF-5
27. Cleaning, greasing of generator breakers motor operating mechanisms, replacement of bearings in N1.
28. Replacement of heating cable in boiler room.

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CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month FEBR **Year** 1994

MAIN ENGINE

1.ME4 cyl.2 and 6 - overhaul.
2.ME2 cyl.2 and 6 - change of cyl.covers.
3.ME2 -repairing of automat.lub.oil filter.
4.Overhaul of spare cyl.covers,cleaning,grinding.

AUXILIARE ENGINE

1.AE3,4 - checking,adjusting of inl.and exh.valves.
2.AE4 cyl.1 -change of fuel injector valve.
3.AE3 -repairing of air starting valve.
4.AE1,2,3,4 -checking of found.bolts.

PUMPS

1.ME cooling pump nr.2 stb.- repairing.
2.ME preheat.pump stb.-change of bearings.
3.Thermaloil circul.pump nr.1 -change of coupl.buffers.
4.Thermaloil boiler pump nr.2 -change of coupl.buffers.

COMPRESSORS

1.Air compr."Tamrock" -change of end part.
2.Air compr.nr.1 -change of coupl.buffers.
3.Air compr.nr.2 -change of 3 stage air pipe.

PIPE SYSTEM

1.Repairing of fire system pipes.
2.Repairing of tailshaft bearings cooling system pipes.

1.L.O.purif.3 - change of vert.shaft.
2.Therm.oil boiler 1 -repairing of bottom insul.-covering.
3.Service of therm.oil boilers 1,2 burnes.

MISCELLANEOUS

1.Cleaning of ME,AE,separ. rooms tanktop.
2.Painting in fin room.

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NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month FEBR. **Year** 1994

AIRCONDITIONING

1. Cleaning of AC 14-16 heaters.
2. Cleaning AC filters.

ACCOMMODATIONFANS

1. Repairing or change of therm.regulators and air mixers.

KITCHEN

1. Installation of freezers 2 pcs.

HOTEL

1. Change or repairing of hot water mixers.

SEWAGESYSTEM

1. Sewage plant nr.1 - repairing of pump nr.
2. Sewage plant nr.2 - repairing of pump nr.
3. Repairing of EVAC-equipment.
4. Cleaning of sewage system blocked pipes.

MISCELLANEOUS

1. Repairing of carbage container.
2. Paperpress on deck 6 - change of belts.
3. Paperpress on deck 5 - service.

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WORKS MS ESTONIA Month FEBR. **Year** 1994

JOBS MADE IN FEBRUARY (el. part).

1. Repairing of paper press in tax free.
2. Installing of spare parts in order in finroom store.
3. Replacement of ME Stbd fuel booster pump st.by time relais.
4. Replacement of window washing nozzles heaters on bridge.
4. Replacement of window washing nozzles heaters on bridge.
5. Dismantling, cleaning, greasing of elevator N 2 el. magn. brakes,assembling, adjusting.
6. Replacement of Stbd stern"ramp in upper position"sensor.
7. Repairing of 3 broken by passengers outside lamps d.8 fs stern.
8. Drawing of cable, installing of socket for new washing machine in E.R.
9. Drawing of telephone cable to fanroom deck 7 fore.
10. Installation of socket for playing automates deck 5.
11. Repairing of power voltage stabiliser, RPM measuring circuits,adjusting of gap for start automatic unit of aux. diesel N 2.
12. Repairing of safety lock contacts of elevators: 3 (5-th, 6-th floors), 1 (0-th floor).
13. Repairing of "inner doors closed" contact of elevator N 2.
14. Replacement of air compressor N 2 contactor main contacts.
15. Repairing of paper press in galley.
16. Repairing of signal circuits of stern ramps, restauration of working ability, replacement of signal lamps holders.
17. Greasing of front bearings of two stern thermal oil circulation pumps motors.
18. Adjusting of rotation sensing switch in Graviner of ME 3.
19. Installing of two holiday lighting winches.
20. Restauration of gyro compass repeater on bridge's Ps wing.
21. Installing of wall socket for officer's drier.
22. Making of Nautic accumulator batteries low voltage alarm.
23. Replacement of charging cable for loader in cardeck.
24. Drawing of cash desks data cables.
25. Repairing, adjusting of scrab container photo cell.
26. Repairing of high bilge water level sensor.
27. Restauration of finroom fan board.
28. Repairing of conditioning air temperature regulator.

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WORKS MS ESTONIA Month JAN **Year** 1994

MAIN ENGINE

1.ME4 cyl.8 - overhaul.Cyl.7-change of exhaust manifolds expansion pieces.
2.ME2 - change of aircooler.Cyl.6 - change of cyl.cover.
3.ME1,4 -checking and adjusting clearences of inlet and exhaust valves.

AUXILIARE ENGINE

1.AE2 - change of fuel injector valves.Survey of camshaft (bearings,cams,gear wheels) and roller guide assembly.Checking and adjusting clearences of inl. and exh.valves.Measure and record crankweb deflections.
2.AE3 - Measure and record crankweb deflections.

PUMPS

1.ME seawater pump nr.2 (PS) - change of impeller.
2.Thermaloil boiler pump nr.1 - change of rot.gasket and bearing.

COMPRESSORS

1.Air compressor nr.1 - change of cooler 3-stage.
2.Air compressor nr.2 - change of induction and exhaust valves 2-stage.

PIPE SYSTEM

1.Repairing of fire system pipes on deck 7.
2.Connection of fin cooling system pipes with AE cooling system.
3.Instalation of oil pipes to headers of fin system.
4.Change of 'valves on fresh and seawater cooling systems (4 pcs).

1.L.O.puif.3 - change horizot.shaft bearings.
2.Cleaning of therm.oil boiler nr.1
3.Cleaning of ME and AE exh.gas boilers.
4.Service of therm.oil boilers 1,2 burnes.

MISCELLANEOUS

1.Cleaning of ME,AE and sep.rooms tanktop.
2.Works before and after installation stabilizers in finroom.

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WORKS MS ESTONIA Month JAN **Year** 1994

AIRCONDITIONING
1. Cleaning AC filters. 2. Cleaning AC rooms.
ACCOMMODATIONFANS
1. Repairing oftherm.regulators and air mixers 32 pcs. 2. Change of therm.regulators 6 pcs.
KITCHEN
1. Replacing of freon pipes in kitchen. 2. Repairing of freezers in kitchen.
HOTEL
1. Repairing of ice-generator in sauna. 2. Repairing of WC ventilation valves on deck 4. 3. Repairing of hot water mixers on deck 5,7 and 8.
SEWAGESYSTEM
1. Change of level sensor in galley grey water tank. 2. Cleaning of sewage plant nr.1,2. 3. Cleaning of sewage system blocked pipes.
MISCELLANEOUS
1. Repairing of carbage containers.

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WORKS MS ESTONIA Month JAN. **Year** 1994

JOBS MADE IN JANUARY /el. part/

1. Rewinding, installing of luboil purifier N2 el. motor.
2. Repairing of elevator N 1 floors indication.
3. Cleaning of Port propulsion plant friktion of manoevre handle on Sb wing.
4. Repairing of coffee machine in conference.
5. Repairing of dishwashing machine in galley.
6. Replacement of galley boiler heater.
7. Repairing of luboil transfer pump starter.
8. Replacement of lighting board L15a breaker on Main Distributing board.
9. Mounting, connection of Stab. syst. Roll sensor.
10. Replacement of luboil purifier N3 contactor in K15 board.
11. Mounting of new lighting board on deck 5 stern.
12. Repairing of power source for central office computer.
13. Checking of oil mist detector N 1 .
14. Repairing of foodstore refr.compressor N 1 el. motor terminals.
15. Adjusting of Aux. eng. 2 RPM measuring unit.
16. Repairing of milk cooler in Poseidon.
17. Replacement of wall socket in store room deck 1.
18. Adjusting of elevator N 2 outer doors safety lock.
19. Printing out and putting in of coefficients in Steermaster.
20. Repairing of phone in boiler room.
21. Mounting of roulette spotlight in pub.

JOBS MADE DURING DOCKING.

1. Helping in mounting of new panel on bridge, mooving of navigational lights panel, 4 ETA-piloti cables drawing under the bridge deck, drawing of cable from bridge stabilisers panel to Doppler log central unit, installing of ETA-pilot switch.
2. Repairing of shore connection box Sb after short current between shore cable fases.
3. Repairing in passengers cabins according to remarks.
4. Repairing of separators boards K14, K15, replacement of contactors and overcurrent relais.
5. Repairing of MDB 220 V panels.
6. Adjusting of generator voltages.
7. Drawing of cable, connecting of new lighting board, unloading of lighting board L12.
8. Cleaning, repairing of ranges, grill, cooking boilers in galley.

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WORKS MS ESTONIA Month JAN **Year** 1994

9. Replacement of oil separators pumps el. motors cables.
10. Replacement of bearings in oil separators pumps el. motors(2 pcs.).
11. Replacement of bearings in ME fuel booster pumps(4 pcs.).
12. Repairing of ME local control panels,remote control and safety systems.
13. Replacement of local/remote switch of thermal oil circulation pump.
14. Synchronizing of KaMeWa port propulsion plant control handles on bridge.
15. Repairing of hair driers and ice machine in passenger sauna.
16. Repairing of coffee machine in mess.
17. Disconnectong and connecting back of el. equipment in gift shop and halls because of new carpets putting.
18. Repairing of elevator N2.
19. Mounting and installing of cable trays,installing of remaining cables,connecting of them to stabilizers units.

JOBS MADE IN JANUARY AFTER DOCKING.

1. Repairing of stern ramp Sb ,replacement of two sensors.
2. Replacement of bilge and ballast valves control pushbuttons.
3. Repairing of Berkel slicing machine in galley.
4. Replacement of bearings in oil separator N3 el.motor.
5. Repairing of dishwashing machines.
6. Repearing of cardeck lighings.
7. Maunting of new pultlamps on bridge.
8. Repairing of oil mist detektor N1.
9. Cleaning,adjusting of brake of lift N2.
10. Checking of emergangy lightinds.
11. Replacement of cable of bow slide projector with zoom.
12. Replasement of firesensors in cardeck.
13. Cleaning,checking.adjusting of firedoor with automatic release.

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WORKS MS ESTONIA Month DEC **Year** 1993

MAIN ENGINE

1.ME1 cyl.5 -change of fuel injector valve and fuel pump.
2.ME2 -change of main bearing nr.8 and air cooler.
3.ME1,2,3.4 -cleaning of turbocharges lub.oil tanks.
4.ME2,3 -measure and record crankweb deflections.

AUXILIARE ENGINE

1.AE4 -change of fuel injector valves,measure and record crankweb deflections,checking and adjusting inlet and exhaust valves clearences.
2.AE3 -checking and adjusting inlet and exhaust valves clearences.

PUMPS

1.Repairing of AE seawater pump nr.2
2.Repairing of emergency engine fuel transfer pump.

COMPRESSORS

1.Air compr.1 -change of induction and exhaust valves 1.and 2.stages.Change of lub.oil.

PIPE SYSTEM

1.Repairing of cooling seawater pipes in eng.room.
2.Rebuilding of fuel settling and daytanks drain system pipes.

1.L.O.purif.2 -change of vert.shaft and bearings.
2.Cleaning of AE exhaustgas boilers.
3.Cleaning of boiler nr.2.
4.Boiler 1,2 -cleaning,survey of burners nozzles.

MISCELLANEOUS

1.Cleaning of ME,AE and sep.rooms tanktop.
2.Works for installation fin stabiliser.

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WORKS MS ESTONIA Month DEC **Year** 1993

AIRCONDITIONING
1.Cleaning AC filters. 2.Repairing of control valves AC 9,8,10.
ACCOMMODATIONFANS
1.Repairing of pass.cabins air mixers. 2.Change of thermoregulators in pass.cabins.
KITCHEN
1.Repairing of freezers in kitchen. 2.Repairing of galley steam oven.
HOTEL
1.Repairing of drain pipes in "Baltic Bar". 2.Repairing of hot water mixers.
SEWAGESYSTEM
1.Washing of sewage plants 1,2. 2.Repairing of small sewage tank on deck 6. 3.Repairing of pump nr.2 (stern grey water tank) and non-return valve.
MISCELLANEOUS
1.Repairing of carbage container. 2.Repairing of washing machine in eng.room. 3.Cleaning of sewage system blocked pipes.

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WORKS MS ESTONIA Month DEC **Year** 1993

JOBS MADE IN DECEMBER (el. side).

1. Making of cable connections for cardeck.
2. Washing of generators air filters.
3. Making of new scale for wind direction shower.
4. Replacement of start air compressor 2 current transformer.
5. Replacement of ME2 air charger luboil pressure transmitter.
6. Repairing , cleaning , prophylactic of shore connection box Stbd.
7. Repairing of timer,thermostate,replacement of heater element of officers sauna.
8. Repairing of bow ramp inductive sensors.
9. Repairing of dishwashing machine in mess.
10. Repairing of elevators n 2,3: replacement of safety lock magnets assembles, time relais.
11. Making, repairing, installing of Cristmas trees lighting.
12. Repairing of air conditioning AC10 automatic valves.
13. Replacement of waterproof door control system contactor in prov.store.
14. Replacement of Aux. eng.2 RPM sensor.
15. Repairing, cleaning, prophylactic of ME connection boxes.
16. Adjusting of ME & propeller shafts tachometers.
17. Repairing of ME4 shaft turning device control box, pushbuttons.
18. Cleaning of friction gear of rudder wheel on bridge.
19. Replacement of coocking pan feeding cable.
20. Replacement of terminal connector, cleaning,drying of convectional oven.
21. Repairing, washing, drying of potato peeler.
22. Cleaning of Aux. eng.2 connecting box.
23. Installing of heating cable for fuel oil filter drain pipe warming.
24. Making of LED bar indicator instead of lamps to alarm system STL.
25. Drawing of stabilizer cables on bridge.
26. Installing of light fittings ,transformers,regulators in Pub.
27. Repairing of PF2 printed sircuits of alarm system STL.
28. Replacement of fuel sensor N 13 on cardeck.
29. Mooving away everything stored in finroom stbd.
30. Repairing of lift deckés indication.
31. Repairing of purifair oil ME2 motor.
32. Replacement of bridge dimmer.
33. Repairing of galley steam oven.
34. Replasement of bearings of busterpump purifier N1 motor.

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WORKS MS ESTONIA Month NOV **Year** 1993

MAIN ENGINE

1.ME3 cyl.5 – overhaul. ME1 cyl.3 – overhaul.
2.ME4 cyl.8 – change of exhaust valves.
3.ME1 – repairing of turning gear.
4.ME4 cyl.7 – change of exhaust manifolds expansion pieces.
5.ME3 – change of fuel injector valves.

AUXILIARE ENGINE

1.AE1 and AE3 –change of fuel injector valves.
2.AE2 – survey of camshaft (cams,bearings,gear wheels).
3.AE4 – checking and adjusting clearences of inlet and exhaust valves.

PUMPS

1.Change of trim pump seal.
2.Repairing of pump 4 of sewage plant 1.

COMPRESSORS

PIPE SYSTEM

1.Installation of cooling water system pipelines for fin stabiliser.
2.Repairing of ME seawater pipelines.
3.Repairing and painting of seawater filters. (4 pcs)

PURIFIERS

1.L.O.purif.2 – change of vert. and horizontal shafts bearings, gear wheel.

MISCELLANEOUS

1.Cleaning and repairing of ME4 water cooler.
2.Cleaning and painting in AE room.
3.Change of control valve of stern ramp (PS).
4.Elevators nr.1.2,3 – change of wire ropes and wheels.
5.Repairing of lifeboat nr.4 winch gear.

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WORKS MS ESTONIA Month NOV **Year** 1993

AIRCONDITIONING
1. Change of fan bearings. 2. Cleaning AC filters.
ACCOMMODATIONFANS
1. Repairing of pass.cabins air mixers. 2. Change of thermoregulators in pass.cabins.
KITCHEN
1. Repairing of dishwashing machine drainwater pipelines.
HOTEL
1. Change of hotwater mixers on deck nr.1 and 4.(4pcs)
SEWAGESYSTEM
1. Repairing of transmitters in stern greywater tank. 2. Change and repairing of EVAC-equipment.
MISCELLANEOUS
1. Repairing of hot water system valves. 2. Repairing of washing machines.

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WORKS MS ESTONIA Month NOV. **Year** 1993

JOBS MADE IN NOVEMBER (EL. PART).

1. Repairing of AlaéCarte coffee machine heater.
2. Repairing of juice maker in galley.
3. Repairing of control & indication unit of elevator 4.
4. Repairing of refrig. case in galley.
5. Adjusting of ME sea cooling water pressure analog transmitters.
6. Cable & installing jobs in Pub.
7. Drawings of two data cables in Pub.
8. Cleaning of analog sensors of ME.
9. Replacement of dish washing mashine safety limit switch in mess pantry.
10. Replacement of el.magn. valve in dish wash. machine in Night Club.
11. Drawing of new DB L 13B feeding cable.
12. Replacement of sewage blower 1 bearings.
13. Repairing of shaker in Pub.
14. Replacement of Steermaster back up acc.batteries.
15. Repairing of deck washing mashines Kärcher - 2 pcs.
16. Mounting of three lock switches in elevators 3, 4.
17. Adjusting of elevator 3 slow speed switches u 10.
18. Replacement of aux engine exhaust gas thermocouples.
19. Repairing of galley elevator bell.
20. Replacement of swimming pool heater.
21. Cleaning & adjusting of RPM indicators on bridge.
22. Repairing of Karaoki machine stabilizer.
23. Repairing of two ampermeters on MDB.
24. Greesing of all 7 MDB breakers motor operating mechanisms mooving parts with Molycote Longterm 2 plus.
25. Repairing of stern holiday lighting.
26. Drawing of fin system cables.
27. Replacement of fire alarm station smoke sensors(2 pcs).
28. Dismantling, replacement of back bearing of sewage water pump motor.
29. Repairing, prophylactic of PS shore connection board.
30. Repairing of phone apparatus from store.
31. Replacement of regulating switch of food warmer in Poseidon.
32. Repairing & testing of fire alarm smoke detectors.
32. Repairing of main engines turbocharge air cooling system sensors.
33. Installing of stern winch of central part of holiday lighting.
34. Repairing of food warmer in Poseidon.
35. Repeiring of 8 deck lidhting.
36. Mounting of fuil nozzle tube heater.
37. Replacement of bow ramp detecteur indact.
38. Replacement of CPP level pump port magnet coil & transformer.
39. Adjusting of contr. sea water ME 3,4.

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WORKS MS ESTONIA Month OCT. **Year** 1993

MAIN ENGINE
1.ME3 cyl.7 and 8 overhaul.Cyl.1 change of exh.valves. 2.ME1 cyl.2 overhaul.Repairing of starting pilot valve. 3.ME4.cyl.2 change of cyl.cover.Cyl.8 and 5 change of exhaust valves.Repairing of starting pilot valve. 4.ME2 and ME4 change of fuel injector valves.
AUXILIARE ENGINE
1.AE 1,2,3,4 .Checking and adjusting clearences of inl.- and exh. valves.Survey of camshafts (bearings,cams, gear wheels) and roller guide assembly.Change of oil in turbocharger and governor. 2.AE1.Test and survey safety devices.
PUMPS
1.Repairing of boiler circul.pump no.1 (bearing,seal). 2.Repairing of boiler pumps no.1 and 2. 3.Repairing of hot water circul. pump no. 2. 4.Repairing of trim pump.
COMPRESSORS
1.Air compr.no.1.Change of 1.and 2.stages coolers. Cleaning of 3.stages cooler. 2.Air compr.no.2.Change of induction and exhaust valves of 3.stage.
PIPE SYSTEM
1.Repairing of ME sea water system pipelines.
PURIFIERS
1.L.O.purifier no.1.Change of vertical shaft with bearings,change of horizotal shaft bearing(st.b.) 2.L:O: purifier no.3.Change of vert.and horizontal shafts bearings.
MISCELLANEOUS
1.Cleaning of tanktop in E.R.Cleaning and painting in sewage room.Repairing of bow ramp locks. Overhaul of ME cyl.covers.Overhaul of ME fuel injector valves.

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WORKS MS ESTONIA Month OCT. **Year** 1993

AIRCONDITIONING
1.Cleaning AC filters. 2.Change of fans belts.
ACCOMMODATIONFANS
1.Change of themoregulators in pass.cabins. 2.Repairing of pass.cabins air mixers.
KITCHEN
HOTEL
1.Removing of freezers in "Neptunus",removing of freon and water pipelines. 2.Installation of new sink,water and drainwater pipelines in "PUB".
SEWAGESYSTEM
1.Repairing and change of EVAC-equipment. 2.Repairing of outlet valve sewage plant no.2 3.Repairing of non-return valve sewage plant no.2.
MISCELLANEOUS
1.Repairing of hot water system valves. 2.Repairing of washing machines

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WORKS MS ESTONIA Month OCT. **Year** 1993

JOBS MADE IN OCTOBER (EL.)

1. Repairing & adjusting of code locks & their timer.
2. Repairing of terminal connection of ME exhaust fan.
3. Repairing & adjusting of generators breakers.
4. Replacement of back bearing of ME oil purifier N2.
5. Repairing of galley pans.
6. Making & installing of exchange office alarm,cable drawings
7. Cable drawings for Tallinn shore phone to INFO.
8. Repairing of bilge & sea valves indication sensors 6 pcs.
9. Repairing of gas alarm buzzer on bridge.
10. Replacement of time relais in ECR pulpet.
11. Grinding of bow thruster N2 sliprings.
12. Repairing of toaster(Poseidon restaurant).
13. Reassembling of luminaires in gift shop.
14. Adjusting of RPM sensor on aux.engine N1.
15. Testing, adjusting of TAMROCK pressostate.
16. Repairing of oil flow meters of boilers.
17. Replacement of exhaust gas thermocouple ME N3 cyl.N3.
18. Repairing of el. range in cold galley.
19. Repairing of Kärcher washing mashine main switch.
20. Assembling of distr. board for PUB.
21. Cable jobs in PUB.
22. Replacement of el.magnet valve in Night club dishwashing machine.
23. Dismantling of el. equipment in cafeteria.
24. Repairing of foodshop refrigerator.
25. Replacement of Salvico fire detect.station sensor.
26. Replacement of bow ramp position sensor.
27. Replacement of bow ramp signal lamps holders.
28. Repairing of flashing lights in Disco.
29. Deviding of lighting & locking boxes refrig. compressors mains.
30. Cable jobs in cafeteria.
31. Installing of hanging holiday lighting stern winch.
32. Repairing of galley mixer.
33. Repairing of kitchen foodprocessor.
34. Repairing of sauna washing mashine pump.
35. Installing of heater on condensate water keeper in Poseidon.
36. Replacement of swimingpool heater.

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WORKS MS ESTONIA Month SEPT. **Year** 1993

MAIN ENGINE

1.ME1 cyl.4.Change of cyl.cover.
2.ME3 cyl.3.Overhaul of piston,change of cyl.liner O-rings,cover.
3.Overhaul spare cyl.covers,cleaning,grinding valves.
4.Overhaul spare turbine rotor.
5.ME4 cyl.7 -change of fuel injector valve.

AUXILIARE ENGINE

1.AE1.Change of all main bearings.
2.AE2.Change of all cyl.covers,fuel injector valves.
Change of roller guide assembly cyl.2.
Change of high pressure fuel oil pump cyl.2.
3.AE 2,3,4 -Test and survey safety devices.

PUMPS

1.Repairing of grey-water pump nr.1.
2.Change of hot water circul.pump.

COMPRESSORS

1.Air compressor 1.-change of induction and exhaust valves of 1.and 3.stages.
2.Air compressor 2. Change of main bearings,connect. rod with bearings,induction and valves of 1.and 3.stages.

PIPE SYSTEM

1.Repairing of fire extinguishing system pipelines in AE room.
2.Repairing of ballast system pipelines in ME room.
3.Change of part of vacuum system pipelines on 1.deck.

PURIFIERS

1.Change of vertical and horizontal shafts bearings in F.O.purifier 1.

MISCELLANEOUS

1.Cleaning of thermaloil boilers nr.1 and 2.
2.Change of F.O.pump on thermaloil boiler nr.2.
3.Repairing of lifeboat nr.2 winch gear.
4.Repairing of sternramp P.S.

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WORKS MS ESTONIA Month SEPT. **Year** 1993

AIRCONDITIONING
1.Repairing and adjustment of thermal oil valves. 2.Change and cleaning AC filtres.
ACCOMMODATIONFANS
1.Change of thermoregulators in pass.cabines. 2.Repairing of pass. cabines air mixers.
KITCHEN
HOTEL
SEWAGESYSTEM
1.Cleaning of sewage plant nr.1. 2.Cleaning of blocked pipes in sewage system. 3.Repairing and change of EVAC-equipment.
MISCELLANEOUS
1.Repairing of washing machines. 2.Repairing of garbage containes.

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WORKS MS ESTONIA Month SEPT. Year 1993

JOBS MADE IN SEPTEMBER
ELECTRIC PART

1. Repairing of two welding transformers.
2. Repairing of four oil mist detectors.
3. Repairing of overhead, starboard & port side projectors
4. Repairing of temperature regulating valve AC-12.
5. Adjusting of propeller shaft bearings temperature sensors.
6. Replacement of inductive RPM sensor of aux. eng. N 1.
7. Repairing of ME 3 & 4 cooling water pumps stand by time relais.
8. Repairing & prophylactic of all outside lighting.
9. Repairing of generator breakers 1 ,2 ,3, 4 motor operating mechanism.
10. Repairing of ME 3 cyl. 3 exhaust gas thermocouple cable.
11. Repairing of elevator N 2.
12. Replacement of pilot doors connecting boxes.
13. Replacement of grey water pump N 1 bearings.
14. Repairing of code locks.
15. Repairing of bilge valves indication switches.
16. Rebuilding of data office.
17. Cable drawings for data office.
18. Repairing of cash-desk transporter band motor.
19. Replacement of water hydropump N 1 contactor.
20. Replacement of carbidge container pressostate switch.
21. Jobs according to maintenance plan for september.

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NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month AUGUST **Year** 1993

MAIN ENGINE
1.ME1 cyl.8.Piston overhaul,change of cyl.cover. 2.ME3 .Change of exhaust gas turbine rotor. 3.ME1-change of 5 fuel injector valves. 4.Cleaning of lubricating oil coolers ME 1,2,3,4.
AUXILIARE ENGINE
1.Overshaul AE4-change of main bearings,big end bearings,piston rings.Installed overhauled cyl.covers and connecting rods.New o-rings to cyl.liners.Cleaning of lub.oil cooler. 2.Change of high pressure fuel oil pump on cyl.2 AE2 3.Change of fuel oil injector valves on AE3. 4.Change of oil filters,cleaning of purifier AE1.
PUMPS
1.Repairing of sewage pump on plant Nr2. 2.Repairing of sewage flush-water pump Nr4 on plant Nr1.
COMPRESSORS
PIPE SYSTEM
1.Repairing of hot water pipelines on deck Nr6 and Nr7. 2.Repairing of fire water system on deck Nr7. 3.Repairing of cooling seawater and freshwater pipelines in ME-room.
SEPARATORS
1.Change of horizontal shaft bearings and gear wheel on F.O. separator Nr1. 2.Cleaning of F.O.separators Nr 1 and 2,L.O.separator Nr3,aux.eng. lub.oil separator.
MISCELLANEOUS
1.Overhaul of ME cyl.covers -2pcs. 2.Repairing of KaMeWa contr.oil cooler. 3.Overhaul of AE cyl.covers -6pcs. 4.Repairing of car deck pneumatic doors.

HARLI MOOSAAR Moosaar
CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month AUGUST **Year** 1993

AIRCONDITIONING
1.Change and cleaning AC filtres. 2.Filling with oil and freon AC compressor Nr1. 3.Repairing and adjustment of thermal oil valves.

ACCOMMODATIONFANS
1.Repairing of pass.cabines air mixers,change of broken parts. 2.Change of thermoregulators in pass.cabines.

KITCHEN
1.Repairing of water pipelines in kitchen. 2.Installation of new refrigerator. 3.Repairing of dish-washing machines,coffee-makers.

HOTEL

SEWAGESYSTEM
1.Cleaning of sewage plant Nr2. 2.Cleaning of ventilation pipes of sewage plants. 3.Repairing and change of EVAC-equipment. 4.Cleaning of glogged pipes in sewage pipelines.

MISCELLANEOUS
1.Repairing of garbage container. 2.Raepairing of washing machines.

HARLI MOOSAAR [signature]

CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month AUGUST **Year** 1993

JOBS MADE IN AUGUST BY ELECTRIC GROUP.

1.Repairing of lifts N 1-4,cleaning of door contactors,replacement of slide contacts,capacitors.
2.Repairing of hydraulic lift,replacement of capacitors.
3.Replacement of gas sensors N 6,9 of gas sensor system.Checking of system.
4.Replacement of bearings,cleaning and centring of el.motors therm. oil circ.pumps N 1,2.
5.Cleaning of ice generator on deck N5.
6.Adjustment of washing machine "Berkel" in pub.
7.Cleaning of contacts of el.car.
8.Replacement of car deck sensor of "Salvico".Checking of system.
9.Cleaning of searchlights.
10.Adjustment of safety systems ME.
11.Repairing of washing machines deck 1,8,changing of relays.
12.Adjustment of oil mist detectors Of ME 1-4.
13.Replacement of kitchen facilities.
14.Cleaning of K10,K11,K12.
15.Cleaning of batteries.
16.Drawing of data cables on deck N4.
17.Adjustment of time delay of relay switching on st.by pump of ME4.

HARLI MOOSAAR [signature]
CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month JULY **Year** 1993

AIRCONDITIONING

1.Filling with freon and oil AC compressor VSM-57EB N2.
2.Change of filtres on AC No 1-19B,washing filtres.
3.Cleaning of heat exchangers in AC.
4.Change of compressor in engine control room AC.

ACCOMMODATIONFANS

1.Greasing of fans bearings.
2.Repairing of cabines air mixers and thermoregulators.

KITCHEN

1.Repairing the hot water system in kitchen.
2.Cleaning the waste-water pipes.
3.Repairing of card-board press in kitchen.
4.Repairing of dish-washing machine.
5.Repairing barrows,shells,sliceing machines.

HOTEL

1.Repairing works on fresh water and sewage syatems in pass.cabins.
2.Change of water in swimming pool,cleaning of filtres.

SEWAGESYSTEM

1.Change and repairing of EVAC-equipment.
2.Repairing of chlorine dosator.
3.Installation of new aeration pipes to sewage plants No1 andNo2.
4.Cleaning of clocked pipes,repairing of sewage pipelines.

MISCELLANEOUS

1.Installation of new equipment in the bars and restaurants.
2.Repairing of restaurent equipment-coolers,coffee-machines,ice-generators,juice,milk apparats.

Ilorsoan
CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month JULY **Year** 1993

MAIN ENGINE
1.ME1 cyl.1-change of liner,cyl.cover and piston. 2.ME1 cyl.6-change of cyl.cover,overhaul of piston,change pist.rings 3.ME1 cyl.7-change of cyl.liner and cyl.cover,piston overhaul. 4.ME2-change of exhaust gas turbine rotor. 5.ME3 cyl.8-change of cyl.cover.
AUXILIARE ENGINE
1.AE1 cyl.2-change of rocker arms.
PUMPS
1.Repairing of hot water circulation pump. 2.Change of shaft seal on injectors cooling pump.
COMPRESSORS
1.Compr.N2-change of 3rd stage cooler. 2.Compr.N3-change of 1st and 2nd stage coolers.
PIPE SYSTEM
1.Elimination of leakage of cooling system ME4. 2.Elimination of fuel oil leakage on ME4.
SEPARATORS
1.Change of vertical spindel and bearings on lub.oil separator N2 2.Change of vertical spindel and bearings on lub.oil separator N3
MISCELLANEOUS
1.Overhaul and cleaning spare ME cyl.covers-3pcs. 2.Elimination of water leakage in KaMeWa contr.oil cooler Ps. 3.Painting in engine rooms. 4.Washing inengine rooms,cleaning the bilges.

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CHIEF ENGINEER

JOBS MADE IN JULY BY ELECTRIC GROUP

1. Repairing of paper press in galley.
2. Mounting of charger on cardeck & drawing of its cables.
3. Repairing of paper press in store.
4. Drawing of the cable to food shop, mounting of wall sockets.
5. Drawing of cable to dishwashing mashine in pub.
6. Repairing of handdriers in toilets.
7. Repairing of slicing mashine.
8. Replasement of bearings in oil circ.pump N1
9. Repairing of rectifier of hydraulic elevator.
10. Sliprings grinding & replasement of coal brushes of bow thruster N 1.
11. Repairing of window wiper on bridge.
12. Replacement of burned signal lamp transformers in motor starters.
13. Repairing of refrigerator in food shop.
14. Greasing of lower bearing in bow thruster N 1.
15. Hermetizing of lift N 3 door boxes on floor 1.
16. Installing of advertisment light in pub.
17. Repairing of coffee mashine in Poseidon.
18. Installing of grounding contactor of holiday lighting.
19. Installing of new sauna heater.
20. Replacement of two relais of generator breaker N 3.
21. Repairing of program circuit of cafeteria coffee machine.
22. Repairing of hanging deck indication.
23. Repairing of lift N 5 counterweight limit switch.
24. Drawing of cables to & installing of two coffee & two choco machines in Poseidon.
25. Drawing of four NMI antenna cables.
26. Replacement of two galley refrigerator contactors.
27. Repairing of lifeboat N 1 winch limit switch.
28. Greasing of front bearing of burner thermal oil pump N 1.
29. Replacement of aux eng. booster pump motor bearings.
30. Shifting of coffee machines, different connecting jobs in Poseidon.
31. Adjusting of boiler fuel oil heater temperature.
32. Installing of wall sockets in pub, cable drawings.
33. Repairing of bow thruster N1 rotor resistors.
34. Replacing of lift N 2 safety lock magnet.
35. Installing of phone in food shop.
36. Installing of spotlight & dimmer in pub, cable drawing.
37. Installing of door magnets on deck 8, cable drawing.
38. Repairing of generator N 3 undervoltage release delay unit.
39. Cleaning & grinding of emergency gen. starting batt. terminals, refilling.
40. Repairing of A-meters in motor starters.
41. Cleaning , drying , hermetizing, prophylactic of main engine exaust gas & bearings temperature sensores connecting boxes.
42. Installing of new dancing place blinking light transformer & its remote controle.
43. Replacement of mess dishwashing machine contactor.
44. Replacement of window wiper brush on bridge.
45. Cleaning & drying of Coca selling machine on deck 5.

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month JUNE **Year** 1993

MAIN ENGINE

1.Repairing of start air distributor on ME4.
2.Piston overhaul,change of cyl.liner o-rings Cyl.7 ME4.
3.Change of big end bearings upper halves ME4 Cyl.1-8.
4.Change of 10 turbocharger fixing bolts on ME2.
5.Overhaul spare cyl.covers,cleaning,grinding valves.

AUXILIARE ENGINE

1.Change of turbine rotor,bearings & oil on AE1.
2.Change of fuel injectors on AE2.
3.Change of oil filters,cleaning of purifier on AE 2,3&4.

PUMPS

1.Repairing of fresh cooling water pump-change seals,welding body.

COMPRESSORS

PIPE SYSTEM

1.Rebuilding of freon pipeline in PUB.
2.Repairing of hot water pipes in kitchen.
3.Repairing of waste water pipes on car-deck.

BOILERS

1.Cleaning of thermal oil boilers,checking of control system,cleaning leakage detectors.
2.Cleaning of boiler burners,survey.

MISCELLANEOUS

1.Cleaning the bilges in engine rooms.
2.Washing and painting in engine rooms.
3.Greasing of life-boat equipment,checking of life-boat motors.
4.Cleaning of provision plant coolers.
5.Overhaul of start air valves on ME4 Cyl.7&8.

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CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month JUNE **Year** 1993

AIRCONDITIONING

1. Change of filtres on AC No 1-19B. Washing filtres.
2. Repairing of 2 thermal oil valves.
3. Greasing of AC fans bearings.
4. Repairing of thermovalve on ECR AC.

ACCOMMODATIONFANS

1. Repairing of cabines air mixers.
2. Change of thermoregulators in cabines No 4322,4619.

KITCHEN

1. Repairing of isolation in kitchens cooling chambers.
2. Repairing of refrigerators.
3. Repairing of shells and barrows in kitchen.
4. Repairing of dish-washers.
5. Repairing of food cutting machines.

HOTEL

SEWAGESYSTEM

1. Cleaning of sections on sewage plant No 1 and 2.
2. Cleaning and checking of air compressor on sew.plant No 1.
3. Repairing of chlorine dosator.
4. Repairing of EVAC-equipment.
5. Cleaning of clocked pipes in sewage and waste-water systems.

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1. Repairing of ice-generators in bars.
2. Installation of new equipment in PUB and new shop.

MISCELLANEOUS

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CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month JUNE **Year** 1993

ELECTRICAL WORKS

1.Repairing the coffee machine in Poseidon.
2.Cable works in Pub.
3.Repairing of transporting band of cassa in the shop.
4.Replacement of contactor coil of fan N 17.
5.Refilling of loader batteries (cargo in cardeck).
6.Creasing of thermal oil circulating pump's motor bearings.
7.Repairment of elevator N 1:replacement of limit switch b 4, tension weight for lifts car speed governor.
8.Elevator N2 tightening of inner door.
9.Replacement of paper press belts in galley.
10.Replacement of d4 relais of control of watertight door N 12.
11.Repairment of cooking boilers in the galley,replacement of transformer & thermostate.
12.Repairing of washing machine deck 8.
13.Repairing of pressostate of boiler pressure.
14.Replacement of two st-by relais in ECR board.
15.Drawing of cable from cash desk in A la Carte to the bar.
16.Cooling water pump for refrigeration plant-replacement of bea-rings,greasing washing.
17.Repairing of 4 light armatures in fan rooms.
18.Eliminating of low insulation resistance L13,F17.
19.Replacement and connecting of rectifier (charger) of el.car.
20.Repairing of purifier in night club.
21.Adjusting of charger in life-boat N2.
22.Repairment of impeller of the cardeck fan N3 fore.
23.Replacement of bearings in fan motors ER39,41,AC7,AC19.
24.Taking off the lighting equipment in the pub,installing of new lamps,transformers.
25.Repairing of elevator N4,hermetizing of safety lock boxes in elevator N 3.
26.Repairment of rectifier in control box of hydraulic lift.
27.Checking cleaning of the level sensors of fresh water expanding tank.
28.Checking of all tachometers of all ME.
29.Repairing & adjusting of temperature regulators of AC plant.
30.Repairing of control electronic diagram of cafeteria coffee mach.
31.Repairing of window wiper at bridge.
32.Replacing of thermostate Of food heater in Poseidon.
33.Replacement of bearings in boiler circ.pump N2.
34.Grinding of slip ring 1 on bow thruster N1.
35.Replacement of fan motors bearings fans ER32,E25,installing of of steering gear room fans.
36.Repairing of coffee machine in Poseidon pantry.
37.Repairing of burned EXIT lamp armature in cardeck.
38.Replacement of burned signal lamp transformers in motor starters.
39.Replacement of pressostate of low pressure in hydrotank alarm.
40.Checking and greasing of toaster in the galley.
41.Repairing of timer in steamheated owen.

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CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month JUNE **Year** 1993

42.Drawing of data and 220 VPS main cables from gift shop to the food shop.
43.Drawing of cables to & installing of two Hartec safety valves.
44.Revision of all ramps control cirquits,replacement of 3 burned coils,cleaning,drying of connecting boxes,hermetizing.
45.Installing of rewinded transformer to K11 panel.
46.Installing of motor to wash.machine d7.
47.Repairing of vegetables cutter.
48.Changing of contacts in C2 contactor lift N4.
49.Replacement of burned coil of ECR air conditioner.
50.Checking of grill in the galley.
51.Checking of icecube machines d6,d4.
52.Repairing,changing of bearings,greasing of dishwashing machines in the galley.
53.Repairing of slicing machine.
54.Checking of all batteries,refilling,checking of battery chargers drawing of cable to navigation batteries charger.
55.Lighting equipment in accomodations,superstructure-checking, repairing.

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CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month MAY **Year** 1993

MAIN ENGINE
1.ME No 1 Cyl.5.Elimination of cooling water leakage between cylinder liner and frame.Overhaul of piston,change of cyl.cover. 2.ME No 2 Cyl.4.Elimination of cooling water leakage between cylinder liner and frame.Overhaul of piston,change of cyl.cover. 3.Elimination leakage of cooling water in exh.valves ME2 Cyl.2.
AUXILIARE ENGINE
1.Change of valve gear thrust piece and pipe on AE1 Cyl.2 2.Piston overhaul AE3 Cyl.1.Cheking of big end bearing.Change of cylinder cover studs.
PUMPS
COMPRESSORS
Repairing of compr No2.Change of piston,connecting rod,cylinder, all bearings,valves,piston rings.Crankshaft repaired in Sweden.
PIPE SYSTEM
1.Repairing of sea cooling water system in engine room.Change of flanges. 2.Elimination of oil leakage in the car deck hydraulic system. 3.Repairing AE 3 exhaust pipe in the funnel.
BOILER N 2
1.Change of shaft seal in fuel oil pump. 2.Repairing burner and change of solenoid valve.
MISCELLANEOUS
1.Cleaning spare ME cyl. covers,grinding the valves. 2.Change vertical shaft bearings in fuel oil purifier No 1. 3.Cleaning the bilges in engine rooms.

[signature]
CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month MAY **Year** 1993

AIRCONDITIONING
1.Change of filtres on AC No 1-19B.Washing filtres. 2.Cleaning of air coolers and heaters in AC 1-3. 3.Repairing and adjustment of thermal oil valves.-4 pcs.
ACCOMMODATIONFANS
1.Repairing and adjustment of thermoregulators in pass.cabines. 2.Repairing of pass.cabines air mixers.-5 pcs.
KITCHEN
1.Maintenance works of ice generators,cooling tables,refrigerators in restaurants,cafeteria,provision store. 2.Repairing the shells and barrows. 3.Repairing of disc washing machine.
HOTEL
SEWAGESYSTEM
1.Cleaning sewage system pipes with Gamazime DPS. 2.Repairing of EVAK-equipment. 3.Cleaning of clocked pipes on sewage and waste water systems.
MISCELLANEOUS

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CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month MAY **Year** 1993

ELECTRICAL WORKS

1.Restauration of start air compressor N 1 alarm & security diagram testing of air compressor N 2,3.
2.Replacement of cooking boiler's heating elements.
3.Repairing of air temperature regulators of AC-4,6,8.
4.Repairing of coffee machines of night club & Poseidon.
5.Dismantling,repairing of all outside alarm bells.
6.Repairing of three temperature measuring circuits of gear bearings
7.Replacement & repairing of two time relays in MKR console.
8.Replacement of burned coil of locking of cardeck door.
9.Drawing of 2 cables to crew's cabins DS PS.
10.Replacement of lamps armature in crew's dayroom.
11.Restauration of dry safety system of cooking boilers.
12.Checking of batteries& chargers.
13.Installing of two new syrenes in ER.
14.Restauration of automatic diagram of hot water circ.pumps.
15.Dismantling of burned motor of washing machine D7.
16.Dismantling of burned motor of potato slicer.
17.Replacement of bearings & installing of bow thruster room fans.
18.Replacement of bearings of AC-1 fan motor.
19.Repairing of washing machine deck 8.
20.Revision,tightening etc.of ECR consoles.
21.Revision,tightening,test of disc washing machines 1,2 in galley.
22.Replacement of current relay of bow hydr.pump N 2.
23.Replacement of inductive switch of stern ramp.
24.Repairing & adjustning of cooling liquid sensor of Emerg.Gener.
25.Adjustning of air shield opening solenoids of Emerg.Gener.
26.Installing of dacing light transformer.
27.Repairing of pass.elevator N 1.
28.Repairing of fire alarm pushbuttons.
29.Cleaning greasing,testing of slicing machine.
30.Repairing,replacing of disc washing machine water pump.
31.Repairing of air shield reducting gear of oil burner.N2.

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NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month APRIL **Year** 1993

AIRCONDITIONING
1.Change and cleaning filtres of AC N1-:-19B 2.Repairing and cleaning the AC unit in computer-room. 3.Elimination of freon leckage in engine control roomAC.
ACCOMMODATIONFANS
1.Repairing of pass.cabines air mixers,change broken parts.3 cabs. 2.Change thermoregulators in pass.cabines.4 pcs.
KITCHEN
1.Repairing of milk-cooler,elimination of leckage. 2.Cleaning of ice-generator. 3.Installation of kitchen equipment,pipeline works.
HOTEL
SEWAGESYSTEM
1.Cleaning of sewage plant N1 2.Repairing the EVAK-equipment. 3.Cleaning of blocked pipes.
MISCELLANEOUS

[signature]
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NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month APRIL **Year** 1993

MAIN ENGINE
1.Main engines N1&3.Change of connecting rod big end bearings upper halves.Cyl.N1-8. 2.Main engine N3,cyl.N4.Piston overhaul.Change of pisto,piston rings,cyl.cover.Cleaning of cyl.cover,grinding valves. 3.Main engine N4.Change of charging air turbine.Cleaning the spare turbine change of bearings.
AUXILIARE ENGINE
1.Overhaul AE N3.Replacement of pistons,piston rings,cyl.liners, connecting rods,main bearings,big end bearings,cyl.covers. 2.Overhaul spare cyl.covers,taken from AE3,cleaning,grinding valves
PUMPS
1.Repairing of main engine sea water pump.Change of impeller,shaft, and shaft seals. 2.Repairing of circulation pump of warm washing water. 3.Repairing of swimming pool circulation pump.
COMPRESSORS
PIPE SYSTEM
1.Repairing by welding sea water pipelines in eng.rooms. 2.Change of leaking waste water pipes on the ceiling of car-deck. 3.Change pipes of water system on deck N5. 4.Cleaning the clocked pipes in sewage system.
BOILER N2
1.Cleaning the boiler and fuel oil burner.
MISCELLANEOUS
1.Repairing the cover of warm water heater,cleaning the heater. 2.Repairing of thermostatic valve in fresh cooling water system of main engine N2. 3.Cleaning the bilges in engine rooms,washing works in engine rooms.

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CHIEF ENGINEER

NORDSTRÖM & THULIN AB

WORKS MS ESTONIA Month APRIL **Year** 1993

Works made in april(el.side)

1.Adjustment of floor switches of lifts NN 1,2,tighiening of contacts of all lifts,replacement of one floor switch [illegible] N2.
2.Checking up,refilling of all batteries,checking of chargers.
3.Restauration of floor & kile's switches of [illegible] lift.
4.Replacement of 3 coal brushes of bow thruster [illegible].
5.Cleaning of main distributing board,emergency DD,K-DD.
6.Restauration of bilge water separator heaters [illegible] p.p.m.-meter.
7.Replacement of bearings of ME preheater water pump.
8.Adjustment of idle voltage of gen.N2.
9.Change of capacitor of computer room's air conditioner.
10.Replacement of magn.valve of gen.N1 starting syst.
11.Repairing of lift N1 door closing motor & mechanism.
12.Replacement of barings of bow thruster room fans.
13.Replacement of fuel gas detecting sensor.
14.Checking of overhead projectors.Tightening.[illegible]
15.Replacement of generator N2 breaker contacts.
16.Control & adjustment of alarm bells inside.
17.Replacement of floor switches of galley lift.
18.Cleaning of N2 panel of sewage treatment plant.
19.Cleaning,tightening of contacts of ME control panels in eng.room.
20.Repair of coocking boilers in the galley.

Moosaar
CHIEF ENGINEER

SUPPLEMENT No. 231

Extracts from docking specification and quotation 25.9.1992 for Wasa Line re MV WASA KING's docking 1993.

EXCL X

1/5

M/S Wasa King
Dockningsspecifikation 1993

Particulars	
Passengership	
LOA 157.00	Bureau Veritas
LPP 137.40	DWT 3345
B.extr. 24.2	Gross 15598
Draft 5.55	Net 8394

Allmän del

01 Indockning, utdockning, 1 dag dockstående

02 Dockstående / dygn

03 Anslutning av elkablar
Leverans av el 1200 A, 380 V, 50 Hz

04 Anslutning av brandslangar

05 Anslutning av dricksvatten
Leverans av dricksvatten

06 Anslutning av telefon
Samtalsavgifter

07 Brandvakt

08 Avfall

Övrigt

70.22 Akterramperna, skalkningarna service samt förstärkningar

71.22 Akterramperna, gångjärn överhalas, nya bussningar.

72.22 Förramp och Visir skalkningar överses förstärkes.

73.22 Förramp, gångjärn överhalas eventuellt nya bussningar.

74.22 Visir 15 m och ramp-packningar 10 m förnyas

75.22 Vajerbyten på bildäckshyllorna

.TD

To: VAASANLAIVAT OY

No: 961-3260199

Attn:

From:

Date: 25.9.1992

Ref:

No. of pages including cover sheet: 16

IF NOT CORRECTLY RECEIVED PLEASE REPORT IMMEDIATELY

Subject: M/S "WASA KING"

OHEISENA LÄHETÄMME TYÖ-
KAPPALEEN TARJOUKSESTAMME
KOSKIEN 18.9 PÄIVÄTTYÄ ERITTELYÄ
ALUKSELLA SUORITETTAVISTA TÖISTÄ
TAMMIKUUSSA -93.
PUHTAAKSIKIRJOITETUN TARJOUKSEN
LÄHETÄMME VIIKKO 40 ALUSSA.

YSTÄVÄLLISIN TERVEISIN

TURUN KORJAUSTELAKKA OY
MYYNTIOSASTO

EI TARVITSE LÄHETTÄÄ PUHTAAKSI KIRJOITETTUA! puh. kesk. 25.9 klo 11.40 KLAAVAN KANSSA RAUKAU-N KULKUESSA!

25.9.1992

EHCL Y

PELAKOINTI TURUSSA

M/S "VAASA KING"

1.	In och utdockningen inkl. en dag i docka	,-
1.1.	Omändring av dockningsbädden	),-
2.	Stående i docka, dockshyra/dygn	),-/dygn
3.	Anslutning av el-kabel	,-/anslutning
3.1.	Leverans av el-ström 1200 A, 18000,- VAS: NAANTALISSA	0,60/kWh
4.	Anslutning av brandslang	-/anslutning
5.	Anslutning av dricksvatten	/anslutning
5.1.	Leverans av dricksvatten	11,-/m³
6.	Anslutning av telefon	,-/kabel
6.1.	Samtalsavgifter	0,65/impuls
7.	Brandvakt	,-/8 h skift
8.	Borttransport av avfall 150 l	,-/gång
9.	Anslutning av kylvatten för hjälpmotorer	-/anslutning
9.1.	Leverans av kylvatten	,-/dygn
10.	Anslutning av tryckluft	-/anslutning
10.1	Leverans av tryckluft 7 kp/cm²	,-/ arbetsskift

58.26 Röret mellan fettavskiljningstanken i spritförrådet och gråvattentanken i separatorummet förnyas. Diam 110 mm, L 12 m, 4 st krökar 90° samt flänsar.

INDIKAATIO HINTA

59.26 Bilgevattentank no 33, 22 m³, rengöring.

60.26 Smutsoljetank no 42, 13 m³, rengöring.
JÄTEÖLJYN MÄÄVITYS FAKTAN MUKAAN

61.26 Sludgetank no 44, 25 m³, rengöring.

HINTA TARKASTUKSEN JÄLKEEN

62.26 HJM Avgaspannor 4 st, Sanea 65 m² reparation, förnyande av bottnet.

INDIKAATIO HINTA

63.26 Hisschakten på 2 provianthissar, skotten riktas, avståndet för stort till hisskorgen

HINNOITELLAAN KUN TYÖN LAAJUUS ON MÄÄRITELTY

64.26 Flexibel tryckslang med stålväv, diam 50 mm, längd 200 mm, 150°C, 8 st insättes i HUM H.O.fuel tryck och returrör.

65.26 Expansionstankar i HUM kylsystem rengöres och målas 2 st x 1,5 m³.

Övrigt

70.22 Akterramperna, skalkningarna service samt förstärkningar

71.22 Akterramperna, gångjärn överhalas, nya bussningar.

72.22 Förramp och Visir skalkningar överses förstärkes.
HINTA TARKASTUKSEN JÄLKEEN

73.22 Förramp, gångjärn överhalas eventuellt nya bussningar.

74.22 Visir 15 m och ramp-packningar 10 m förnyas

75.22 Vajerbyten på bildäckshyllorna (12 VAIJERIA)

SUPPLEMENT No. 401

Weather Conditions on the Northern Baltic at September 28, 1994.

Estonian Meteorological and Hydrological Institute.

Tallinn 1995.

ESTONIAN METEOROLOGICAL AND HYDROLOGICAL
INSTITUTE

WEATHER CONDITIONS ON THE NORTHEN BALTIC AT SEPTEMBER 28, 1994

Tallinn

Stormy night on Baltic sea September 27-28, 1994.

Meteorological conditions.

September 27, in the morning at 06 GMT, a new Low formed over South Norway.The developing Low moved quickly towards east-northeast and reached September 28 at 00 GMT Aland archipelago.
During this period south, soutwesterly winds gradually icreased.

Wind.

About weather conditions at night of the shipwreck of the ferry "Estonia" we can judge by data observed on meteorological station Ristna (peninsula Kõpu, Hiiumaa), the nearest available station to the place of the shipwreck and characterising best of all the weather condition in the Northen Baltic.

Tab.1 Wind speed in **Ristna** and theoretical heights of waves in Northen Baltic

Data	Time (GMT)	Direction	Mean speed (m/s)	Gusts (m/s)	Height of waves, mean/max (m)
27.09.	11	SW	12	16	2-4/ 5
"	14	SW	12	16-17	2-4/ 5
"	17	SW	8	12-16	2-4/ 5
"	20	S, SW	8	14-15	2-4/ 5
"	23	SW	16	21-22	4-6/ 7
28.09.	02	SW	15	22-23	5-7/ 8
"	05	W	18	24-29	6-7/ 9
"	08	W	17	26	6-7/ 9
"	11	W	12	18	4-6/ 7

Additional storm information from observation stations:

1.Ristna	- Sept. 27	20.45 GMT	230°	9-16 m/s
	- Sept. 28	02.36 GMT	240°	15-25 m/s
	"	03.00 GMT	260°	20-29 m/s
2.Vilsandi	-Sept.27	21.25GMT	230°	15-20 m/s
	Sept.28	03.30GMT	240°	15-20 m/s
	"	07.25GMT	260°	20-27 m/s

We can see that before midnight (GMT) the speed of the SW wind was up to 20 - 22 m/s in gusts.
Maximum wind speeds - 25 -30 m/s in gusts were observed between 00 and 03 GMT (02-05 local time) September 28, which was connected with passing of the cold front.

Waves.

The (theoretical) height of waves is determined by method of the State Oceanografical Institute USSR. By this method were made wave height field maps, taking into concideration direction,speed and time of affect of the wind. From these maps were taken the heights, given in the table above and which were dominating in the "Estonia" shipwreck region at night September 28 1994 .
The dominating theoretical height of waves in the evening September 27 in the Northen Baltic was about 2-4 m, increased toward midnight and at the time of the shipwreck it was 4 - 5m. Early in the morning September 28 wave heights at the mentioned place were not more than 5 - 7 m.

The maximum wave heights in the Northen Baltic could be 6 - 7 m before and up to 9 m after shipwreck.

Forecasts.

In the morning September 27 were given galewarnings and forecast about increasing soutwesterly wind 12-17 m/s and wave heights 2-3 m at the Northen Baltic in the afternoon.
At 12.30 (GMT) September 27 a new warning was given about increasing SW wind to 17-20 m/s in the evening and veering to W in the morning September 28.

Marmor
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Chief of the hydrological forecast section

Ivo Saaremäe
Vice director of the Meteorological Centre

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The BALTIC SEA STORM on 28.9.1994

An investigation into the weather situation which developed in the northern Baltic at the time of the accident to m/s Estonia

Marja-Leena Komulainen

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THE BALTIC SEA STORM ON 28.09.1994

Abstract

At the time m/s Estonia sunk the weather was stormy. This storm was caused by a depression, typical for the time of year, which moved across the Baltic Sea and Gulf of Bothnia on the night 28.09., when the accident occurred. On the evening preceding the accident the wind in the accident area blew ahead of the front from the south or south-south-east with a mean speed varying between 12 and 15 m/s. According to the weather data the front passed the accident location at about 19 UTC, after which the prevailing wind direction was from between south-west and west. At 21 UTC the mean wind speed in the accident area was approx. 18 m/s, with gust up to 24 m/s. At 00 UTC (02 local time) a south-westerly wind with a mean speed of approx. 20 m/s prevailed, the strongest gust measured between 00 and 03 UTC being 29 m/s at Ristna. At 03 UTC the wind blew from the west, later veering further to between west and north-west, at which time the mean wind speed was 23 m/s, with a gust maximum of over 27 m/s. At Finnish stations the highest wind speeds were measured at about 06 UTC (08 local time). In the early hours of the morning the sea temperature was approx. 13 deg. C and the air temperature about 10 deg. C International shipping receives weather information through various different channels. Over the Baltic Sea region weather forecasts and warnigs in English are disseminated by coastal radio stations. On 27.09. and 28.09. gale warnings issued by FMI were transmitted over VHF channels by Helsinki and Mariehamn coastal radio stations. The storm warning was heard on the Finnish Broadcasting Company's Radio Suomi in Finnish and Riksradio in Swedish as part of the regular marine weather broadcasts. Strong wind and gale forecasts are issued in English by the Navtex system. According to an agreement made in 1983, Sweden coordinates weather warning activities on this system in the Baltic Sea region. The Baltic area has recently seen the emergence of several newly-independent countries. Coordination of the wind forecasts and warnings issued by different countries for international shipping in the same area needs to be strengthened.

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CONTENTS

1. INTRODUCTION

Early on the morning of 28th. September, 1994, the Finnish Meteorological Institute (hereafter FMI) received news of the occurrence of a major marine disaster, the loss of the m/s Estonia, off the island of Utö.

The FMI put at the disposal of the Ministry of Communications and the international commission of inquiry its expertise to carry out an analysis of the weather situation prevailing on the night of the accident (letter no. 14/090/94 dated 3.10.1994 from the FMI to Minister Ole Norrback). In support of this, observations from FMI weather stations near the location of the accident, weather map material and Doppler weather radar network data for the hours preceding and following the accident have been collated in this report. FMI marine weather forecasts from the preceding evening and the night of the accident have also been included. The weather analysis has been made with especial care regarding the track of the deepening depression and the movement of the associated fronts. Changes in the direction and speed of the wind affected the formation of waves and e.g. the drift direction of the lifeboats and rafts.

Finnish marine lifesaving centres receive wind forecasts for different sea areas twice daily. The Archipelago and Åland coast guard districts received such wind forecasts from FMI on 27.9.1994, the day preceding the accident, at about 9.30 and 21.30 local time. (In this report, local time is used to denote Finnish local time, 2 hours ahead of UTC). In addition to these, the Finnish Broadcasting Company broadcast marine weather forecasts and a storm warning for the area at 19.10 and 22.10 in Finnish and at 19.10 and 22.05 (all times local) in Swedish. Helsinki coastal radio broadcast forecasts and warnings in English at 21.33 and Mariehamn coastal radio at 22.33 local time. Supplementary information for those taking part in the rescue operations was given by FMI Central Weather Service marine forecasters and by forecasters at the Southern Finland Regional Office and its subsidiary unit at Turku. A marine weather facsimile service was also initiated to aid the rescue work.

2. DEVELOPMENT OF THE WEATHER SITUATION

At 00 UTC on 27.9.1994 (02.00 local time) a wave on the polar front was situated in the vicinity of the British Isles; to the north of the wave, and associated with it, was a trough in the cold air-mass. The trough is denoted on the synoptic charts as an occlusion, as the trough and polar-front wave together constitute a so-called "instant occlusion" (Pearson and Stewart, 1992). The depression had already begun to deepen (Fig. 1A). At 12 UTC the deepening low, with a central pressure of 987 hPa, was situated near Oslo and was moving eastwards. The associated polar front wave and trough also moved east (Fig. 1B). 12 hours later, at 00 UTC on 28.9.1994, the low centre of 982 hPa was to be found

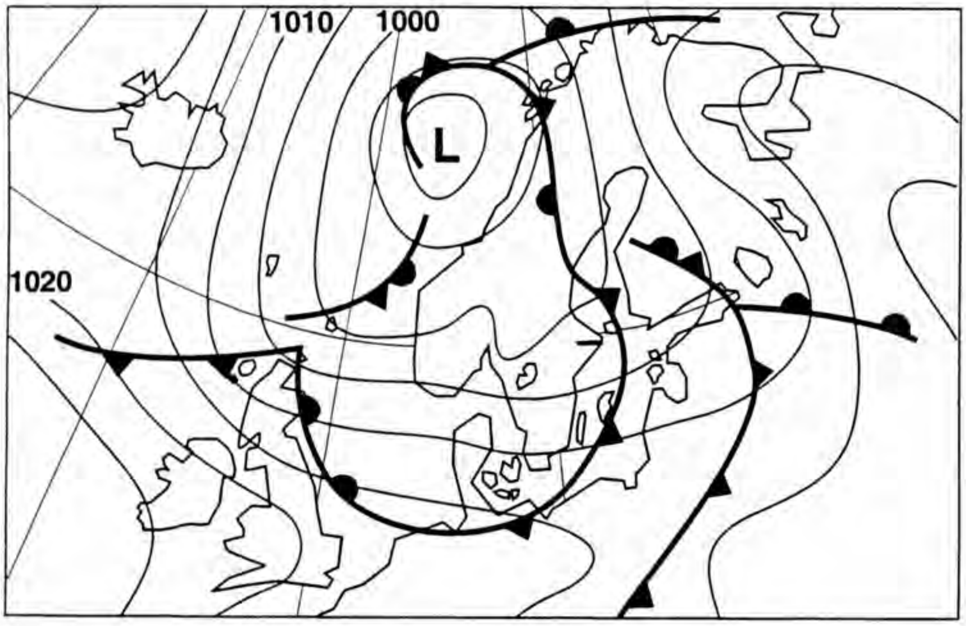


Fig. 1A)
Synoptic weather situation
27.9.94 00 UTC

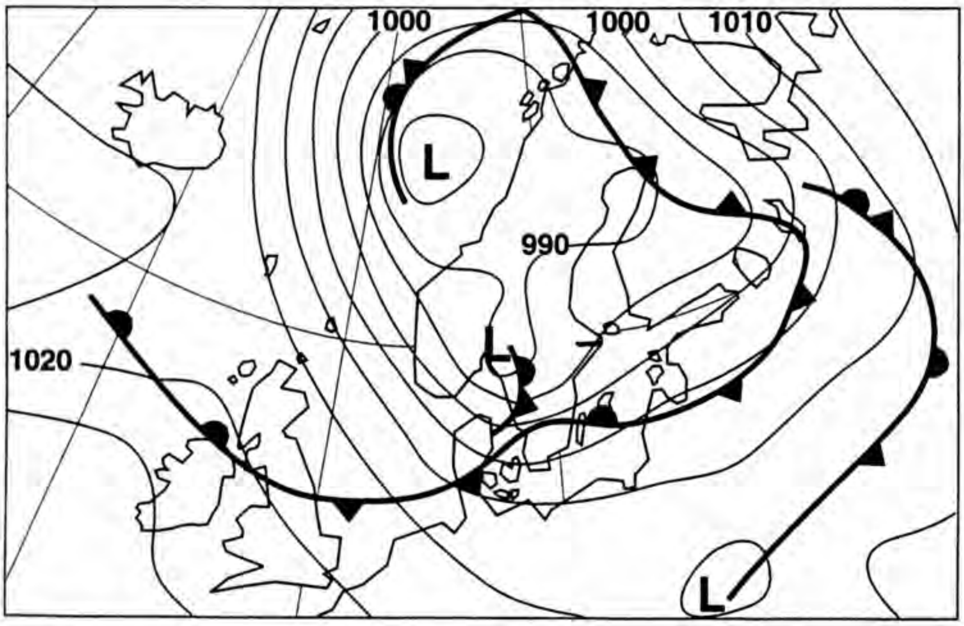


Fig. 1B)
Synoptic weather situation
27.9.94 12 UTC

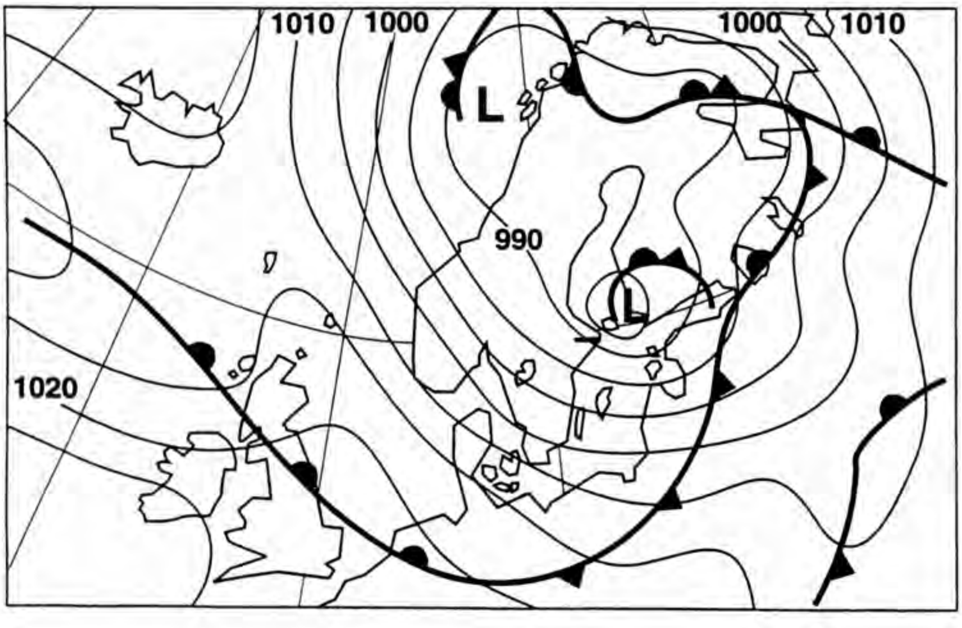


Fig. 1C)
Synoptic weather situation
28.9.94 00 UTC

north of Åland in the southern Gulf of Bothnia. At this time the actual wave on the polar front was already moving away to the east of Finland, but the depression situated in the cold air-mass, together with the trough, moved more slowly. The depression deepened slightly still further (Fig. 1C). The synoptic weather situation at the time of the accident is depicted in Fig. 2. The track of the low centre can best be seen from Fig. 3F. The fronts in the vicinity of the area of the accident are also shown in Figs. 3A - 3F. The position of the centre of the low is marked in the figures with an asterisk. In this particular weather situation the passage of the fronts was not associated with sudden changes in wind speed or direction. Statistically, the tracks of depressions at the end of September and during October run from the south of Iceland over southern Scandinavia and then in a north-easterly direction, so that the track taken by this depression was quite usual. Central pressures below 980 hPa are unusual: depressions this deep cross Finland on average twice in October. Storm-force winds may be associated with them. The central pressure of the low on 28.9 was 981 hPa. The strongest momentary gust measured in connection with this low, 29 m/s, was recorded at the Ristna weather station between 00 and 03 UTC. At that time the ten-minute average wind speeds measured by weather stations in the northern Baltic Sea were in the range 17 - 23 m/s.

2.1 The weather from 18 UTC (20 local time) on 27.9.1994 onwards

The synoptic weather situation near the time of the accident is depicted in Fig. 2. The front is shown as an unbroken thick line. To the rear of the front the winds have strengthened and veered (turned clockwise) to the south-west. The arrows mark the position of a dry and gusty airstream which has intruded between the front and the centre of the depression as a narrow tongue of clearer weather. Shower clouds are associated with the cloudy area of the depression, but before 00 UTC on 28.9. no lightning was observed in the sea area; after that time lightning was observed locally inland over south-western Finland. In the series of figures 3A - 3F are shown the locations of the weather observation stations surrounding the accident area. The wind speed and direction, as well as the sea temperature, have been plotted at each station location. The convention shows the wind blowing towards the station. The wind speed is depicted with barbs and black triangular flags. A black flag indicates a wind speed of 25 m/s (50 kt), a long barb a speed of 5 m/s (10 kt) and a short barb a speed of 2 - 3 m/s (5 kt). The wind information from the stations has been shown in the figures at 3-hourly intervals. The frontal zone movement can be seen from Figs. 3A - 3D; the front is estimated to have passed over the accident location at approximately 19 UTC (21.00 local time), after which the wind veered south-west and strengthened. Before the passage of the front the wind backed (turned counter-clockwise), and for a period of about two hours probably blew from the south or south-south-east. As is usual during the passage of a front, the wind veered, in

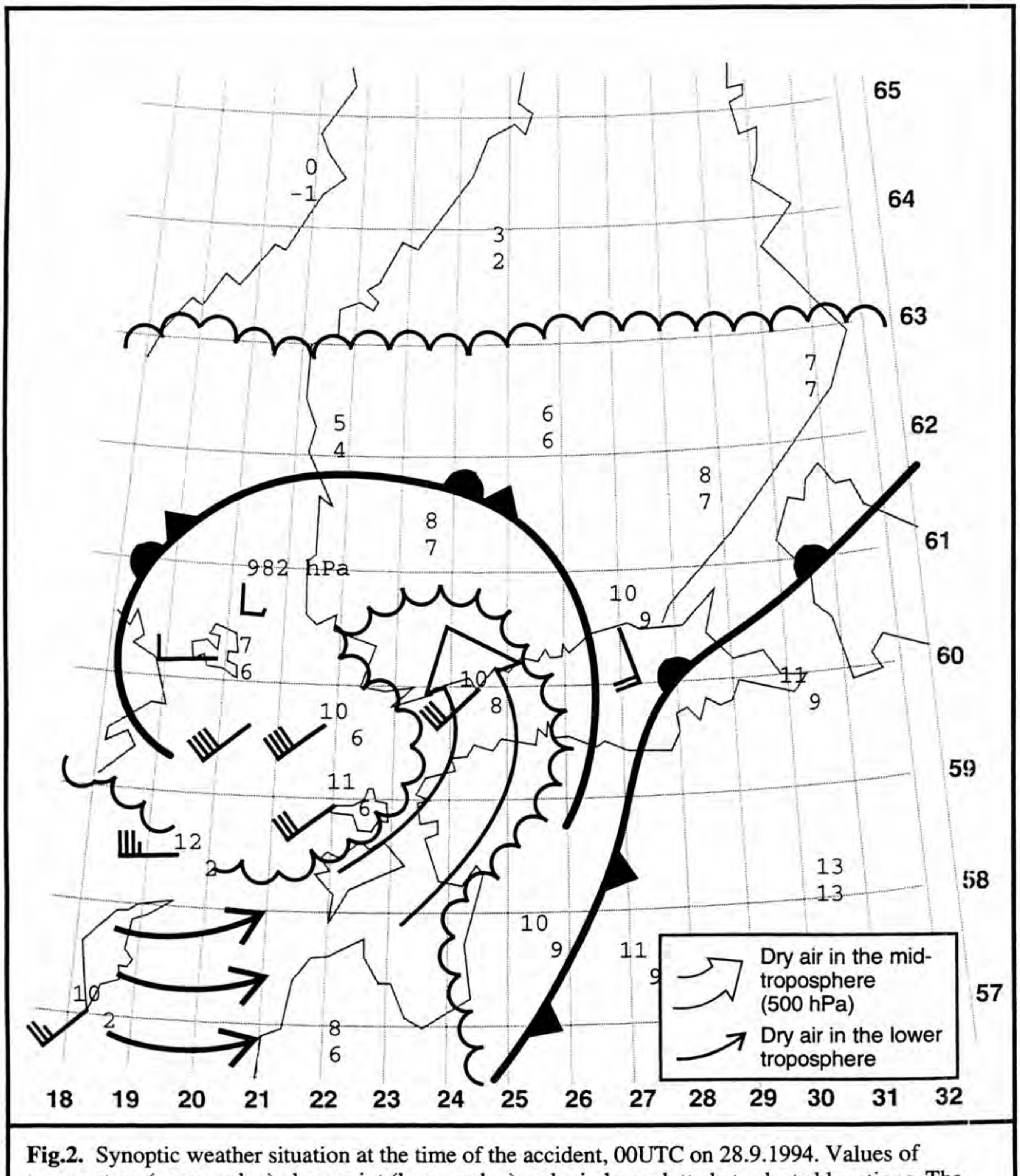


Fig.2. Synoptic weather situation at the time of the accident, 00UTC on 28.9.1994. Values of temperature (upper value), dew-point (lower value) and wind are plotted at selected locations. The wind speed is in knots, with the longer barb representing 10 kt, and the shorter 5 kt.

this case to between south-west and west. At Bogskär a momentary gust maximum of 24.6 m/s was recorded at 21.26 UTC (23.26 local time). At this time the wind in the area of the accident was blowing from between south-west and west at an average speed of about 18 m/s. The wind continued to strengthen, by 00 UTC (02.00 local time) attaining a mean speed of 20 m/s at the location of the accident, and 3 hours later 23 m/s. At 04.39 UTC (06.39 local time) the weather station at Nyhamn recorded a mean speed of 24.8 m/s from the west-north-west. At 06 UTC Nyhamn's mean wind speed was 24 m/s, and at about the same time (05.25 UTC) a maximum gust of 27.7 m/s was measured at Bogskär. The anemometer height at Nyhamn is 50 m and at Bogskär 31 m. In stable conditions the readings from these two stations have to be subjected to a reduction of about 20% in order to make them comparable with wind speeds at the internationally-agreed height of 10 m. Since the prevailing weather situation was showery and unstable, it is possible that the wind at sea level may also have momentarily reached the previously-mentioned gust strengths. According to the observations, the wind was at its strongest during the rescue operations on the morning of 28.9. The sea surface temperature in the northern Baltic Sea was 14 deg. C during the evening of 27.9, after midnight 13 deg. C and 12 deg. C on the morning of 28.9. On the night of the accident the air temperature in the area varied between 12 deg. C and 8 deg. C.

3. METEOROLOGICAL DATA

3.1 Weather observations from synoptic and automatic stations

Finnish synoptic weather stations, making weather observations at 3-hourly intervals, are situated at Utö and Russarö in the neighbourhood of the accident. Finnish automatic marine weather stations (AWS = automatic weather station) are located at Tulliniemi, Vänö, Fagerholm, Bogskär and Nyhamn. Observations from Kumlinge and Harmaja AWS's have been made use of in the investigation, as have also wind readings from the Sottunga wind-energy experimental station. Observations at 3-hourly intervals from the Ristna synoptic station as well as hourly observations from the Prangli and Osmussaare AWS's have been obtained from Estonia (Eesti Vabariik). Additionally weather observations from certain Swedish stations (Gotska Sandön, Svenska Högarna and Söderarm) have been plotted on the weather charts at three-hourly intervals (Figs. 3A, 3B, 3C, 3D, 3E, 3F). Time-series from certain of the observation stations in the vicinity of the accident have been included (Annex 1).

3.2 Surface weather analyses

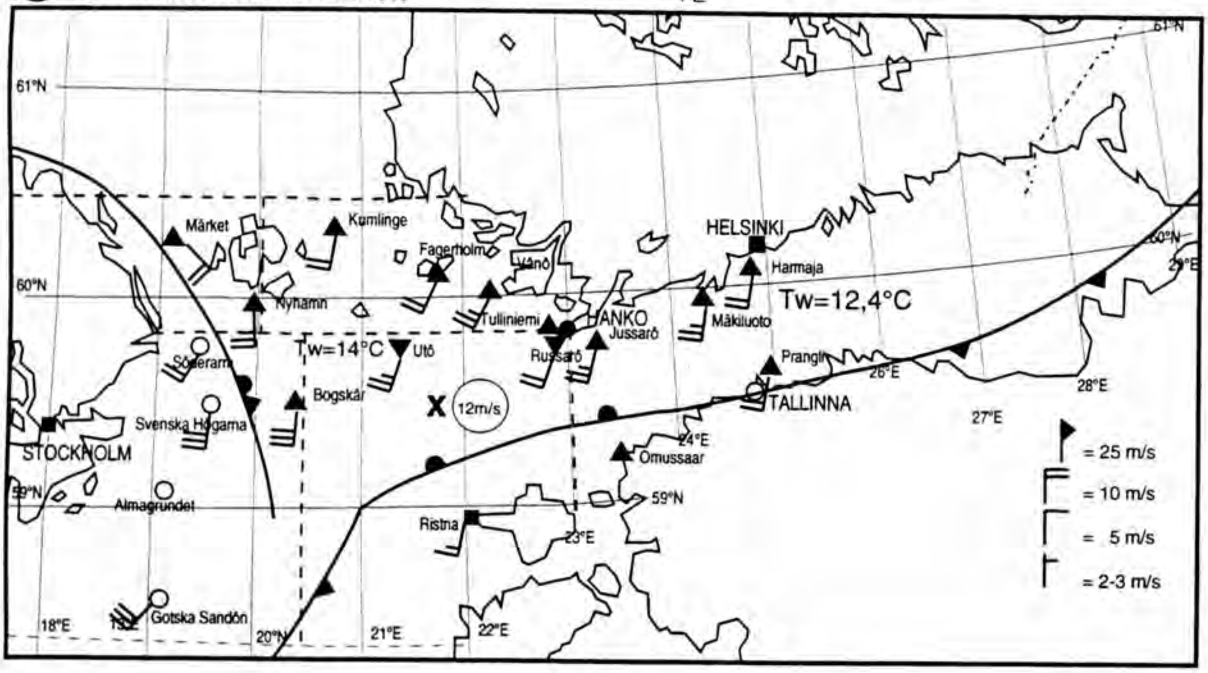


Fig. 3A)
Synoptic weather situation
27.9.1994 18UTC

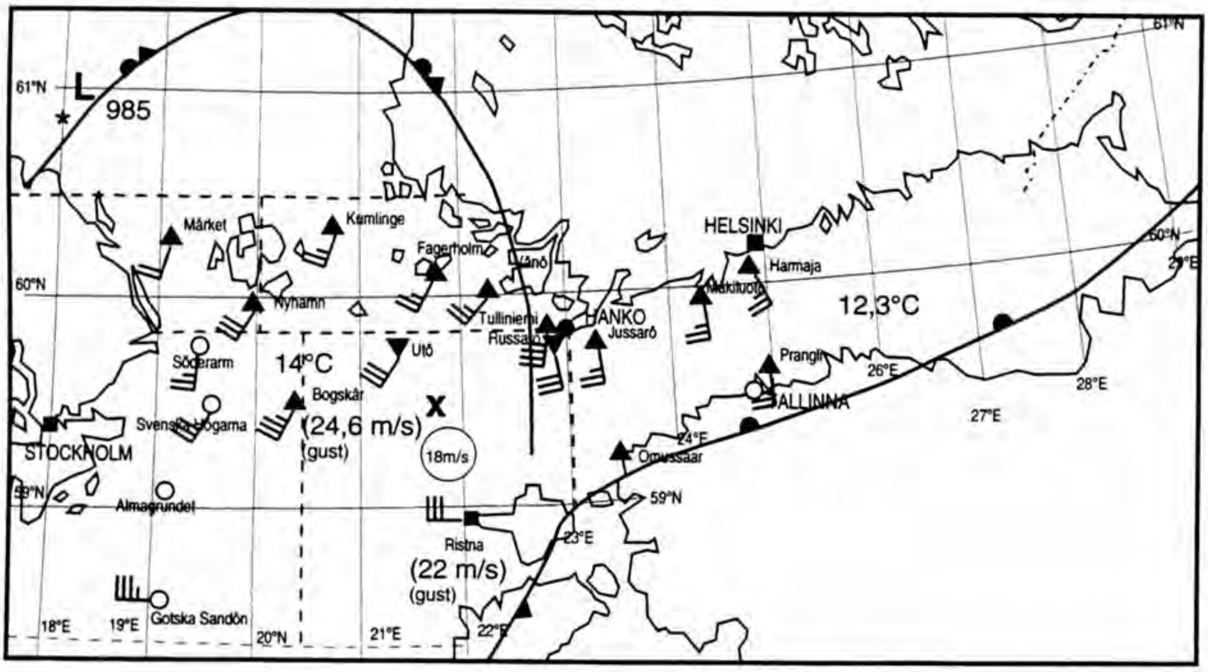


Fig. 3B)
Synoptic weather situation
27.9.1994 21UTC

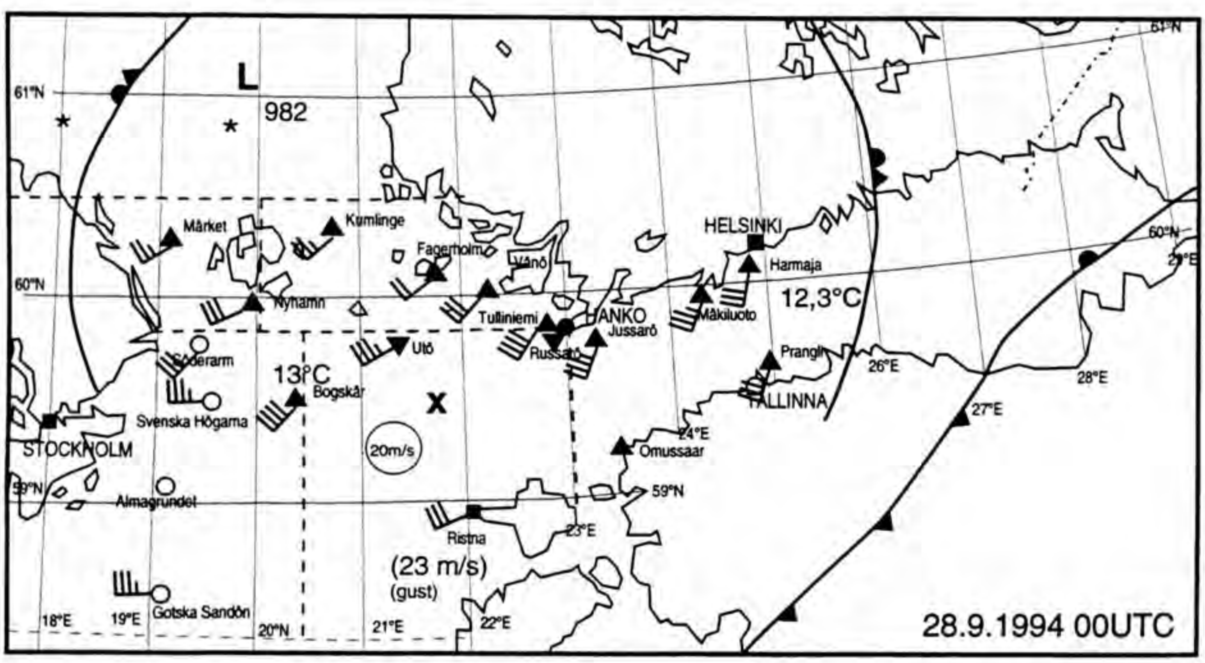


Fig. 3C)
Synoptic weather situation
28.9.1994 00UTC

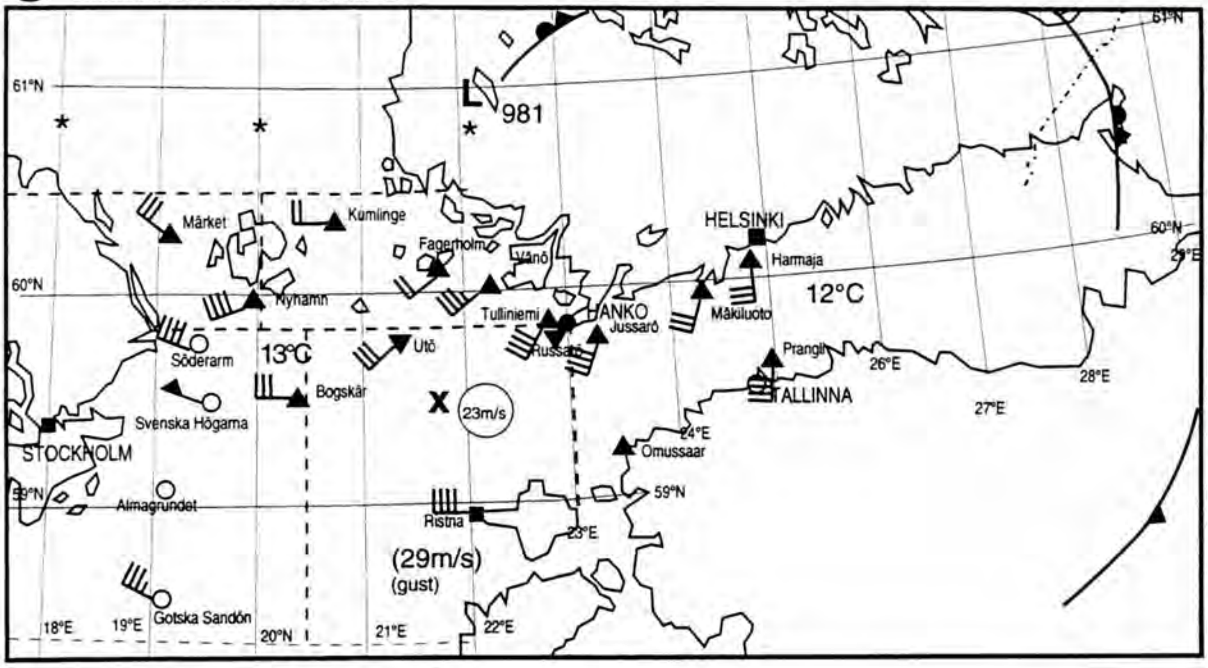


Fig. 3D)
Synoptic weather situation
28.9.1994 03UTC

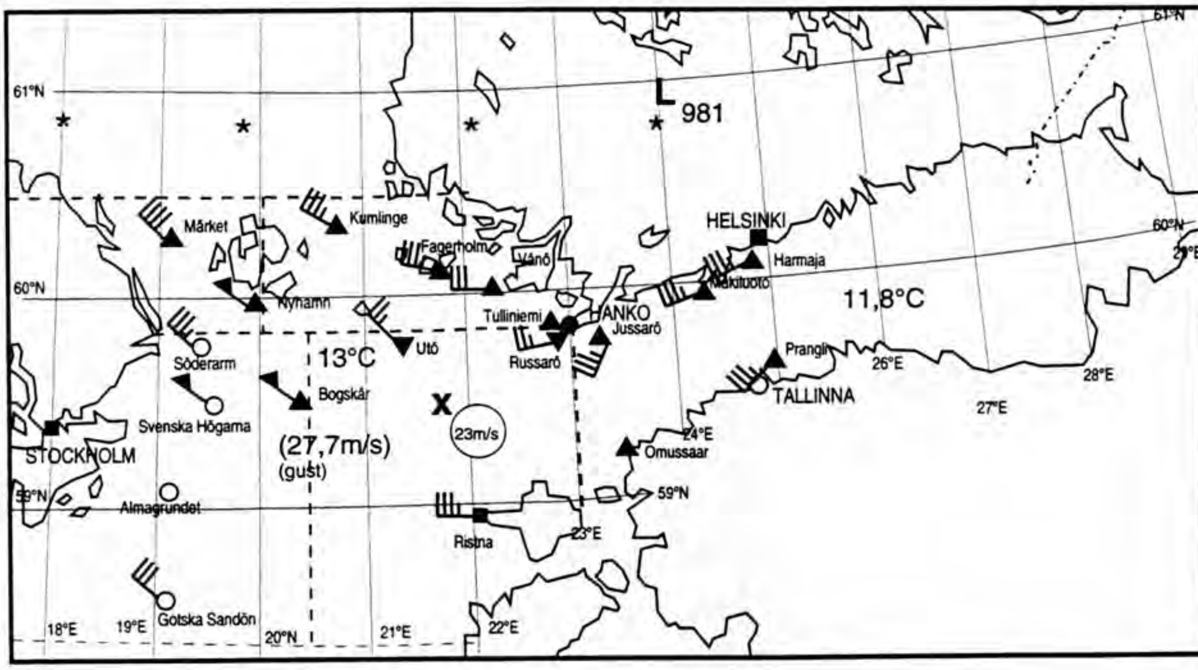


Fig. 3E)
Synoptic weather situation
28.9.1994 06UTC

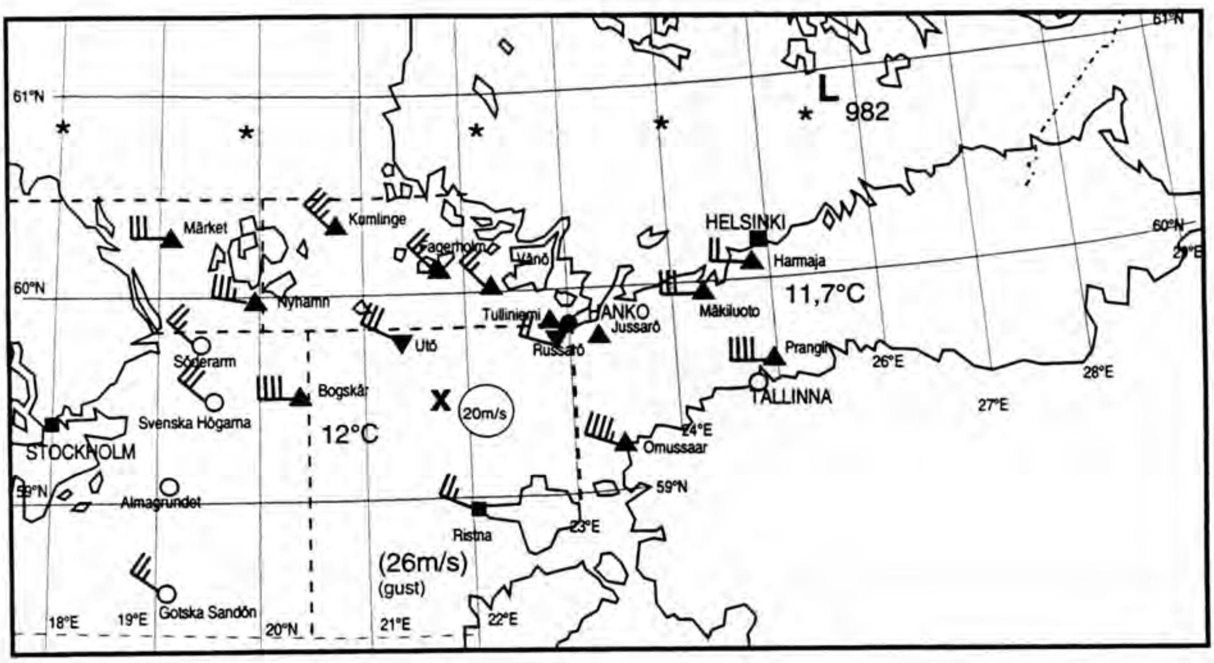


Fig. 3F)
Synoptic weather situation
28.9.1994 09UTC

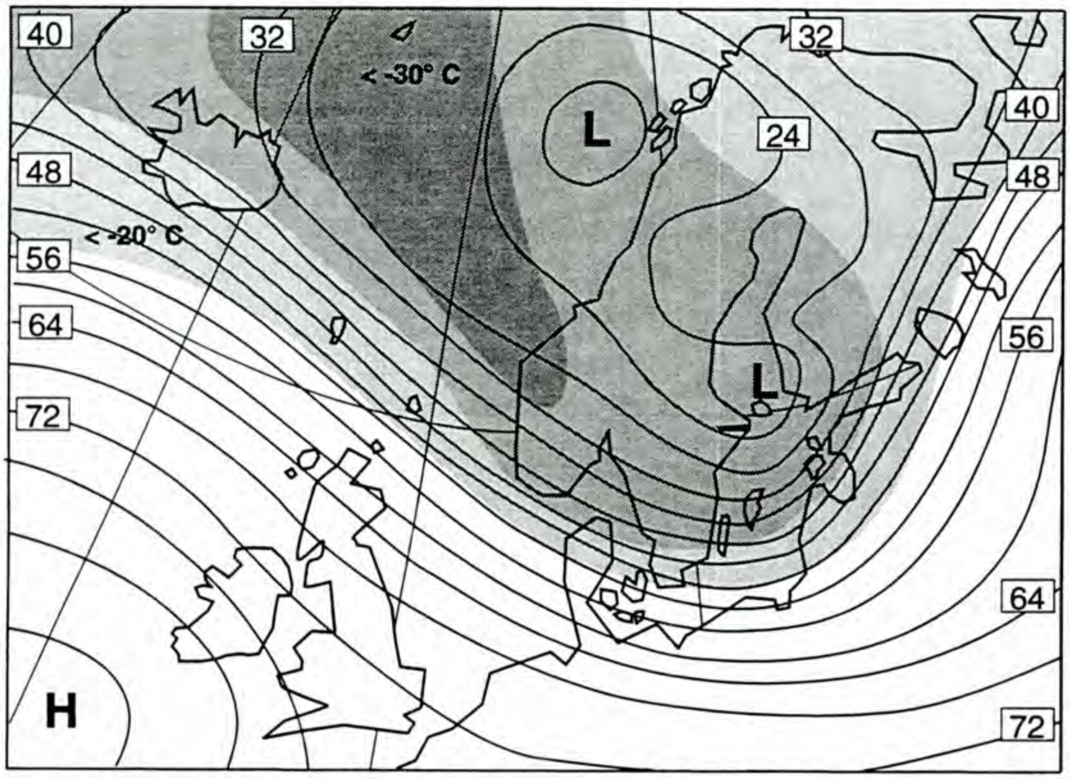


Fig. 4A) 500hPa height isopleths and temperature analysis for 00UTC on 28.9.1994

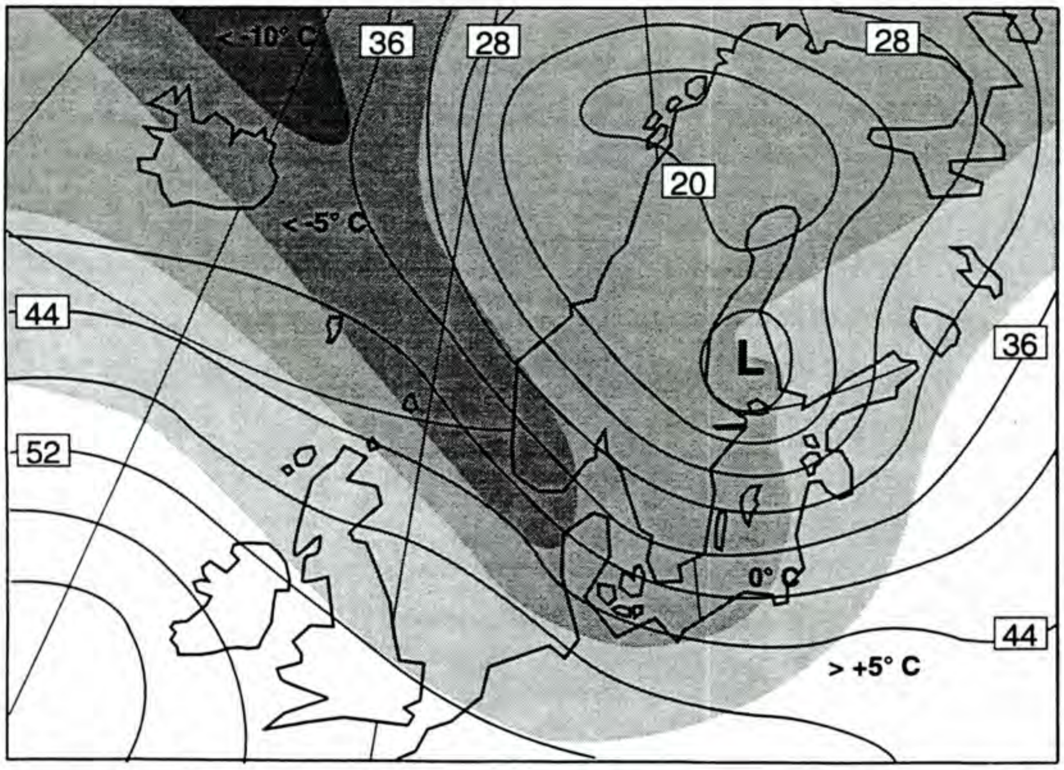


Fig. 4B) 850hPa height isopleths and temperature analysis for 00UTC on 28.9.1994

The analyses in Figs. 1, 2 and 3 have been prepared on the basis of FMI Central Weather Service chart material.

3.3 Upper air analyses

Fig. 4A shows the 500 hPa height isopleths and temperature analysis for 00 UTC on 28.9., while Fig. 4B depicts the corresponding 850 hPa analysis. These have been prepared on the basis of FMI Central Weather Service upper-air analysis material. In the figures cold air can be seen to flow from the north-west towards southern Scandinavia and the Baltic Sea. A cold air-mass aloft is a prerequisite for gusty winds.

3.4 Satellite images

Satellite images received from NOAA are for the times of 06.46 UTC on 27.9.1994 and 06 UTC on 28.9.1994. The developing cloud and frontal area over southern Scandinavia can be seen from the images to move over the period of a day to Finland. The satellite images can be found in Annex 2.

3.5 Weather radar images

The composite image covering Southern Finland contains data from the three Finnish radars at Anjalankoski, Ikaalinen and Vantaa, as well as from the Swedish radars at Arlanda, Hudiksvall, Örnsköldsvik and Gotland. The series contains images from data at 01.00, 01.30, 02.00 and 03.00 local time (23.00, 23.30, 00.00 and 01.00 UTC). The movement of the frontal and rain areas can be seen from the images. At 00 UTC the centre of the depression is situated, according to the weather observations, to the north of Åland (cf. Fig. 3C). Rain shower echoes are present in the accident area. The radar image series may be found in Annex 3.

3.6 Lightning location data

Data from the lightning locator system for the period 00 - 03 UTC on 28.9.1994 are presented in Annex 4.

3.7 Verbal and tabular weather forecasts

Verbal and tabular marine weather forecasts issued by the FMI Central Weather Service, together with the forecast for drifting issued by the Southern Finland Regional Office are appended in Annex 5.

3.8 Other data

Data from Sweden and Estonia (Eesti Vabariik) and drifting calculations made by Environmental Impact Assessment Centre of Finland Ltd (Ympäristövaikutusten Arviointikeskus) are given in Annex 6.

4. SUMMARY

At the time m/s Estonia sunk the weather was stormy. This storm was caused by a depression, typical for the time of year, which moved across the Baltic Sea and Gulf of Bothnia on the night of 28.9, when the accident occurred. On the evening preceding the accident the wind in the accident area blew ahead of the front from the south or south-south-east with a mean speed varying between 12 and 15 m/s. According to the weather data the front passed the accident location at about 19 UTC, after which the prevailing wind direction was from between south-west and west. At 21 UTC the mean wind speed in the accident area was approx. 18 m/s, with gusts up to 24 m/s. At 00 UTC (02 local time) a south-westerly wind with a mean speed of approx. 20 m/s prevailed, the strongest gust measured between 00 and 03 UTC being 29 m/s at Ristna. At 03 UTC the wind blew from the west, later veering further to between west and north-west, at which time the mean wind speed was 23 m/s, with a gust maximum of over 27 m/s. At Finnish stations the highest wind speeds were measured at about 06 UTC (08 local time). In the early hours of the morning the sea temperature was approx. 13 deg. C and the air temperature about 10 deg. C.

Over 900 persons died and 136 survived in the accident (Pelastustieto 8/94). International shipping receives weather information through various different channels. Over the Baltic Sea region weather forecasts and warnings in English are disseminated by coastal radio stations. On 27.9 and 28.9 gale warnings issued by FMI were transmitted over VHF channels by Helsinki and Mariehamn coastal radio stations. The storm warning was heard on the Finnish Broadcasting Company's Radio Suomi in Finnish and on Riksradio in Swedish as part of the regular marine weather broadcasts. Strong wind and gale forecasts are issued in English by the Navtex system. According to an agreement made in 1983, Sweden coordinates weather warning activities on this system in the Baltic Sea region (Kjellegård, 1983). The Baltic area has recently seen the emergence of several newly-independent countries. Coordination of the wind forecasts and warnings issued by different countries for international shipping in the same area needs to be strengthened.

ACKNOWLEDGEMENTS

I wish to express my thanks to the staff of various departments of FMI who by their efforts have made this report possible, in particular to Anja Häkkinen, Timo Kallio, Eila Savilaakso, Marika Reikko, Päivi Mikkola, Pirkko Pylkkö and Anu Kallio, who helped in the production of the figures and images. I also wish to thank Pirkko Saarikivi and Jarmo Koistinen for helping to clarify the text of the manuscript. Robin King was responsible for the translation into English.

REFERENCES

Pearson, G.M. and Stewart, R.E., 1992. A Diagnostic Study of an Apparent "Instant Occlusion" Cyclogenesis Event During Erica. Ontario. Atmospheric Environment Service.

Katajamäki, Juhani, 1994. Murhenäytelmä Itämerellä. Pelastustieto 8/94 s.8-14

Kjellegård, B., 1983. Report from the meeting in Norrköping 1983-05-03/04 on "Coordination of transmissions of meteorological and safety information in the Baltic Sea". The National Swedish Admininistration of Shipping and Navigation.

SYNOPTIC AND AUTOMATIC WEATHER STATIONS

Time series of the weather observations on 27.9-28.9 1994 are drawn from some of the observation stations in the vicinity of the accident area.

Synoptic weather stations (wind, air pressure, temperature, visibility, sea state):
Utö (59°47'N 21°2'E),
Russarö (59°46'N 22°57'E),
Ristna (58°55'N 22°04'E)

Automatic weather stations (AWS stations):
Bogskär (59°30'N 20°21'E),
Vänö (59°52'N 22°12'E),
Prangli (59°39'N 24°58'E)
Harmaja (60°06'N 24°59'E)

Wind speed observations represent 10-minute averages. The max.wind speed is the strongest 10-minute mean value during 3 hours interval. The max. gust speed is the measured strongest 2 seconds gust. Air temperatures and sea water temperatures are given in centigrades. Visibilities and sea states are given in meters.

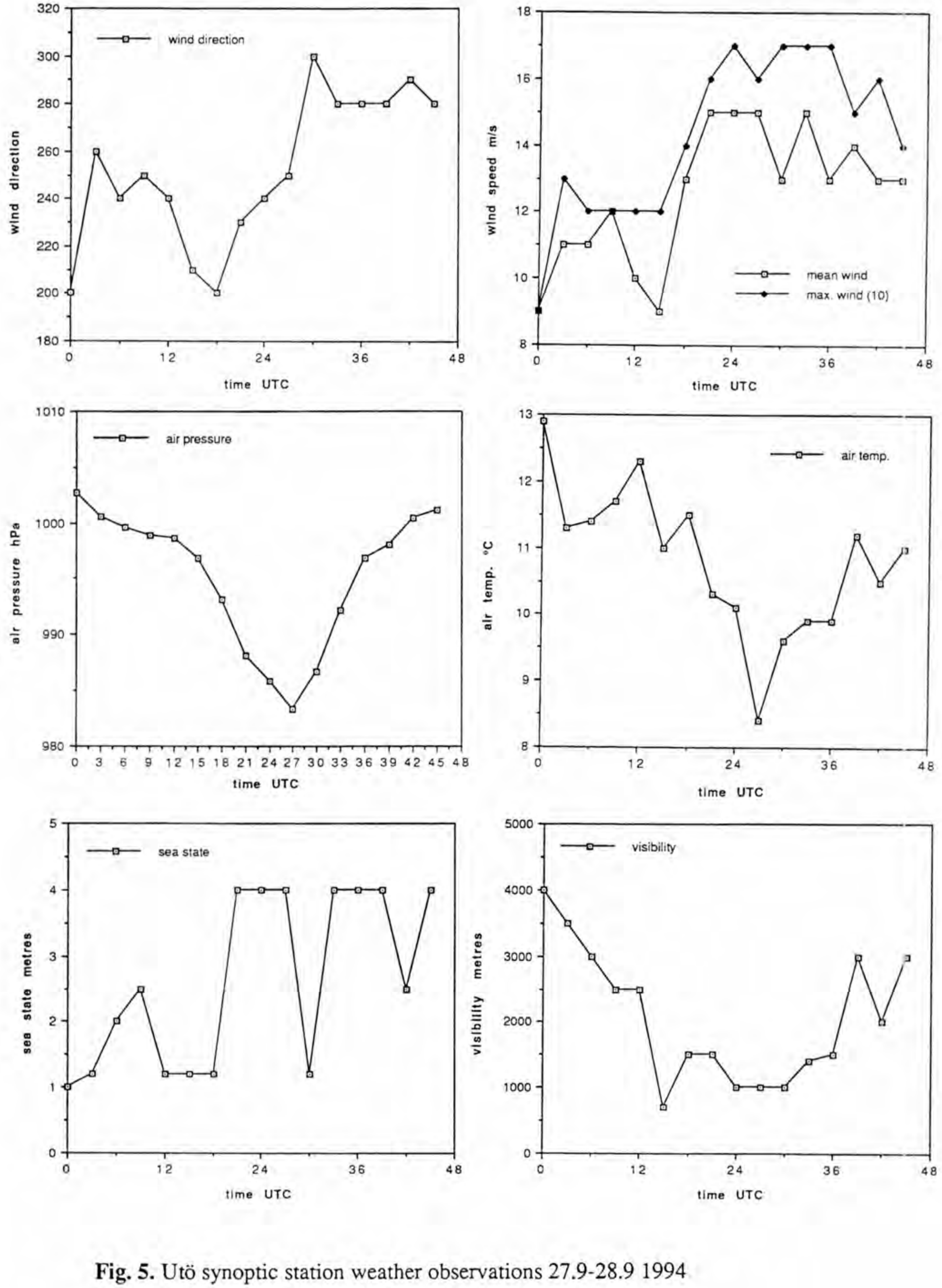


Fig. 5. Utö synoptic station weather observations 27.9-28.9 1994

Annex 1/3

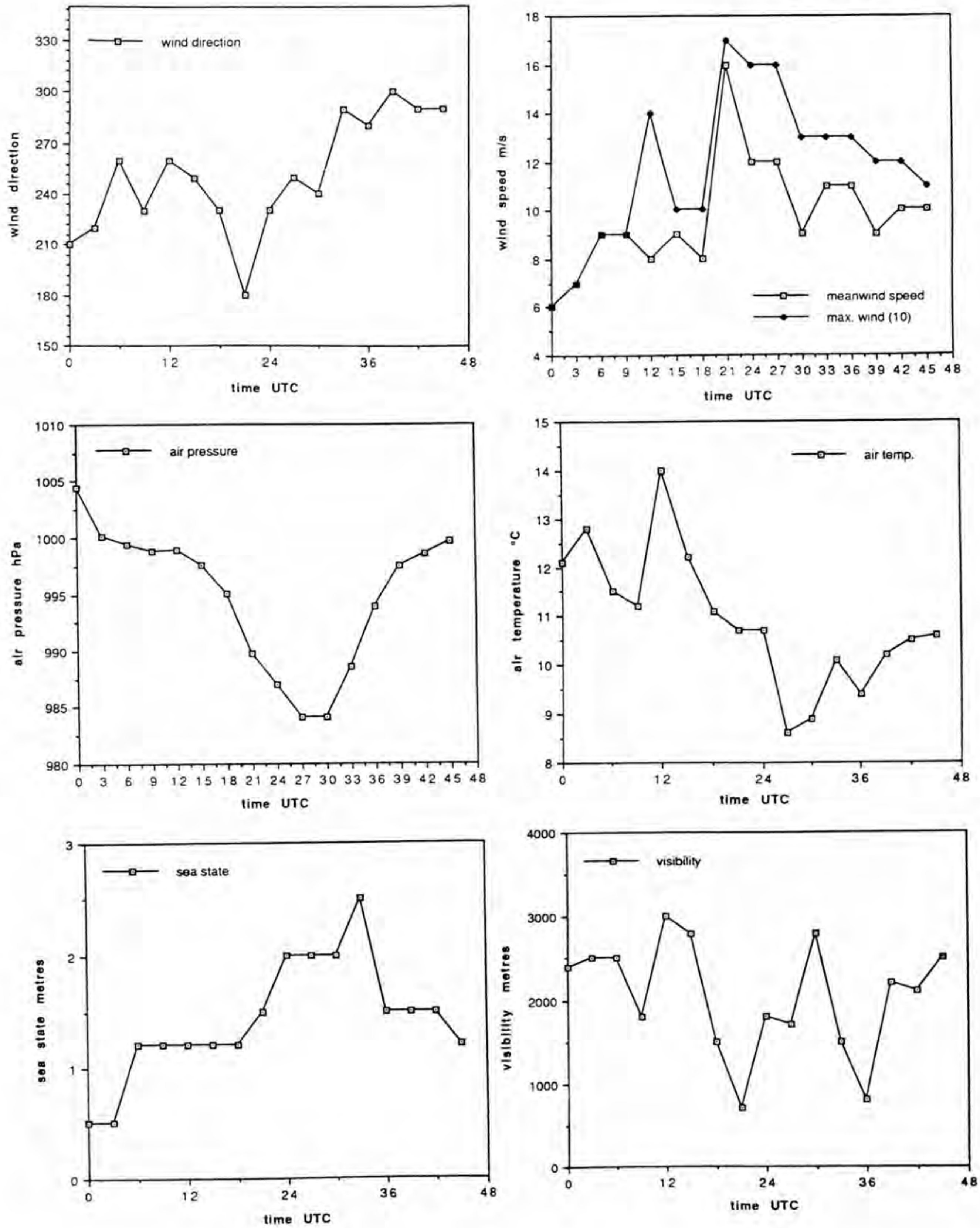


Fig. 6. Russarö synoptic station weather observations 27.9-28.9 1994

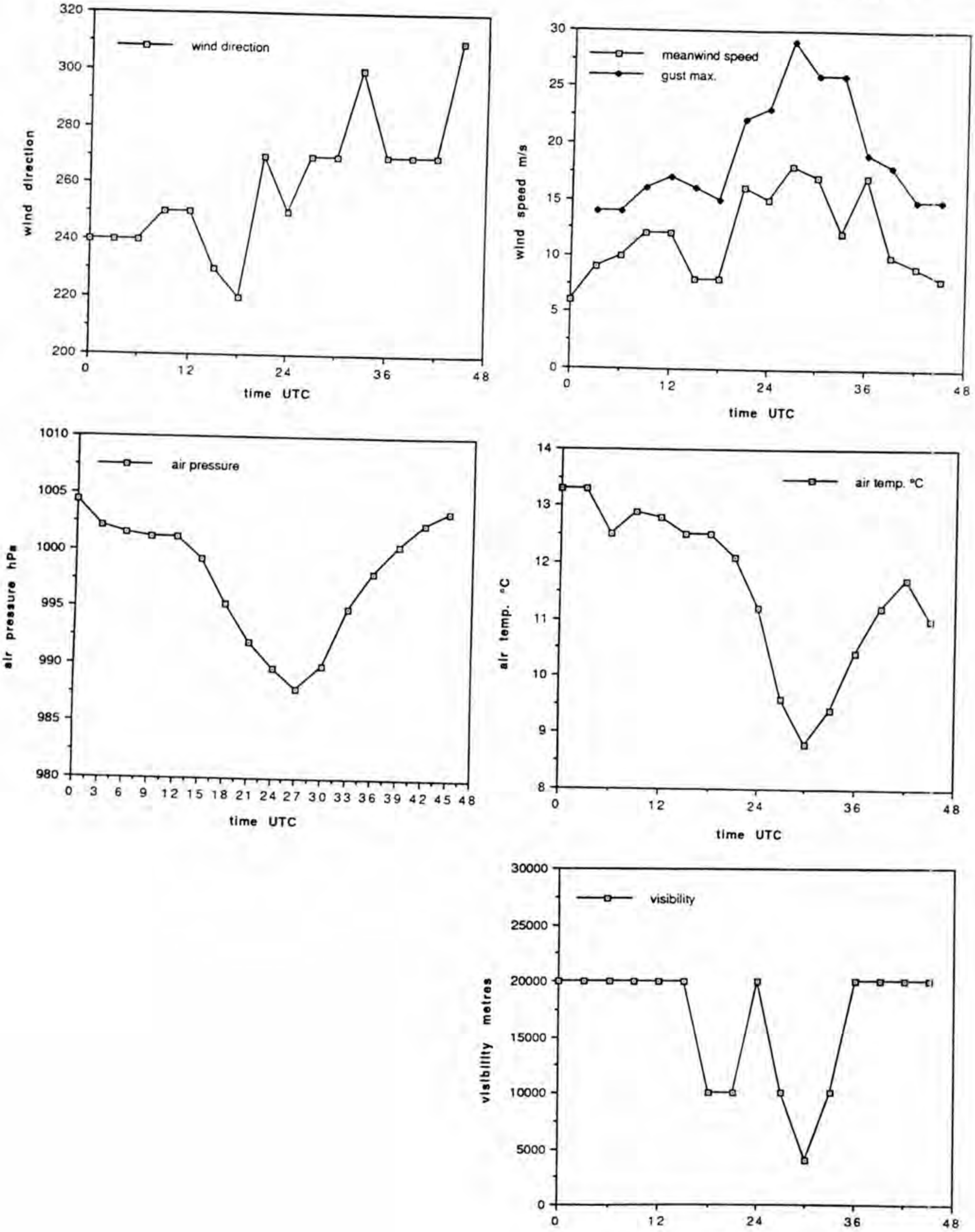


Fig. 7. Ristna synoptic station weather observations 27.9-28.9 1994

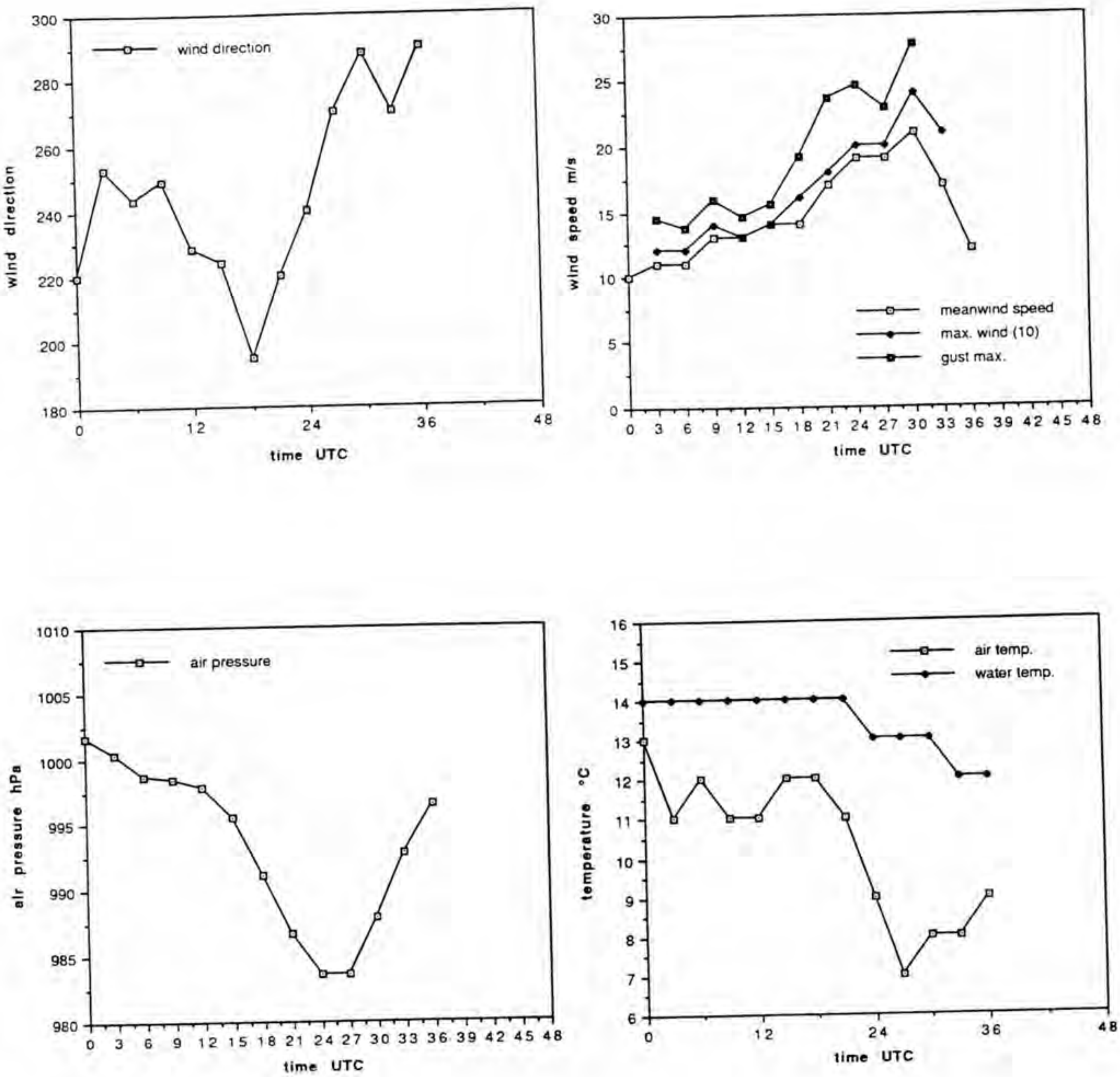
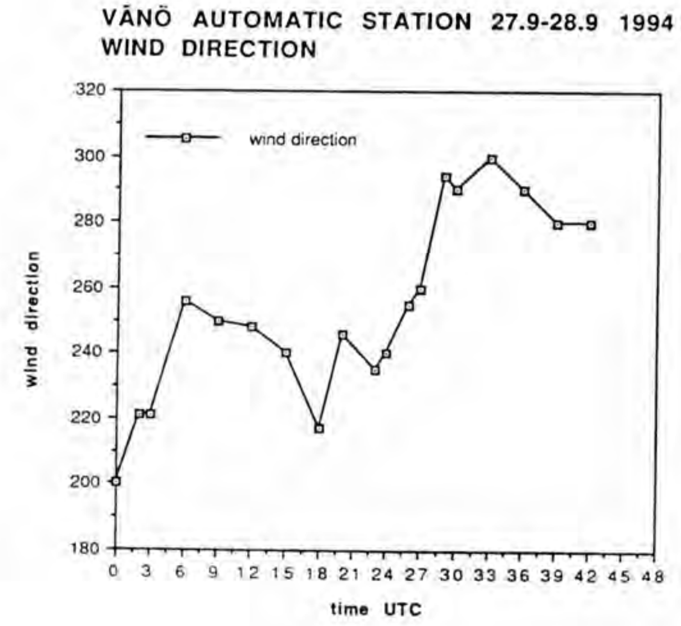


Fig. 8. Bogskär automatic station weather observations 27.9-28.9 1994



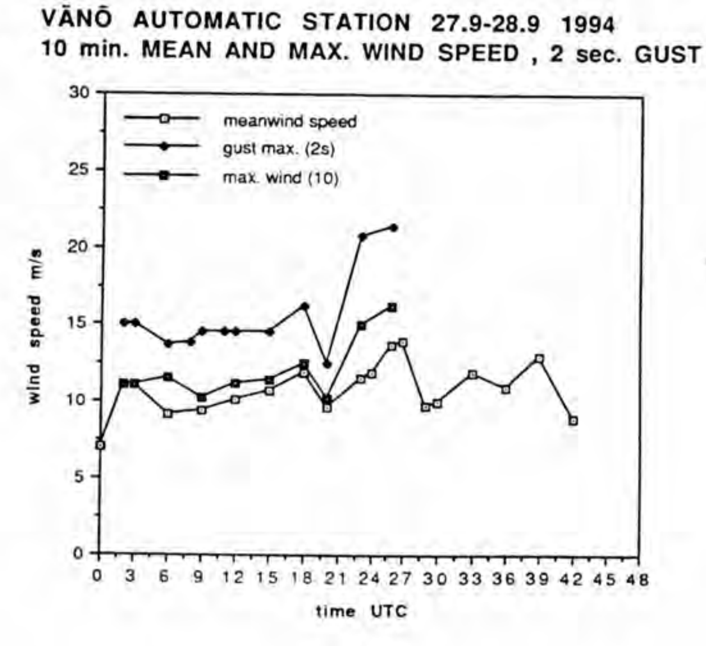


Fig. 9. Vänö automatic station weather observations 27.9-28.9 1994

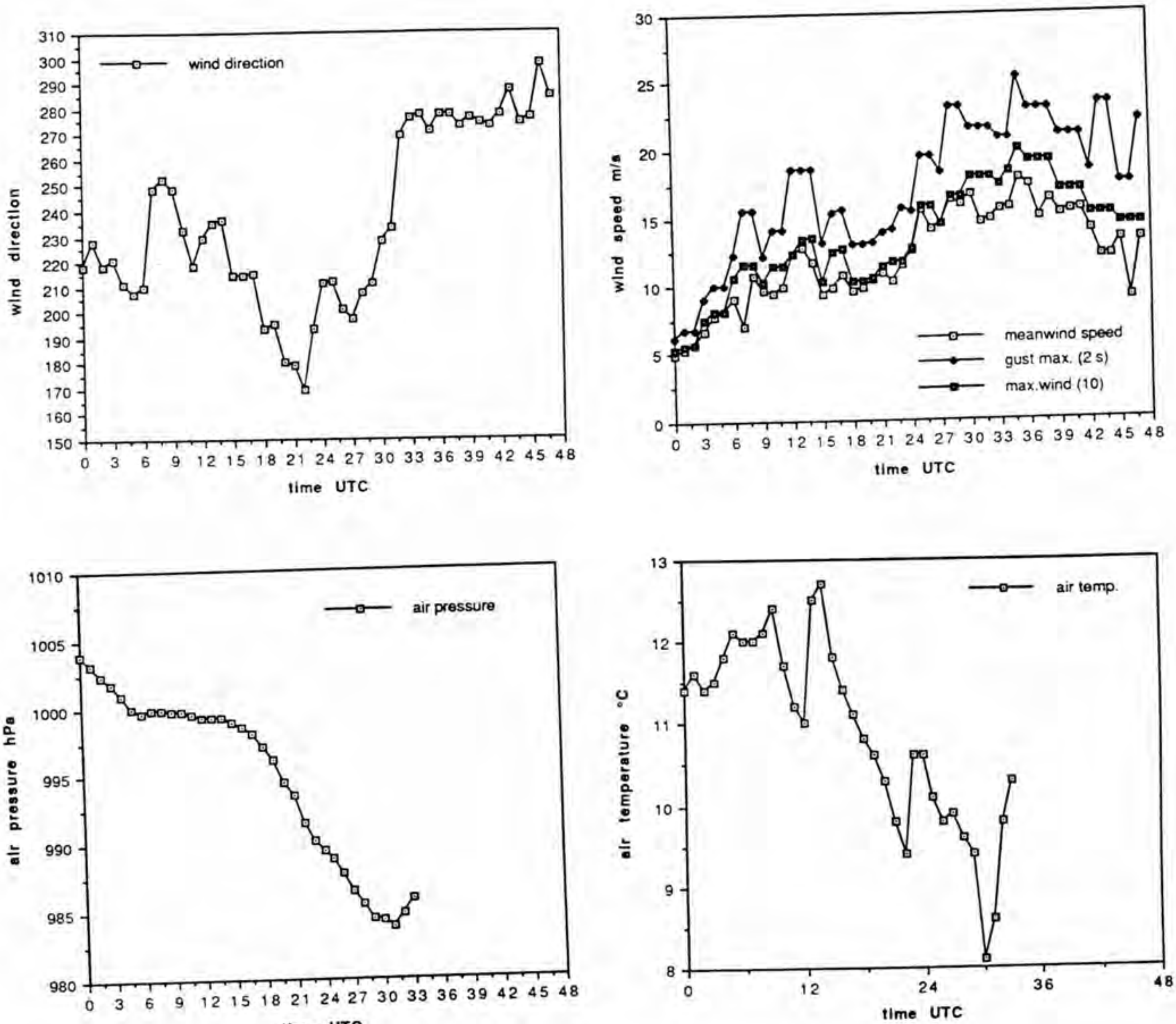


Fig. 10. Prangli automatic station weather observations 27.9-28.9 1994

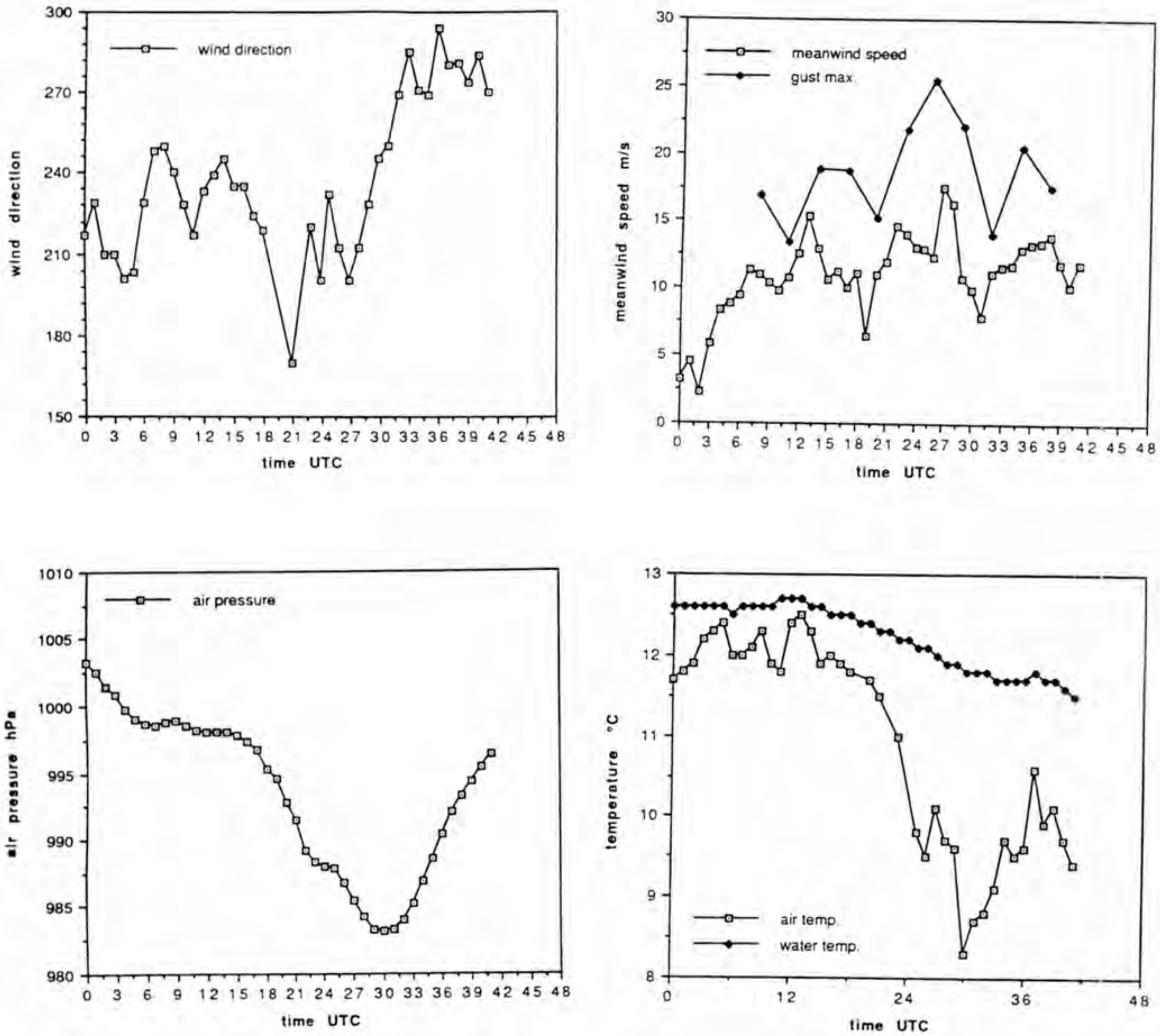


Fig. 11. Harmaja automatic station weather observations 27.9-28.9 1994

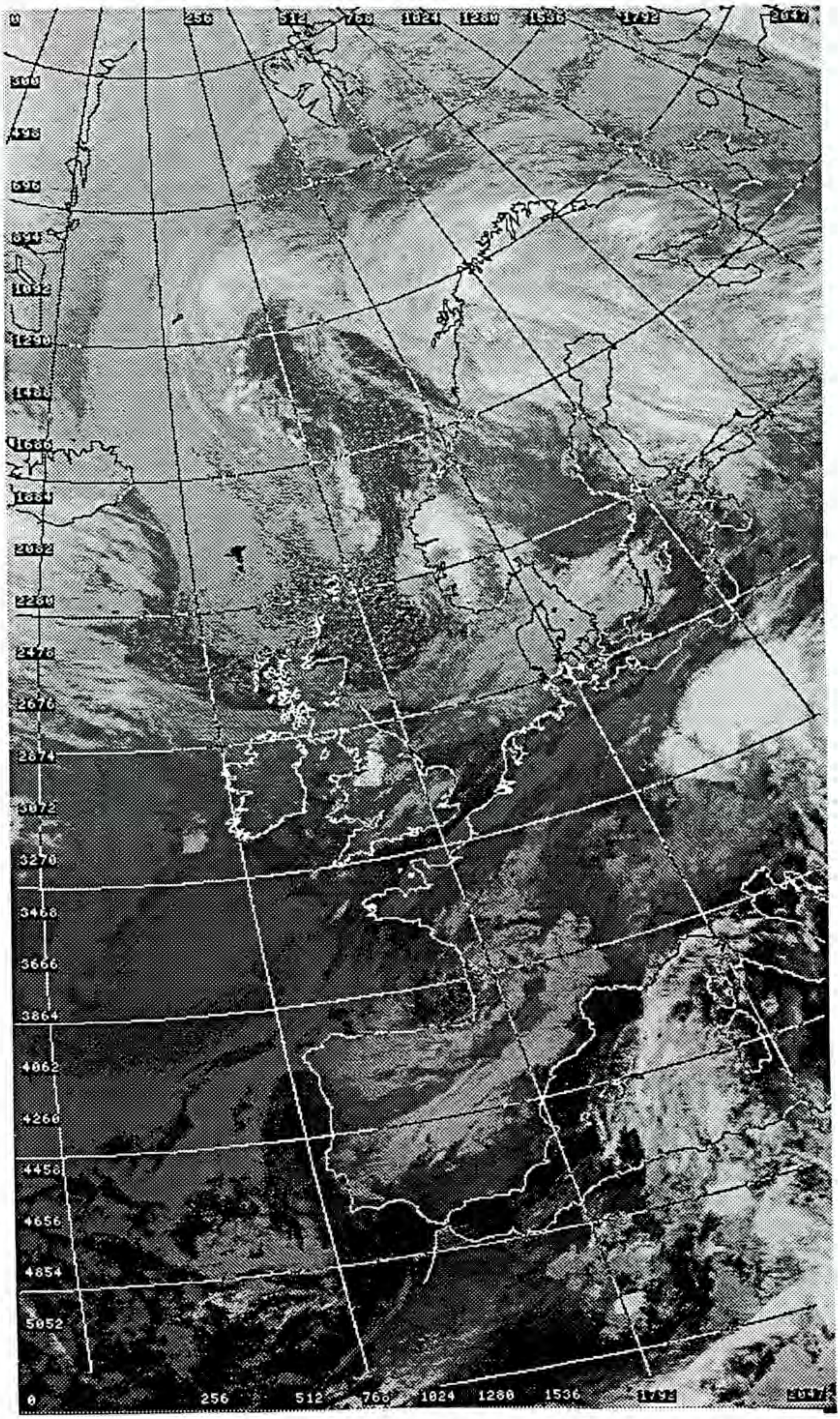


Fig. 12. The satellite image received from NOAA (at 06.46 UTC on 27.9.1994)

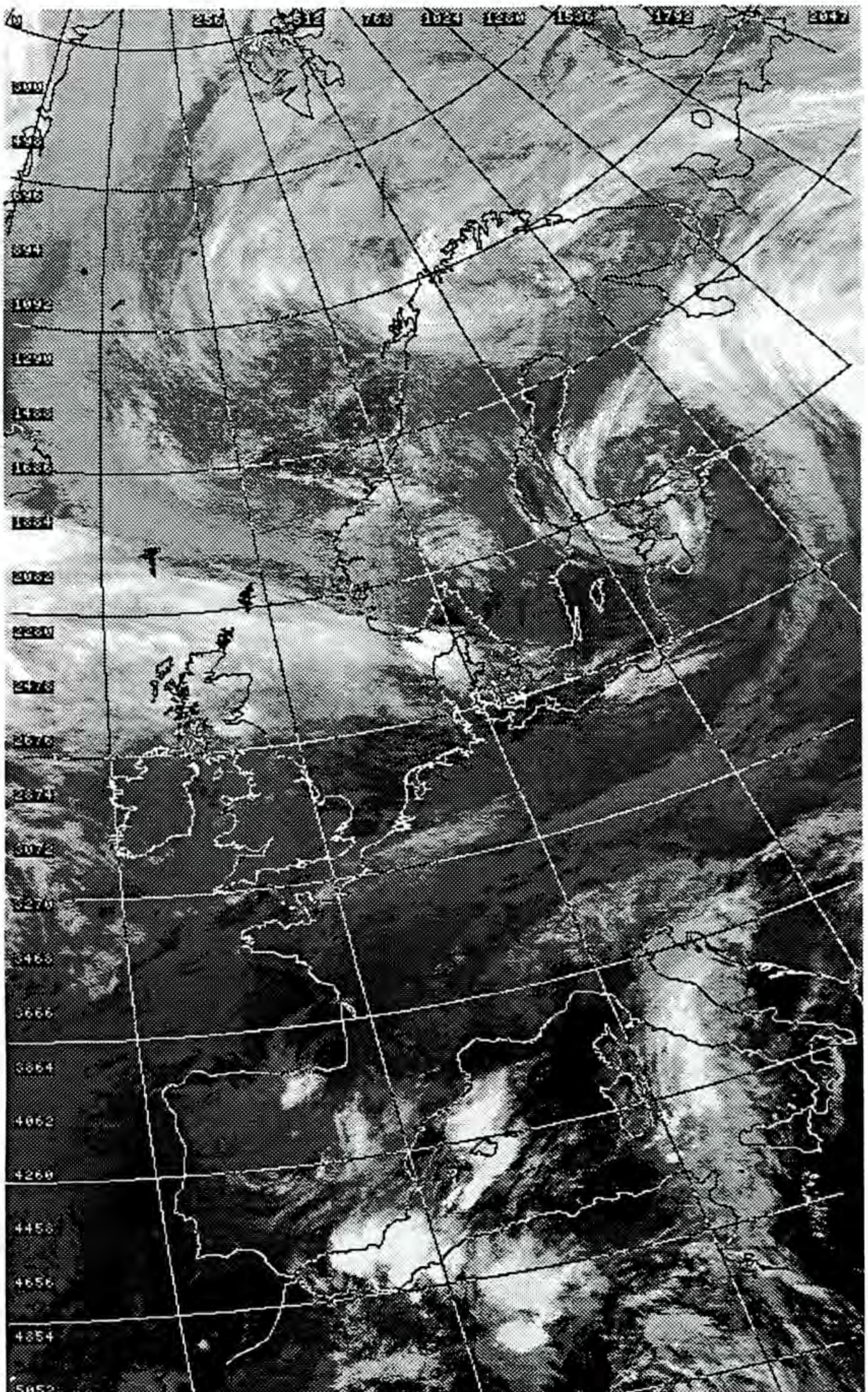


Fig. 13. The satellite image received from NOAA (at 06.00 UTC on 28.9.1994)

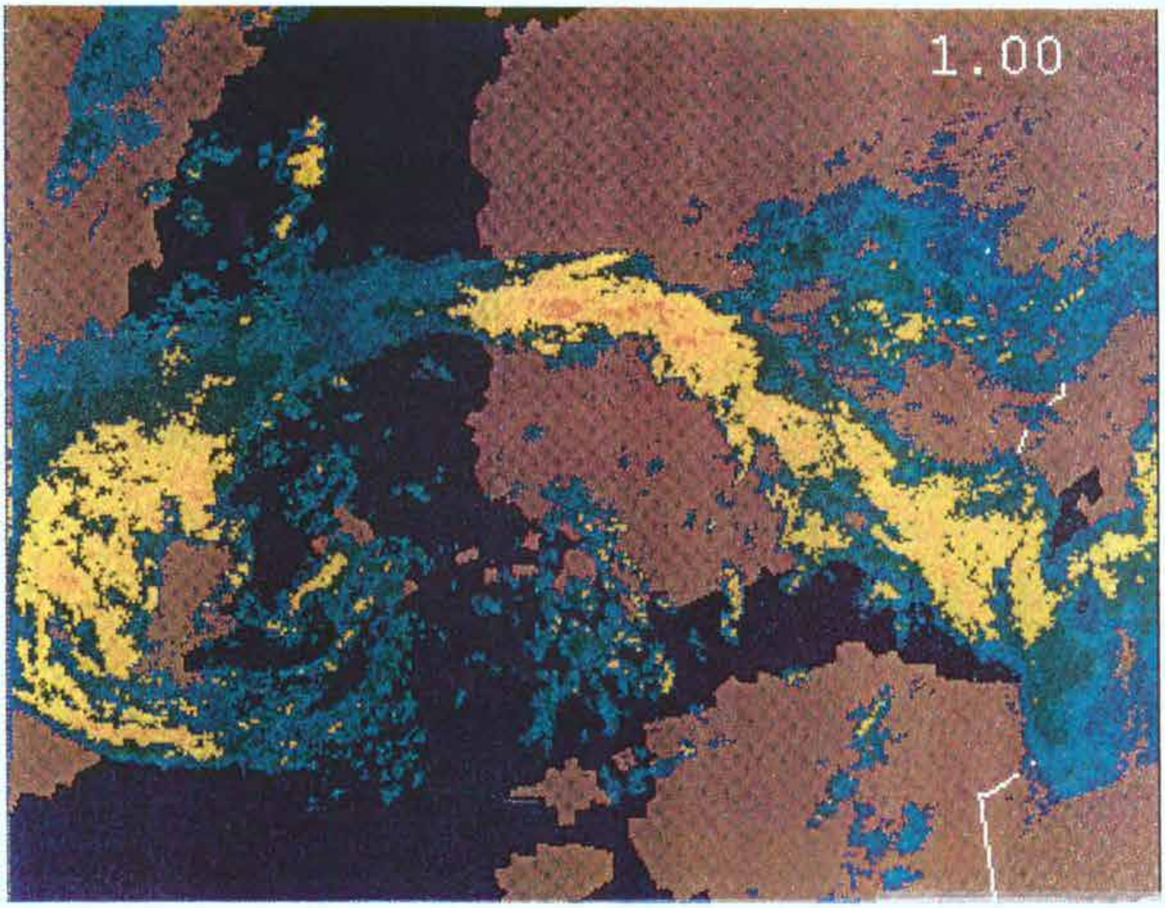


Fig. 14 A). The composite image on 27.9.1994 at 23.00 UTC (28.9.1994 01.00 local time).

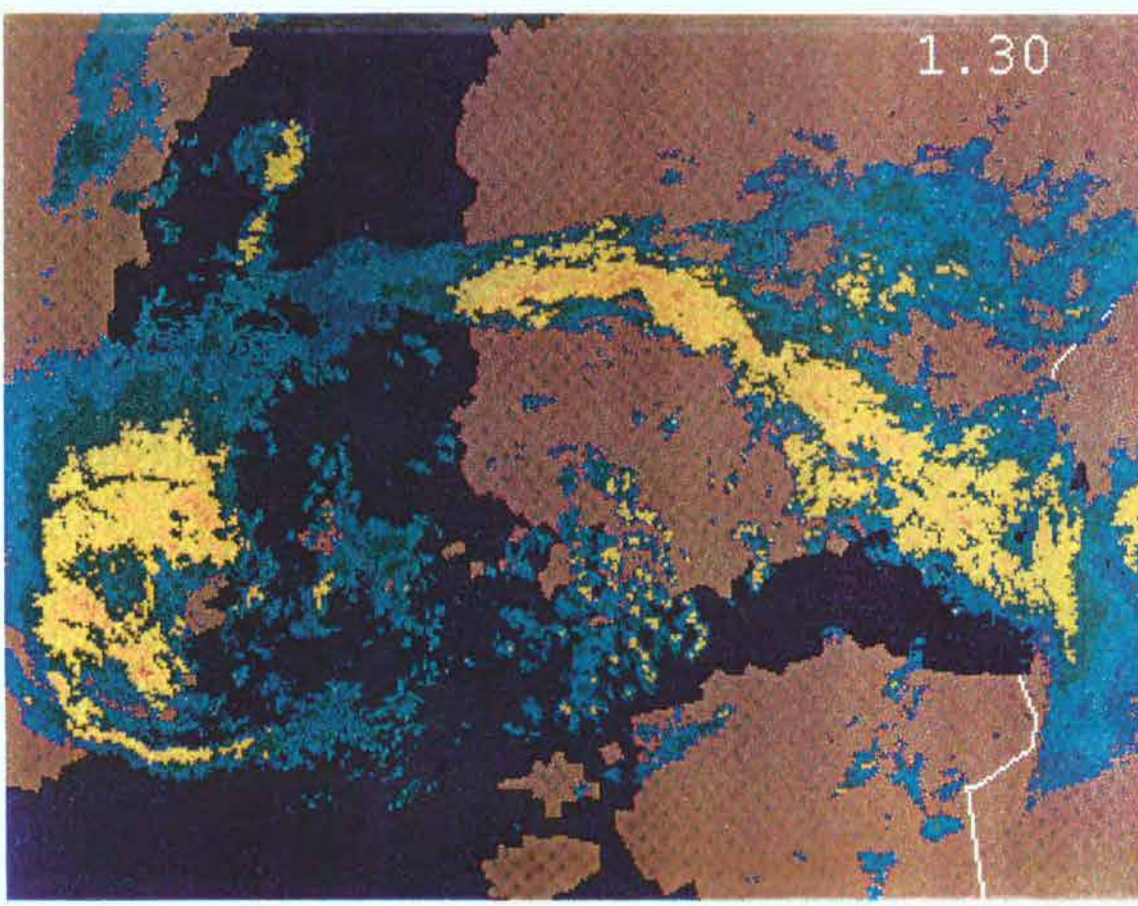


Fig. 14 B). The composite image on 27.9.1994 at 23.30 UTC (28.9.1994 01.30 local time.

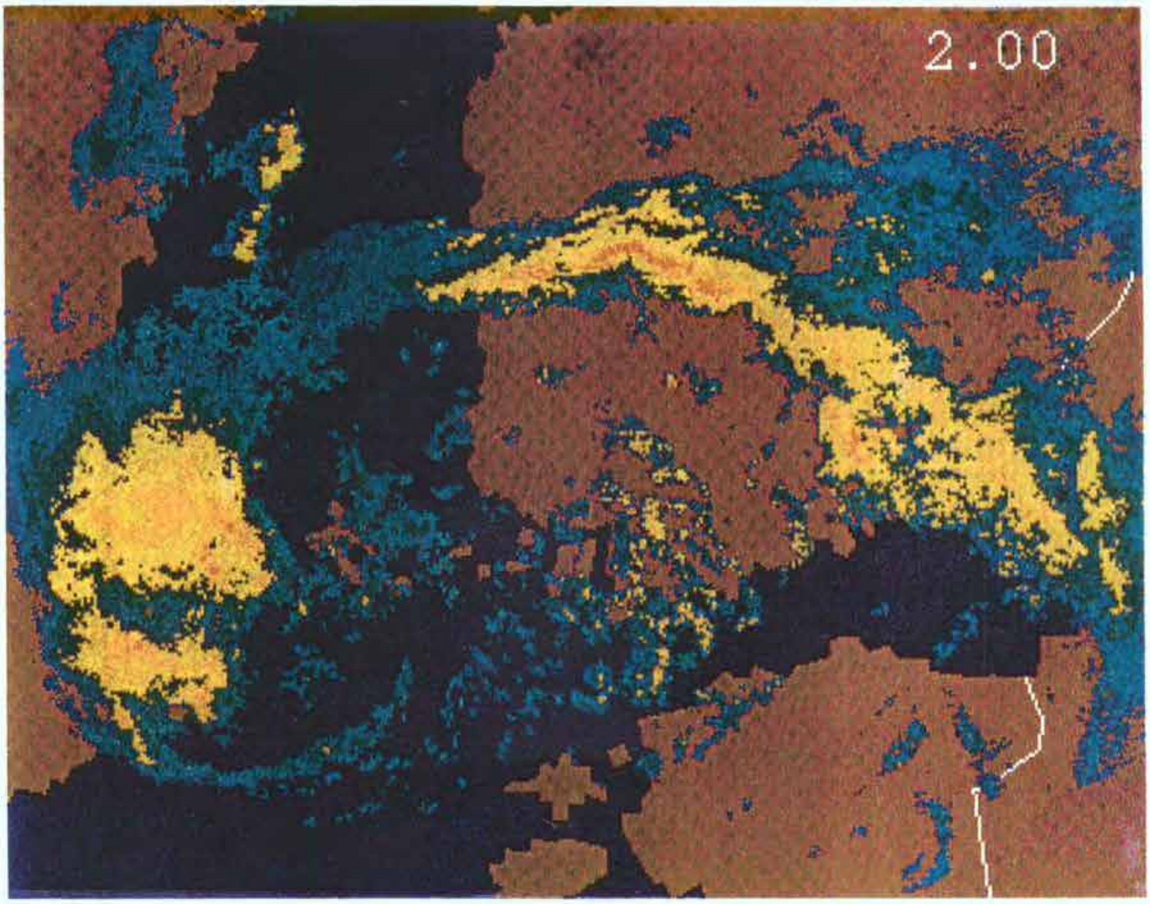


Fig. 14 C). The composite image on 28.9.1994 at 00.00 UTC (02.00 local time).

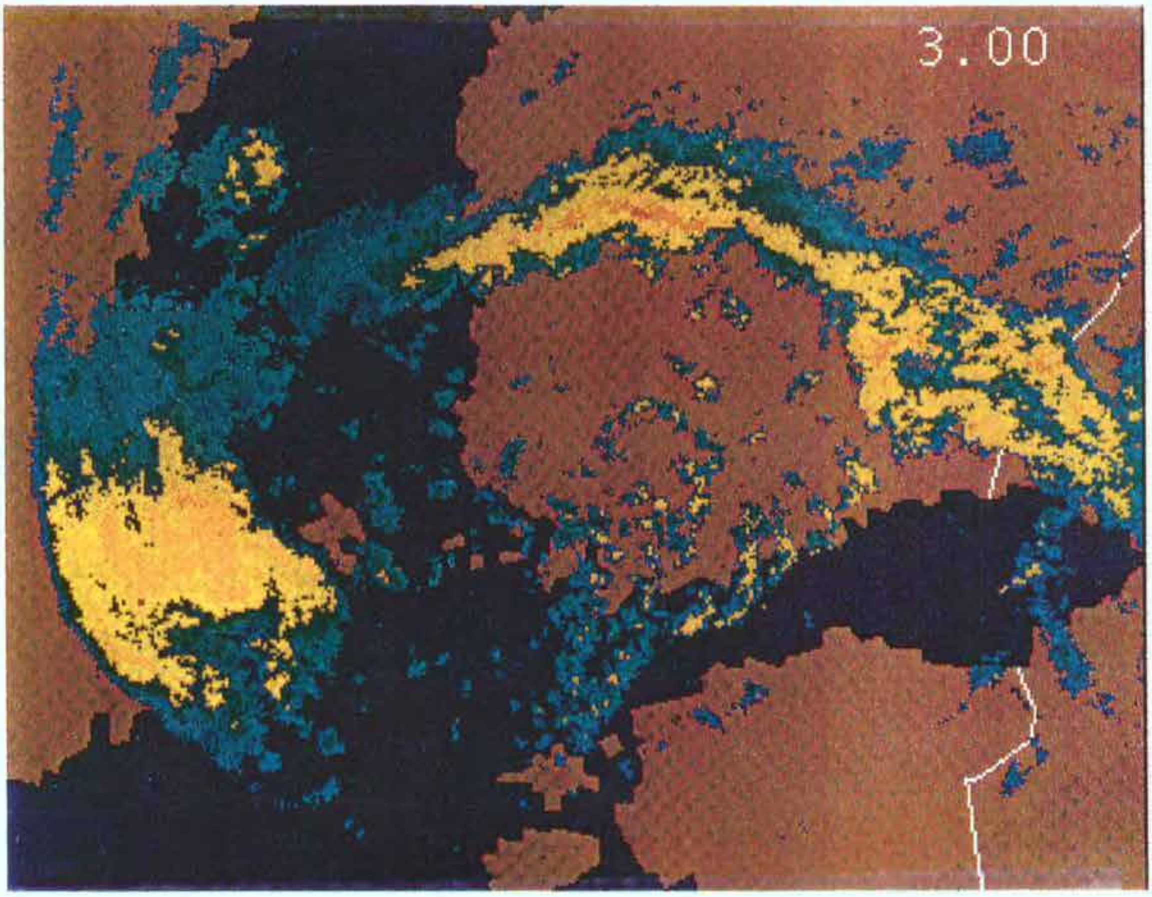
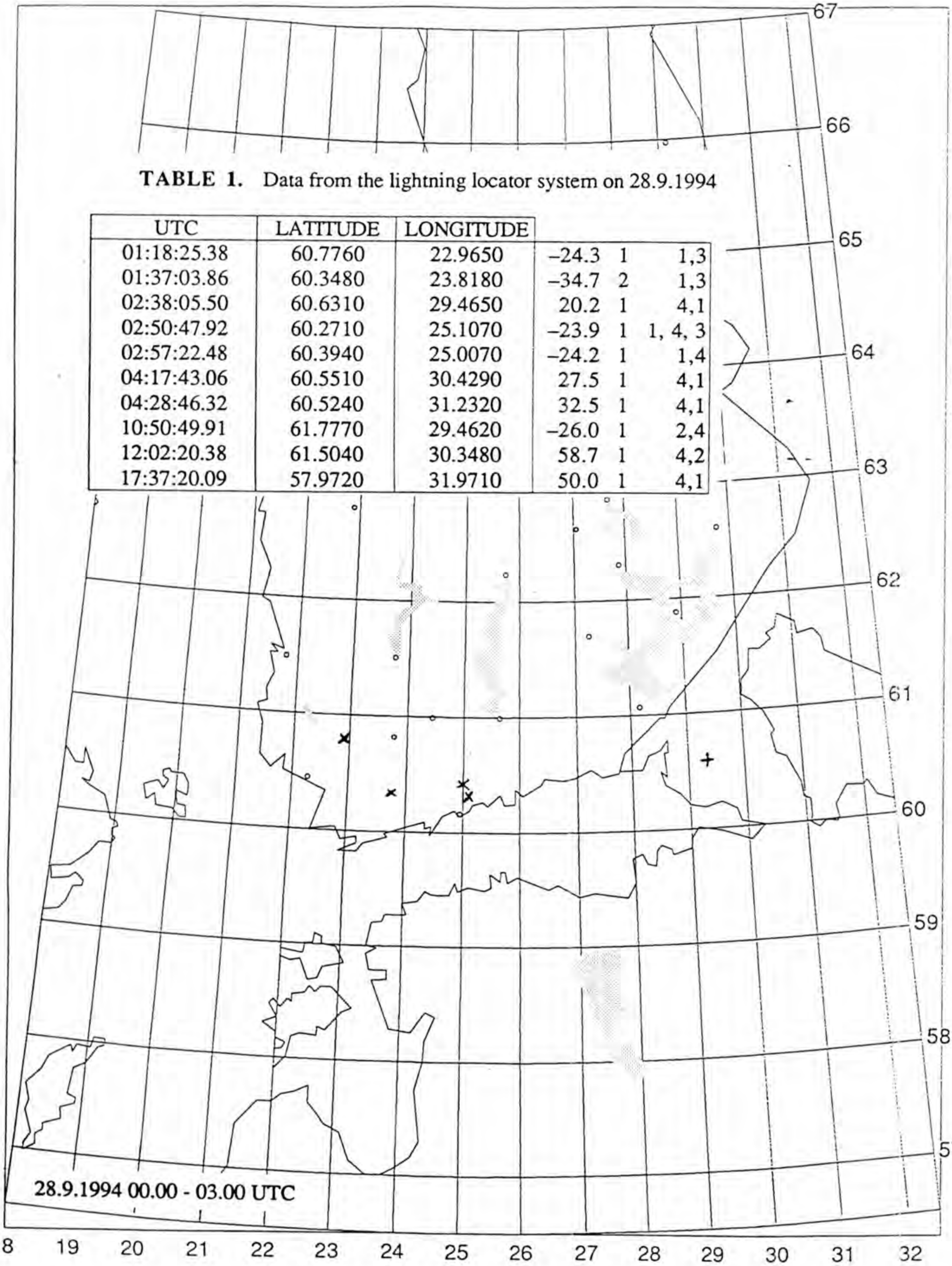


Fig. 14 D). The composite image on 28.9.1994 at 01.00 UTC (03.00 local time).

Fig. 14 A), B), C), D). The composite image contains data from the three Finnish radars at Anjalankoski, Ikaalinen and Vantaa, as well as from the Swedish radars at Arlanda, Hudiksvall, Örnsköldsvik and Gotland. The series contains images from data on 27.9.1994 at 23.00 and 23.30 UTC, on 28.9.1994 at 00 and 01 UTC (local time 28.9.1994 01.00, 01.30, 02.00 and 03.00).

TABLE 1. Data from the lightning locator system on 28.9.1994

UTC	LATITUDE	LONGITUDE			
01:18:25.38	60.7760	22.9650	–24.3	1	1,3
01:37:03.86	60.3480	23.8180	–34.7	2	1,3
02:38:05.50	60.6310	29.4650	20.2	1	4,1
02:50:47.92	60.2710	25.1070	–23.9	1	1, 4, 3
02:57:22.48	60.3940	25.0070	–24.2	1	1,4
04:17:43.06	60.5510	30.4290	27.5	1	4,1
04:28:46.32	60.5240	31.2320	32.5	1	4,1
10:50:49.91	61.7770	29.4620	–26.0	1	2,4
12:02:20.38	61.5040	30.3480	58.7	1	4,2
17:37:20.09	57.9720	31.9710	50.0	1	4,1



ILMATIETEEN LAITOKSEN SALAMANPAIKANNIN 1:5 000 000

VERBAL AND TABULAR WEATHER FORECASTS

The marine weather forecasts given by the FMI Central Weather Service on the evening of 27.9.1994, i.e. "Sääennuste merenkulkijoille" in Finnish at 19.00 and 22.00 (local time), "Väderrapporten för sjöfarande" in Swedish at 19.00 and 22.00 (local time) and "Weather forecast for shipping" in English at 17 and 20 UTC, had the same contents. An additional verbal forecast was made for marine lifesaving units at 07.05 on 28.9.1994. Before that, information on weather conditions had been given by telephone. The FMI Regional Office for Southern Finland had made forecasts for drifting earlier in the morning, and the Central Weather Service initiated a marine weather facsimile service.

FPFI43 EFKL DDHH00 2L

Sääennuste merenkulkijoille 27.09.1994 klo 19

Myrskyvaroitus:
Suomenlahti, Pohjois-Itämeri, Ahvenanmeri ja Saaristomeri sekä Selkämeren eteläosa: Länsi- tai luoteismyrskyä 21 m/s.

Kovan tuulen varoitus:
Selkämeren pohjoisosa: Länsi- tai luoteistuulta 16 m/s.

Huomautus veneilijöille:
Merenkurkku ja Perämeri:
Myöhemmin huomenna länsituulta 11 m/s.
Saimaa: Etelän puoleista tuulta 11 m/s.

Pohjois-Euroopassa on laaja matalapaineen alue. Voimakas osakeskus liikkuu yöllä Selkämeren yli itään ja huomenna edelleen kohti Keski-Suomea. Toinen osakeskus on Pohjois-Ruotsissa.

Odotettavissa huomiseen iltaan asti:

Suomenlahti:
Yöllä etelä- tai lounaistuulta 12-16 m/s, aamulla sekä aamupäivällä tuuli kääntyy lännen puolelle ja on 15-21 m/s. Yöllä ja aamulla sadetta ja ajoittain huono näkyvyys. Päivällä näkyvyys paranee lännestä alkaen.

Pohjois-Itämeri, Ahvenanmeri ja Saaristomeri:
Etelä- tai lounaistuulta, myöhemmin yöllä sekä aamulla länteen tai luoteeseen kääntyvää tuulta 15-21 m/s. Keskiviikkoiltaa kohden tuuli heikkenee vähän. Sadetta ja ajoittain huono näkyvyys, huomenna näkyvyys paranee.

Selkämeri:
Etelän ja idän välistä tuulta 7-14 m/s, myöhemmin yöllä länteen tai luoteeseen kääntyvää tuulta, aamusta alkaen 11-16, eteläosassa paikoin 21 m/s. Sadetta ja ajoittain huono näkyvyys, huomenna näkyvyys paranee.

Merenkurkku ja Perämeri:
Yöllä ja aamulla suunnaltaan vaihtelevaa tuulta 3-9 m/s, päivällä tuuli kääntyy lännen puolelle ja voimistuu vähitellen, keskiviikkoiltaa kohden tuulta on paikoin 11 m/s. Kohtalainen tai hyvä näkyvyys, yöllä ja aamulla utuista.

000 59540
FPFI44 EFKL DDHH00

Väderrapporten för sjöfarande 27.09.1994 kl.19 2L

Stormvarning:
Finska viken, norra Östersjön, Ålands hav och Skärgårdshavet samt södra Bottenhavet: Västlig eller nordvästlig storm 21 m/s.

Varning för hård vind:
Norra Bottenhavet: Västlig eller nordvästlig vind 16 m/s.

Meddelande för båtförare:
Kvarken och Bottenviken: Senare i morgon västlig vind 11 m/s.
Saimen: Vind omkring syd 11 m/s.

Nordeuropa hör till ett omfattande lågtrycksområde. Ett kraftig delcentrum passerar i natt södra Bottenhavet österut och rör sig i morgon fortfarande mot mellersta Finland. Ett annat delcentrum befinner sig i Nordsverige.

Utsikter till i morgon kväll:

Finska viken:
I natt sydlig eller sydvästlig vind 12-16 m/s, i morgon bitti och på förmiddagen vridande till omkring väst 15-21 m/s. I natt och i morgon bitti regn och tidvis dålig sikt. På dagen västerifrån bättre sikt.

Norra Östersjön, Ålands hav och Skärgårdshavet:
Sydlig eller sydvästlig vind, senare i natt och i morgon bitti vridande till väst eller till nordväst 15-21 m/s. Mot onsdag kväll något avtagande. Regn och tidvis dålig sikt, i morgon bättre sikt.

Bottenhavet:
Vind mellan syd och ost 7-14 m/s, senare i natt vridande till väst eller till nordväst och tilltagande, från i morgon bitti 11-16, i södra del lokalt 21 m/s. Regn och tidvis dålig sikt, i morgon bättre sikt.

Kvarken och Bottenviken:
I natt och i morgon bitti varierande vind 3-9 m/s, på dagen vridande till omkring väst och småningom tilltagande, mot onsdag kväll lokalt 11 m/s. Måttlig till god sikt, i natt och i morgon bitti disigt.

FPFI45 EFKL DDHH00

27.09.1994 2

Weather forecast for shipping 271700 UTC

Warnings:

Gulf of Finland, Northern Baltic, Sea of Aaland and Archipelago, Southern Sea of Bothnia:
West to northwest gale 21 m/s.

Northern Sea of Bothnia:
West to northwest near gale 16 m/s.

Inference:
Wide area of low pressure over Northern Europe. Vigorious center of low moving over Sea of Bothnia towards east. Another minor low over Northern Sweden.

Forecast for next 24 hours:

Gulf of Finland:
By night south to southwest 12-16 m/s. Tomorrow morning veering to west 15-21 m/s. By night and tomorrow morning rain and at times poor vis. By day vis getting better from west.

Northern Baltic, Sea of Aaland and Archipelago:
South to southwest, after midnight and tomorrow morning veering to west or northwest 15-21 m/s. Later in the afternoon somewhat decreasing. Rain with at times poor vis, tomorrow vis getting better.

Sea of Bothnia:
South to east 7-14 m/s. After midnight backing to west or northwest, from morning on 11-16, in the southern part locally 21 m/s. Rainwith at times poor vis, tomorrow vis. getting better.

The Quark and Bay of Bothnia:
By night and tomorrow morning variable 3-9 m/s. By day becoming mainly west and gradually increasing, later in the afternoon locally 11 m/s. Moderate to good vis, by night and tomorrow morning misty.

ILMATIETEEN LAITOS
SÄÄPALVELUTOIMISTO
28.09.1994 KLO 7.05

ENNUSTE POHJOISITÄMERELLE, AHVENANMERELLE JA SAARISTOMERELLE.

Lännen ja luoteen välinen tuuli on voimakkaimmillaan lähituntien aikana. Pohjoisitämerellä, ja myös Saaristomerellä Utön läheisyydessä 20-25 m/s. (kymmenen minuutin keskituuli) Tuuli on puuskaista. Tuuli alkaa aamupäivästä lähtien hitaasti heiketä, mutta on vielä iltapäivällä 16-21 m/s, illalla 13-18 m/s. Aluksi sadekuuroja ja näkyvyys ajoittain huono. Päivällä näkyvyys paranee.

THE WIND FORECAST TO THE FINNISH MARINE LIFESAVING CENTRES

The wind forecast for different sea areas, based on the high resolution limited area model of Finland (HIRLAM), checked by the Central Weather Service of the Finnish Meterorological Institute on 27.9.1994 . The forecast was sent to the Finnish marine lifesaving centres at about 10 pm local time. The wind direction is given in degrees and the wind speed represents ten-minute averages (meter/second).

TUULIENNUSTE MERIALUEILLE (m/s) 18 27 9 94
POHJAUTUU HIRLAM-mallin 12z-RUTIINIIN

	VVKK 9409	PPTT 2718	PPTT 2800	PPTT 2806	PPTT 2812	PPTT 2818	PPTT 2900	PPTT 2906
PERÄMERI	B1N	23009	22007	30006	29006	29009	27009	26009
	B1S	21009	21006	32006	29007	29009	27010	26011
MERENKURKKU	B2	20006	09005	35007	29008	28009	27010	26011
SELKÄMERI	B3N	17004	03007	34012	29012	30013	28012	28012
	B3S	16007	29009	32016	27015	29014	27014	27012
SAARISTOMERI	B4E	20009	24016	28019	27015	28014	27013	27011
AHVENANMERI	B4W	15010	25016	30017	28015	28015	27014	27011
POHJ.-ITÄMERI	B7	18013	260**20**	270**21**	27018	28017	27015	27011
SUOMENLAHTI	B5W	23012	23016	260**20**	27018	27015	27014	26010
	B5E	21012	19015	22016	27019	26017	26014	25012

The used abbreviations:

VV year (vuosi)
KK month (kuukausi)
PP day (päivä)
TT UTC- time (UTC-aika)
B1N Bay of Bothnia northern part (Perämeren pohjoisosa)
B1S Bay of Bothnia southern part (Perämeren eteläosa)
B2 The Quark (Merenkurkku)
B3N Sea of Bothnia northern part (Selkämeren pohjoisosa)
B3S Sea of Bothnia southern part (Selkämeren eteläosa)
B4E Sea of the Archipelago (Saaristomeri)
B4W Sea of Åland (Ahvenanmeri)
B7 Northern Baltic (Pohjois-Itämeri)
B5W Gulf of Finland western part (Suomenlahden länsiosa)
B5E Gulf of Finland eastern part (Suomenlahden itäosa)

For example:
B7 = Northern Baltic 27.9.1994 at 18 UTC (at 20 o´clock local time) 18013 means 180° 13 m/s = South 13 m/s. The next value 28.9.1994 at 00 UTC (at 02 o´clock local time) 26020 means that the wind is veering to west-south-west and increasing, the mean wind is 20 m/s.The wind is gradually increasing and 28.9.1994 at 06 UTC blows westerly wind 21 m/s. The storm warning will be given in Finland, when 10-minute averages are 21 m/s or more.

COORDINATES OF THE PLACE OF THE ACCIDENT 59°23N 21°41E (at 02 local time)

DRIFTING OF RAFTS

TIME	WIND		DRIFTING		DISTANCE	LONGITUDE		LATITUDE	
HRS	DIRECTION	SPEED	DIRECTION	SPEED	NAUT.MILES	DEGREE	MIN	DEGREE	MIN
0	240.	15.00	68.	0.58	0.0	21.0	41.0	59.0	23.0
3	268.	12.13	92.	0.48	3.4	21.0	47.2	59.0	24.3
6	300.	13.00	123.	0.49	2.8	21.0	52.7	59.0	24.2
9	288.	15.27	117.	0.59	2.9	21.0	57.4	59.0	22.6
12	280.	18.00	111.	0.69	3.4	22.0	3.4	59.0	21.1
15	280.	17.00	112.	0.67	4.0	22.0	10.7	59.0	19.6
18	280.	16.00	112.	0.64	3.9	22.0	17.8	59.0	18.1
21	275.	14.94	108.	0.61	3.7	22.0	24.7	59.0	16.7
24	270.	14.00	103.	0.57	3.5	22.0	31.3	59.0	15.7

Speed of wind and flow is given in m/s.
Distance = drift in nautical miles during 3 hours. Total distance = 27.68 nautical miles

DRIFTING OF LIFEBOATS

TIME	WIND		DRIFTING		DISTANCE	LONGITUDE		LATITUDE	
HRS	DIRECTION	SPEED	DIRECTION	SPEED	NAUT.MILES	DEGREE	MIN	DEGREE	MIN
0	240.	15.00	90.	0.38	0.0	21.0	41.0	59.0	23.0
3	268.	12.13	118.	0.30	2.2	21.0	45.3	59.0	23.0
6	300.	13.00	150.	0.33	1.8	21.0	48.4	59.0	22.2
9	288.	15.27	138.	0.38	1.9	21.0	50.2	59.0	20.5
12	280.	18.00	130.	0.45	2.2	21.0	53.1	59.0	18.9
15	280.	17.00	130.	0.43	2.6	21.0	57.1	59.0	17.2
18	280.	16.00	130.	0.40	2.5	22.0	0.8	59.0	15.6
21	275.	14.94	125.	0.37	2.3	22.0	4.3	59.0	14.1
24	270.	14.00	120.	0.35	2.2	22.0	7.8	59.0	12.8

Speed of wind and flow is given in m/s.
Distance = drift in nautical miles during 3 hours. Total distance = 27.68 nautical miles

MESSAGE SENT TO:
Fax: 949 108064
921 2500950
Tel 949 485942

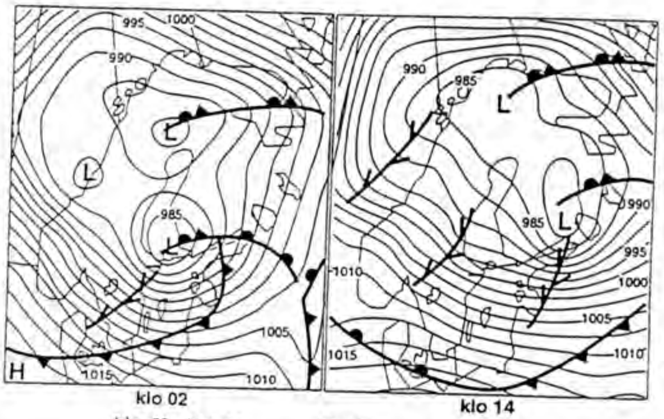
The above drifting forecast has been made at the FMI Regional Office for Southern Finland.

MERISÄÄFAX

Tuulivaroitukset voi tarkistaa numerosta 970 81 eller 970 82 (noin 5 mk/min)

Merisäämeteorologi 24 h/vrk 0600-1-0600 (noin 15 mk/min)

Keskiviikkona 28.09.1994



klo 02 klo 14

	klo 08 DDD	FF	klo 14 DDD	FF	FX	W	klo 20 DDD	FF	FX	W	klo 02 DDD	FF	FX	W
B1N Perämeren pohjoisosa	W	07	WNW	07	09	S	WNW	08	11	-	WNW	08	11	-
B1S Perämeren eteläosa	NW	06	WNW	07	10	S	WNW	08	10	-	W	08	10	-
B2 Merenkurkku	NW	06	WNW	06	10	S	WNW	07	11	-	W	07	11	-
B3N Selkämeren pohjoisosa	N	09	WNW	08	13	S	WNW	10	14	-	W	10	13	S
B3S Selkämeren eteläosa	NNW	15	WNW	13	17	S	WNW	12	16	-	W	11	14	-
B4E Saaristomeri	W	17	W	16	16	S	W	12	16	-	W	11	14	-
B4W Ahvenanmeri	WNW	17	W	16	15	S	W	11	15	-	W	09	13	-
B7W Pohjois-Itämeren länsiosa	W	18	W	16	17	S	W	14	16	-	W	10	13	-
B7E Pohjois-Itämeren itäosa	W	18	W	17	21	S	W	14	16	-	W	12	14	-
B5W Suomenlahden länsiosa	WSW	12	W	17	21	S	W	09	18	S	W	09	13	-
B5E Suomenlahden itäosa	SSW	12	WSW	14	17	S	W	11	18	S	W	10	14	S

ILMATIETEEN LAITOS
Sääpalvelutoimisto

Ennuste tehty 28.09.1994
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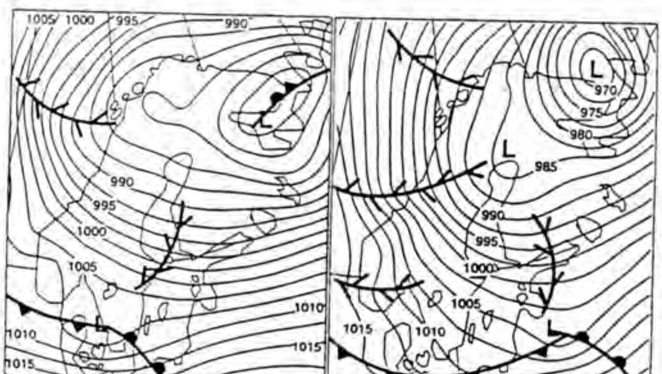
MERISÄÄFAX

Tuulivaroitukset voi tarkistaa numerosta 970 81 eller 970 82 (noin 5 mk/min)

Merisäämeteorologi 24 h/vrk 0600-1-0600 (noin 15 mk/min)

Torstaina 29.09.1994



klo 02 klo 14

	klo 08 DDD	FF	FX	W	klo 14 DDD	FF	FX	W	klo 20 DDD	FF	FX	W	klo 02 DDD	FF	FX	W
B1N Perämeren pohjoisosa	W	06	10	S	W	06	10	S	W	05	10	-	NNW	06	11	-
B1S Perämeren eteläosa	W	06	10	S	W	07	10	S	W	06	10	S	NW	07	10	-
B2 Merenkurkku	W	07	12	-	W	08	12	S	W	07	13	-	NW	09	14	-
B3N Selkämeren pohjoisosa	W	10	13	-	W	10	14	S	W	11	15	S	NW	12	16	-
B3S Selkämeren eteläosa	W	10	13	S	W	09	14	S	W	11	15	S	WNW	12	16	-
B4E Saaristomeri	W	09	13	-	W	08	13	S	WNW	09	14	S	W	11	15	-
B4W Ahvenanmeri	W	08	12	-	W	07	12	S	W	08	14	-	W	10	15	-
B7W Pohjois-Itämeren länsiosa	W	07	11	-	W	07	12	S	WNW	09	14	-	WNW	11	15	-
B7E Pohjois-Itämeren itäosa	W	09	13	-	W	08	13	S	WNW	10	14	S	W	12	15	S
B5W Suomenlahden länsiosa	WSW	08	12	-	W	07	11	S	W	07	12	S	W	08	13	S
B5E Suomenlahden itäosa	WSW	10	13	-	WSW	08	11	S	WSW	07	12	S	W	08	12	S

ILMATIETEEN LAITOS
Sääpalvelutoimisto

Ennuste tehty 28.09.1994
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OTHER DATA

Data from the Swedish Meteorological and Hydrological Institute (SMHI) is given on page 6/2 and data from the Estonian Meteorological and Hydrological Institute (EMHI) is given on page 6/3.

On pages 6/4 and 6/5 there are the calculations for the drifting of the lifeboats and rafts as well as the calculations for the drifting of the oil spill, made by Environmental Impact Assessment Centre of Finland Ltd (Ympäristövaikutusten Arviointikeskus Oy). The calculations are based on the wind data of the Finnish Meteorological Institute.

28-OKT-1994 09:52 SMHI 46 011 174103 SID 02

SMHI
Sjöfart

Svante Andersson

Observationer från några svenska synopstationer i samband med Estonias förlisning 27-28 september.

Nedan anges medelvind samt den maximala medelvind som noterats sedan tidigare synop.

Datum/kl UTC	Söderarm riktning medelvind (m/s)	Svenska Högarna	Gotska Sandön
27/ kl 15 UTC	SW 09 max 12	SW 12 max 14	WSW 11 max 12
27/ kl 18 UTC	SW 11 max 13	SSW 14 max 16	SW 16 max 16
27/ kl 21 UTC	S 13 max 17	SW 16 max 18	W 17 max 20
28/ kl 00UTC	SW 14 max 15	W 17 max 18	W 17 max 18
28/ kl 03 UTC	W 20 max 20	WNW 24 max 24	WNW 16 max 18
28/ kl 06 UTC	WNW 17 max 20	WNW 18 max 25	WNW 12 max16
28/ kl 09 UTC	WNW 12 max 17	WNW 14 max 18	WNW 11 max 15

FROM
OCT.17.94 2:38P P.001

EMHI | Date: Oct 17,1994 | No. | Number of pages, incl. this one:

To: F M I	From: Estonian Meteorological and Hydrological Institute
Telefax No. 358 0 179 581	Meteorological Centre
Att: Maija Komulainen	Originator: Helve Kotli
	Phone (372) 2 44 40 59
Ref. Your: The phonecall from Mr.R.Hyvönen	Fax (372) 2 44 94 84

Dear Mrs.M.Komulainen,

According to your request I am informing You about the weather conditions Sept 27 and 28,1994 at the Meteorological station Ristna (58°55'N 22°04'):

Date Time	Air temp (°C)	Air pressure(mb)	Wind direction	Wind speed metres per sec ond mean	max in gusts a.	max in gusts b.
27.09						
02	13,3	1004,4	SW	6		
05	13,3	1002,1	SW	9	14	
08	12,5	1001,5	SW	10	12	(14)
11	12,9	1001,1	WSW	12		(16)
14	12,8	1001,1	SW	12	16	(17)
17	12,5	999,3	SW	8	12	(16)
20	12,5	995,3	SSW	8	14	(15)
23	12,1	991,9	W	16	21	(22)
28.09						
02	11,2	989,7	WSW	15	22	(23)
05	9,6	987,9	W	18	24	(29)
08	8,8	989,9	W	17		(26)
11	9,4	994,9	WNW	12	18	(26)
14	10,4	998,1	W		16	(19)
17	11,2	1000,4	W	10	15	(18)
20	11,7	1002,3	W	9		(15)
23	11,0	1003,4	NW	8	14	(15)

Attention: a. means maximum wind speed in gusts at the observation moment
b. maximum wind speed in gusts during the last three hours

Ristna Station has transmitted storm warnings:

27.09.94 at 20.45 wind 230 degrees 9 to 16 metres per second

28.09.94 at 02.36 wind 240 degrees 15 to 25 metres per second

at 03.00 260 degrees 20 to 29 metres per second in gusts

at 03.33 the last warning was cancelled

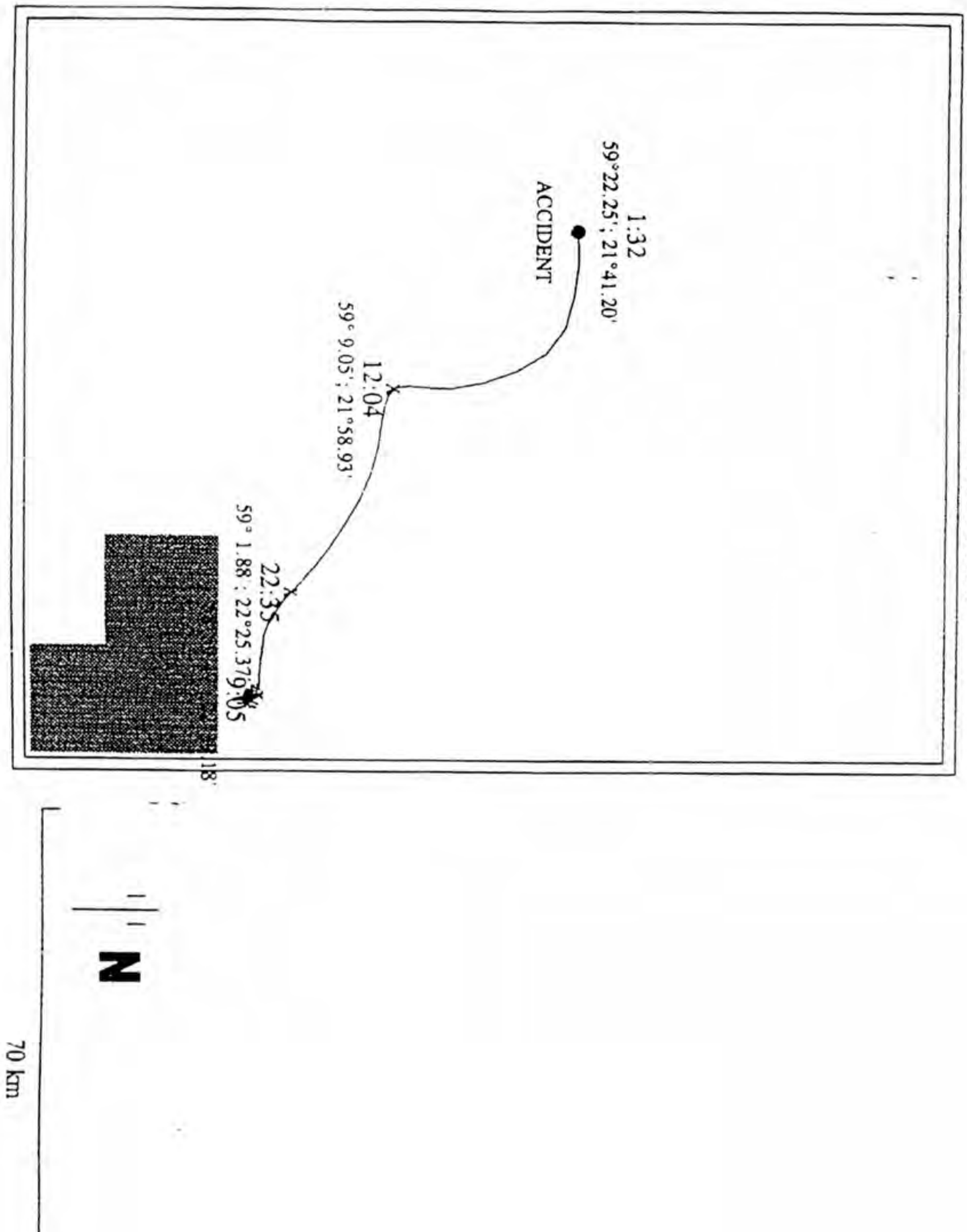
Yours sincerely

Helve Kotli

Director

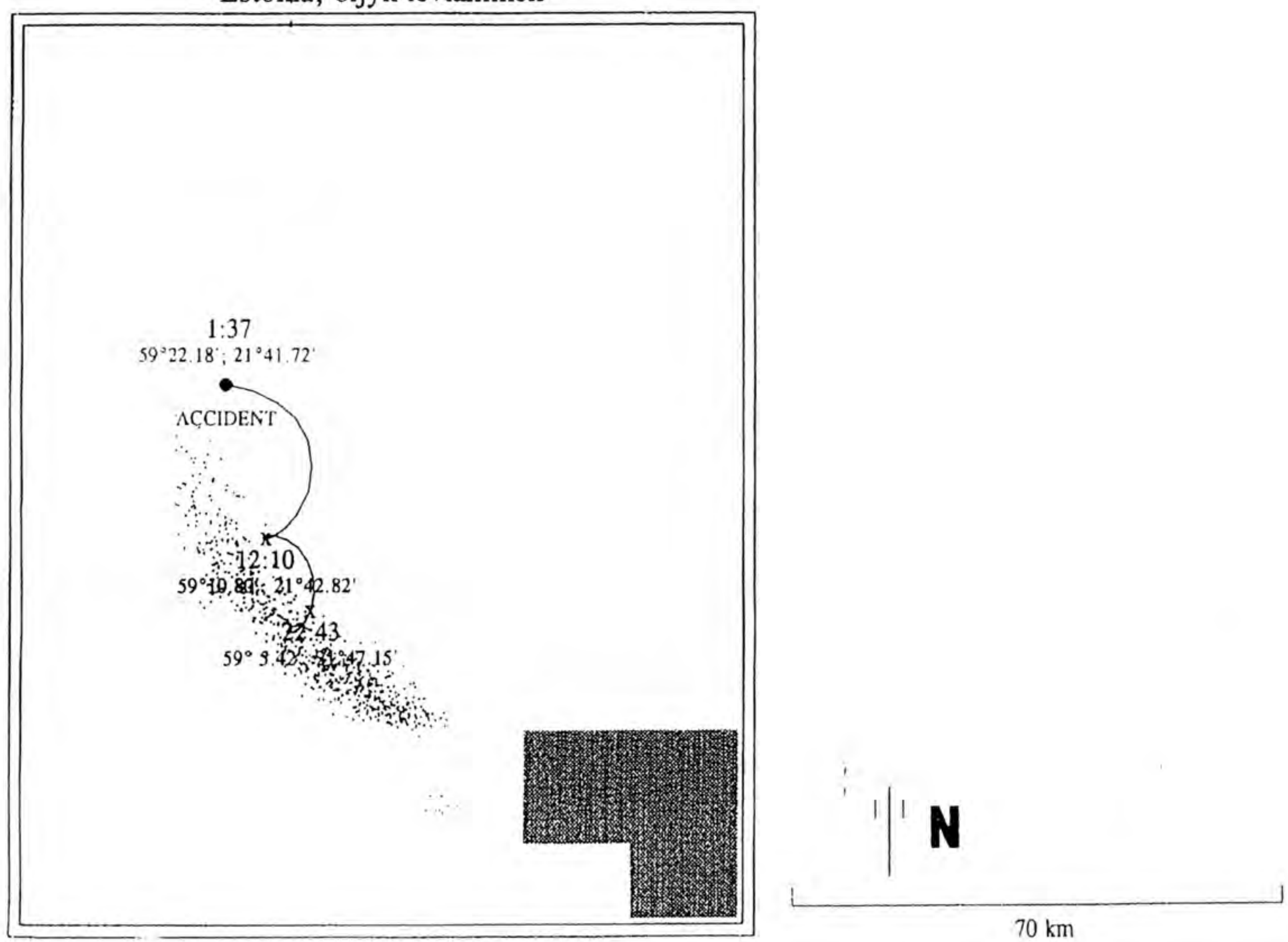
Estonia, effect of flow and wind

Estonia, virtaus + tuulivaikutus



Estonia, spreading of the oil

Estonia, öljyn leviäminen



SUPPLEMENT No. 403

The m/s ESTONIA accident. Weather conditions on September 27th and 28th 1994.

Swedish Meteorological and Hydrological Institute.

Norrköping 1995.

SMHI

1995-12-04

STATENS HAVERIKOMMISSION
Ink 1997 -10- 08
Dnr ESTONIA
Aktbil. nr C 35

Board of Accident
Investigation,
Sweden

The m/s ESTONIA accident;

Weather conditions on September 27th and 28th 1994

General

The weather conditions on the 27th was dominated by an intense and large low pressure area with several sublows, covering northern Scandinavia and the Norwegian Sea. Refer to the weather chart over Europe in figure 1 (bilaga 1) from 12 UTC Sept. 27th.

One of the sublows intensified on the 27th and rapidly moved eastward via southern Norway and eastern Sweden to southern Finland. The low became relatively intense and was located over Oslo on Sept. 27th at 12 UTC with pressure 995 HPA, on Sept. 28th at 00 UTC over the southeastern part of Sea of Bothnia with 980 HPA and on Sept. 28th at 12 UTC over eastern Finland with 985 HPA. A warm front, associated with the low, together with an area of rain, moved quickly eastward during the evening of the 27th over the northern Baltic sea. South and southwest of the low the wind shifted from southwesterly to westerly, the westerly becoming very gusty.

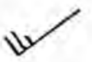
THE WEATHER CONDITIONS ON NORTHERN BALTIC SEA AND GULF OF FINLAND SEPTEMBER 27TH

The weather can be described with a map of observations from different places. In figure 2 to 6 (bilaga 2-6) these maps are shown for the period of interest.
Weather observations are made simultaneously every third hour, beginning at 00 UTC.
Swedish time is equal to UTC-time plus 1 hour.
Finnish and Estonian time is equal to UTC-time plus 2 hours.
In this report, Swedish time, called L.T. (UTC time plus 1 hr) is used unless indicated otherwise. In some of the figures, the time notation Z is used, which is equal to UTC.

The winds on the chart is denoted by an arrow flying with the wind. The arrow has short and/or long cross bars indicating the wind speed.
One short bar means 2.5 m/s, one long bar means 5 m/s.

Swedish Meteorological and Hydrological Institute
S - 601 76 NORRKÖPING
Telephone +46 1115 80 00 * Telefax +46 11 17 41 03

For example:


SW (southwest) 12.5 m/s


W (west) 20.0 m/s

Figure 7 (bilaga 7) shows a map of selected observation sites which have been found representative to present the weather conditions on northern Baltic sea: Söderarm, Svenska Högarna, Bogskär, Utö, Russarö, Bagaskär and Ristna.
Observations are also made in Tallinn, however those are impaired by lee wind effects. For instance, no wind speed over 7 m/s were reported from Tallinn during the period of strong winds which occurred on Sept. 27-28th.
In figure 8 (bilaga 8), the weather observations from the above mentioned sites are listed in table form for each third hour during the period of interest.

DEFINITION OF WIND

The wind is defined by an international agreement (WMO), used by all countries, as the mean wind registered on a height of 10 meters over the ground during a period of 10 minutes preceding the observation occasion. The wind is, in most cases, measured with the help of an instrument called anemometer.
In Sweden, the maximum mean wind during the last 3-hour period is also noted. The Finnish lighthouse, Bogskär, is equipped with an automatic weather station which also measures maximum mean wind and gust-winds.
Also on the Estonian site Ristna, maximum and gust winds are measured. Refer to figure 8 (bilaga 8).

The variation of the wind hour by hour as registered by Söderarm and Svenska Högarna (copies of original registrations) are shown in figure (bilaga) 9 and 10. Note that the time is UTC. Clearly, the maximum winds occurred after the accident of Estonia.

COMMENTS TO THE TABLE OF THE WEATHER CONDITIONS

The wind observations from the listed observation sites are relatively representative for open sea area although some reduction is always present even at a lighthouse close the coast. Additionally, at some lighthouses, the lee effect is significant from certain wind directions. Observations from Bogskär and Ristna is estimated to be the most representative in this weather situation.

In order to better assess the winds at sea, SMHI is using a computer model which takes into account the actual weather observations, effects on the wind due to topography over land and coastal areas and over the sea. Included in the model is also sensitivity to the actual type of air mass and water temperatures. The physical relationships are well known and by running this weather model one enhances the assessment of the winds in different areas of the sea. The figures (bilaga) 11-14 depict such computer generated maps valid 19, 22, 01 and 04 hours L.T. on Sept. 27-28th.

WAVES

DEFINITION OF WAVES

The wave height of a single wave is defined as the vertical distance from bottom to top. According to international agreements, measurements are done using significant wave height and maximum waves. The significant wave height is defined as the mean value of the highest third of all waves. This concept has been introduced as a way to achieve a better relationship between waves measured by instruments and manually assessed wave heights. It is known that a human eye tends to over-estimate the "mean wave height". The concept "significant wave height" then provides a better relation between manual observations and those made by instruments.

The concept maximum wave height is introduced because waves, which interferes with each other, occasionally form waves considerably higher than the significant wave height.

Statistically, every 500th to 1000th wave will become generally 70-80% higher than the significant wave height and in some extreme cases, 100% higher. On this occasion, it is estimated to have happened between every second and every third hour.

In the cases of waves passing over shoals, the frequency of the above described interference phenomena increases. This also occurs when the wind direction shifts more than 45 degrees, lasting for at least a couple of hours. Wave fronts will then intersect and interfere with each other.

Wave measurements were missing at the occasion in the northern Baltic sea. The only measurements made routinely in this area are made at Almagrundet. Due to technical problems this station has not been in use for some time. However, on this occasion, wave measurements from Almagrundet would not have been representative for the area from the western part of the Gulf of Finland to south of Utö, in particular not with wind directions from south and southwest followed by west.

The daily wave forecast, used by SMHI, is produced by a numerical wave model which uses the speed, direction and duration of the wind, plus the sea depth, in its calculations. The dynamic processes are well known, and the model has been verified to be very accurate in both Germany and Sweden. The result is presented as significant wave height.
In order to calculate the wave conditions on the occasion as accurate as possible, SMHI has used the above mentioned numerical weather model to produce the initial weather conditions as input in the wave model. The outcome being waves based on the actual wind conditions during Sept. 27-28th in the area of interest.
Figure (bilaga) 15-17 shows calculated waves at 19, 01 and 07 L.T., based on the numerical weather model.

This report also includes a theoretical study of wave heights and an assessment of probabilities for some extreme wave heights which may have occurred on the occasion. See figure 18 (a-b).

AIR TEMPERATURE

The air temperature at sea varied between 11 and 13 degrees during the day on the 27th. Behind the narrow front which passed eastward during the evening, the temperature sunk to 10-11 degrees. The temperature dropped to 8-9 degrees after the wind had shifted to west during the later part of the night.

SEA SURFACE TEMPERATURE

Daily maps of the sea surface temperature of surrounding seas are produced by SMHI. Data is acquired from measurements made by ferries and merchant vessels and from satellite measurements made with infrared sensors.

The sea surface temperature in the the area of interest during the night between 27-28th was between 12-13 degrees. From the 28th the temperature sunk to 10-11 degrees. Refer to figure (bilaga) 19.

CURRENTS

Sea current measurements are not made on a daily basis in the Baltic sea. However, a numerical model which calculates currents is run daily at SMHI. This information is mainly used for oil discharge fighting and rescue operations. Since the weather conditions entirely steer the sea currents in the Baltic sea, it is possible, as in the wave height case, to calculate the sea current conditions with the help of weather models.

These calculations, which in this case shows the current at 5 m depth, does not reveal any strong currents along the route of m/s Estonia in the beginning of evening.

Shortly before midnight the current is calculated to have increased to about 0.5 knots towards the direction between east and northeast. From 02-03 L.T. shifting toward southeast, still around 0.5 knots.

REPORTS FROM EYEWITNESSES

Information about wind and waves have been gathered from:

* The ferries Silja Europa and Mariella, which run almost parallel to Estonia. They arrived to the place shortly after the loss.

* The ferry Finnjet, which was located about 25 n.m. behind Estonia, arriving to the place at 02.20 L.T.

* The ferries Silja Symphony and Isabella, which departed from Stockholm toward Helsinki and estimated to have passed the place of the loss 2-3 hours after it happened.

* Two Swedish merchant vessels, Westön and Ingrid Gorthon, arriving to the place of accident 3-4 hours after it happened.

* Helicopters from the Air Force and the Navy , which participated in the rescue operation and arrived 3-5 hours after the loss.

Wind and waves

Vessels

All vessels reported the mean wind in the beginning of the evening (Sept. 27th) to about south 10-15 m/s. Later, further increasing to south 15-20 m/s. Then 2-3 hours before midnight shifting to southwest 15-20 m/s. From the later part of the night, that is after the loss, about west 20-25 m/s with gusts up to 26-30 m/s. During the early morning decreasing to west about 20 m/s, later in the morning 15 m/s.

The wave height has been estimated to 4-5 m, with occasional maximum waves 6-7 m before the accident, after the accident 5-6 m with occasional waves up to 7-8 m.

The wind gauge instruments on the ferries are placed between 40-50 m over the sea surface but the wind speed readings are reduced to be valid at a height of 10 m. After many years of experience, the general opinion among the crew on board the vessels is that this reduction of the wind very well corresponded to the real conditions.

Observations of wind and waves on merchant ships are always estimated. The captains on board these vessels point out that according to their experience, the wave height was at the most 5-6 m, compared to 6-10 m which has been figured in the press.

Helicopters

The Swedish helicopters from the Air Force and the Navy which arrived to the site of the loss between 02.50 and 05.00 L.T. have made the following estimates:

Wind about west 25 m/s, gusts up to 30 m/s. One helicopter reported gusts of up to 40 m/s.

Concerning the wave heights, the range varies more than for the wind. The majority reports 5-6 m or 6-8 m. One helicopter reported 6-9 m, another 6-10 m.

One helicopter even reported a gigantic wave of 12 m.

Comments to observations from vessels and helicopters

The wind and wave conditions of interest are those which occurred before the accident. There is a close agreement between observations from the different meteorological stations, observations made on vessels and the numerical model calculations of the wind and wave conditions. Close agreement remains also after the accident except for wave height reports from helicopters. It may prove difficult to evaluate the different observations, but SMHI wants to comment on those since there have been speculations about extreme conditions in the press.

Wind

Before the accident, reports were available from ferries and merchant ships. There is close agreement here about the southwest wind 15-20 m/s, also supported by meteorological observations and computer models.

After the accident, i.e. the late part of the night and the early morning, both vessels and helicopters were generally in agreement of wind speed west 20-25 m/s, gusts up to 30 m/s.

One helicopter reports gusts up to 40 m/s.

These reports are generally supported by observations made by meteorological stations as well as computer models, which indicated gusts of up to 30-34 m/s.

Significant wave height

There is close agreement between observations and calculations on the wave height 3.5-4.5 m before the accident. During the time after the accident, there is significant difference between the reports from the vessels, which report 5-6 m, and the helicopters, which report wave heights from 5-6 m to 6-10 m.

One has to assume that reports from helicopters do not distinguish between significant and maximum waves, which result in the large range of wave heights.

Since observations of significant wave height from ferries and merchant vessels before and after the accident is in close agreement with numerical calculations and theoretical studies, the conclusion made by SMHI is that is most likely that the wave height before the accident was 3.5-4.5 m and 2-3 hours after the accident had increased to 5.0-6.0 m.

Maximal wave height

The maximal wave height, both observed by vessels and theoretical, are also in close agreement here. Occasional maximal waves occurring before the accident is estimated to about 7 m, but statistically, an 8 m wave could have occurred every second hour. A couple of hours after the accident, the expected maximum wave is 8-9 m, possibly with some extreme wave up to 10 m. This wave may have been observed by the helicopter which reported the 12 m wave.

As a comparison, the highest waves ever measured in the Baltic Sea since 1976 is from Almagrundet with a significant wave height of 7.8 m, maximum height 12.8 m and from Svenska Björn with a significant wave height of 8.1 m, maximum height 12.2 m. Both of these readings are made during a long lasting southerly storm during January 13-14th 1984.

During the rescue operation later in the night, the waves must have been experienced as very difficult due to the fact that "old" waves from southwest with longer period were superimposed by waves from the west with shorter periods, forming a confused sea state.

THE CONDITIONS FOR M/S ESTONIA

An attempt is made here to retrospectively give the most probable wind and wave conditions which m/s Estonia experienced during her last voyage, based on observations and calculations referred to earlier in this report.

The magnitude of the force of the gusts are estimated from both observations and theoretical calculations made on the present weather situation.

Note that the significant wave height is calculated while the maximal wave height is based on theory, statistics and eyewitnesses.

The time is referred to as Swedish time. The vessel's speed is based on the normal time table/speed normally used according to EstLine including information from Officer Kukk to media and m/s Mariella.

Estimated conditions on m/s Estonia's last voyage:

* 18.00-19.00 L.T. Tallinn roadstead - point just west of Naissar. (Speed 19-20 knots?)
Wind S-SW 8-10 m/s. Gusts up to 13 m/s.
Waves 1.0-1.5 m, max 2.0 m.

* 19.00-20.00 L.T. Point just west of Naissar - line Pakri/Jussarö. (Speed 16 knots?)
Wind S 10-13 m/s. Gusts up to 16 m/s.
Waves 1.5-2.0 m, max 3.0 m.

* 20.00-21.00 L.T. line Pakri/Jussarö - abeam of Osmussar. (Speed 15 knots?)
Wind S 11-15 m/s. Gusts up to 18 m/s.
Waves 2.0-3.0 m, max 4.0 m.

* 21.00-22.00 L.T. Abeam of Osmussar - line Tahkuna/Russarö. (Speed 14 knots?)
Wind S-SW 13-17 m/s, gusts up to 24 m/s. (At the front shortly strong gusts.)
Waves 2.5-3.5 m, max 5.0 m.

* 22.00-23.00 L.T. Line Tahkuna/Russarö - abeam of Bengtskär. (Speed 14 knots?)
Wind SW 13-17 m/s. Gusts up to 21 m/s.
Waves 3.0-4.0 m, max 6.0 m.

* 23.00-24.00 L.T. Abeam of Bengtskär - abeam of Ristna. (Speed 13 knots?)
Wind S-SW 14-18 m/s. Gusts up to 21 m/s.
Waves 3.5-4.5 m, max 6.5 m.

* 00.00-00.30 L.T. Abeam of Ristna - point just east of the accident. (Speed 12 knots?)
Wind SW 16-20 m/s. Gusts up to 23 m/s.
Waves 3.5-4.5 m, max 7.0 m.

At the sight of the loss:

* 00.30-02.00 L.T.
Wind SW 16-20 m/s. Gusts up to 24 m/s.
Waves 4.0-5.0 m, max 7.5 m.

* 02.00-06.00 L.T.
Wind W 20-25 m/s. Gusts up to 30-34 m/s.
Waves 5.0-6.0 m, max 9.0 m, possibly an occasional wave up to 10 m.

* 06.00-08.00 L.T.
Wind W 17-22 m/s. Gusts 26 m/s.
Waves 4.0-5.0 m, max 7.0 m.

FORECASTS

Presentation of forecasts valid on the occasion of the accident including the customized forecast which was sent to m/s Estonia.

The General Weather Forecast for Sea areas

In the general weather forecast for sea areas transmitted on the Swedish radio P1 on the 27th at 08.00 L.T. and the forecast transmitted in English via Coastal Radio Station and NAVTEX on the 27th at 06.56 UTC, it was indicated that the wind from SW 10-13 m/s would be increasing to 17-22 m/s, during the night further increasing to westerly storm 20-25 m/s. Refer to figure (bilaga) 20 and 21.
The following reports transmitted during the day and evening of the 27th, repeated this forecast. Refer to figure (bilaga) 22-25.

Customized Forecast

Like many other ferries, m/s Estonia subscribed to a daily forecast service from SMHI via fax. These forecasts are customized to a specific route and offer relevant information. The forecast was sent by fax and acknowledged by m/s Estonia in the afternoon on the 27th is shown in figure (bilaga) 26.
Besides a detailed wind forecast for separate stretches along the route, a wave forecast is included, based on the earlier mentioned numerical wave model.

Forecast preparation

The data used by SMHI for making 72 hour forecasts is provided by a numerical weather model which is run on a main frame computer four times a day. Longer forecasts of up to 10 days are calculated on a co-European weather model twice a day, but the space and time resolution in the latter model is not as high.
In cases of technical problems and for reasons of comparison, SMHI also receive numerical weather models from Great Britain, Germany and the United States.

All available information about the present weather condition on a global basis from the surface, the atmosphere and through satellite sensors are continuously transmitted into these models. The data is also supervised directly by meteorologists on screens and maps in order to closely follow the weather development.
The weather development on Sept. 27-28th was well predicted by SMHI's weather model and supported by the rest of the above mentioned weather models. The meteorologist on duty at SMHI during Sept. 27-28th had access to a reliable forecast and was able to issue a storm warning already Tuesday morning for the upcoming night on northern Baltic Sea.
The operational wave model, which uses winds from the numerical wind model as input, produced maps of waves which, although slightly smaller, relatively well corresponded to the actual wave heights.

FINAL COMMENTS

Weather and wave conditions

As mentioned earlier, the conclusion is that the hardest winds and windshift to a westerly storm force, with corresponding heavy sea, occurred not until 1-2 hours after the accident and then continued 3-5 hours in the morning.

The weather on Sept. 27-28th is not extreme in any way, instead a rather 'normal' autumn storm occurring a number of times during the autumn and winter periods, statistically 5-15 times per year.

Forecasts

SMHI's opinion about the general forecasts, which were transmitted on Swedish radio station P1, coastal radio station and NAVTEX, is that the weather development was well predicted on the evening of the 27th and morning of the 28th on the northern Baltic Sea. Additionally, the customized forecast sent to and acknowledged by m/s Estonia, must have matched the expected quality requirements, although the waves in the forecast were underestimated to some degree, especially the maximal waves.

Up until the accident the wave height was in the forecast 2.5-3.5 m, max 5.5 m. In the analysis of this report the actual wave height is estimated to have been 3.5-4.5 m, max 7.0 m before the accident.

SMHI finds no physical or topographical conditions in the sea which may have caused any extreme waves over 7 m before the accident.

The conditions after the accident with waves 5.0-6.0 m, max 8-9 m, occurring 2-6 hours later in the morning on the 28th, would never have been experienced by m/s Estonia if the vessel had continued westward with 14-16 knots, since the wave height decreases toward the lee shore further westward.

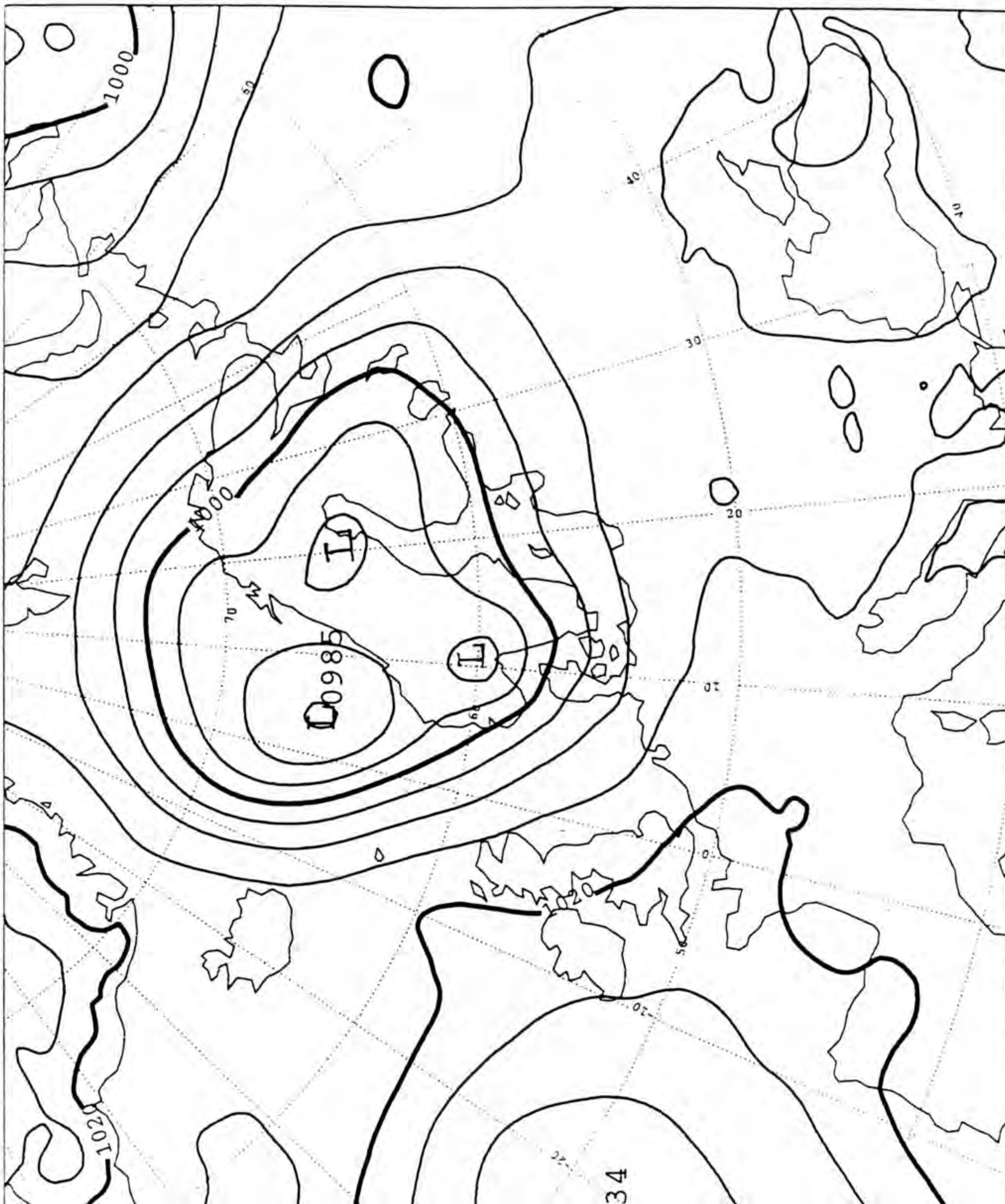
This is why the customized forecast from SMHI for the period 04-07 Estonian time (03-06 L.T.) indicated decreasing waves, although the wind was predicted to increase to west 18-25 m/s.

SMHI's opinion is that the forecast in this case did not have a deterrent effect to the officers on m/s Estonia, since these conditions are experienced a number of times each year on the northern Baltic Sea, and at times even worse.

For SMHI

Svante Andersson
Head of SMH I -Marine Services

Bilaga 1.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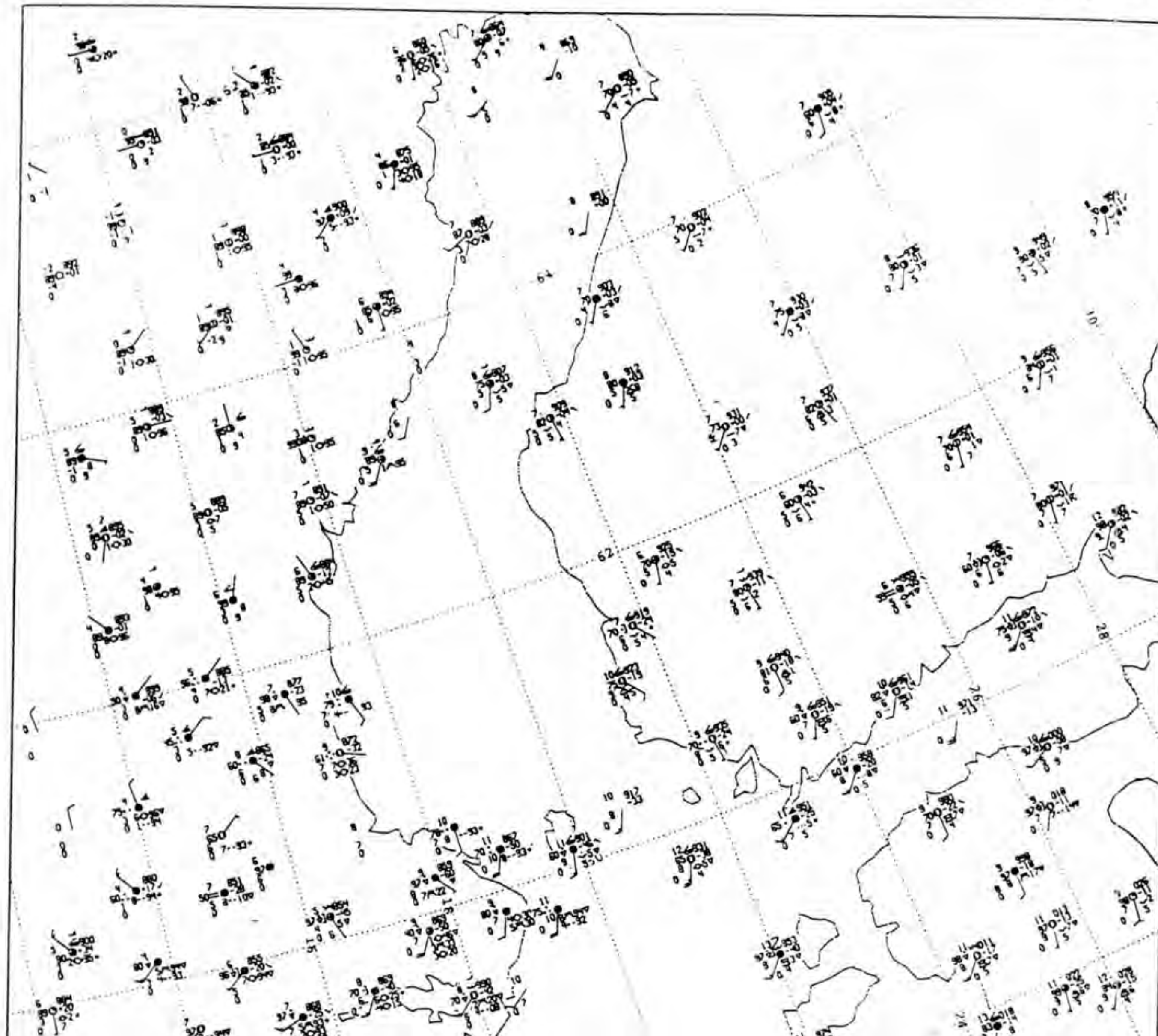
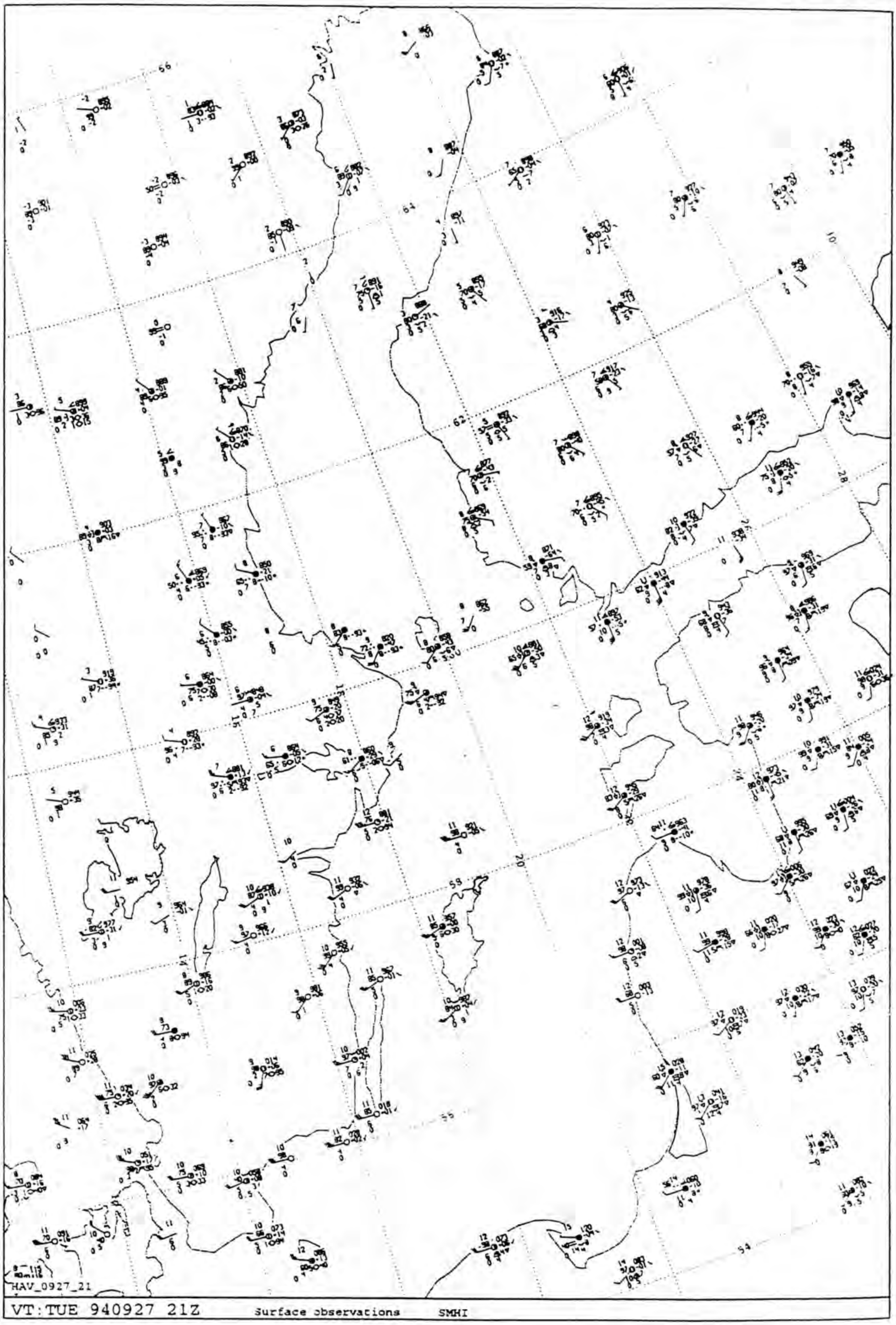
Bilaga 2.



VT:TUE 940927 18Z Surface observations SMHI



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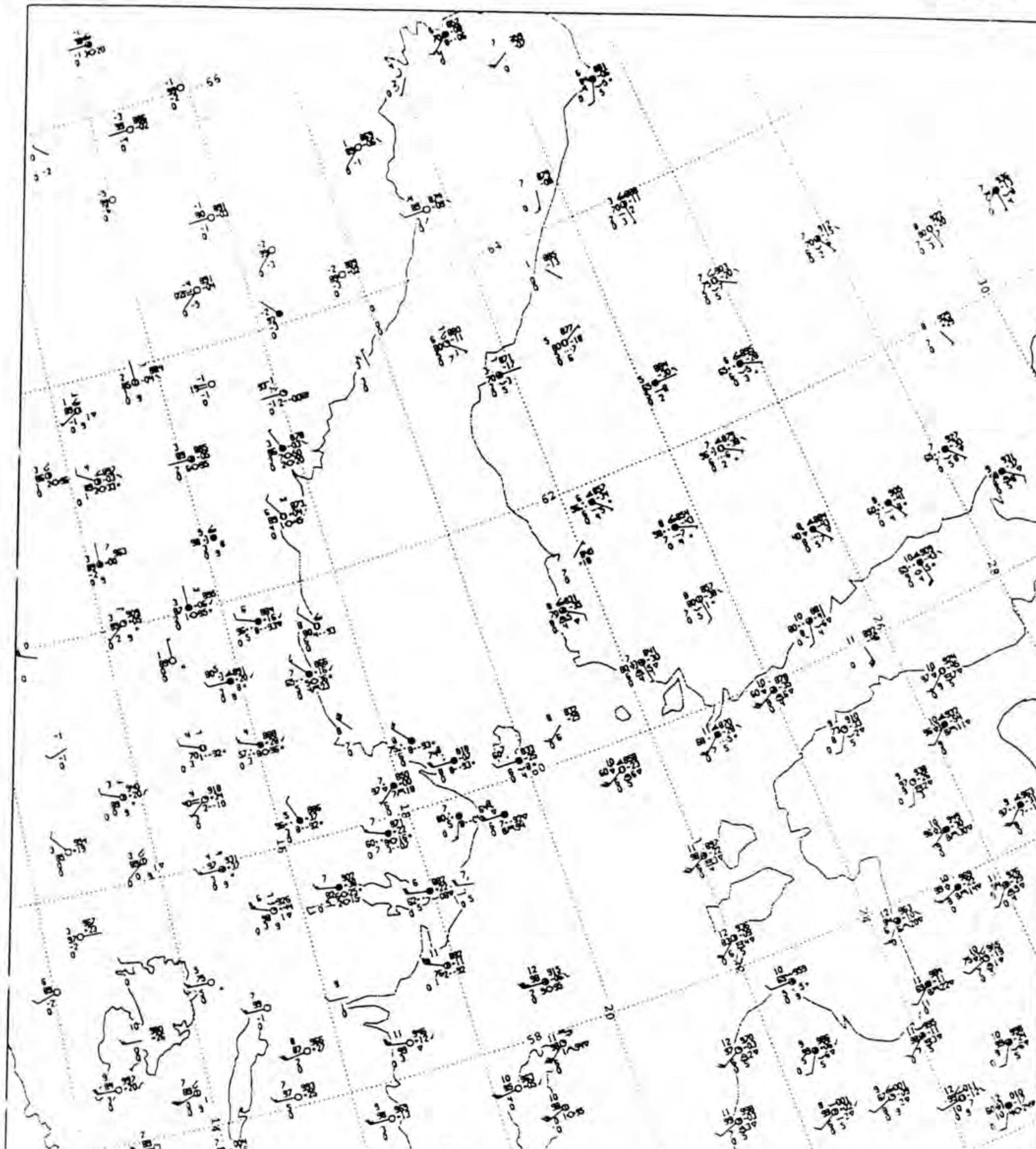
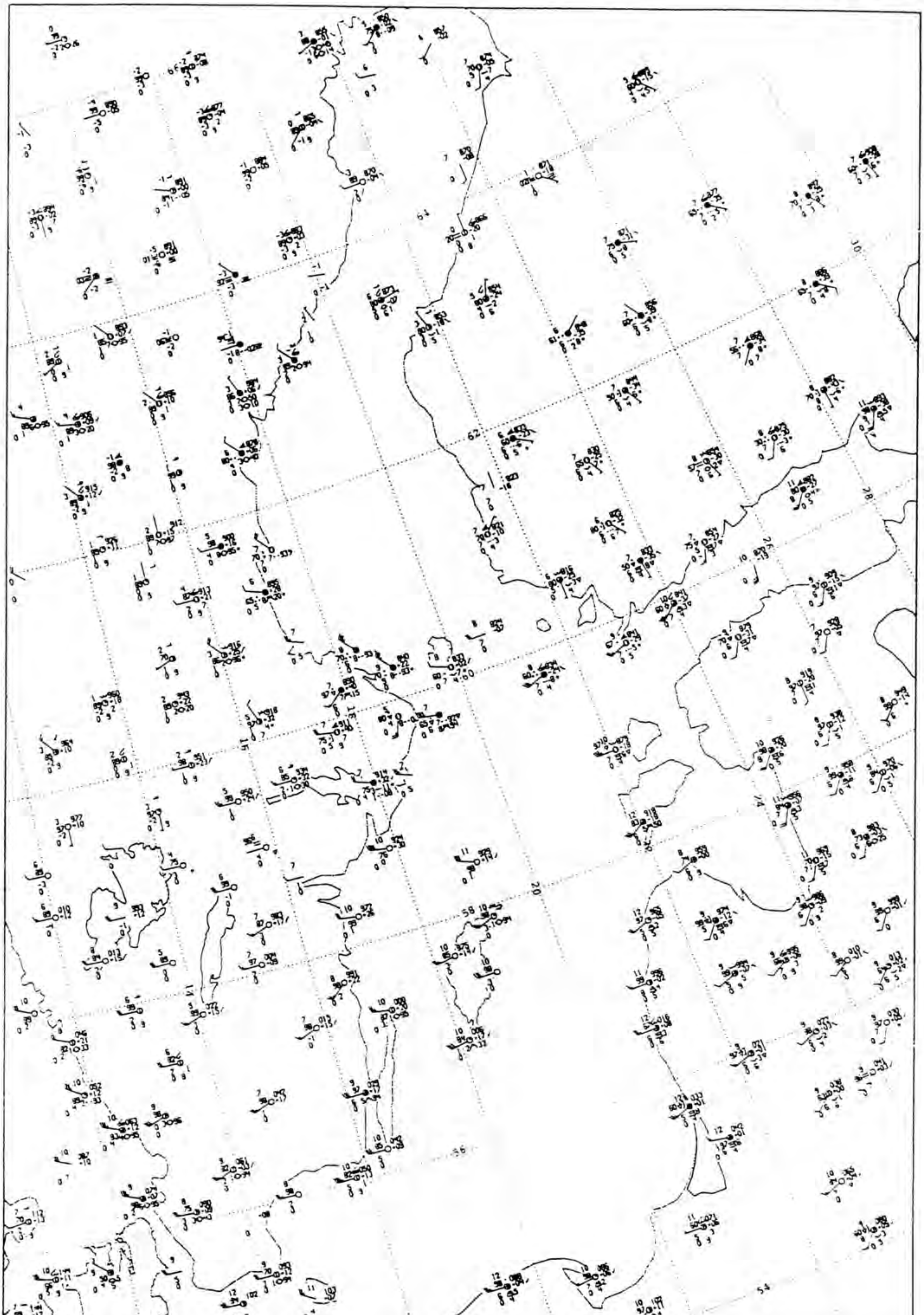


VT:WED 940928 00Z   Surface observations   SMHI

Bilaga 5.



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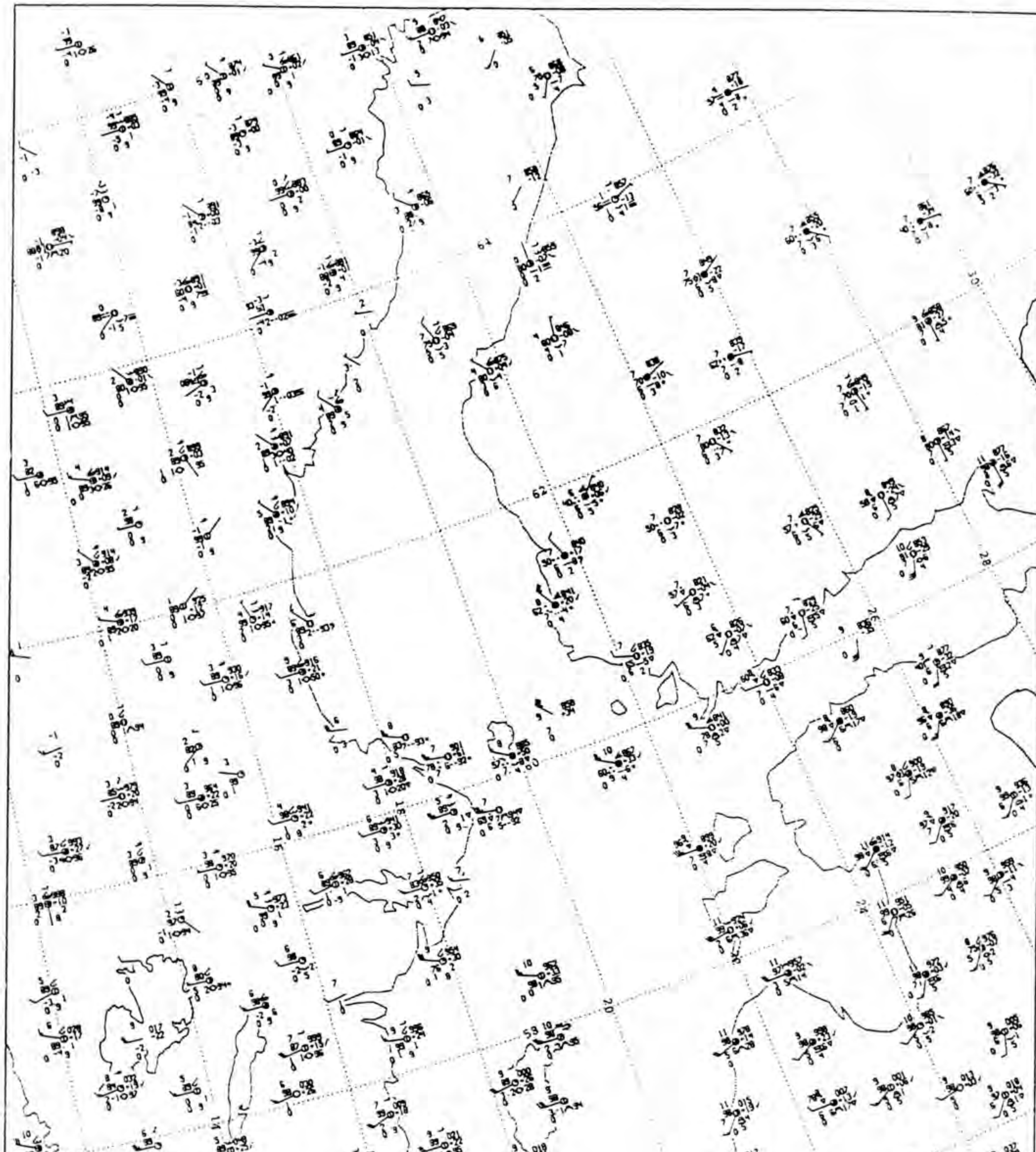
HAV_0928_06
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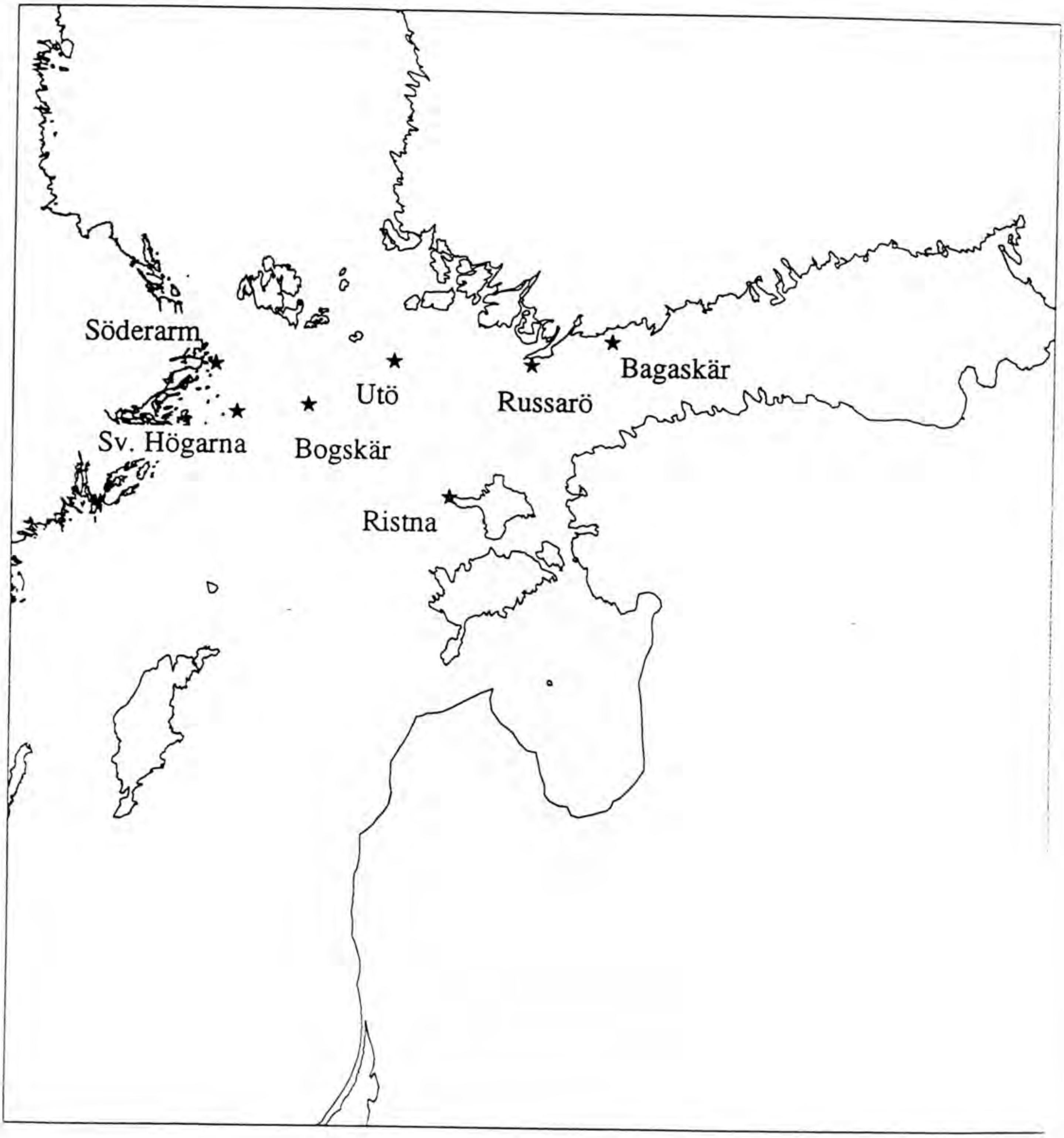
Surface observations
SMHI


Söderarm
Sv. Högarna
Bogskär
Utö
Russarö
Bagaskär
Ristna

OBSERVATIONER

Nedan visas de observationer av medelvind till riktning respektive hastighet som noterades 27-28 september.
Endast de svenska stationerna plus den finländska automatstationen Bogskär anger vilka maximala medelvindar man noterat sedan förra observationen, 3 timmar tidigare. Notera att man aldrig mäter vindhastigheten i byarna vid någon av dessa stationer förutom vid Bogskär och Ristna.
Tiden är svensk vintertid.

Dag/ kl	Söderarm riktning medel/max (m/s)	Svenska Högarna	Bogskär byvindar, se Not.	Utö	Russarö	Ristna / bymax	Bagaskär
27/kl 16	SW 09 /12	SW 12 /14	SW 13 /14	SW 09	WSW 09	SW 08 /12	SW 12
27/kl 19	SW 11 /13	SSW 14 /16	S 14 /17	SSW 13	SW 08	SSW 08 /14	SW 09
27/kl 22	S 13 /17	SW 16 /18	SW 17 /18	SW 15	S 16	WSW 16 /21	S 15
28/kl 01	SW 14 /15	W 17 /18	SW 20 /21	SW 15	SW 12	WSW 15 /22	SW 16
28/kl 04	W 20 /20	WNW 24 /24	W 19 /22	WSW 15	WSW 12	W 18 /29	SW 18
28/kl 07	WNW 17 /20	WNW 18 /25	WNW 21 /24	WNW 13	WNW 09	W 17 /26	W 04
28/kl 09	WNW 12 /17	WNW 14 /18		W 15	WNW 11	W 12	W 10

Not.
Bogskär uppmätte de högsta byvindarna:
27 september kl 22.46 till 24.6 m/s.
28 september kl 06.25 till 27.7 m/s.

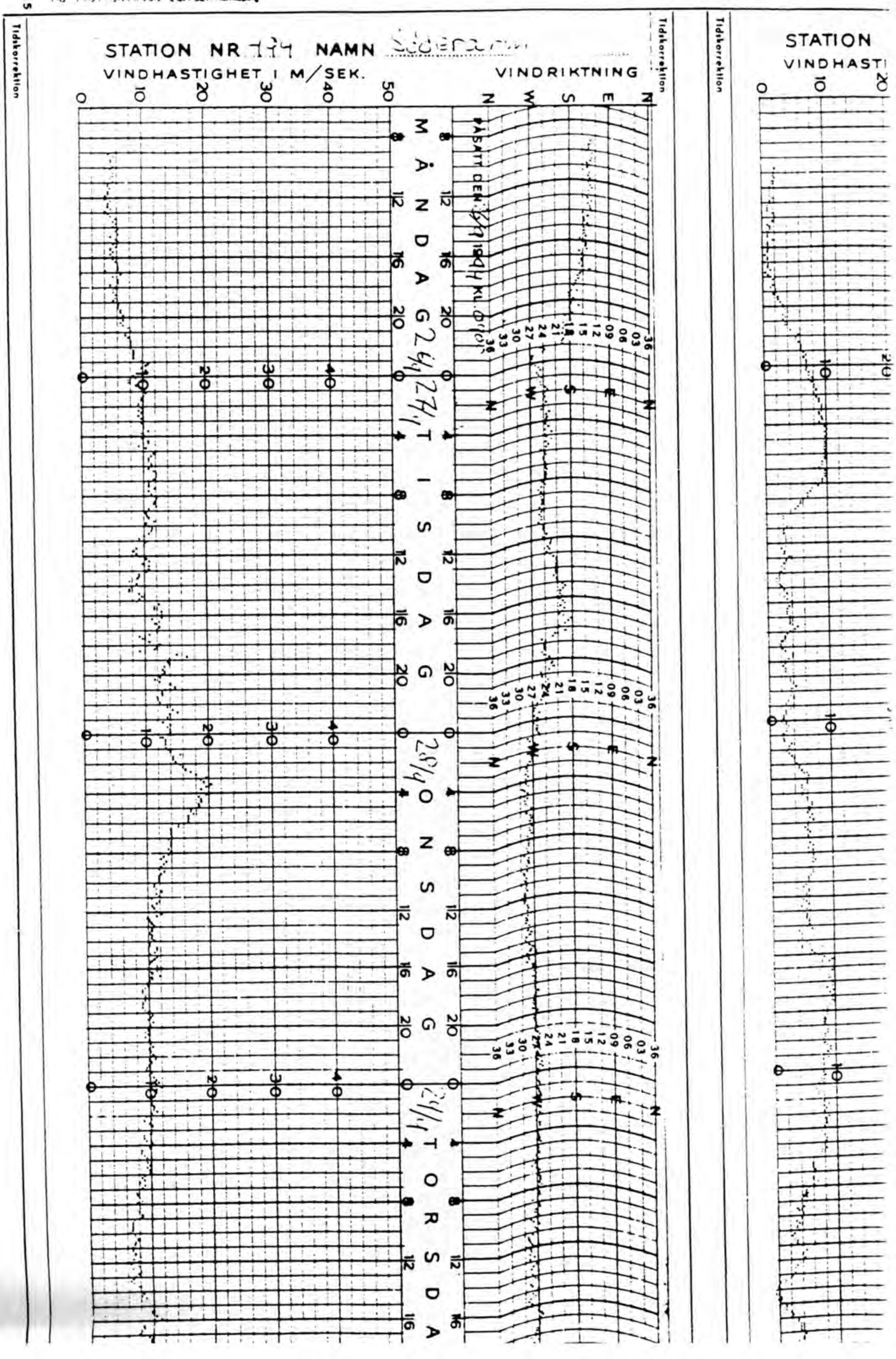
Däremellan var bymax betydligt lägre.

Bilaga 9.

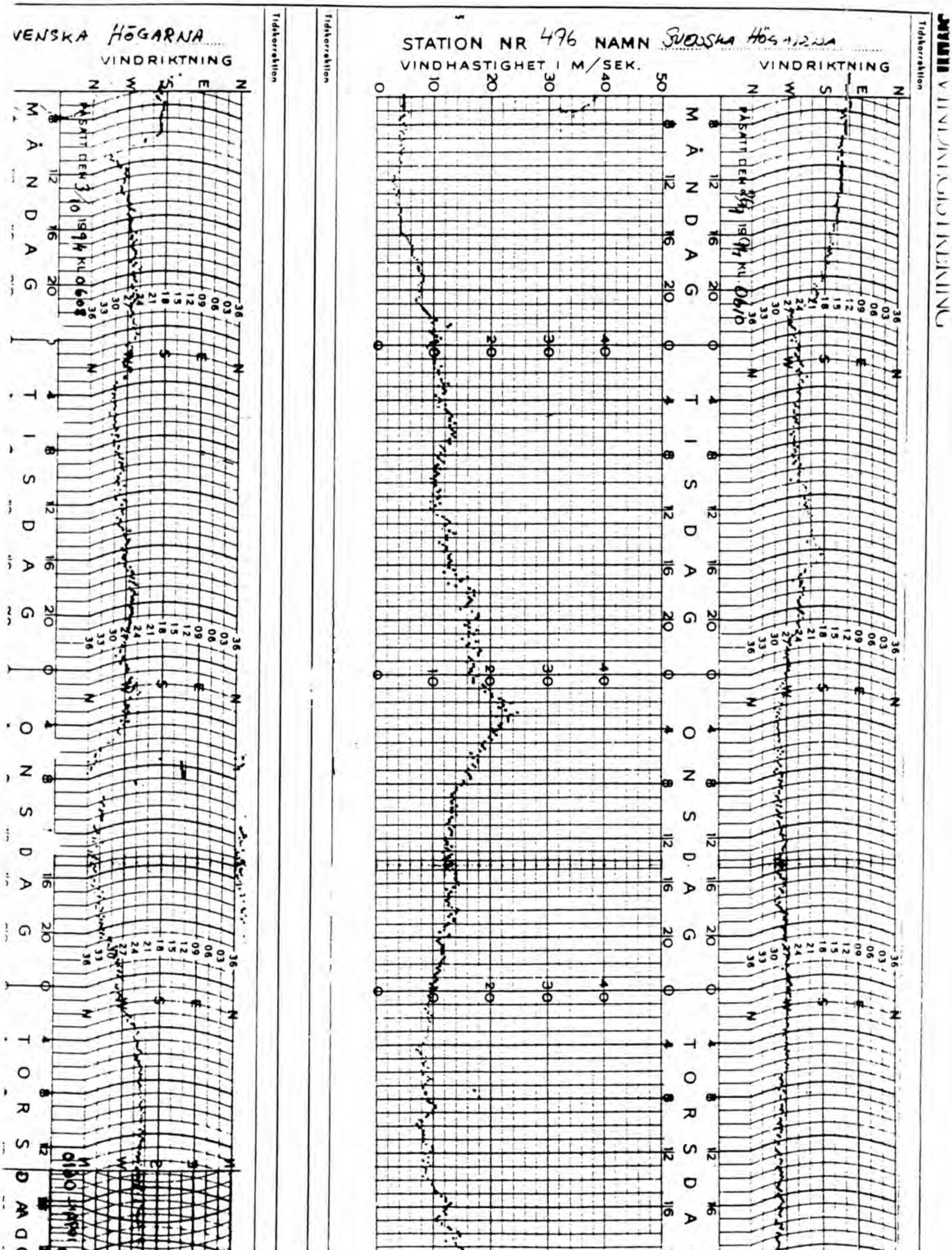
SÖDERARM

SMHI 4315

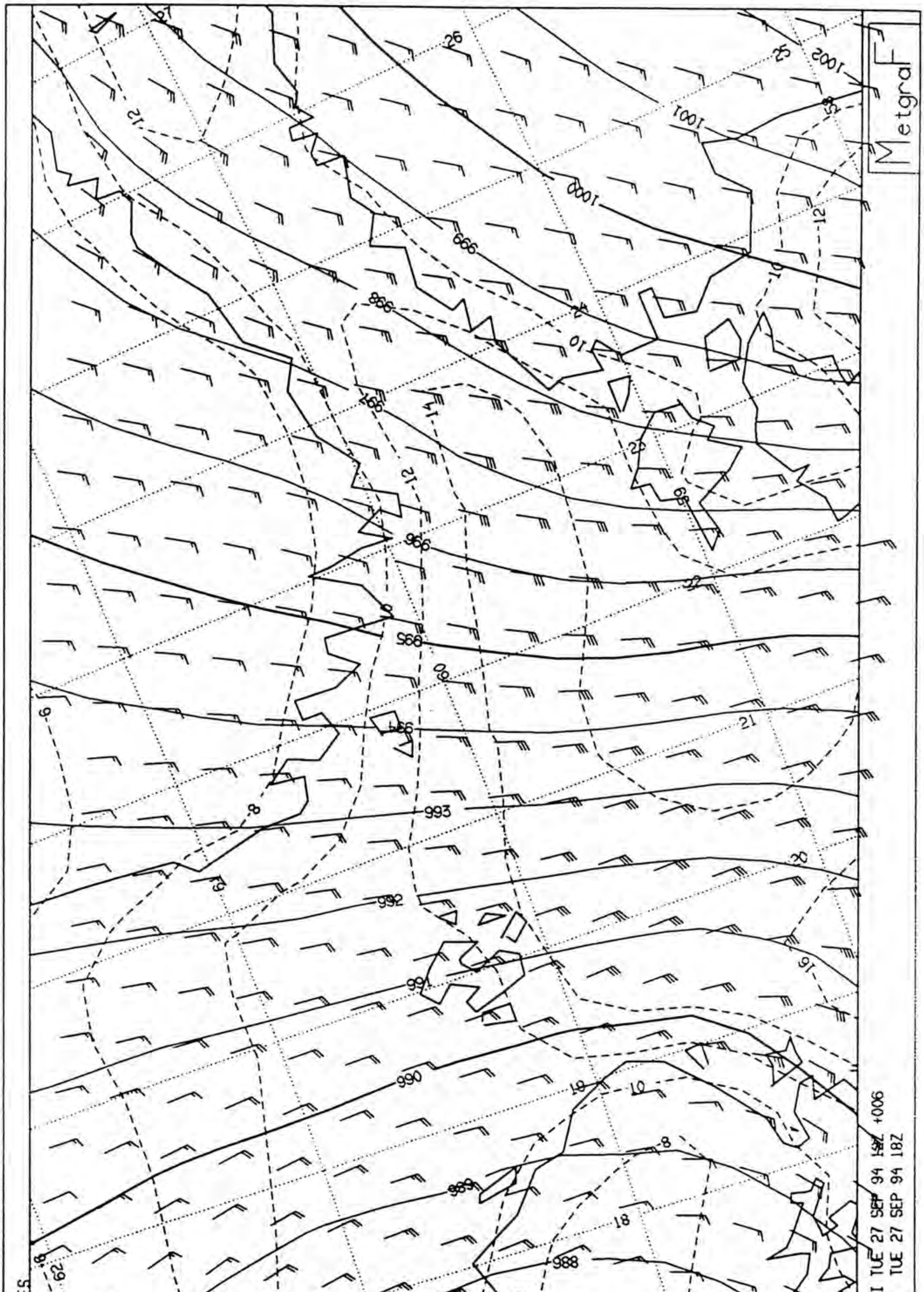
Mo 1989 ... LOFFSET Norrköping



SVENSKA HÖGARNA

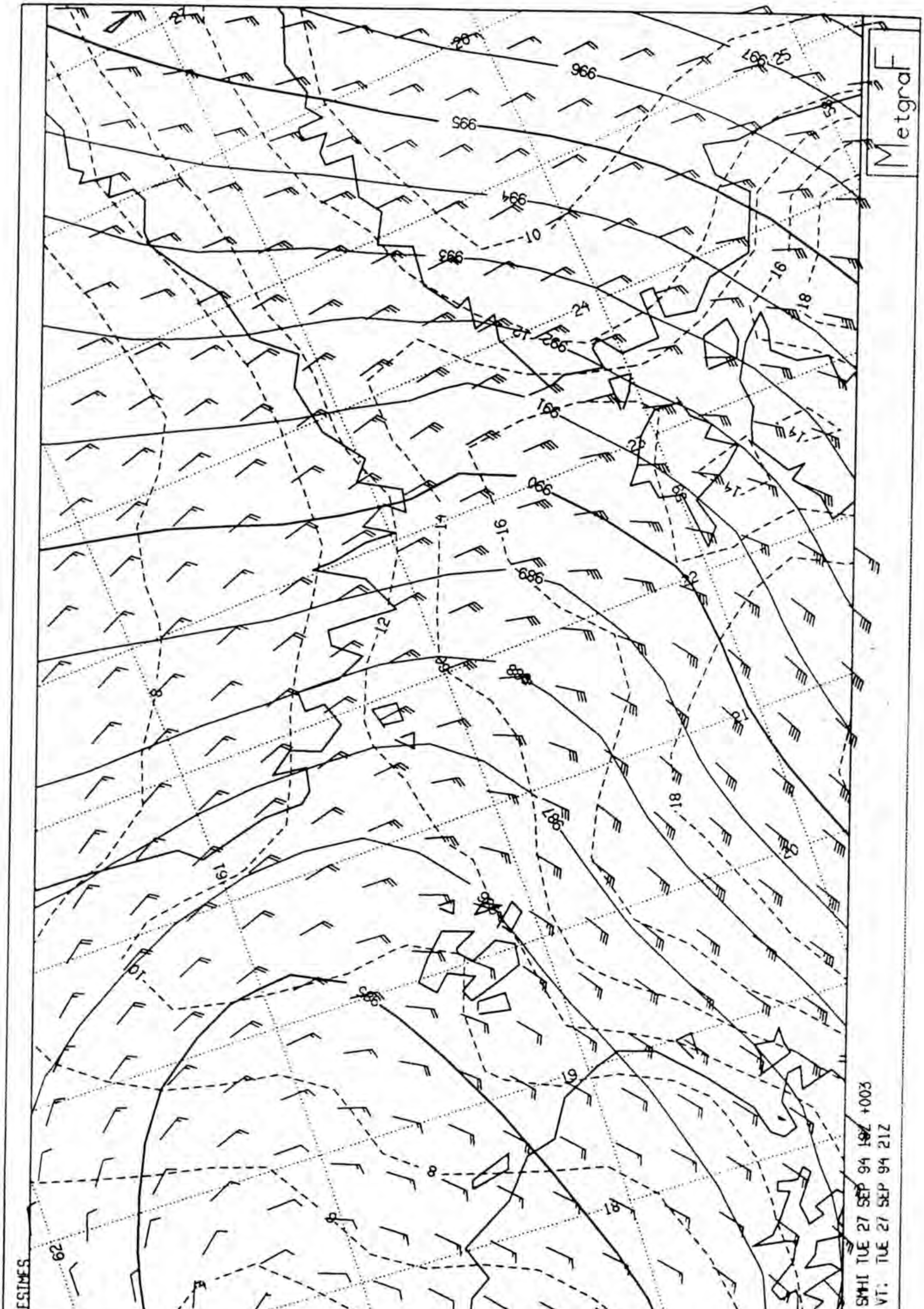


Datorbaserad tolkningsmodell kl 19.

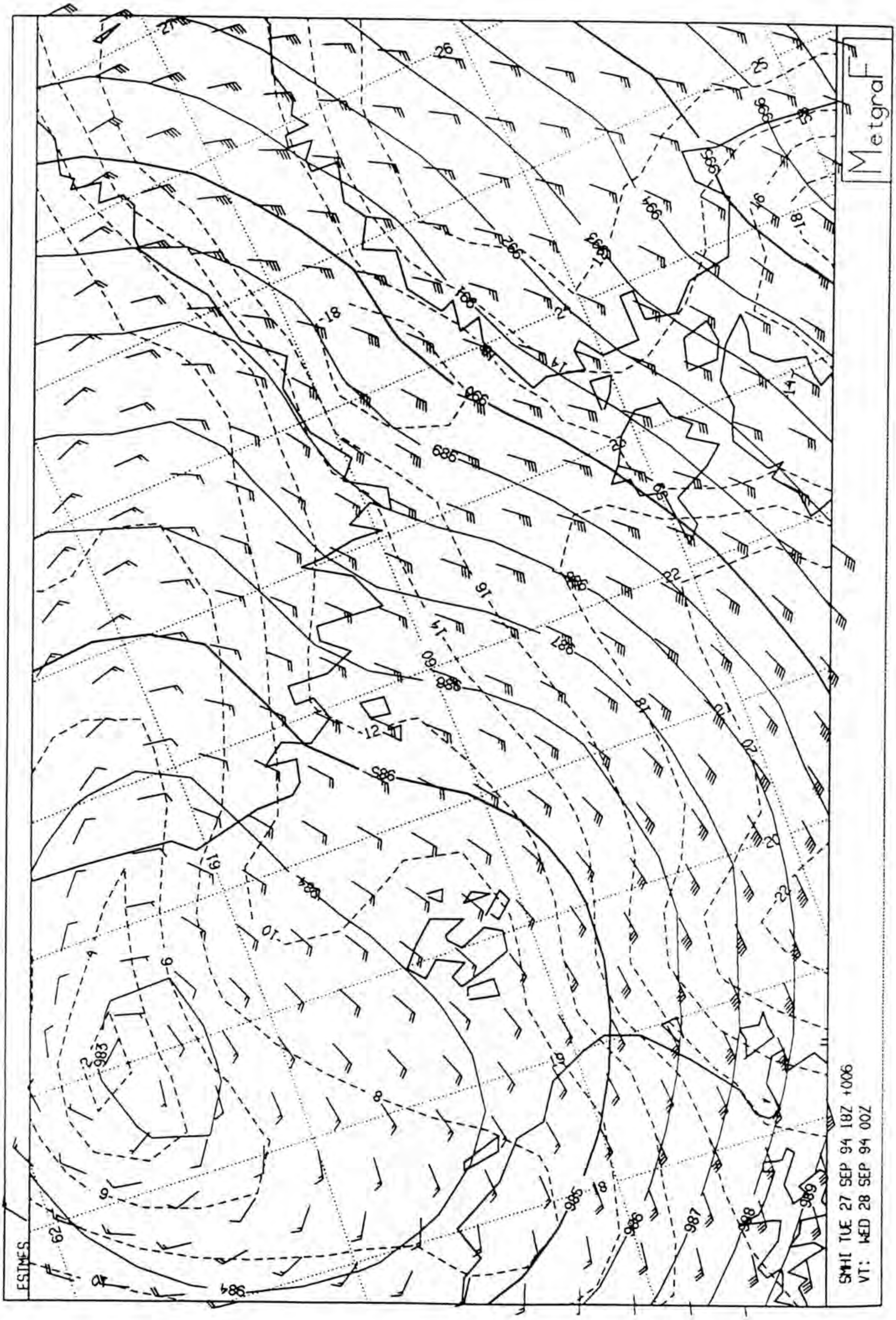


~24

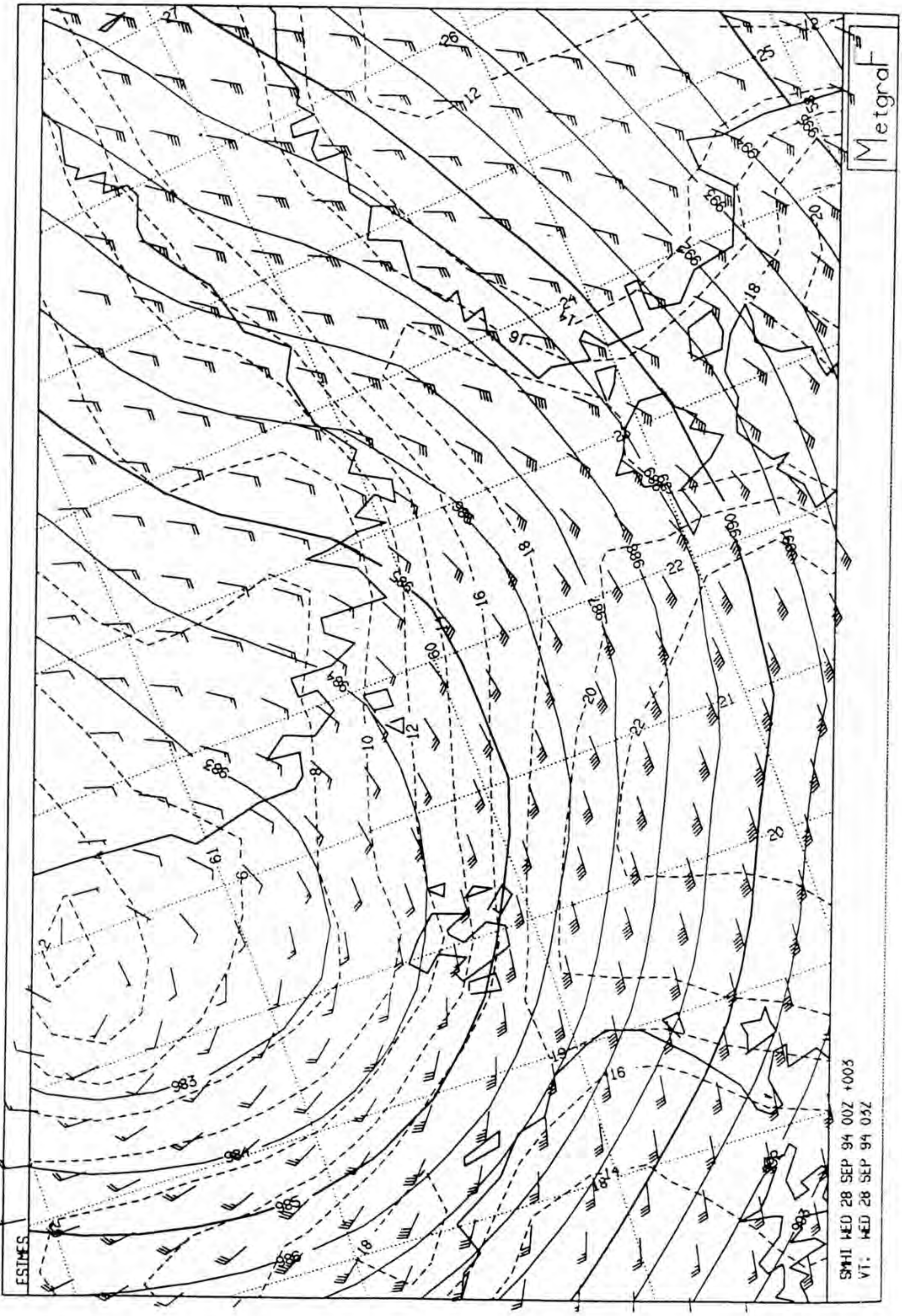
Bilaga 12.



Bilaga 13.



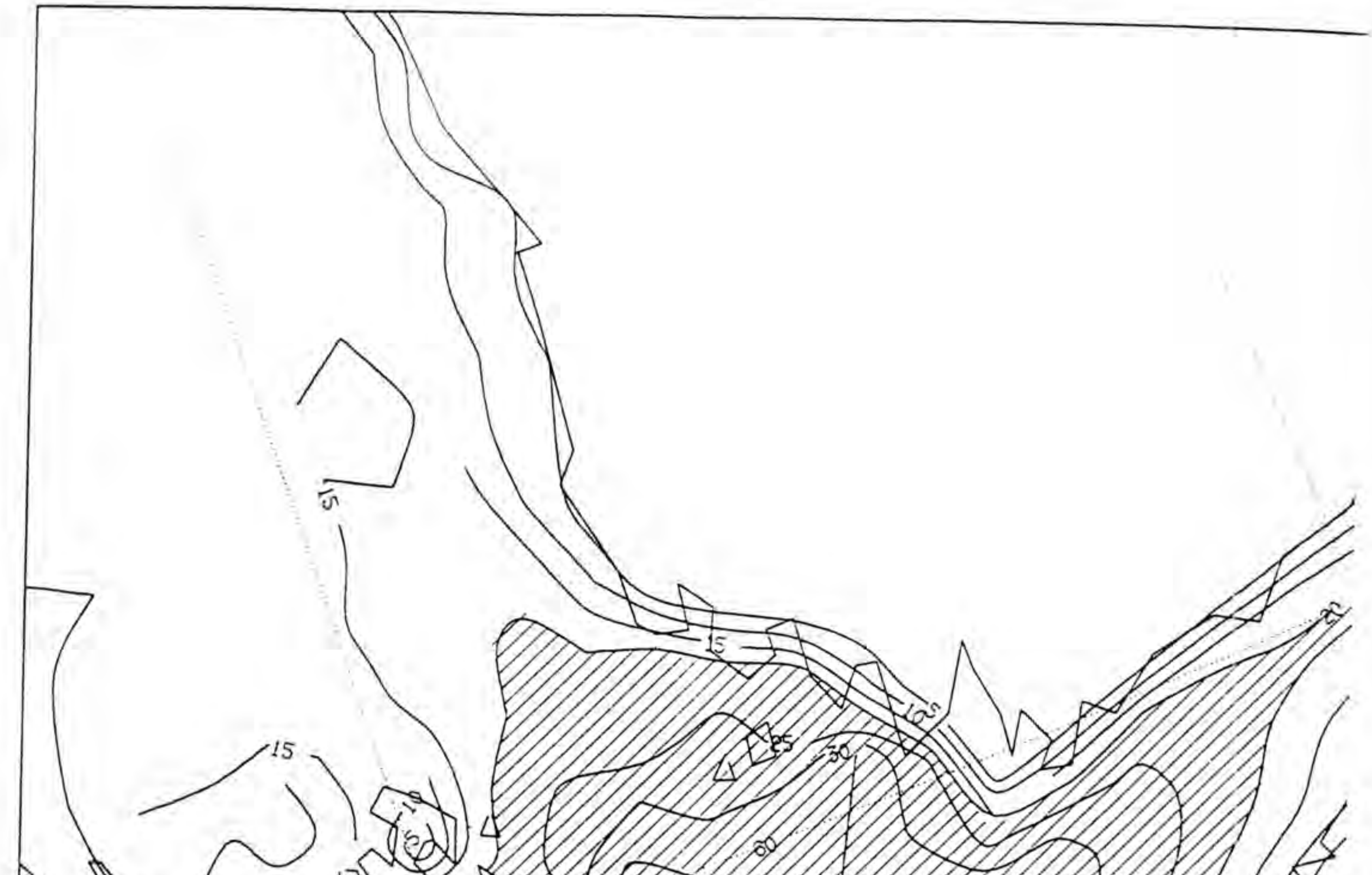
Bilaga 14.



Bilaga 15.

SMHI TUE 27 SEP 94 06z + 12
VT: TUE 27 SEP 94 18z

Bilaga 16.



SMHI TUE 27 SEP 94 06z + 18
VT: TUE 27 SEP 94 24z

Bilaga 17.

SMHI TUE 27 SEP 94 06z + 24
VT: WED 28 SEP 94 06z

A theoretical studie of the wave conditions in the northern Baltic with S-SW winds 15-20 m/s.

Definitions

The wave height and wave length depends primarily on the wind speed, but very important is also the duration of time of the wind speed and the fetch (how wide/long the open area is from which the wind blows).
The wave length is the distance from wave top to wave top.
Wave period is the time between two wave tops.
The significant wave height is the average heightof the 33% (1/3) of the highest waves.

Wave heights and wave lenghts in the northern Baltic at S-SW 17-18 m/s.

A wind speed of 17-18 m/s generates wave heights up to 5.0-5.5 m over open water. However it takes more than 24 hours with this wind speed and a fetch of over 1000 km (500 nm) before this wave height is reached.
As an example we can study the area from Gotland to the Gulf of Finland, with a fetch of 300 km (150 nm). With a wind of S-SW of 17 m/s, this condition must remain for more than 10 hours before it creates significant waves of 4.0 m.
Before a radical change in the wind direction or a radical increaseing of the wind speed has modified the waves in order to create the maximum wave height and wave length, it would take at least 6-8 hours.
A situation with rather "new" waves, which means short and moderate waves, is experienced as very rough when old waves (swell) penetrates into this area after a radical change in the wind direction has occurred.

If we have a condition with winds of 17 m/s and wave heights of around 4.0 m in the northern Baltic, measurements and theoretical calculations gives a wave period of about 8 s and a wave length of about 100 m.

How different wave systems can interact and create extreme waves.

The wave systems at sea are normally not an area with uniform waves. Instead different wave systems often are mixed so that the sea becomes confused, sometimes chaotic, with short and long waves. Due to this interaction between different "wave trains" more extreme waves rather frequently are formed. These maximum waves are noramlly 70-80 % higher than the significant wave height, at times even 100 % higher, but the waveperiod and wavelength does not change. Measurements and theoretical studies have shown that when one extreme wave occur, there are normally at least two further extreme waves following.

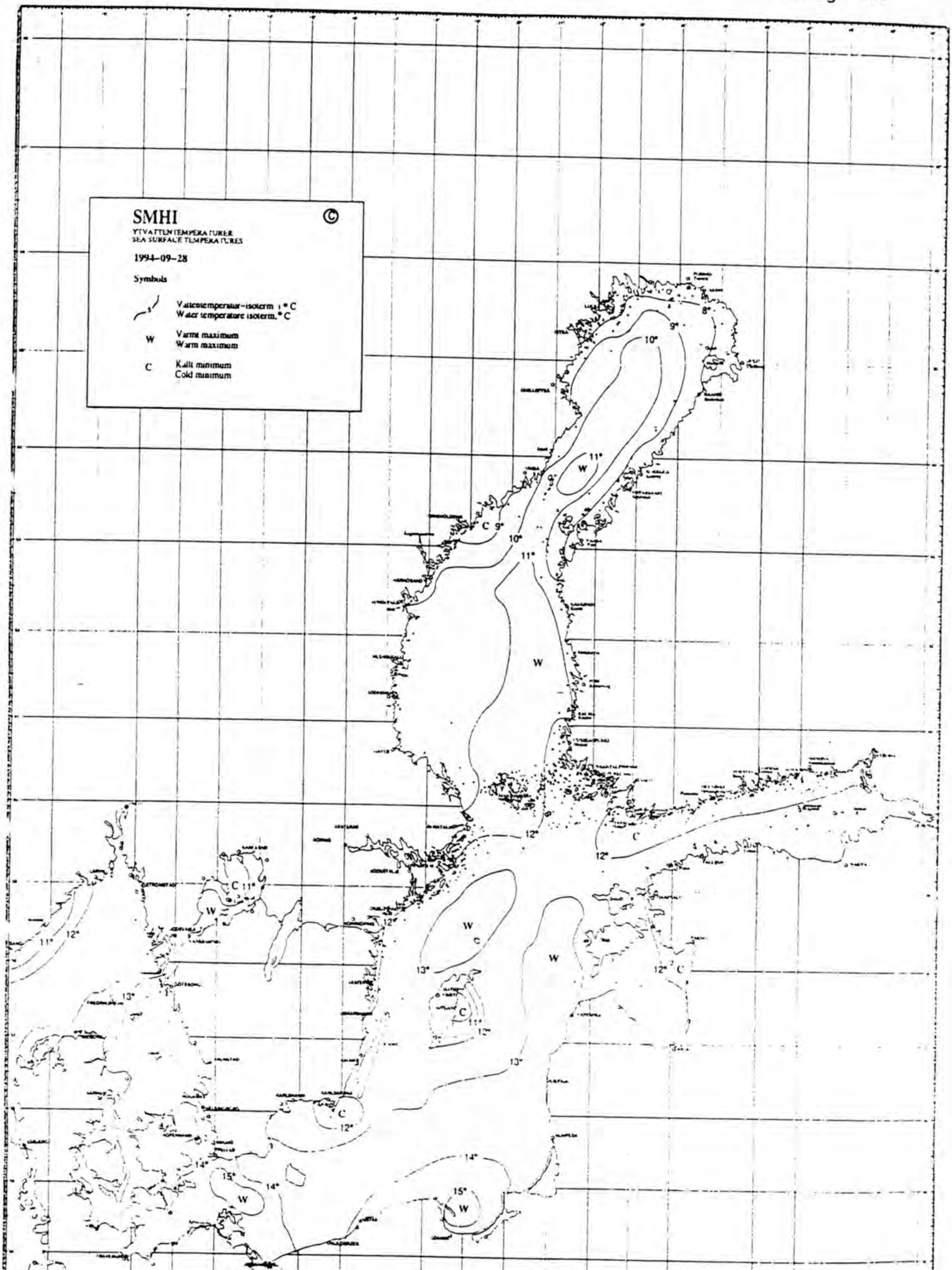
The shallow water influence on storm waves.
At some places the wave direction always changes and creates extreme waves.
If the water depth is less than 1/4 of the wave length, the bottom will have influence on the waves. The most noteable thing is that the wave speed reduces.
For example around a shallow water area/shoal bank this is normal and the waves are inteferring in lee of the bank where high or extreme waves will be formed.
This phenomenon is caused by the fact that the waves passing over a shoal will reduce its speed and the wavelength shortens, while the waves on both sides changes direction and propagates around the bank.
If the waves penetrates into a larger shallow water area, the wave height increases and the wave length decreases. For example, if waves with a wave length of 100 m from S-SW reaches the shallow water area south of Åland, the wave height increases where the depth is less than 25 m. In these grounder areas the wave conditions also becomes more chaotic due to refraction from the shore.

Theoretical estimation of the waves at the location of m/s Estonia's accident.
Around the position N59.25 E21.42 there are no known ground areas at all on the available nautical charts. The theoretical studies gives that the waves at the time of the accident, in this area should have been the same as in the rest of the area of northeasternmost Baltic, i.e. round 4 m with possibilities of some maximum waves up to near 8 m.
However 5-10 nm north of this area, there are several places with water depths of 20-30 m, and in this area there would have been more unregular sea with higher waves.

During the night the 28th the wind changed (after 01.00, swedish time) from S-SW to around W and increased later on up to near 24 m/s.
After 1 hour (02.00) waves from W of about 1.5 m may have superimposed onto the "old" SW-sea of still near 4 m. After about 3 hours (04.00) the W-ly waves would be up to 3.5 m, but at this time the old SW-sea already must have been rather much reduced.

If m/s Estonia the last 1-2 hours had a significant wave height of 4.0 m, the statistical wave theory gives that every 10 minute she should have experienced a wave height of about 6.5 m, and every 2nd or 3rd hour (2 hours 40 min) a wave of about 8.0 m.

Bilaga 19.


SMHI
YTVATTENTEMPERATURER
SEA SURFACE TEMPERATURES
1994-09-28
Symbols
Vattentemperatur-isoterm °C
Water temperature isoterm °C
W
Varmt maximum
Warm maximum
C
Kallt minimum
Cold minimum
8°
9°
10°
11°
W
C
9°
10°
11°
W
12°
C
12°
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C
12°
14°
15°
W
14°
14°
15°
W

Sjörapport 27/9 kl 0805 Bilaga 20.

Prognostiker	Uppläsare	Datum	Sändningstid
Gu	LF	94-09-27	8:05

VÄDERÖVERSIKT

Storm- ~~och~~ kulingvarning är utfärdad för
SKAGERACK, KATTEGATT, VÄNERN, ÖRESUND OCH BÄLTEN, HELA ÖSTERSJÖN, ÅLANDSHAV OCH SKÄRGÅRDSHAVET.

Utsikter till Onsdag morgon

SKAGERACK: Byig väst kuling 14-18 m/s ökande, i ~~kväll~~ e.m 18-22, i natt långsamt avtagande.

KATTEGATT, VÄNERN, ÖRESUND OCH BÄLTEN, SYDVÄSTRA ÖSTERSJÖN, SÖDRA ÖSTERSJÖN: Byig ~~väst 12- kuling~~ (möjligen storm 25) 16, på Kattegatt i eftermiddag och i kväll upp till 20. I natt långsamt avtagande.

SYDÖSTRA ÖSTERSJÖN, MELLERSTA ÖSTERSJÖN, NORRA ÖSTERSJÖN, ÅLANDSHAV OCH SKÄRGÅRDSHAVET: Ökande sydväst, från i eftermiddag kuling 14-17, i natt byig väst 18-22, på norra och mellersta Östersjön storm 25.

BOTTENHAVET, NORRA KVARKEN: Syd eller sydväst 8-12.

BOTTENVIKEN: Sydost 9-13 m/s, i eftermiddag syd och något avtagande.

STORM- OCH KULINGVARNING FÖR
SKAGERACK: Väst 14-18 m/s, i kväll 18-22, i natt långsamt avtagande.
KATTEGATT, VÄNERN, ÖRESUND OCH BÄLTEN, SYDVÄSTRA ÖSTERSJÖN, SÖDRA ÖSTERSJÖN: Väst 14-18, på Kattegatt i em. och i kväll ca 20.
SYDÖSTRA ÖSTERSJÖN, MELLERSTA ÖSTERSJÖN, NORRA ÖSTERSJÖN, ÅLANDSHAV OCH SKÄRGÅRDSHAVET: Från eftermiddagen sydväst 14-17, i kväll ytterligare ökande, i natt ca 20, på MELLERSTA och NORRA ÖSTERSJÖN STORM 25 m/s.

(Ingen nedisningsvarning)

SMHI NORRKÖPING - 1994-09-27 06:56 UTC

WOSN42 ESWI 270700
SWEDISH GALEWARNINGS 0700 UTC

SKAGERRAK:
WESTERLY 14-18 M/S. THIS EVENING 18-22. TONIGHT SLOWLY DECREASING.

KATTEGAT. LAKE VAENERN. THE SOUND AND THE BELTS. WESTERN BALTIC. SOUTHERN BALTIC:
WESTERLY 14-18. IN KATTEGAT THIS AFTERNOON AND EVENING 20.

SOUTHEASTERN BALTIC. CENTRAL BALTIC. NORTHERN BALTIC. SEA OF AALAND AND AALAND ARCHIPELAGO:
FROM AFTERNOON SOUTHWESTERLY 14-17. THIS EVENING FURTHER INCREASING. TONIGHT 20. IN CENTRAL AND NORTHERN BALTIC 25 M/S.

REMAINING AREAS NIL.

Bilaga 22.

Prognostiker	Uppläsare	Datum	Sändningstid
Ha	Ha	94-09-27	13:00

VÄDERÖVERSIKT
Ett intensivt lågtryck vid Oslotrakten rör sig österut under fördjupning. I morgon drar det bort över Finland.

~~Storm- och kulingvarning är utfärdad för~~ :
STORMVARNING för mellersta och norra Östersjön.
KULINGVARNING för övriga delar av Götalands farvatten, Svealands farvatten och sydligaste Bottenhavet.
Utsikter till Onsdag kväll

SKAGERACK, NORRA KATTEGATT:	Omkring väst kuling 17-23 m/s, i morgon avtagande till 10-13. Måttlig till god sikt.
SÖDRA KATTEGATT, ÖRESUND och BÄLTEN, SYDVÄSTRA ÖSTERSJÖN:	Omkring väst, ökande till 13 till kuling 17. I morgon på dagen något avtagande. Mest god sikt.
VÄNERN:	Omslag till väst eller nordväst 13 till kuling 17, i morgon avtagande till c:a 10. Måttlig till god sikt, till en början regnskurar.
SÖDRA, SYDÖSTRA, MELLERSTA och NORRA ÖSTERSJÖN:	Sydväst 10-13, ökande till kuling 17-22, i natt väst, på mellersta och norra Östersjön STORM 25, under dagen avtagande. Måttlig sikt, regnskurar.
ÅLANDSHAV och SKÄRGÅRDSHAVET, SYDLIGASTE BOTTENHAVET:	Sydväst 7-11, i kväll tillfälligt växlande, därefter nordväst 13 till kuling 18, senare under dagen något avtagande. Måttlig sikt, efterhand regn eller regnskurar.
NORRA BOTTENHAVET, NORRA KVARKEN:	Sydväst 4-7, ikväll växlande, i morgon väst eller nordväst och ökande till 10-13. God sikt.
BOTTENVIKEN:	I de norra farvattnen till en början sydost, i övrigt sydväst 4-8 m/s, i morgon något ökande. Måttlig sikt, upphörande regn.

STORM- OCH KULINGVARNING FÖR
SKAGERACK, NORRA KATTEGATT: Omkring väst 17-23 m/s, i morgon avtagande.
NORRA KATTEGATT, ÖRESUND OCH BÄLTEN, SYDVÄSTRA ÖSTERSJÖN: Väst 14-17, i morgon avtagande.
VÄNERN: Väst eller nordväst 14-17, i morgon avtagande.
SÖDRA OCH SYDÖSTRA ÖSTERSJÖN: Sydväst, ökande till 17-22, i natt väst och på dagen avtagande.
× MELLERSTA ÖSTERSJÖN, NORRA ÖSTERSJÖN: Sydväst, ökande till 17-22, i natt väst 25 m/s, därefter avtagande.
ÅLANDSHAV OCH SKÄRGÅRDSHAVET, SYDLIGASTE BOTTENHAVET: I natt nordväst 14-18 m/s, under dagen avtagande.

(Ingen nedisningsvarning)

FPSN72 ESWI 271400

Prognostiker	Uppläsare	Datum	Sändningstid
Ha	EWA	94-09-27	15:55

VÄDERÖVERSIKT
Ett intensivt lågtryck - med centrum över Värmland - rör sig nästan rakt österut. I morgon drar det bort över Finland.

~~Storm- och kulingvarning~~ är utfärdad för
STORMVARNING för mellersta och norra Östersjön.
KULINGVARNING för övriga delar av Götalands farvatten, Svealands farvatten och sydligaste Bottenhavet.

Utsikter till Onsdag kväll

FLADEN, DOGGER:	Nordväst 12 till kuling 15 m/s, något avtagande, i morgon sydväst. Måttlig till god sikt.
TYSKA BUKTEN, FISKEBANKARNA, SYD UTSIRA:	Nordväst kuling 16-22, i natt avtagande, på dagen sydväst 8-13. Måttlig sikt, till en början regnskurar, i morgon övergående regn.
SKAGERACK, NORRA KATTEGATT:	Väst eller nordväst kuling 17-23, i morgon avtagande till 8-13 och efterhand sydväst. Måttlig till god sikt.
SÖDRA KATTEGATT, ÖRESUND och BÄLTEN, SYDVÄSTRA ÖSTERSJÖN:	Omkring väst 13 till kuling 17, i morgon på dagen 7-12. Mest god sikt.
VÄNERN:	Nordväst 13 till kuling 17, i morgon väst och avtagande till 7-10. Måttlig till god sikt.
SÖDRA, SYDÖSTRA, MELLERSTA och NORRA ÖSTERSJÖN:	Sydväst 10-13, ökande till kuling 17-22, i natt väst, på mellersta och norra Östersjön STORM 25, under dagen avtagande. Måttlig sikt, övergående regn, därefter regnskurar.
ÅLANDSHAV och SKÄRGÅRDSHAVET, SYDLIGASTE BOTTENHAVET:	Sydväst 6-10, i kväll tillfälligt växlande, därefter nordväst 13 till kuling 18, senare under dagen något avtagande. Måttlig sikt, regn eller regnskurar.
NORRA BOTTENHAVET, NORRA KVARKEN:	Tillfälligt växlande 3-6, i morgon väst eller nordväst och ökande till 10-13. God sikt.
BOTTENVIKEN:	Omkring sydväst 4-8 m/s, i morgon något ökande. Måttlig sikt.

STORM- OCH KULINGVARNING FÖR
SKAGERACK, NORRA KATTEGATT: Omkring väst 17-23 m/s, i morgon avtagande.
NORRA KATTEGATT, ÖRESUND OCH BÄLTEN, SYDVÄSTRA ÖSTERSJÖN: Väst 14-17, i morgon avtagande.

Bilaga 24.

Prognostiker	Uppläsare	Datum	Sändningstid
AB	EWA	94-09-27	21:50

~~VÄDERÖVERSIKT~~

Ett djupt lågtryck över inre Svealand fortsätter österut. Ett annat lågtryck söder om Island, rör sig snabbt mot sydligaste Skandinavien, men blir inte lika intensivt som dagens lågtryck. Ett tredje lågtryck förskjuts åt nordväst över nordligaste Skandinavien.

~~Storm- och kulingvarning~~ är utfärdad för
STORMVARNING för mellersta och norra Östersjön.
KULINGVARNING för övriga delar av Götalands och Svealands farvatten och för sydligaste Bottenhavet.

Utsikter till Onsdag kväll

FLADEN, FISKEBANKARNA, SYD UTSIRA,	Omkring väst 10-kuling 15 m/s, tillfälligt avtagande till 6-10, i de norra farvattnen sent under onsdagen växlande. God sikt, under dagen tidvis regn.
DOGGER, TYSKA BUKTEN,	Omkring väst 7-12, från middagen ökande till 10-kuling 15. Måttlig eller god sikt.
SKAGERACK, NORRA KATTEGATT:	Omkring väst kuling 15-20, långsamt avtagande till 5-10, onsdag kväll möjligen växlande. Mest god sikt.
SÖDRA KATTEGATT, ÖRESUND och BÄLTEN, SYDVÄSTRA ÖSTERSJÖN:	Omkring väst 10-kuling 15, på dagen 7-12. Mest god sikt, sent i morgon regn.
VÄNERN:	Väst 12-kuling 17, under dagen avtagande till 4-8. Mest god sikt.
SÖDRA OCH SYDÖSTRA ÖSTERSJÖN,	Väst kuling 15-20, under dagen avtagande till ca 10. Mest god sikt.
MELLERSTA ÖSTERSJÖN, NORRA ÖSTERSJÖN,	Omkring väst kuling 17-storm 25, under dagen långsamt avtagande till 8-13. God sikt.
ÅLANDSHAV och SKÄRGÅRDSHAVET, SYDLIGASTE BOTTENHAVET,	Omslag till väst eller nordväst, ökande till 13-kuling 20, blåsigast i södra farvattnen, under dagen långsamt till ca 10. Förbättring till god sikt men någon regnskur.
BOTTENHAVET UTOM DEN SYDLIGASTE DELEN, NORRA KVARKEN:	Växlande 5-10, från morgonen väst 9-13. Mest god sikt.
BOTTENVIKEN:	Syd 4-8 m/s, i morgon väst eller nordväst och något ökande. God sikt.

- - -

Vindutsikter för Torsdagen

I samtliga farvatten vind mellan väst och nordväst, på många håll kuling.

SMHI NORRKÖPING - 1994-09-27 18:56 UTC

WOSN42 ESWI 271900
SWEDISH GALEWARNINGS 1900 UTC

NEW:
SOUTHERNMOST PART OF BOTHNIA

SKAGERRAK.NORTHERN KATTEGAT:
AROUND WEST 15-20 M/S. SLOWLY DECREASING .

LAKE VAENERN:
WESTERLY OR NORTHWESTERLY 14-17. DURING THE DAY DECREASING.

SOUTHERN KATTEGAT. THE SOUND AND THE BELTS. WESTERN BALTIC:
WESTERLY. AT FIRST 15.

SOUTHERN BALTIC. SOUTHEASTERN BALTIC:
AROUND WEST 15-20. DURING WEDNESDAY DECREASING.

CENTRAL BALTIC. NORTHERN BALTIC:
AROUND WEST. TONIGHT 17-25. LATER DECREASING.

SEA OF AALAND AND AALAND ARCHIPELAGO. SOUTHERNMOST PART OF SEA OF BOTHNIA:
FROM LATE TONIGHT WESTERLY OR NORTHWESTERLY 14-20 M/S. TOMORROW DECREASING.

REMAINING AREAS NIL.

S M H I   Bilaga 26.
Sjöfart   Tel 011-17 01 02   (kl 08-16)

To: m/s ESTONIA
Att: MASTER

Fax: 010 - 261 98 08
CC: 08-666 60 52   ATT: BENGT BRYUNGS

Issued: 1994-09-27 1311 LT

TALLINN - STOCKHOLM

Stretch	Time (svensk tid)	Mean wind speed on 10 m level m/s		Prob. for mean wind >15 m/s in %	Wave height sign (m)	Wave height max (m)	Remarks
Naisaar-N Osmusaar	(19-21) 20-22	S-SW	10-15	20	1,0-2,0	3,0	
N Osmusaar-S Bogskär	(21-03) 22-04	SW-W	15-20	70	2,5-3,5	5,5	
S Bogskär-Sandhamn	(03-06) 04-07	W-NW	18-25	90	3,5-2,0	5,5	

COMMENTS: INTENSE LOW NEAR OSLO MOVING E-WARD VIA SOUTHERN SEA OF BOTHNIA TO SUOTHERN FINLAND. IT WILL CAUSE INCREASING SW- LATER W-NW. FROM TO NIGHT GUSTY WIND. AT DEP. RAIN WITH MOD VIS. LATER SOME SHORT SHOWERS.

BEST REGARDS/

SUPPLEMENT No. 405

Kahma Kimmo - Pettersson Heidi - Myrberg Kai - Jokinen Hannu:
Estimated Wave Conditions and Currents during the last Voyage of M/S Estonia.

Finnish Institute of Marine Research.

Helsinki 1996.

ESTIMATED WAVE CONDITIONS AND CURRENTS DURING THE LAST VOYAGE OF M/S ESTONIA

Kimmo Kahma Heidi Pettersson

Kai Myrberg Hannu Jokinen

Finnish Institute of Marine Research

1995

SUMMARY

Wave hindcast for 27th and 28th September, 1994:

Point A: 10 nautical miles north of Osmussaar at 22:00 EET.
The swell has turned into a sea, and the waves are growing steeper.

Significant wave height	ca.	2.5 m
Significant period	ca.	6.5 s
Mean direction of waves	ca.	250°

Point B: North of Hiiumaa (59°25'N 22°35'E) at 23:00 EET.
The sea is growing; the waves are steep.

Significant wave height	ca.	3 m
Significant period	ca.	7 s
Mean direction of waves	ca.	260°

The site of the shipwreck at		01.00	01.30	02.00	08.00 EET
Significant wave height	ca.	4 m	4.2 m	4.4 m	5 m
Significant period	ca.	7.8 s	8 s	8.2 s	8.7 s
Mean direction of waves	ca.	260°	260°	260°	270°

We have not found large areas where bottom effects could have increased wave height significantly at 01.30. At those areas near the shipwreck that are covered by the detailed bathymetric data, there probably were no small focal points at 01.30. The detailed bathymetric data does not cover all the area of concern. We have found that the bathymetry has be known up to details that are not described adequately in the nautical charts.

The current at depth 0...5m at 01:30 has been estimated to have been ca. 10 cm/s in direction 90°...100°.

CONTENTS

1. GENERAL

At the request of the International Research Commission on M/S Estonia, the Finnish Institute of Marine Research (FIMR) has performed a hindcast on the wave and current conditions prevailing during the last voyage of M/S Estonia.

The northern Baltic Proper, in which M/S Estonia met with her accident, has the severest wave climate found in the Baltic Sea. The nearest place from which wave measurements are available is south of Bogskär: there the highest measured individual wave was 12.2 m. This measurement was made on January 14, 1984; the greatest significant wave height during the same storm was 6.7 m, and the average of the highest third of the waves was 7.7 m.

The conditions on September 27th, 1994 were severe but not exceptional. The average wind speed in the area reached 20 m/s just before the accident, but the waves had not grown to their maximum height for the local fetch and wind speed. The wind had changed direction by 80° during the six hours before the accident, and this limited wave growth.

On the other hand, the waves grew long enough to be influenced by the bottom topography. The experience of ship captains regularly plying these waters is that there are "bad spots".

2. WIND DATA

The wind data used for the wave hindcast has been provided by the Finnish Meteorological Institute (FMI). It is presented in Appendix A.

We have used the areal sea wind estimates provided by the Finnish Meteorological Institute. Model comparisons have shown that our wave model hindcasts are more accurate when these estimates are used instead of extrapolating directly observed wind data.

3. WAVE HINDCAST WITHOUT SHALLOW WATER EFFECTS

3.1 The model

Wave growth has been estimated (hindcast) by the parametric wave-ray model developed at the FIMR.

As regards the underlying physics, the FIMR model is a second-generation model. It differs from the standard grid-based models in that it is set up individually for a point, and it takes into account the detailed coastline geometry and its influence on the difference between wind and wave direction, as well as incorporating in parametric form other special factors, if any, affecting wave growth and dissipation in the area.

The model uses a very large grid chosen manually for the locality; wave growth on this grid is then integrated along precomputed wave rays to the single forecasting point. The model uses most recent growth curves by Kahma and Calkoen, (1994). The version used here will predict significant wave height, significant wave period, and direction of the waves. Figure 1 shows the most recent operational model verification in the Gulf of Finland.

The effects of shallow water are not incorporated in the present version of the model. They are estimated separately by the wave refraction model described in the next section.

Setting up this model for a new point and calibrating it usually entails a considerable amount of work. Fortunately, the model had been previously set up for a point sufficiently near the site of the accident that it could be reliably modified for the three points required by the Commission.

The estimated r.m.s. error of the wave hindcast:

r.m.s. error in significant wave height	0.5 m
r.m.s. error in significant period	ca. 1 s
r.m.s. error in mean direction of waves	ca. 10°

Significant wave height is defined as $4\sqrt{\frac{E}{\rho g}}$ where E is the total energy of waves in a unit area and ρ is the density of water and g the acceleration of gravity. Significant wave height is close to the visual estimated of average wave height. Significant period is defined as the peak period of the wave spectrum. In this report the direction of waves means the direction from which the waves arrive, in keeping with the convention for the direction of the wind.

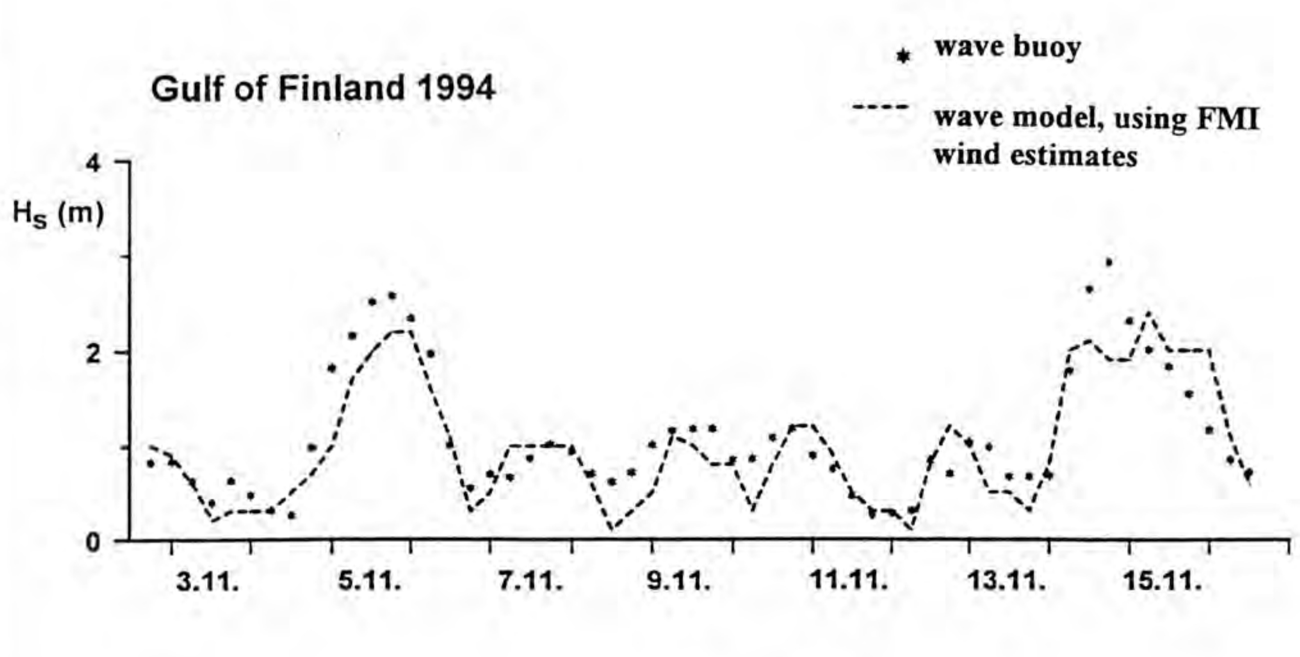


Figure 1. Model verification measurements made in the Gulf of Finland.

3.2 Hindcasts

Point A: 10 nautical miles north of Osmussaar at 22:00 EET

Significant wave height	ca.	2.5 m
Significant period	ca.	6.5 s
Mean direction of waves	ca.	250°

The swell has turned into a sea, and the waves are growing steeper.

Point B: North of Hiiumaa (59°25'N 22°35'E) at 23:00 EET

Significant wave height	ca.	3 m
Significant period	ca.	7 s
Mean direction of waves	ca.	260°

The sea is growing; the waves are steep.

The site of the shipwreck at		01.00	01.30	02.00	08.00 EET
Significant wave height	ca.	4 m	4.2 m	4.4 m	5 m
Significant period	ca.	7.8 s	8 s	8.2 s	8.7 s
Mean direction of waves	ca.	260°	260°	260°	270°

3.3 Other estimates of waves in the area

As was discussed before, the wind had turned 6 hours before the accident, and the waves were still duration-limited. If the wind had remained constant in direction from the beginning of the storm, the waves would had been fetch-limited, and we estimate that significant wave height could have been about 5 m, and the significant wave period about 9.8 s.

For purposes of comparison we also performed the hindcast on the basis of the directly measured station winds extrapolated into the relevant area. The results for 02:00 EET are: significant wave height about 3.6 m, significant wave period about 7.8 s.

4. WAVE REFRACTION BY SHALLOW WATER

4.1 General

When waves arrive in to shallow water the phase speed is reduced and the waves refract. The refraction model calculates how the waves change direction in water of variable depth. The model follows the progress of waves along a wave ray at right angles to the wave front, starting at the map boundary and continuing until the waves reach the shore or go out of the map area again. The pattern of the wave rays shows where the waves concentrate into a small spot or spread out into a larger area. In the first case the wave height grows; in the second case it decreases.

Calculations indicate that in the Northern Baltic Proper there are focal points where wave refraction in certain conditions can increase the wave height significantly above the surroundings. As an example of phenomenon we show the results at Suomen Leijona, about 25 nm from the place of accident (Fig. 2).

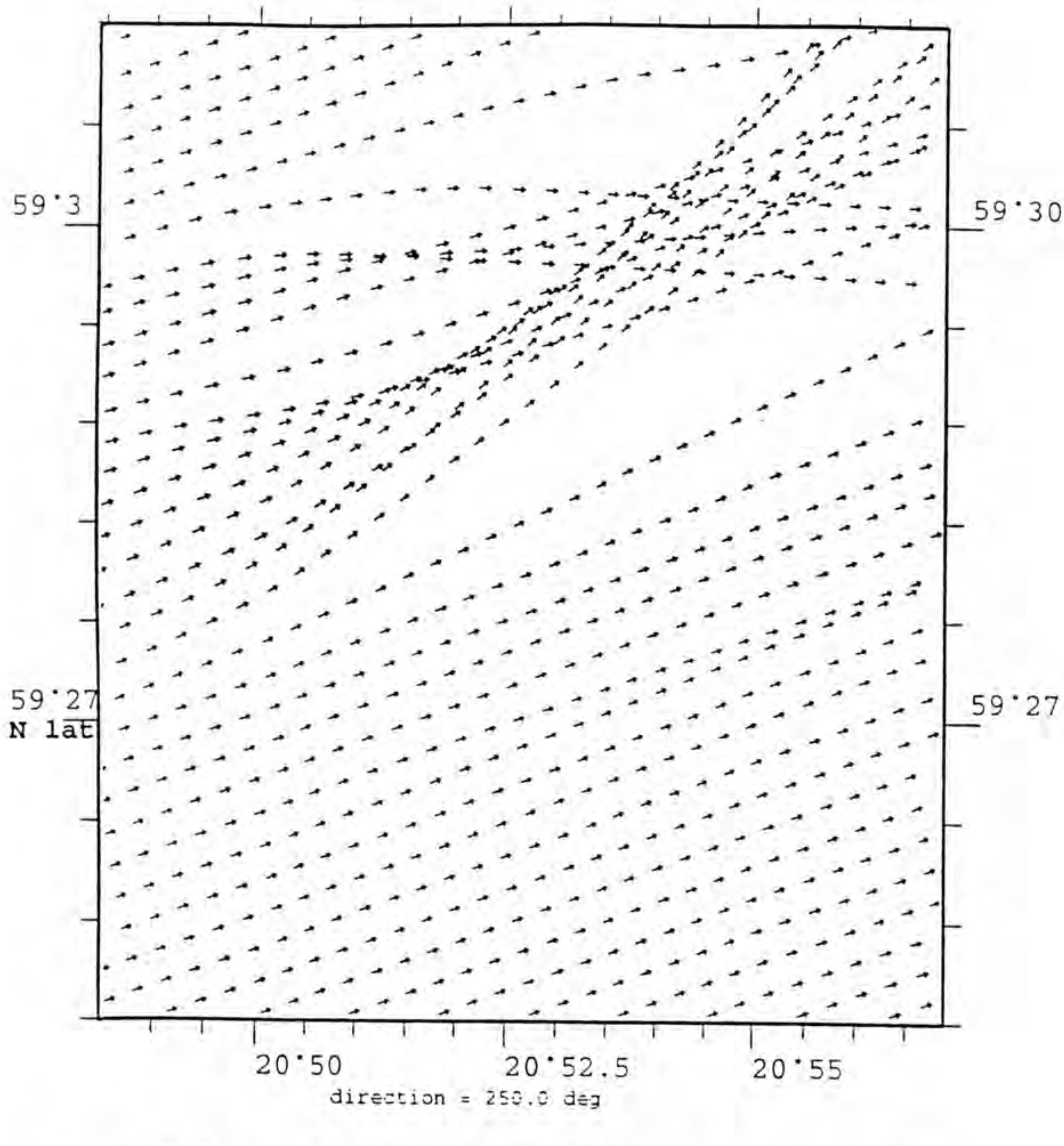


Figure 2a. Refraction of unidirectional waves (log crested swell) over a shoal, wave rays.

The refraction rays describe the behaviour of unidirectional waves. In practice this occurs only when swell is coming into the area from a great distance. When the sea is actively growing under the influence of wind, the direction of the incoming waves is distributed over a broad angle. When the significant wave height is estimated, all these different wave rays have to be taken into account. In our model the Monte-Carlo method proposed by Bouws and Battjes (1982) is used .

Figure 3 shows significant wave height of short crested storm waves behind the same shoal. While the wave height enhancement by refraction is up to double in the case of unidirectional swell (Fig.2.), actively growing wind generated waves are enhanced by factor 1.4 in this case. If the spreading is wider the maximum height is less.

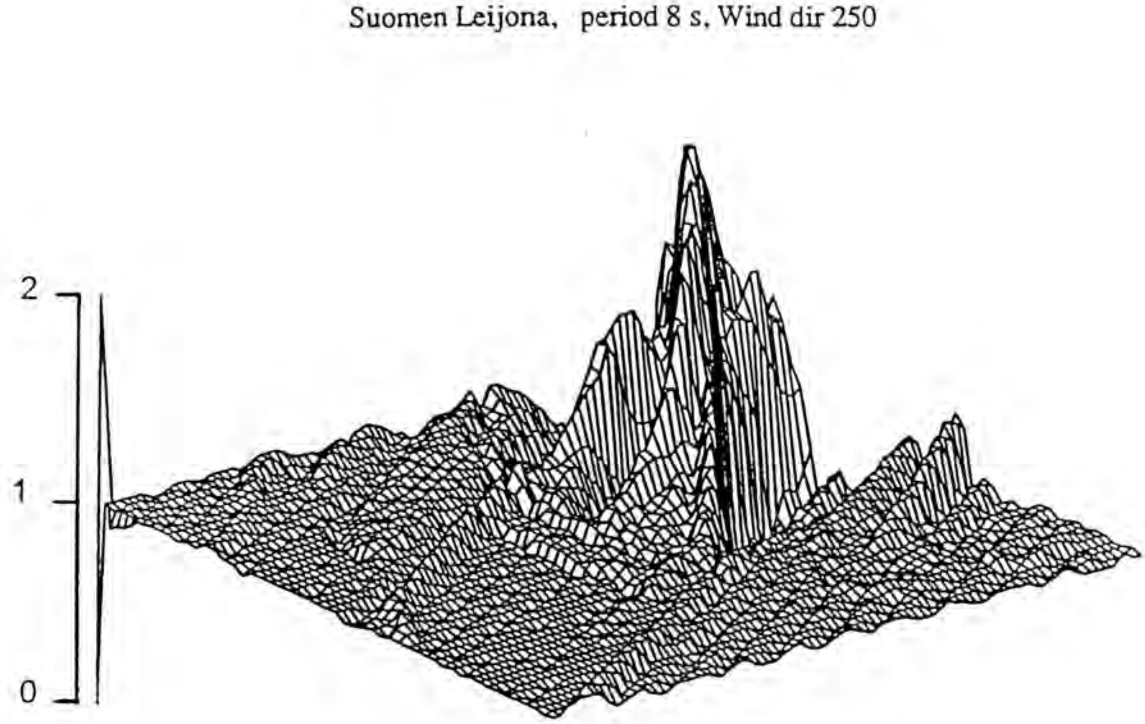


Figure 2b. Refraction of unidirectional waves (log crested swell) over a shoal, the change in wave height.

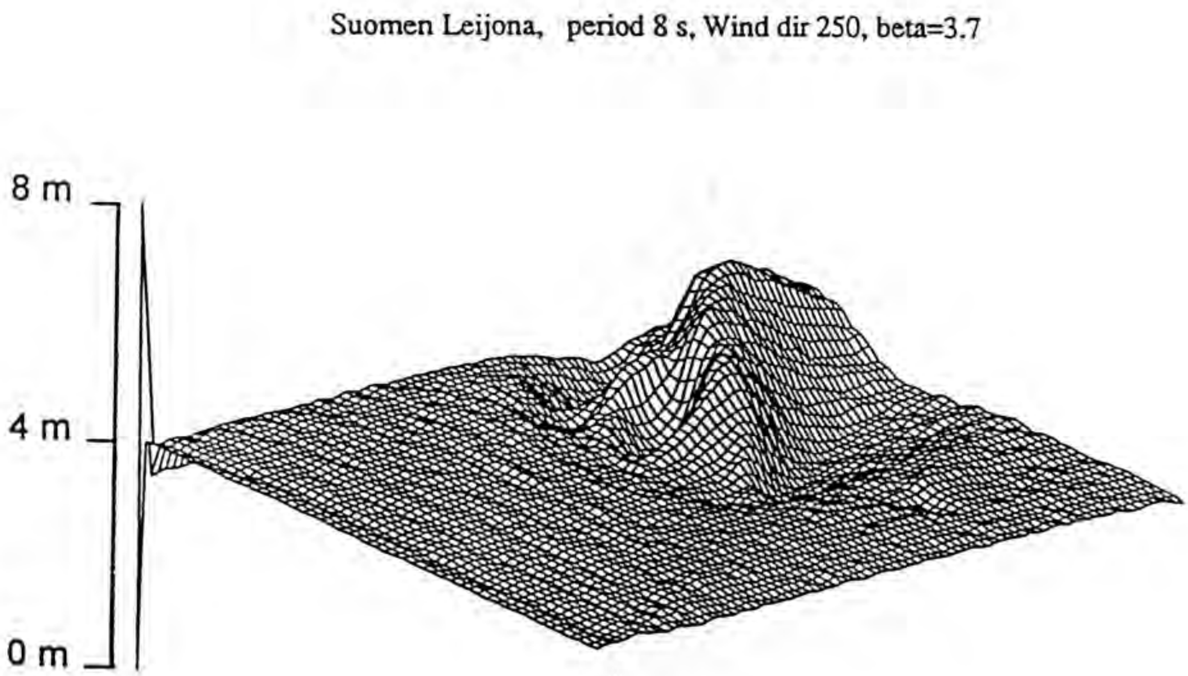


Figure 3. Refraction of wind generated waves (short crested storm waves) over the same shoal. Period 8 s, significant wave height 4 m before the shoal. Wave spreading 14 degrees.

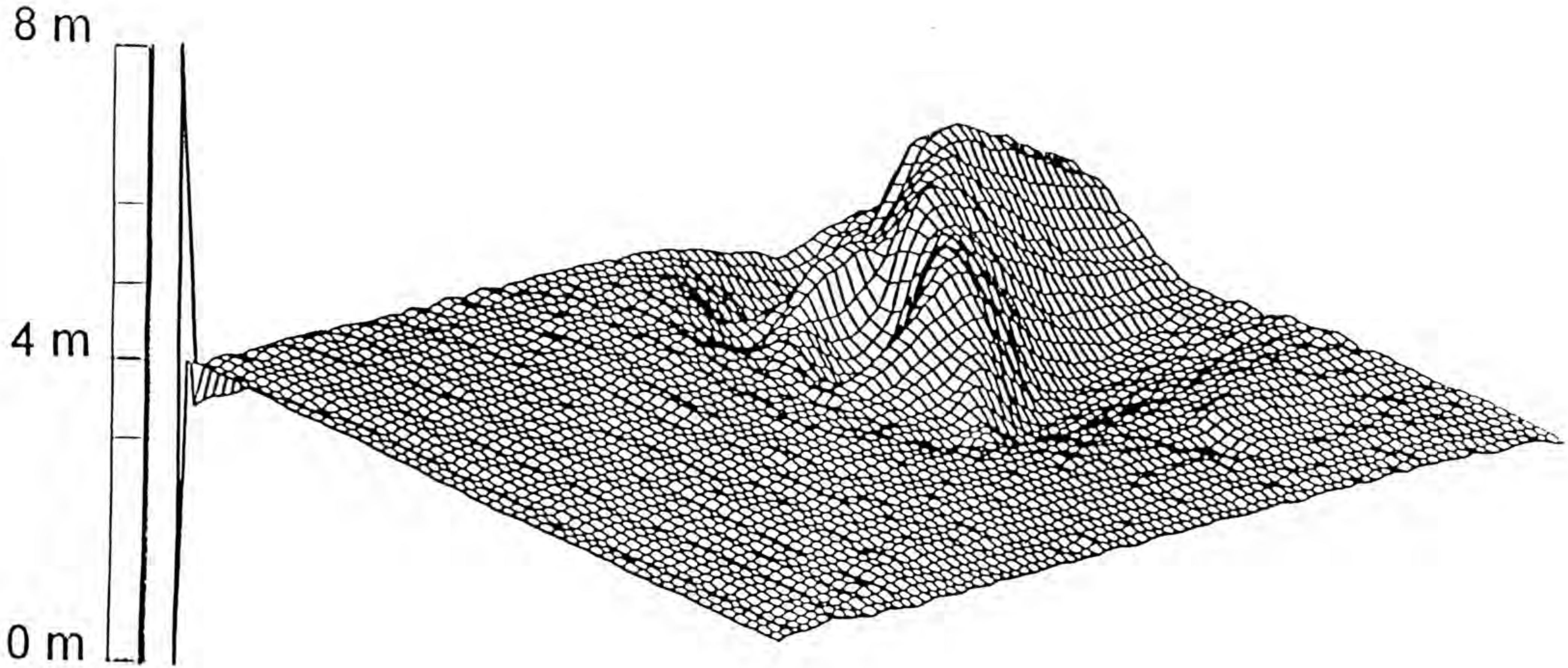


Figure 3. Refraction of wind generated waves (short crested storm waves) over the same shoal. Period 8 s, significant wave height 4 m before the shoal. Wave spreading 14 degrees.

We want to emphasize that the estimates how much the wave height will increase are very sensitive to the details of the topography and the directional properties of the wave spectrum, as well as the assumptions of the physics of the growth of wind generated waves. Estimates of the enhancement of the wave height by refraction are inaccurate when the waves are actively growing by the wind.

4.2 Smoothed large scale bottom topography

Refraction in the whole northern Baltic Proper was first calculated using a grid showing smoothed large scale topography. The grid for the large scale bottom topography is based on nautical charts. Some corrections have been made based on the detailed bathymetric data provided by the Finnish Board of Navigation.

The series of maps in Appendix B shows the wave rays calculated separately for waves coming in from different directions at intervals of 5°, and having different periods in the range 7 s to 9 s. An example is shown as Fig.4. In the refraction map the length of the arrow is directly proportional to the group velocity of the waves.

Figure 4 shows that refraction occurs at 8 second period waves on the northern Baltic Proper. The wave height of unidirectional swell would increase at places where the rays converge. The point of accident is shown by a circle. The waves coming from 270 degrees are enhanced there.

When the angular spreading of growing waves is taken into account the refraction from this large scale bottom topography does not increase the wave height of a growing sea along the assumed route of M/S Estonia (Fig.5). This means that the wave forecasts in section 3 that ignore the refraction can be used to estimate the general wave height along the route. On the other hand the directional properties are changed. This could enhance the refraction if there is a shoal along the route.

Fig.5 also shows how waves arriving from the Baltic Proper would decay as they propagate along the Gulf of Finland. This decay is somewhat overestimated, if the wind is still blowing in the Gulf of Finland.

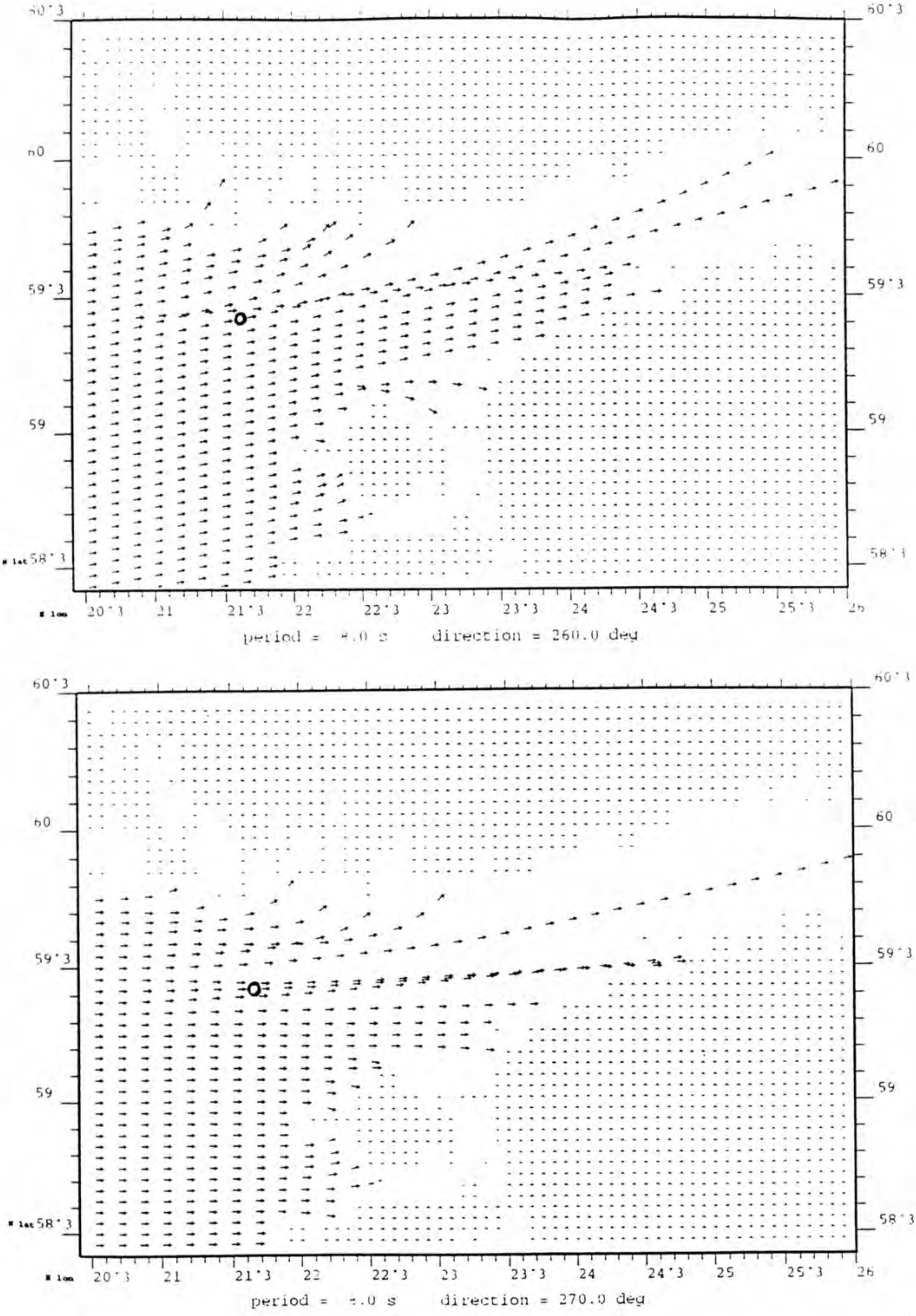
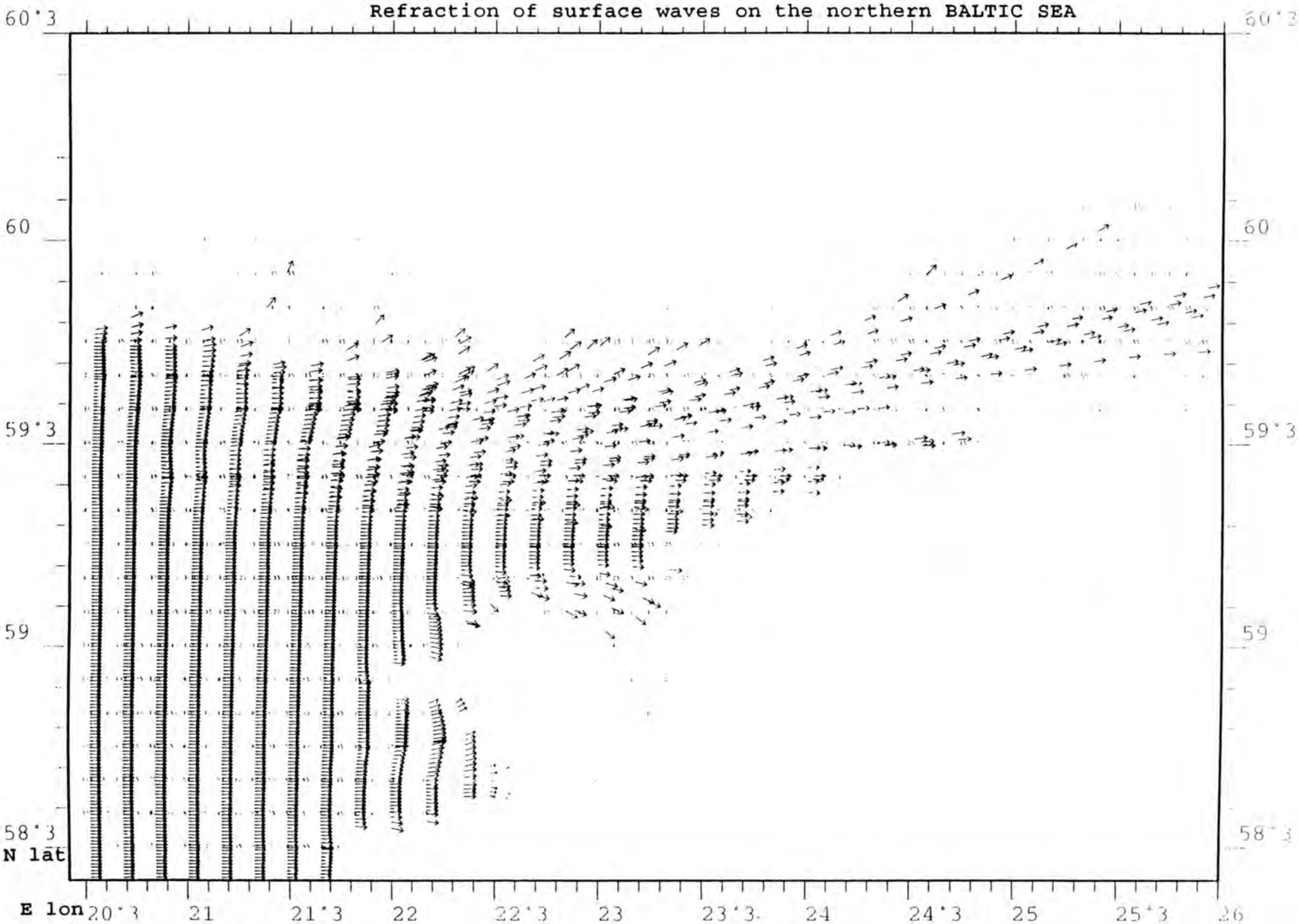


Figure 4. Wave rays, waves coming initially from 260° and 270°, period 8 s.

THE BALTIC SEA



4.3 Small scale topography

In the area of concern the nautical maps show places that in principle could concentrate wave energy into focal areas of a few nautical miles extent. To be able to calculate the refraction effects of these small scale features a dense grid was made of the site of the shipwreck. The data was obtained from the nautical maps.

It was found that the focusing effect depends on such details of the bathymetry that are not adequately described in the nautical charts. Detailed sounding data have just been obtained the Finnish Board of Navigation for some of the shoals. With a few exceptions the data does not cover areas south from 59° 26' N. There is at least one 17 m shoal indicated in the navigational charts that is not covered by the detailed data.

The detailed bathymetric data have not yet been implemented into the refraction model. Preliminary estimates have been made. They indicate that the shoals near the place of accident are too deep and too small to generate any significant refraction focusing when the wave period is 7.8 s. Especially the shoal nearest to the shipwreck is according to detailed data 38 m deep and only a few hundred meters wide. At that depth the shoal is too small to generate any significant enhancement in the wave height.

These conclusions apply only to the areas covered by the detailed bathymetric data. The nautical charts do not describe the bathymetry accurately enough for the small scale calculations.

5. CURRENTS

The current at depth 0...5 m at the time of the shipwreck is estimated to have been ca. 10 cm/s in direction 90°...100°, Figure 6. The dominate direction surface currents was between 45° and 90°. The speed varied between 10 cm/s and 30 cm/s. At site of the accident the surface current was smaller than nearby.

Surface currents were smaller that one could expect from the maximum wind speed. The reason is variation in the wind direction that also reduced the wave height.

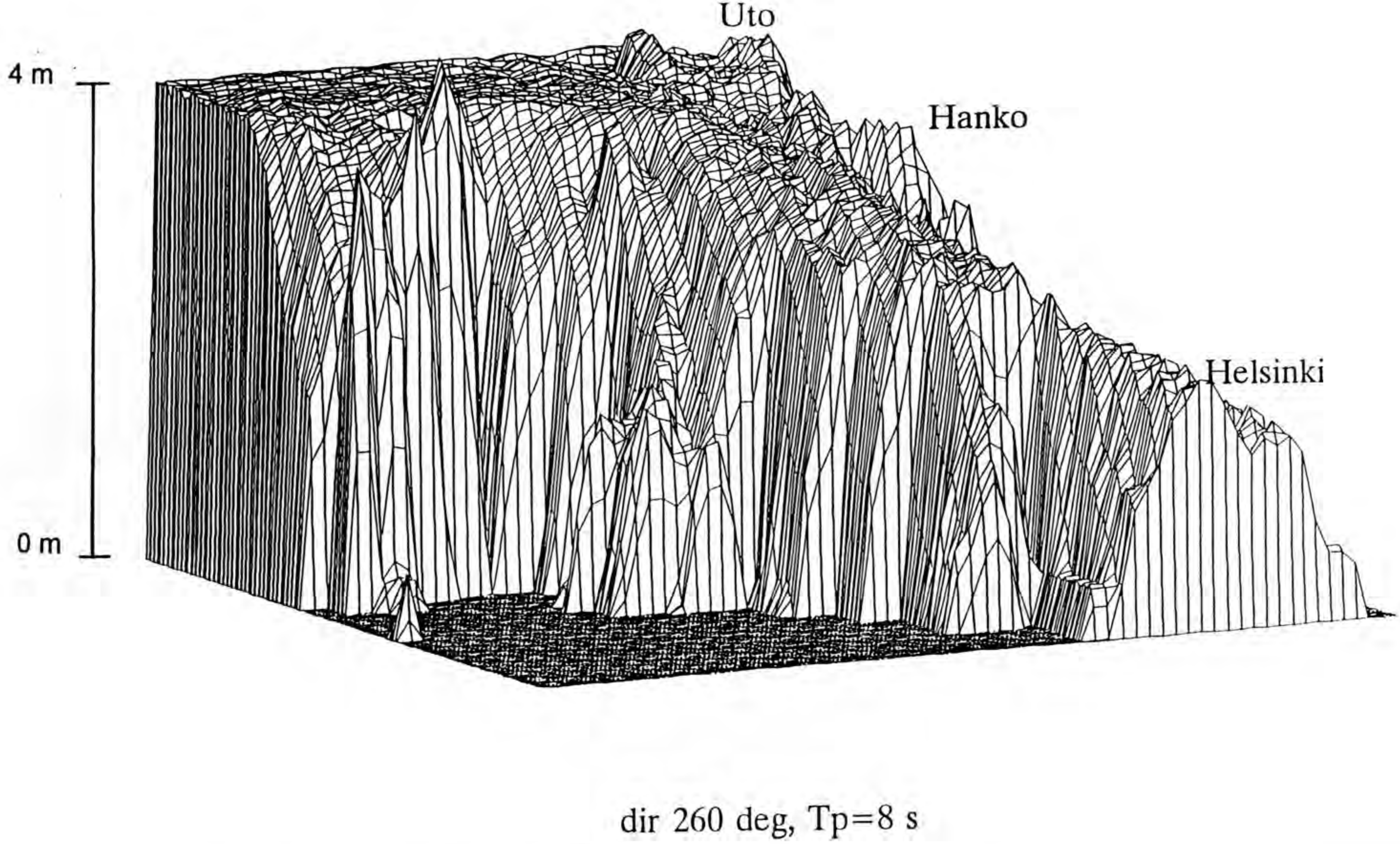


Figure 5. Significant wave height, predicted by the large scale refraction model.

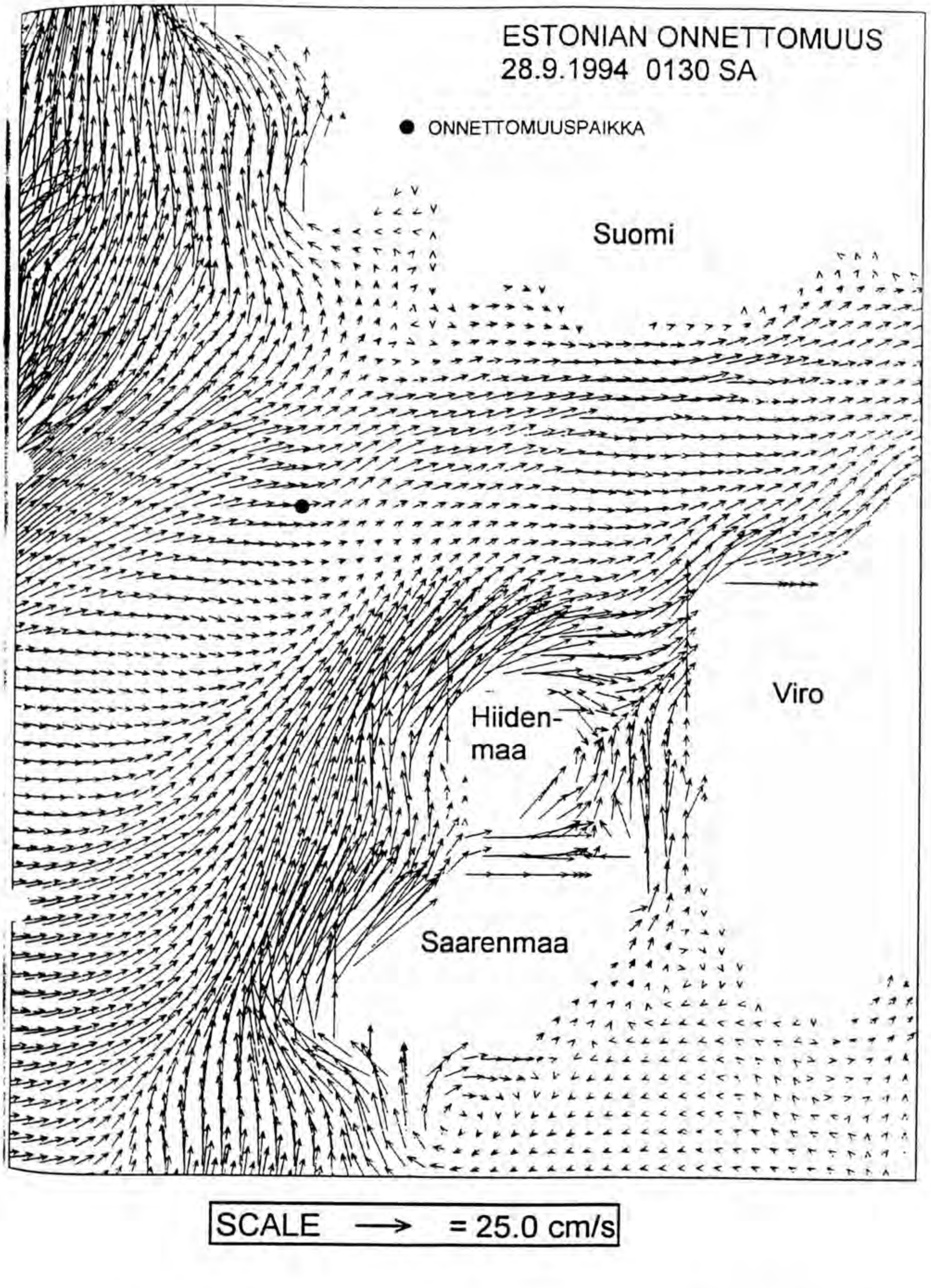


Figure 6. Surface currents at depth 0...5 m at September 28 1994 01:30 EST.

REFERENCES

Bouws, E. and J. A. Battjes, 1982: A Monte Carlo Approach to the Computation of Refraction of Water waves. - J. Geophys. Res. 87(8) 5718-5722.

Kahma, K.K. and C.J.Calkoen, 1994: Growth curve observations. - In Komen et al. Dynamics and Modelling of Ocean Waves. Cambridge University Press, 532 pp.

SUPPLEMENT No. 406

Merkitsevän aallonkorkeuden todennäköisyydet M/V Estonian käyttämillä reiteillä.

Merentutkimuslaitos

Helsinki 11.4.1997

Significant wave height probabilities on the routes operated by MV ESTONIA.

Finnish Institute of Marine Research.

Helsinki 11.4.1997

Merentutkimuslaitos Dno 43/24/97

Estonian kansainvälisen tutkimuskomission tilaus 4.4.1997.

Merkitsevän aallonkorkeuden todennäköisyydet M/V Estonian käyttämillä reiteillä

Todennäköisyydet on laskettu kausipainotetuista suuntaluokitelluista aaltotilastoista avovesikaudelle.

Pohjoinen Itämeri ja Ahvenanmeri

Pohjoisella Itämerellä todennäköisyydet ovat Utön eteläpuolelta ja Ahvenanmerellä Lågskärin läheltä väylän itäpäästä.

Todennäköisyyksien laskemisessa on käytetty Bogskärin eteläpuolella (1982-1986) tehtyjä mittauksia. Tilastoihin on lisätty tammikuun 1984 etelämyrskyn arvot Almagrundetista, koska Bogskärin mittalaite hiljeni hiukan ennen myrskyn huippua. Etelätuulilla aallonkorkeus Bogskärissä on verrattavissa Almagrundetin havaintoihin.

Tilastot on siirretty halutuille paikoille pyyhkäisymatkojen sekä tuulen kestoajan jakauman avulla. Lågskärin todennäköisyyksissä on otettu huomioon pohjan kitka ja refraktio.

Pohjoinen Selkämeri

Todennäköisyydet on laskettu väylän Vaasa-Sundsvall avomeriosuudelle joka on aallokon kannalta väylää Vaasa-Umeå pahempi. Selkämeren (Sandbäck) tilastot on peilattu vastaamaan olosuhteita pohjoisella Selkämerellä ottaen huomioon tuulen suuntajakaumat.

Todennäköisyydet 2, 3 ja 4 metriä ylittäville merkitseville aallonkorkeuksille

Hs (m)	pohj. Itämeri	Ahvenanmeren eteläosa	Selkämeren pohjoisosa
2	24.6 %	5.7 %	12.6 %
3	11.1 %	0.4 %	3.9 %
4	4.2 %	0.04 %	1.2 %

Todennäköisyyksien virhe annetuista arvoista arvioidaan pienemmäksi kuin 30 %.

Helsingissä 11.4.1997

osastonjohtaja Jouko Launiainen

tutkija Heidi Pettersson

SUPPLEMENT No. 407

Kahma Kimmo - Pettersson Heidi:

Wave Height - Wave Period. Distribution from the Northern Baltic Proper.

Finnish Institute of Marine Research.

Helsinki 1996.

WAVE HEIGHT - WAVE PERIOD DISTRIBUTION FROM THE NORTHERN BALTIC PROPER

Kimmo K. Kahma and Heidi Pettersson

Finnish Institute of Marine Research

1996

Wave height - Wave period distribution from the Northern Baltic Proper

This report presents the wave height and wave period distribution from Bogskär in the Northern Baltic Proper. The distribution is based on a reprocessed dataset from the years 1982 - 1986. Reprocessed data from year 1986 have not been available before.

The measuring point, denoted as B on the map, is about 2.5 nautical miles south of the lighthouse at Bogskär. The place represents well the conditions in the open sea in the Northern part of Baltic proper. The wave climate at Bogskär is not representative for the conditions to the north of latitude 59°45' N, where shallow water effects and islands create a wave climate that varies rapidly from place to place. This also applies to a smaller area behind the lighthouse Suomen Leijona.

The wave data were measured as a joint operation with the Finnish Institute of Marine Research (FIMR) and the Swedish Meteorological and Hydrological Institute (SMHI). FIMR provided the measuring instruments and deployed the wave buoy. SMHI provided the telecommunication link from the lighthouse Svenska Björn and the first processing of the data at SMHI. The data in this first format have been distributed by SMHI under a measuring place title Svenska Björn.

There are small differences in the basic processing of the wave data in SMHI and FIMR. While the differences are not very significant, the SMHI dataset is not consistent with FIMR wave data from other places, and therefore the data has been reprocessed. One of the changes made in the reprocessing was to remove the wave energy at frequencies lower than 0.05 Hz (period over 20 s), as shown below in the equation for significant wave height. The peak frequency is also defined slightly differently.

The data were measured by a Datawell Waverider buoy. The measurements were made every hour. The length of one run was 10 minutes. The measurements used here were made in 1982...1986. The wind was measured at Svenska Björn by SMHI.

Significant wave height in this data is calculated by the equation

$$H_s = 4 \cdot \left[\int_{0.05\text{Hz}}^{0.5\text{Hz}} E(f)df \right]^{1/2}$$

where E(f) is the wave spectrum.

The peak wave period is defined as

$$T_p = 1 / f_p$$

where f_p is the frequency of the dominant maximum of the spectrum. The peak frequency was determined by a parabolic fit.

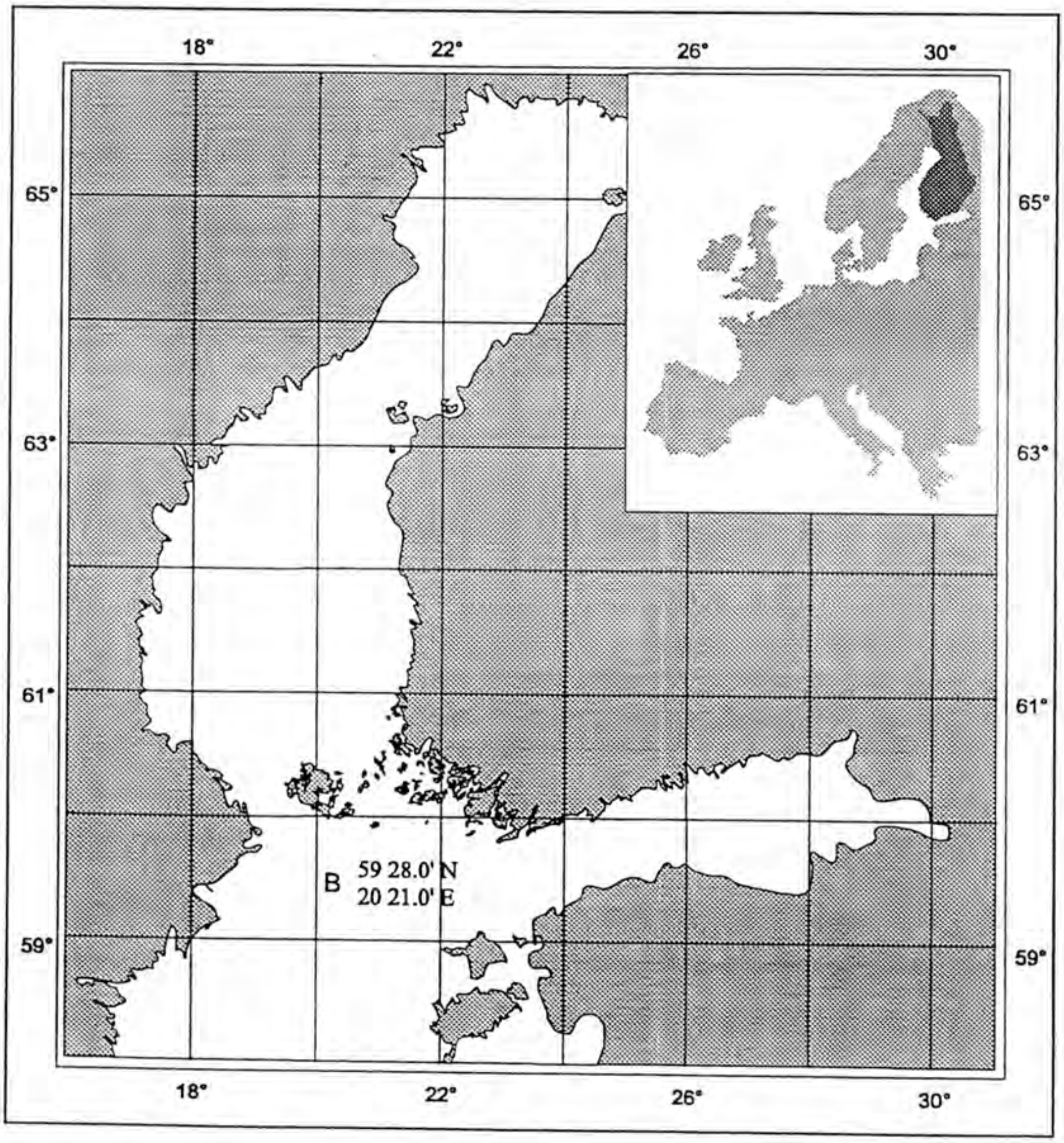


Figure 1. The wave measuring place (B), about 2.5 nautical miles south of the lighthouse of Bogskär.

The statistics are presented in two sets: The first set shows the actual measured data. The second set is an unbiased prediction for the average ice free period. In this data set the missing values have been predicted using seasonally stratified distributions of the data.

The significance of the second set is the following: The Northern part of the Baltic Proper is ice-free on average from the 5th of April to the 11th of February. It is not feasible to make continuous wave measurements with a Waverider when there is risk of ice damaging the buoy. Therefore the actual measuring times are considerably shorter than the ice-free period. In addition, instrument failures have resulted in gaps. The measured data has more measurements in the autumn season than there would be if the measurements covered the whole ice free period uniformly.

The measurements used in this analysis are from the years 1982...1986. Because the data from 1985 covers a very short period, the seasonally averaged data is normalized to represent the ice-free period over three years.

On 13 Jan 1984 the system failed before the peak of a severe storm. Significant wave height at that time was 6.7 m and peak period 9.8 s. The highest waves ever recorded in the Baltic Sea were measured at Almagrundet some hours later at the peak of that storm.

The following data were collected during the storm:

Wave data from Bogskär and wind data from Svenska Björn

			wind		waves		
			dir	U	Hs	fp	Tp
mm	dd		deg	m/s	m	Hz	s
1	13	10.00	208	14.4	3.43	0.121	8.3
1	13	11.00	206	14.9	3.17	0.131	7.6
1	13	12.00	206	15.6	3.17	0.131	7.6
1	13	13.00	203	15.8	3.58	0.122	8.2
1	13	14.00	196	15.7	3.95	0.123	8.1
1	13	15.00	190	18.3	4.31	0.114	8.8
1	13	16.00	183	18.5	4.31	0.114	8.8
1	13	17.00	181	20.9	4.94	0.116	8.6
1	13	18.00	182	20.9	6.24	0.107	9.3
1	13	19.00	184	22.6	6.24	0.107	9.3
1	13	20.00	177	21.6	6.67	0.102	9.8

Buoy failed at Bogskär

Wave data from Almagrundet and wind data from Svenska Björn

mm	dd		deg	m/s	m	Hz	s
1	13	21.00			5.90	0.092	10.9
1	13	22.00	164	18.9	6.10	0.092	10.9
1	13	23.00	185	22.6	6.00	0.092	10.9
1	13	24.00	163	18.1	5.90	0.092	10.9
1	14	1.00	185	19.7	7.20	0.092	10.9
1	14	2.00	194	21.5	7.00	0.092	10.9
1	14	3.00	205	22.5	7.10	0.084	11.9
1	14	4.00	211	20.0	7.70	0.078	12.8
1	14	5.00	214	19.4	6.40	0.084	11.9

Because Bogskär is down-fetch from Almagrundet, estimates based on the wind field show that at the peak of the storm waves at Bogskär were at least as high as at Almagrundet. If the highest waves that cause the system to fail are just left out, the statistics will be biased. Therefore, values for the period from the time when the buoy failed until the end of this particular storm have been taken from the data measured at Almagrundet. Data values from Almagrundet are enclosed in parenthesis in the tables.

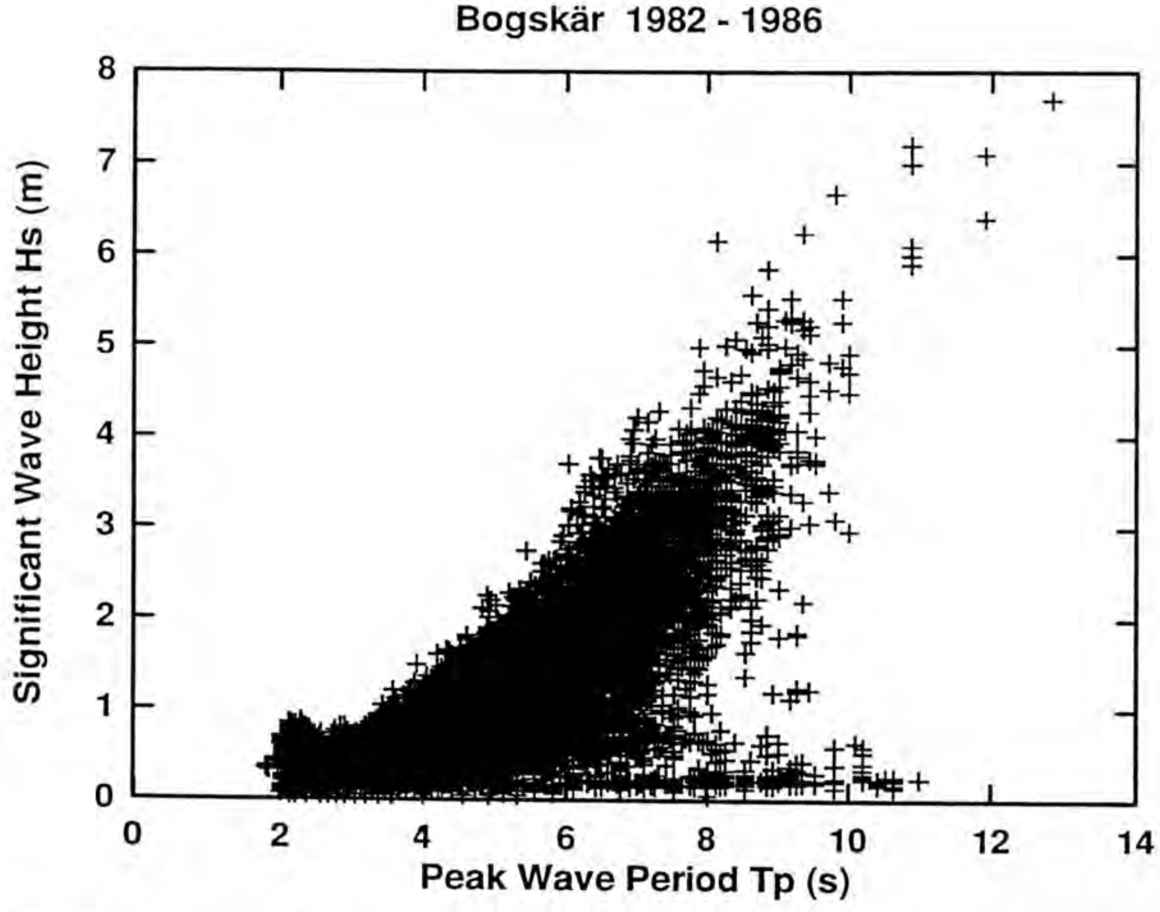


Figure 2. Scattering diagram of peak wave period and significant wave height from wave data collected at Bogskär in 1982...1986.

Finnish Institute of Marine Research

Wave data from Bogskär 59°28.0 N 20° 21.0 E

1982 - 1986
All directions

significant wave height [m]	number of observations	%	cumulative %
0.00 : 0.25	1096	7.4909	7.4909
0.25 : 0.50	1822	12.4530	19.9440
0.50 : 0.75	2310	15.7884	35.7323
0.75 : 1.00	2024	13.8336	49.5660
1.00 : 1.25	1751	11.9677	61.5337
1.25 : 1.50	1349	9.2201	70.7539
1.50 : 1.75	963	6.5819	77.3358
1.75 : 2.00	730	4.9894	82.3252
2.00 : 2.25	682	4.6613	86.9865
2.25 : 2.50	481	3.2875	90.2741
2.50 : 2.75	343	2.3443	92.6184
2.75 : 3.00	315	2.1530	94.7714
3.00 : 3.25	238	1.6267	96.3981
3.25 : 3.50	177	1.2098	97.6078
3.50 : 3.75	108	0.7382	98.3460
3.75 : 4.00	87	0.5946	98.9406
4.00 : 4.25	60	0.4101	99.3507
4.25 : 4.50	32	0.2187	99.5694
4.50 : 4.75	17	0.1162	99.6856
4.75 : 5.00	12	0.0820	99.7676
5.00 : 5.25	9	0.0615	99.8291
5.25 : 5.50	8	0.0547	99.8838
5.50 : 5.75	3	0.0205	99.9043
5.75 : 6.00	1+(2)	0.0205	99.9248
6.00 : 6.25	3+(2)	0.0342	99.9590
6.25 : 6.50	(1)	0.0068	99.9658
6.50 : 6.75	1	0.0068	99.9727
6.75 : 7.00	0	0.0000	99.9727
7.00 : 7.25	(3)	0.0205	99.9932
7.25 : 7.50	0	0.0000	99.9932
7.50 : 7.75	(1)	0.0068	100.0000
7.75 : 8.00	0	0.0000	100.0000

Data in parenthesis are from Almagundet 1984-01-13 21:00 - 01-14 05:00

Finnish Institute of Marine Research

Wave data from Bogskär 59°28.0 N 20°21.0 E
Missing values predicted by seasonal distributions

1982 - 1986
All directions

significant wave height [m]	number of hours/year	%	cumulative %
0.00 : 0.25	1542	6.8622	6.8622
0.25 : 0.50	2639	11.7440	18.6062
0.50 : 0.75	3329	14.8146	33.4209
0.75 : 1.00	2899	12.9011	46.3219
1.00 : 1.25	2668	11.8731	58.1950
1.25 : 1.50	2107	9.3765	67.5715
1.50 : 1.75	1527	6.7954	74.3670
1.75 : 2.00	1174	5.2245	79.5915
2.00 : 2.25	1131	5.0332	84.6246
2.25 : 2.50	795	3.5379	88.1625
2.50 : 2.75	610	2.7146	90.8771
2.75 : 3.00	585	2.6034	93.4805
3.00 : 3.25	445	1.9803	95.4608
3.25 : 3.50	347	1.5442	97.0050
3.50 : 3.75	226	1.0057	98.0108
3.75 : 4.00	152	0.6764	98.6872
4.00 : 4.25	104	0.4628	99.1500
4.25 : 4.50	59	0.2626	99.4126
4.50 : 4.75	31	0.1380	99.5505
4.75 : 5.00	22	0.0979	99.6484
5.00 : 5.25	18	0.0801	99.7285
5.25 : 5.50	16	0.0712	99.7997
5.50 : 5.75	5	0.0223	99.8220
5.75 : 6.00	1+(6)	0.0312	99.8531
6.00 : 6.25	9+(6)	0.0668	99.9199
6.25 : 6.50	(3)	0.0134	99.9332
6.50 : 6.75	3	0.0134	99.9466
6.75 : 7.00	0	0.0000	99.9466
7.00 : 7.25	(9)	0.0401	99.9866
7.25 : 7.50	0	0.0000	99.9866
7.50 : 7.75	(3)	0.0134	100.0000
7.75 : 8.00	0	0.0000	100.0000

Data in parenthesis are from Almagundet 1984-01-13 21:00 - 01-14 05:00

Finnish Institute of Marine Research

Wave data from Bogskär 59° 28.0 N 20°21.0 E

1982 - 1986
All directions

peak wave period Tp [s]

significant wave height [m]	2	3	4	5	6	7	8	9	10	11	12	13	total
0.00 : 0.25	185	321	224	103	65	58	73	50	11	6	0	0	1096
0.25 : 0.50	192	692	562	206	74	25	31	27	10	3	0	0	1822
0.50 : 0.75	147	443	918	559	162	50	21	5	5	0	0	0	2310
0.75 : 1.00	25	54	914	723	241	58	9	0	0	0	0	0	2024
1.00 : 1.25	0	2	416	852	400	68	7	6	0	0	0	0	1751
1.25 : 1.50	0	0	81	708	465	78	16	1	0	0	0	0	1349
1.50 : 1.75	0	0	9	351	441	138	23	1	0	0	0	0	963
1.75 : 2.00	0	0	0	127	373	188	35	7	0	0	0	0	730
2.00 : 2.25	0	0	0	38	312	261	67	4	0	0	0	0	682
2.25 : 2.50	0	0	0	9	169	223	75	5	0	0	0	0	481
2.50 : 2.75	0	0	0	0	83	172	80	8	0	0	0	0	343
2.75 : 3.00	0	0	0	1	39	145	117	12	1	0	0	0	315
3.00 : 3.25	0	0	0	0	17	83	126	11	1	0	0	0	238
3.25 : 3.50	0	0	0	0	5	49	105	17	1	0	0	0	177
3.50 : 3.75	0	0	0	0	5	37	52	13	1	0	0	0	108
3.75 : 4.00	0	0	0	0	3	10	44	29	1	0	0	0	87
4.00 : 4.25	0	0	0	0	0	3	23	33	1	0	0	0	60
4.25 : 4.50	0	0	0	0	0	1	9	21	1	0	0	0	32
4.50 : 4.75	0	0	0	0	0	0	6	9	2	0	0	0	17
4.75 : 5.00	0	0	0	0	0	0	1	8	3	0	0	0	12
5.00 : 5.25	0	0	0	0	0	0	2	7	0	0	0	0	9
5.25 : 5.50	0	0	0	0	0	0	0	7	1	0	0	0	8
5.50 : 5.75	0	0	0	0	0	0	0	2	1	0	0	0	3
5.75 : 6.00	0	0	0	0	0	0	0	1	0	(2)	0	0	1+(2
6.00 : 6.25	0	0	0	0	0	0	1	2	0	(2)	0	0	3+(2
6.25 : 6.50	0	0	0	0	0	0	0	0	0	0	(1)	0	(1
6.50 : 6.75	0	0	0	0	0	0	0	0	1	0	0	0	1
6.75 : 7.00	0	0	0	0	0	0	0	0	0	0	0	0	0
7.00 : 7.25	0	0	0	0	0	0	0	0	0	(2)	(1)	0	(3
7.25 : 7.50	0	0	0	0	0	0	0	0	0	0	0	0	0
7.50 : 7.75	0	0	0	0	0	0	0	0	0	0	0	(1)	(1
7.75 : 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0
total	549	1512	3124	3677	2854	1647	923	286	41	9+(6)	(2)	(1)	1463

In this table the middle of the range of the peak wave period Tp is shown: 2s means Tp < 2.5s, 3s means 2.5s < Tp < 3.5s etc.
Data in parenthesis are from Almagrundet 1984-01-13 21:00 - 01-14 05:00

Finnish Institute of Marine Research

Wave data from Bogskär 59 28.0 N 20 21.0 E
Missing values predicted by seasonal distributions
1982 - 1986
All directions

peak wave period Tp [s]

significant wave height [m]	2	3	4	5	6	7	8	9	10	11	12	13	total
0.00 : 0.25	260	464	324	146	86	75	95	67	16	9	0	0	1542
0.25 : 0.50	254	998	806	314	128	43	41	38	13	4	0	0	2639
0.50 : 0.75	190	668	1319	787	240	79	30	7	9	0	0	0	3329
0.75 : 1.00	32	87	1311	1017	352	86	14	0	0	0	0	0	2899
1.00 : 1.25	0	6	666	1290	575	103	11	17	0	0	0	0	2668
1.25 : 1.50	0	0	151	1128	671	119	35	3	0	0	0	0	2107
1.50 : 1.75	0	0	24	582	657	214	47	3	0	0	0	0	1527
1.75 : 2.00	0	0	0	222	573	298	64	17	0	0	0	0	1174
2.00 : 2.25	0	0	0	79	500	420	124	8	0	0	0	0	1131
2.25 : 2.50	0	0	0	21	279	353	132	10	0	0	0	0	795
2.50 : 2.75	0	0	0	0	167	283	145	15	0	0	0	0	610
2.75 : 3.00	0	0	0	3	76	261	219	23	3	0	0	0	585
3.00 : 3.25	0	0	0	0	34	141	248	19	3	0	0	0	445
3.25 : 3.50	0	0	0	0	14	98	206	28	1	0	0	0	347
3.50 : 3.75	0	0	0	0	13	86	107	17	3	0	0	0	226
3.75 : 4.00	0	0	0	0	4	25	76	44	3	0	0	0	152
4.00 : 4.25	0	0	0	0	0	5	44	54	1	0	0	0	104
4.25 : 4.50	0	0	0	0	0	3	18	35	3	0	0	0	59
4.50 : 4.75	0	0	0	0	0	0	15	12	4	0	0	0	31
4.75 : 5.00	0	0	0	0	0	0	1	14	7	0	0	0	22
5.00 : 5.25	0	0	0	0	0	0	4	14	0	0	0	0	18
5.25 : 5.50	0	0	0	0	0	0	0	15	1	0	0	0	16
5.50 : 5.75	0	0	0	0	0	0	0	4	1	0	0	0	5
5.75 : 6.00	0	0	0	0	0	0	0	1	0	(6)	0	0	1+(6)
6.00 : 6.25	0	0	0	0	0	0	3	6	0	(6)	0	0	9+(6)
6.25 : 6.50	0	0	0	0	0	0	0	0	0	0	(3)	0	(3)
6.50 : 6.75	0	0	0	0	0	0	0	0	3	0	0	0	3
6.75 : 7.00	0	0	0	0	0	0	0	0	0	0	0	0	0
7.00 : 7.25	0	0	0	0	0	0	0	0	0	(6)	(3)	0	(9)
7.25 : 7.50	0	0	0	0	0	0	0	0	0	0	0	0	0
7.50 : 7.75	0	0	0	0	0	0	0	0	0	0	0	(3)	(3)
7.75 : 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0
total	736	2223	4601	5589	4369	2692	1679	471	71	13+(18)	(6)	(3)	22471

In this table the middle of the range of the peak wave period Tp is shown: 2s means Tp < 2.5s, 3s means 2.5s < Tp < 3.5s etc.
Data in parenthesis are from Almagrundet 1984-01-13 21:00 - 01-14 05:00

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MV ESTONIA ACCIDENT INVESTIGATION

Numerical predictions of wave loads on the bow visor

CONFIDENTIAL

TECHNICAL REPORT VALC106

Tuomo Karppinen, Sakari Rintala & Antti Rantanen

Espoo, December 1995

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MV ESTONIA ACCIDENT INVESTIGATION

Numerical predictions of wave loads on the bow visor

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ABSTRACT

Wave loads on the bow visor of MV Estonia have been simulated in irregular head and bow seas at different forward speeds by applying a non-linear numerical method. Conclusions are based on the present estimate of the sea state, speed and heading at the time of the accident. The numerical predictions indicate that the vertical component of the wave load on the bow visor of MV Estonia may have been on the accident night quite well over 500 tons. Rough estimates of the horizontal force component and moment arm around the hinges combined with the vertical force component show that the visor opening moment may have beeen over 2 000 ton-metres. The strong dependence of the visor loads on the wave height and shape adds uncertainty in the estimates.

CONTENTS

1 INTRODUCTION

The Estonian flagged passenger ferry MV Estonia encountered 28 September 1994 heavy bow seas on a scheduled voyage from Tallinn to Stockholm in the northern part of the Baltic. The lockings of the bow visor of the vessel broke and the visor fell off forcing the bow ramp open. Water flooded the car deck, the vessel lost stability and sank shortly before 2 a.m. Finnish time.

As part of the accident investigation wave loads on the bow visor of MV Estonia on the accident voyage have been estimated by a numerical method. The method and the results of the predictions are presented here. The load simulation is based on simulation of the wave-induced motions of the vessel. However, seakeeping characteristics of MV Estonia from the point-of-view of wave-induced motions are discussed in an another technical report VTT VALC53. Estimates of the sea conditions during the accident night by the Swedish, German and Finnish marine research institutes have been used in the numerical predictions.

The Swedish ship laboratory SSPA has made a systematical series of model experiments where the wave loads have been measured on bow visors different in shape than the visor of MV Estonia. Some of the results by SSPA have been compared to the numerical predictions. After the systematical series, SSPA has made wave load experiments also with a model of MV Estonia. The wave load simulations have been validated also with these test results.

Several fairly accurate methods, for instance the linear strip method (Raff, 1972), are available for predicting linear wave loads and wave-induced motions of ships in bow waves. The linear strip method, however, cannot be used for evaluating wave loads on parts of ship hull which are above the waterplane since only the underwater hull up to the mean waterline is considered in the calculations. There is no general, exact numerical method for solving the flow around a body entering water (Trosch & Kang, 1988). Due to the very complicated non-linear free surface and body boundary conditions the calculation of the impact forces on a body entering water requires simplification. Von Karman (1929) presented the first solution for this problem in two dimensions and since then several methods have been developed. A review of the solutions for circular cylinders and wedges is given by Greenhow & Yanbao (1987) and Greenhow (1987), respectively.

A practical method applied quite often for estimating the flare impact loads on ships is the non-linear strip method (e.g. Yamamoto et al. 1980). A variant of this method based on the work of Matusiak & Rantanen (1986) has been used here for simulating the vertical component of the visor load. Unfortunately the method does not give the pressure distribution on the surface of the visor and thus determination of the opening moment of the visor around the hinges must be based on quite rough estimates. On the other hand, the method is not very consuming on computer time so that it has been possible to run long simulations to find out statistics of the high visor loads.

2 CONDITIONS

2.1 Sea states

Numerical simulations of the vertical wave load on the bow visor of MV Estonia have been made in four sea states. The long-crested, irregular wave time history has been generated according to the JONSWAP wave spectrum formula given in Appendix 4. The wave spectrum shows the wave energy distribution versus frequency. In the JONSWAP spectrum, the wave energy is concentrated over a narrower frequency band than in the ISSC spectrum. The significant wave height, H_S, has been 4.0, 4.5 and 5.5 m with a modal period, T_O, of 8.0 s. The modal period is the period corresponding to the peak of the wave spectrum. In addition, a simulation has been carried out in a sea state with $T_O = 8.5$ s and $H_S = 4.0$ m. Simulations were also made in a few regular waves to compare with model test results of SSPA.

The present estimate of the sea state during the MV Estonia accident is 4 m significant height and 8 s modal period. Estimates of the modal period and the significant wave height were obtained from the Finnish, Swedish and German institutes of marine research, MTL, SMHI and DW, respectively. Table 2.1 gives their predictions determined by numerical models at the accident site at 02 Finnish time 28 September 1994, i.e. about one hour after the accident.

Table 2.1 Estimates of wave conditions at 02 28.9.1994 at the site of the accident.

Institute	H_S [m]	T_O [s]	T_1 [s]	Mean dir. [deg.]
MTL, Finland	4.4	8.2		260
SMHI, Sweden	4.2	8.5	7.2	218 - 233
DW, Germany	4.3	8.3	7.0	218

In the table, T_1 is the mean wave period. SMHI gives both the wave direction corresponding to the peak frequency (first) and the direction of the shortest waves which is the same as the wind direction. MTL and SMHI have also made estimates of the wave conditions before and after the accident. A summary of these estimates is in Table 2.2.

Table 2.2 A summary of wave conditions before and after the accident.

Institute	Position	Time	H_S [m]	T_O [s]	Mean dir.
MTL	59 25, 22 35	27.9, 23.00	3	7	260
SMHI	59 27, 22 50	27.9, 23.00	2.5	6.7	250 - 185
MTL	Accident site	28.9, 01.00	4.0	7.8	260
MTL	Accident site	28.9, 01.30	4.2	8.0	260
MTL	Accident site	28.9, 08.00	5.0	8.7	270
SMHI	Accident site	28.9, 08.00	5.1	9.5	236 - 272

The estimates of the significant wave height by the different institutes agree remarkably well. The Finnish MTL has assumed in predicting the mean wave direction that the wind shift to south on 27.9 did not last long enough to change the direction of the major wave components. This conclusion is based on their wave observations in the northern part of the Baltic. The experience of MTL is that the mean error in the predicted significant wave height is about 0.5 m, in the wave period about one second and in the wave direction about 10 degrees.

All the wave estimates are for deep water. Numerical predictions by MTL show that the significant wave height may increase significantly in shallow water due to wave focusing (Kahma et al. 1995). If waves with significant wave height 4 m and modal period 8 s enter an area where the waterdepth is around 20 m, the significant wave height may increase to 6 m while the period remains approximately constant. At the same time, statistics of the waves change so that a large part of the waves will have heights near the significant height. However, the maximum wave height will not increase respectively and remains approximately on the same level as with the original 4 m significant height.

The Finnish Lion, about 25 nautical miles west from the MV Estonia accident site, is an example of a shallow area where the significant wave height will increse in suitable weather conditions. The Finnish National Board of Navigation has analysed soundings in a sector reaching over 10 nautical miles east from the wreck of MV Estonia. The area covers the probable route of MV Estonia before the accident. The minimum waterdepth measured was 52 m which indicates that there cannot be sites shallower than about 40 m between the sounding lines. Thus, shallow waterdepth did not have an effect on the wave formation when the lockings of the bow visor of MV Estonia were broken. It may be assumed that the significant wave height was about 4 m and the modal period about 8 s at the time of the accident.

2.2 Speeds and headings

Wave loads on the bow visor have been simulated at the vessel speeds of 10, 12 and 15 knots. The present estimate of the forward speed of MV Estonia just before the accident is about 15 knots which is based on witness accounts. Simulations have been carried out in head seas corresponding to a heading angle of 180^{o} and in bow seas at a heading of 150^{o}. MV Estonia encountered the waves probably slightly to the port from direct head seas though there are estimates which indicate that the heading may have been closer to beam seas. The heading 150^{o} is considered to be quite close to the actual conditions at the time of the accident.

2.3 Definition of the vessel hull form

Figure 2.1 shows the body plan and lines of MV Estonia. In the predictions of the heave and pitch Response Amplitude Operators by the SCORES-program (Raff, 1972) based on the strip method, the vessel hull form was defined by 11 and 21 sections. The number of sections had an insignificant effect on the wave-induced motions. Lewis-forms were used in defining the section shapes. Table 2.4 presents a summary of the main particulars of MV Estonia.

Table 2.4 Main particulars of MV Estonia.

	Symbol	Dimension	Value
Length over all	L_{oa}	m	155.4
Waterline length	L_{wl}	m	144.8
Length betw. perp.	L_{pp}	m	137.4
Beam mld, A deck	B	m	24.2
Waterline beam	B_{wl}	m	23.6
Draught at aft. perp.	T_a	m	5.75
Draught at forw. perp.	T_f	m	5.25
Trim, positive by stern		m	0.50
Displacement	∇	m^3	12 243
Longitudinal CG from aft. perp.	LCG	m	63.7
Vertical CG	KG	m	10.50
Transverse metacentric height	GM_T	m	1.28
Roll radius of gyration	k_{xx}	m	8.96
Pitch radius of gyration	k_{yy}	m	36.2
Depth to stemhead	D	m	10.0

The numerical predictions are for a vessel mean draught of 5.5 m and an aft trim of 0.5 m, i.e. the draft at the forward perpendicular was 5.25 m and at the aft perpendicular 5.75 m. The displacement of 12 365 tons at a water density of 1.01 tons/m^3 and the longitudinal centre of gravity were taken from hydrostatic calculations by the NAPA-program. After the predictions had been made, the load condition of MV Estonia during the accident trip was estimated as 12050 tons and 0.435 aft trim. The fore and aft draughts are respectively 5.172 m and 5.607 m. The difference between the actual and the assumed loading condition is so small that it has hardly any effect on the wave-induced motions.

Standard values of $0.25L_{wl}$ and $0.38B_{wl}$ were used for the longitudinal and transverse radius of gyration, respectively. The transverse metacentric height was set to 1.3 m while the actual value was 1.17m. Also the actual location of the centre of gravity differed a little from the assumed value. The final estimated values are: LCG = 63.85 and KG = 10.62 m. A summary of the input data is given in Appendix 3.

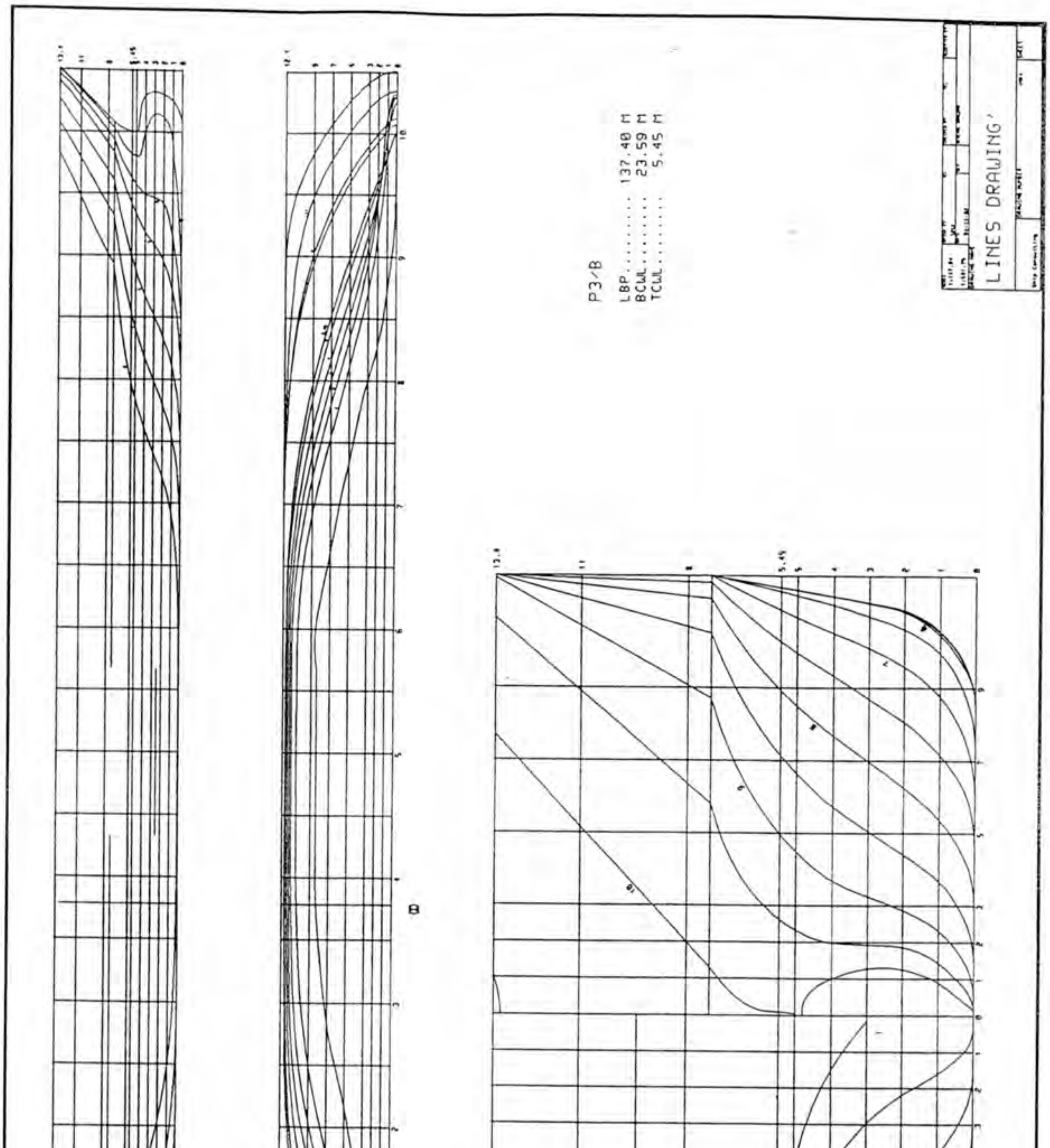


Fig. 2.1 Body and lines plan of MV Estonia.

3 SIMULATION METHOD

The simulation method is based on the so called non-linear strip theory (Yamamoto et al., 1980 and Chiu & Fujino, 1991) which is a practical method for simulating ship motions in waves. A main difference between the linear strip method and the non-linear strip method is that in the linear theory the equations of motion are solved for the mean waterline in the frequency domain while in the non-linear version the motions are simulated in the time domain and the non-linearities of the hydrodynamic forces arising from the variation of the submerged portion of the hull are taken into account. Here the formulas of the non-linear strip method have been applied for simulating the vertical force on the bow visor in long-crested, irregular waves. However, the rigid body wave-induced motions of the ship have been determined by the linear strip method (Raff, 1972) and simulated by applying the linear superposition principle. The approach is based on the work of Matusiak & Rantanen (1986). The non-linearities in the hydrodynamic forces affect only slightly heave and pitch (Yamamoto et al. 1980).

The non-linear hydrodynamic forces on a heaving ship section may be determined by a momentum consideration as shown by Faltinsen (1990). The method has been widely applied for predicting the hydrodynamic forces on prismatic bodies entering water (e.g. Payne, 1981, and Greenhow, 1987) and for instance by Gran et al. (1976) for estimating the hydrodynamic impact forces on a bow with large flare. Here the bow visor has been considered as a small body entering water. The non-linear forces arising from the momentum consideration and the hydrostatic and hydrodynamic forces as defined in the strip theory (Raff, 1972) are taken into account. However, the term involving the longitudinal derivative of the sectional heave added mass has been neglected. This simplification has probably a minor effect on the results. The instantaneous waterplane has been used for determining the added mass, damping and hydrostatic coefficients of the bow visor. All viscous and memory effects have been disregarded.

3.1 Irregular waves

In the simulations, time histories of irregular waves, surface velocities and accelerations are generated by applying the linear superposition principle, i.e. a large number of regular sinusoidal wave components are summed (Fig.3.1). The amplitude of a regular wave component at frequency ω is determined on the basis of the ordinate of the simulated wave spectrum at ω. In order to get non-repeating random time histories of arbitrary length, each harmonic wave component has a random phase angle and its frequency ω is chosen at random in each narrow frequency band.

The elevation of a long-crested wave surface, η, as a function of time, t, is expressed by:

$$\eta(t) = \sum_{i=1}^{N} a_i \cos(k_i X \cos\mu + k_i Y \sin\mu - \omega_i t + \varepsilon_i) \qquad (1)$$

where

a_i = Amplitude of the ith harmonic wave component
ω_i = Circular frequency of the ith harmonic wave component
ε_i = Random phase angle of the ith wave component
k_i = Wave number of the ith wave component
μ = Angle of wave propagation with regard to the positive X-axis

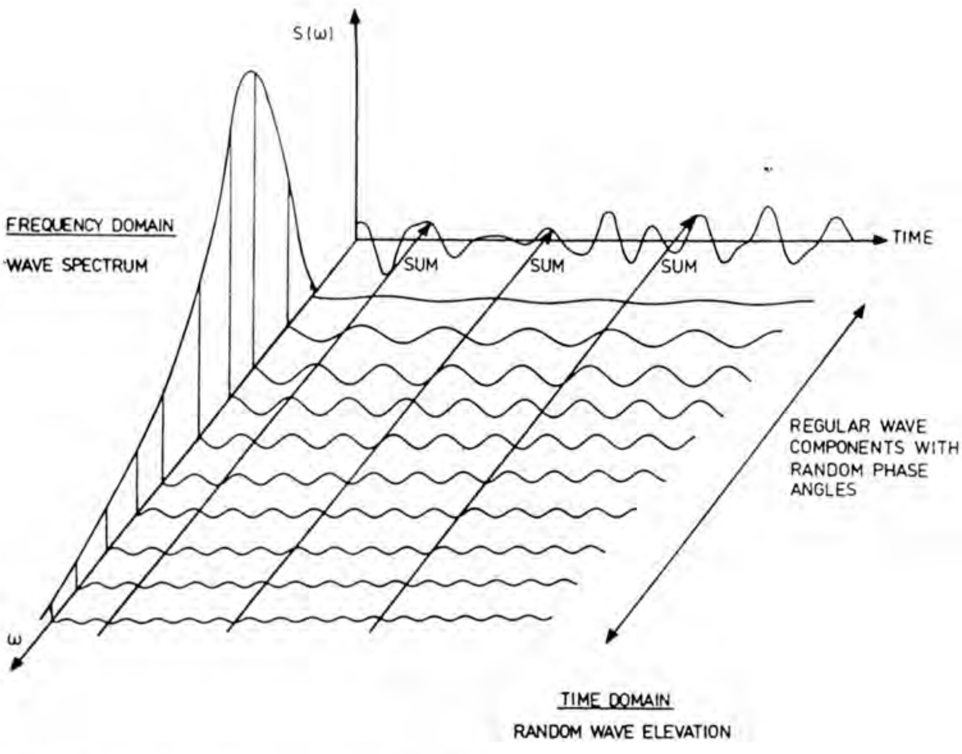


Fig. 3.1 The superposition principle (Faltinsen, 1990).

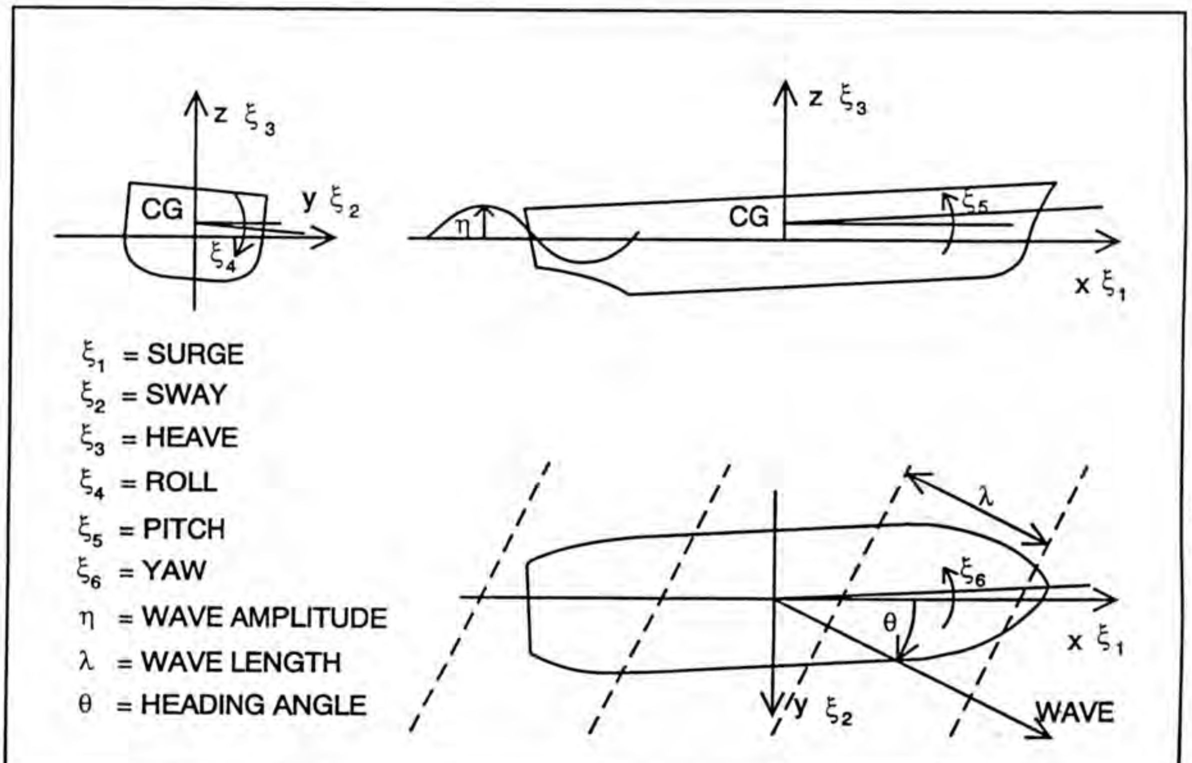


Fig. 3.2 Axis system and definitions.

The wave surface elevation (1) is defined in a Cartesian coordinate system (X,Y,Z) where the origin is fixed to the undisturbed free water surface defined by Z = 0. The positive direction of Z points upwards. The equation (1) may be transformed to a reference frame moving with the steady forward motion of the ship just by replacing the circular frequency of the ith harmonic wave component by the frequency of encounter:

$$\omega_{ei} = \omega_i - k_i V \cos\mu \qquad (2)$$

where V is the steady forward speed of the ship. The origin of the moving reference frame (x,y,z) (Fig. 3.2) translates in the XY-plane with speed V so that the centre of gravity of the ship is in rest position on the vertical z-axis. The ship moves in the positive x-direction which coincides with the earth-fixed X-direction.

In deep water, the wave number is given by $k = \omega^2/g$ where g is the acceleration due to gravity. The vertical velocity and acceleration of the wave surface are obtained as the first and second time derivative of (1), respectively.

The ramdomness of the phase lags implies that there is an equal probability of their having any value between 0 and 2π. The amplitude a_i of the ith wave component is determined by:

$$a_i = \sqrt{2S(\omega_i)\Delta\omega} \qquad (3)$$

where

$S(\omega_i)$ = Ordinate of the simulated wave spectrum at frequency ω_i

$\Delta\omega$ = Frequency increment

The wave time histories have been simulated according to the JONSWAP spectrum. The number of regular wave components used in generating the wave time histories has been 20. This should give an adequate representation of the wave field without lengthening too much the computer time required by the simulation. The high-frequency end of the wave spectrum has been cutted out at ω = 1.72 rad/s to have only wave components with length large relative to the dimensions of the bow visor. In this way the assumption of constant water particle velocity and acceleration over the space occupied by the visor is fulfilled. The high-frequency components have an insignificant effect on the significant wave height but may increase the velocity and acceleration unrealistically.

3.2 Wave-induced motions

Heave and pitch (Fig. 3.2) in the simulated irregular long-crested seas are obtained by determining first the responses to each regular wave component on the basis of heave and pitch response amplitude operators and phase lags predicted by the strip method (Raff, 1972). Summing the heave and pitch responses to the regular wave componets gives the time histories in the form:

$$\xi_j(t) = \sum_{i=1}^{N} \left|R_j(\omega_{ei})\right| a_i \cos(k_i x \cos\mu + k_i y \sin\mu - \omega_{ei} t + \alpha_j(\omega_{ei}) + \varepsilon_i) \text{ for j = 3 and 5} \qquad (4)$$

where ξ_j for j = 3 and 5 are heave and pitch, respectively, R_j for j = 3 and 5 are the heave and pitch transfer functions, respectively, i.e. the response amplitude per unit wave amplitude, and α_j are the heave and pitch phase lags with regard to the wave crest at the origin. The transfer functions and the phase lags depend on the frequency of oscillation, or the frequency of encounter.

During the simulation, at each time step the vertical relative displacement, relative velocity and relative acceleration at the bow visor are determined as the difference between the rigid body vertical displacement, velocity, and acceleration, and the wave surface displacement, velocity and acceleration, respectively. The undisturbed, incident wave surface (1) is used. The vertical relative motion at the bow visor is given by:

$$\xi_r(t) = \eta - \xi_3 - x_b\xi_5 \quad (5)$$

where x_b is the longitudinal coordinate of the centre of the bow visor. Here heave is assumed positive upwards and pitch positive bow up. The vertical relative velocity may be expressed as:

$$\dot{\xi}_r(t) = \dot{\eta} - \dot{\xi}_3 - x_b\dot{\xi}_5 + V\xi_5 \quad (6)$$

where the dots indicate time derivative. The vertical relative acceleration is obtained as a time derivative of (6).

3.3 Vertical force on the visor

The total vertical force component on the visor is predicted by:

$$F_z = F_i + F_{rd} + F_s + F_{FK} + F_{imp} + F_{st} - m_v g \quad (7)$$

where

F_i = Inertia force
F_{rd} = Linear radiation plus diffraction force
F_s = Hydrostatic, or displacement force
F_{FK} = Froude-Krylov force
F_{imp} = Non-linear hydrodynamic impact force
F_{st} = Vertical component of the hydrodynamic force due to the stationary flow
m_v = Mass of the visor = 60.000 kg
g = Acceleration due to the gravity

The inertia force F_i is obtained as the mass of the visor, m_v, times the rigid body vertical acceleration of the ship at the centre of the visor:

$$F_i = -m_v(\ddot{\xi}_3 + x_b\ddot{\xi}_5) \quad (8)$$

The centre of the visor has been assumed to locate at a distance of 3.44 m forward of FP.

The linear radiation plus the diffraction force is determined by:

$$F_{rd} = m_{33}(t)\ddot{\xi}_r + b_{33}(t)\dot{\xi}_r \quad (9)$$

where

m_{33} = heave added mass of the visor up to the instantaneous wave surface
b_{33} = heave damping coefficient of the visor up to the instantaneous wave surface

3.3.1 Added mass and damping coefficients

The heave added mass and damping coefficients of the visor at different waterlines have been computed by a three-dimensional sink-source method (Kalske et al., 1985) which is based on the numerical algorithm developed by Garrison (1974). In these numerical predictions, the surface of the visor has been described by triangular elements (Fig. 3.3). Different numbers of elements have been used at different draughts according to Table 3.1. The shape of the visor has been simplified so that the back bulkhead is vertical and the lower end is sharp (Fig. 3.4). Thus, the original visor has more volume at the lower end than the model used in the simulations. Higher up the difference in volume equalizes.

Table 3.1 Number of elements.

Draught [m]	Elements
7	5
9	24
11	55
13	98
15.4	153

The sink-source method is based on the linear potential flow theory. The velocity potential describing the flow due to the oscillatory motion of the body in six degrees of freedom is obtained as a solution of the Laplace's equation in the fluid domain bounded by the wetted body surface, the free fluid surface and a possible horizontal bottom. In this case, the fluid depth has been assumed infinite. The velocity potential satisfies on the free surface the linear, zero-speed boundary condition and on the body surface the condition of no flow through the surface, i.e. the fluid velocity and the velocity of the surface into the direction normal to the surface are equal. Due to linearization, which is based on the assumption of small motions, the boundary conditions are applied on the plane of the mean free surface and at the mean position of the body. In addition, the velocity potential satisfies a radiation condition of outgoing waves. The added mass and damping coefficients are obtained from the velocity potential.

The predictions were made for three frequencies, f = 0.172, 0.208 and 0.263 Hz covering the range of wave encounter frequencies with the major wave components. The oscillation frequency had a small effect on the results. The largest values of the coefficients have been used in the simulations. Figure 3.5 shows that the added mass versus draught follows closely the displaced volume of the visor. The added mass and damping coefficients were given as input in tabular form to the simulation program and curve fitted by a third degree polynomial. At each time step, the added mass and damping coefficients have been determined for the instantaneous draught by using the curve fitted values.

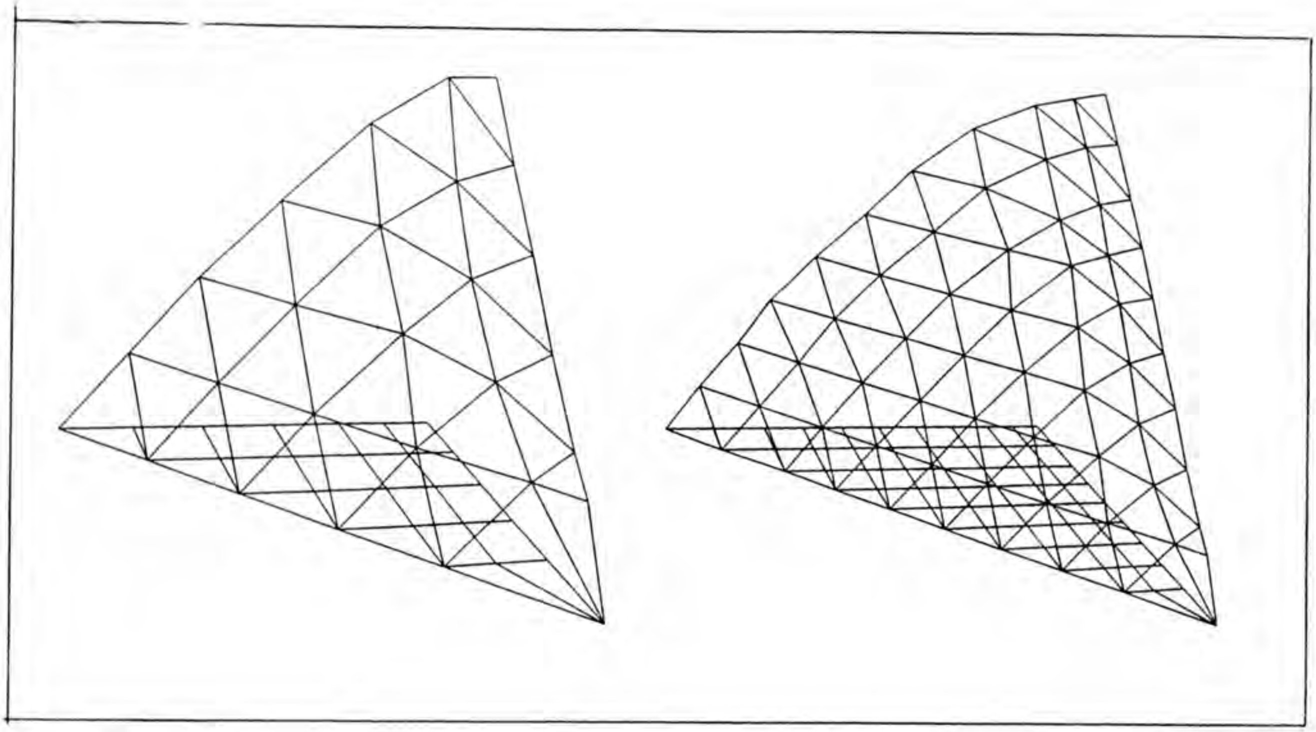


Fig. 3.3 Element mesh of the visor at 11 m and 15.4 m (right) draughts.

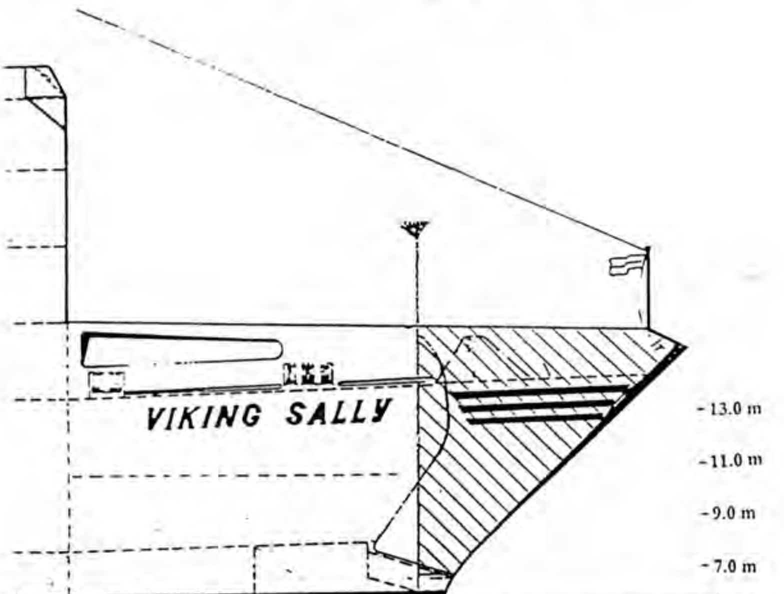


Fig. 3.4 The simplified shape of the visor used in the numerical predictions.

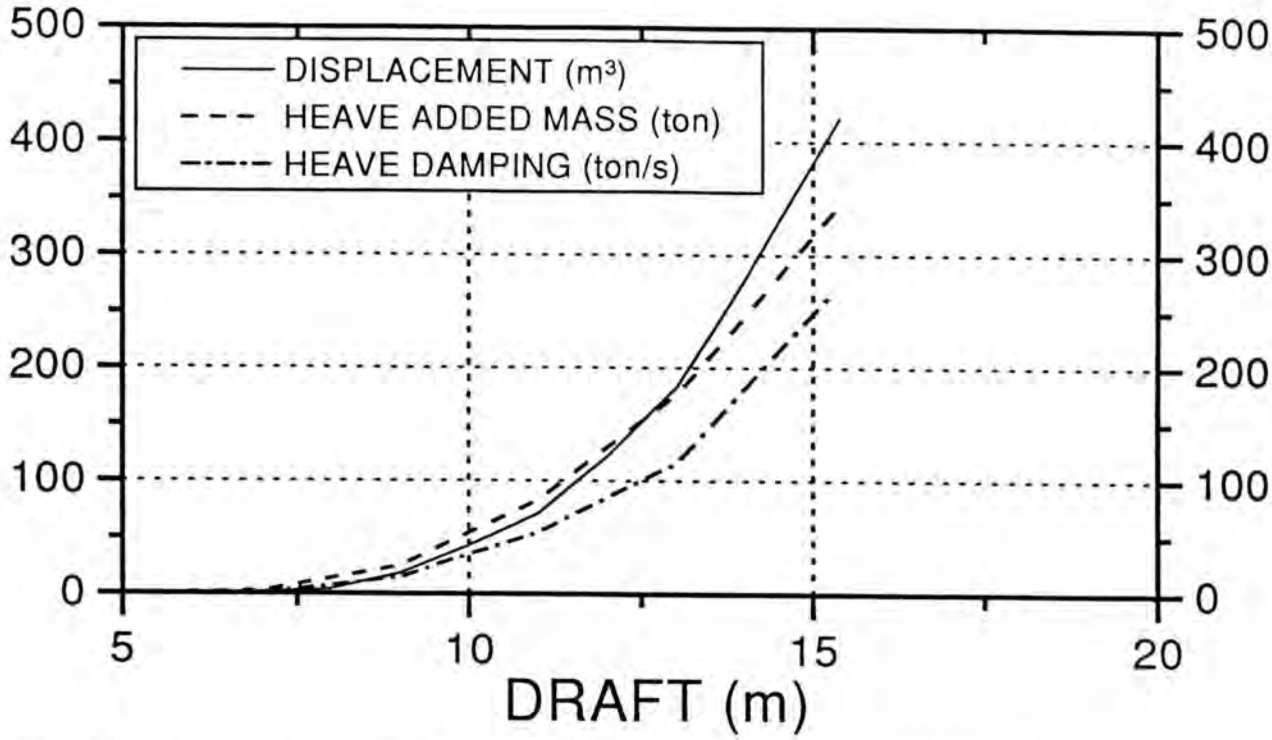


Fig. 3.5 Displacement, heave added mass and damping of the visor versus draught.

3.3.2 Hydrostatic and Froude-Krylov force

The vertical component of the hydrostatic plus the Froude-Krylov force is given by (de Kat & Paulling, 1989):

$$F_s + F_{FK} = \iint_S (p_s + p_d) n_z dS \qquad (10)$$

where

p_s = Hydrostatic pressure = ρgz

p_d = Dynamic pressure in the undisturbed, incident wave

n_z = Vertical component of the unit normal to the body surface

The intergration is carried out over the instantaneous total wetted surface. Thus, in the expression of the hydrostatic pressure, z is the height of the water column up to the wave surface, η(t). In the simulation, the hydrostatic force is expressed as:

$$F_S = \rho g \nabla_V(t) \qquad (11)$$

where

ρ = Water density

∇_V = Instantaneous submerged volume of the visor

The Froude-Krylov force is defined as the force that is obtained by integrating the pressure in the undisturbed, incident wave over the wetted surface of the visor. Thus, it is assumed that the ship does not disturb the incident wave. The wave pressure determined by the linearized Bernoulli's equation in the moving reference frame is given by:

$$p_d = \rho g \sum_{i=1}^{N} a_i \exp(k_i z) \cos(k_i x \cos\mu + k_i y \sin\mu - \omega_{ei} t + \varepsilon_i) \tag{12}$$

In the linearized wave theory, the free fluid surface is defined as the plane z = 0. Using this approximation in (12) yields for the dynamic pressure near the wave surface:

$$p_d = \rho g \eta(t) \tag{13}$$

Assuming further that the pressure variation in the horizontal plane within the dimensions of the bow visor may be neglected, the vertical component of the Froude-Krylov force on the visor may be expressed as:

$$F_{FK} = \rho g A_{wv}(t) \eta(t) \tag{14}$$

where

A_{WV} = Instantaneous waterplane area of the visor

Thus, the undisturbed, dynamic wave pressure has been assumed constant over the surface of the visor. This assumption is consistent with the assumption of small dimensions of the visor compared to the wave length. A similar approach has been used by Hooft (1970), Karppinen (1975) and many others for estimating the wave loads on small structural members of offshore structures. The method is thoroughly discussed by Newman (1977). Consistent with this approach is that in the simulation the vertical relative velocity and acceleration are determined at the centre of the visor, at the station 3.44 m forward of FP on the sea surface.

3.3.3 Non-linear impact force

The non-linear impact force is expressed in the form:

$$F_{imp} = \frac{\partial m_{33}}{\partial z} \dot{\xi}_r^2 + \frac{\partial b_{33}}{\partial z} \xi_r \dot{\xi}_r \tag{15}$$

The impact force consists of two parts the one of which is proportional to the vertical rate of change of the added mass and the other to the rate of change of the damping. The term involving the derivative of the damping coefficient is much smaller than the added mass term which is proportional to the relative vertical velocity squared. At each time step, the values of the coefficients and the relative motion and velocity are updated.

3.3.4 Force due to the stationary flow

The final term in the force equation takes into account the effect of the stationary flow when the bow pitches down to the water. The pressure distribution on the bow in calm water at different fore draughts has been computed by the SHIPFLOW- program at 10, 15 and 20 knots speed of the vessel (Sundell, 1995). An integration of the pressure over the visor area up to the bow wave surface yields the vertical and horizontal component of the force on the visor while an integration of the horizontal pressure component over the total wetted surface of the ship would give the wave resistance. The vertical force component on the visor has been programmed to the simulation method as a simple function giving the force versus the draught at FP (Fig. 3.6).

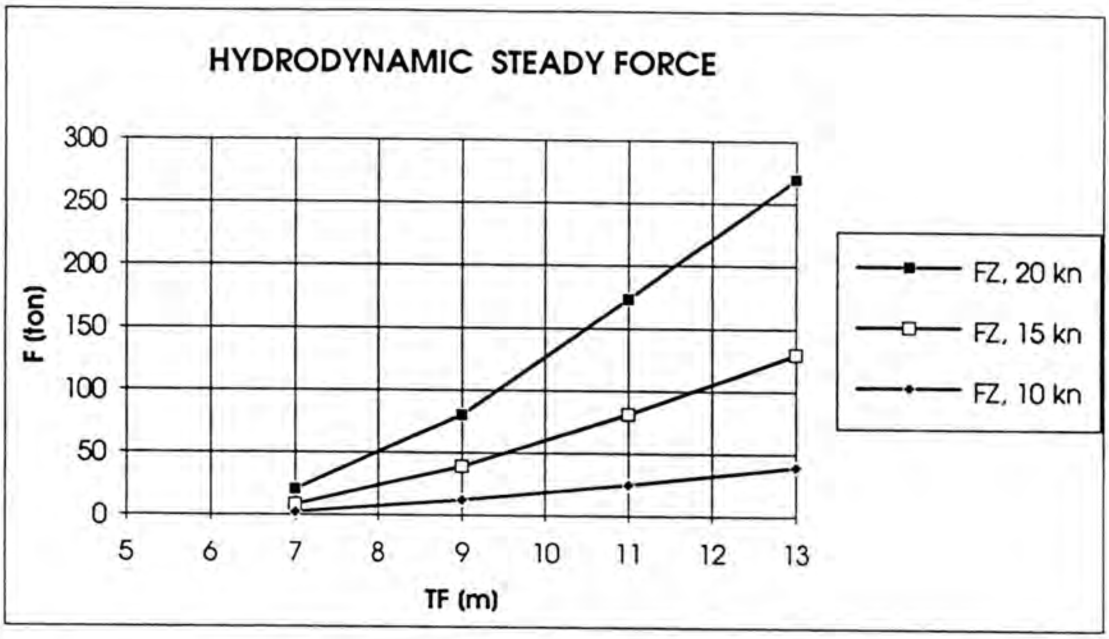


Fig. 3.6 The effect of ship speed and bow submergence on the steady, vertical, hydrodynamic force.

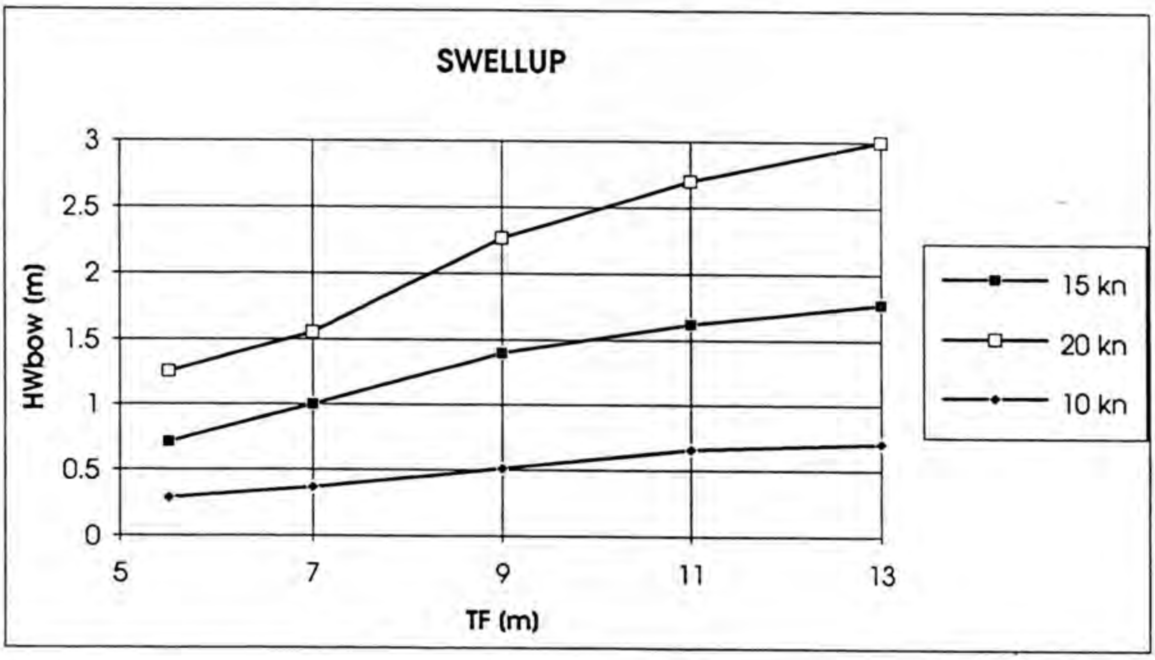


Fig. 3.7 The bow wave height as a function of draught at FP and ship speed.

The SHIPFLOW program is a general program package for predicting the flow around a ship hull and the corresponding forces in still water, in particular the resistance of the ship. The development, basic principles of the solution method and the application of the program are described by Larsson et al (1990) and Larsson (1993). The potential flow part of the program has been used for estimating the forces on the visor. In the potential flow method, the hull surface and part of the free surface are discretized by panels using Rankine sources. The source strengths are determined so that the boundary conditions are satisfied. The program has been run using both the linear and the non-linear version of the free surface boundary condition.

Figure 3.6 shows that the vertical force due to the stationary flow increases quickly with inceasing speed and forward draught. At a large bow submergence, the force is about 100 tons at 15 kn speed and over 200 tons at 20 kn speed. The large force at 20 kn speed is due to the bow wave height rising to over 3 m high. The numerical method does not model wave breaking which would probably take place before the wave grows so high. At 15 kn speed, the bow wave height is 1 to 1.5 m. The predictions are for a steady situation while in waves the bow is pitching up and down at the quite short wave encounter period. It is questionable whether the bow wave rises to the same height during this pitch period as in calm water in a steady flow. However, the predictions by the SHIPLOW-program have not been tried to correct for these effects. On the other hand, the effect of the horizontal water particle velocity in the incoming wave has been disregarded and only the stationary flow due to the vessel forward speed has been considered in the predictions. The neglected effect of the horizontal water particle velocity, in particular if waves are breaking, probably more than compensates for the effect of a too high bow wave.

The bow wave has also the important effect of decreasing the freeboard, or helping lower waves to reach the visor. Since the displacement and the waterplane area of the visor increase dramatically higher up (Fig. 3.5), the bow wave height may have a significant effect on the wave loads of the visor. In the simulations, the bow wave has been considered as a constant offset increasing the submergence of the visor. Thus, the height of the bow wave has been added to the relative motion. In reality, there must be interaction between the bow wave, incoming wave and the waves generated by ship motion so that the simple superposition does not strictly hold. A proper numerical method would give the behaviour of the bow wave as part of the solution.

4 RESULTS

Main results of the simulations are curves presenting probabilites at which the vertical component of the wave force on the visor exceeds different levels. Table 4.1 gives a summary of the figures showing curves of exceedance probabilities. The exceedance probabilities are plotted on a logarithmic scale while the vertical force is on a linear scale. In this form, straight lines seem to fit the data quite well for high load values. There is no theoretical basis for the linear relationship between the logarithm of the exceedance probability and the vertical visor load. In many cases, for instance the long-term distributions of wave heights and hull wave bending moments, the Weibull-distribution gives a good fit to the data.

The wave load on the bow visor is highly non-linear with regard to the wave amplitude and the statistical distribution of the loads is not known. Since the distibution is unknown, long simulations have been made to get relatively accurate estimates for the extreme load values. The simulated sequences have been 36 hours long in which time the vessel encountered about 30 000 waves depending on the speed, heading to waves and wave period. The simulations were carried out in each case in six six hours long runs. The vessel encountered thus in one hour about 1 000 waves. If the probability of exceeding a certain vertical force level is 0.001, for instance, then in the mean one in 1 000 waves encountered causes a vertical wave load on the visor exceeding the level in question. The highest load value in the 36 hours long simulation has an exceedance probability of about 1/30 000. Table 4.2 shows a summary of the wave encounters in 24 hours when $T_O = 8.0$ s.

Table 4.1 Summary of figures showing exceedance probabilities of visor loads.

Heading [deg.]	Bow wave height [m]	Speed [kn]	H_S [m]	T_O [s]	Figure number
Head seas, 180	1.0	15	4.0	8.0	5.4
Head seas	1.0	15	4.0	8.5	5.5
Head seas	0.65	12	4.0	8.0	5.4
Head seas	0.4	10	4.0	8.0	5.4
Head seas	0.4	10	5.5	8.0	5.6
Head seas	0.65	12	5.5	8.0	5.6
Head seas	1.0	15	5.5	8.0	5.6
Head seas	1.5	15	5.5	8.0	5.7
Bow seas, 150	1.0	15	4.0	8.0	5.8
Bow seas	1.0	15	4.5	8.0	5.8
Bow seas	1.5	15	4.0	8.0	5.8

Table 4.2 Number of wave encounters in 24 hours when $T_O = 8.0$ s.

	Speed [kn]		
Heading	10	12	15
180 deg.	18 600	20 000	23 200
150 deg.			20 700

The distribution of peak load values, the maximum peak per one wave encounter period, has been determined for every six hours long simulation. Also the distribution of all the load data, one value taken at each time step, has been determined. Time histories of the four highest positive and negative load peaks and waves have been plotted. The highest positive load peak in every six hours long simulation has been analysed more closely to show the magnitudes of the different load components. The wave and the vertical relative motion at the bow visor which caused the maximum load have also been plotted.

Wave surface elevation, vertical relative motion and the vertical wave load components on the visor plotted at the same time for a short time sequence are given in the same figure. Table 4.3 presents a summary of the figures showing selected time histories of wave elevation, relative motion and wave load components.

Table 4.3 Summary of figures showing sequencies of wave, relative motion and load components.

Heading [deg.]	Bow wave height [m]	Speed [kn]	H_S [m]	T_O [s]	Cases	Figures
Head seas, 180	1.0	15	4.0	8.0	1, 3, 5	A1.1 - A1.3
Head seas	1.0	15	4.0	8.5		
Head seas	0.65	12	4.0	8.0		
Head seas	0.4	10	4.0	8.0		
Head seas	0.4	10	5.5	8.0		
Head seas	0.65	12	5.5	8.0	2, 4, 5	A1.4 - A1.6
Head seas	1.0	15	5.5	8.0	2, 4, 5	A1.7 - A1.9
Head seas	1.5	15	5.5	8.0		
Bow seas, 150	1.0	15	4.0	8.0	2, 3, 6	A1.10 - A1.12
Bow seas	1.0	15	4.5	8.0	2, 3, 6	A1.13 - A1.15
Bow seas	1.5	15	4.0	8.0		

All the figures in Appendix 1 show incidents of high vertical loads on the visor. The case number in the figures refers to a specific six hours long simulation. The upper plot in the figures presents the simulated wave elevation and the vertical relative motion as a function of time. On the vertical axis, the zero level corresponds to the mean freee surface, i.e. to the still water level. The relative motion computed by formula (5) is the submergence (positive) or emergence (negative) of the bow measured from the mean waterplane. The relative motion given in the figures does not include the bow wave height which has been added to the motion before predicting the wave load on the visor.

The lower plot in the figures shows the most important components of the vertical wave load on the visor. The inertia force is the added mass of the visor times the vertical relative acceleration, i.e. the first part of the force given by formula (9). The buoyancy force includes both the hydrostatic and the Froude-Krylov force predicted by formulas (11) and (14), respectively. The slamming force has been computed by (15), and finally the total force by (7).

Figures showing selected peak and level distributions of waves and visor loads are given in Appendix 2. The distributions are from specific six hours long simulations. The following table summarises the visor load distributions.

Table 4.4 Summary of figures showing peak and level distributions of loads.

Heading [deg.]	Bow wave height [m]	Speed [kn]	H_S [m]	T_O [s]	Cases	Figures
Head seas, 180	1.0	15	4.0	8.0	1, 3, 5	A2.4 - A2.6
Head seas	0.65	12	5.5	8.0	2, 4, 5	A2.7 - A2.9
Head seas	1.0	15	5.5	8.0	2, 4, 5	A2.10 - A2.12
Bow seas, 150	1.0	15	4.0	8.0	2, 3, 6	A2.13 - A2.15
Bow seas	1.0	15	4.5	8.0	2, 3, 6	A2.16 - A2.18

5 DISCUSSION

Figures 5.1 and 5.2 show short sequencies of simulated irregular waves and wave loads on the bow visor, respectively. The wave time history includes a wave crest of about 5 m high but otherwise the record seems to be approximately symmetric about the still water level, i.e. the heights of crests and troughs follow the same distribution. The wave load record is highly asymmetric showing only high positive peaks due to the bow submergence. Low waves don't even reach the visor and the vertical force on the visor remains close to its weight of 600 kN. Both the wave and the load record have time scales as the vessel encounters head waves at 15 knots speed.

Time histories of high vertical loads on the visor are given in Appendix 1. The figures show also the wave and the relative motion which caused the high load. The vertical load increases quickly, in about 0.1 s, to a high value which is almost entirely due to the impact force term, or the term proportional to the relative velocity squared. Then also the hydrostatic plus the Froude-Krylov force becomes important and at the maximum load value this "buoyancy" force is approximately equally large as the impact force. The added mass inertia force acts to the opposite direction and decreases the total force. The inertia force has its minimum and the Froude-Krylov force its maximum when the relative motion has the maximum, i.e. the bow is deeply submerged. This occurs approximately when the wave crest passes the visor. The impact force oscillates on a high level about half a second and drops then down. The oscillations seem to be due to the numerical derivation of the visor added mass and have thus no physical origin. The impact force is nearly zero at the maximum of relative motion. In all cases of high loads, the time histories of the load components follow approximately the same pattern.

At the same speed and heading, the same individual waves excite the high loads regardless of significant wave height since the wave time histories have been generated by linearly scaling six basic six hours long time histories in the case of $T_0 = 8.0$ s. This becomes evident by comparing the wave elevations in Figures A1.3 and A1.9 and Figures A1.10 - A1.12 to Figures A1.13 - A1.15. The wave time histories with a modal period of 8.5 s have a different shape than with $T_0 = 8$ s. When the vessel speed or heading is changed, different individual waves of the same wave time history cause the highest loads on the visor.

Often high loads seem to be excited by waves which have a flat trough and a steep front. The crest following the trough may be twice as high as the through is deep. Deep wave troughs, even followed by a relatively high crest, seem to never excite high loads on the visor. Waves associated with the largest loads are not necessarily the highest. Of the four highest load peaks in one six hours long simulation, usually one ore two load peaks are associated with the four highest wave crests in the wave time history. It seems thus that waves with only a small differences in the shape may excite significantly different loads on the visor. This is illustrated by Figure 5.3 where the wave in the upper plot excited on the visor a vertical force of 9 800 kN and the lower a force of only under 5 200 kN in head seas with $H_s = 5.5$ m at a speed of 15 kn. It would be interesting to analyse more closely characteristics of a short sequence of waves preceeding a high load on the visor and try to relate the wave characteristics to the load. Kagemoto et al. (1995) show that a group of high successive waves may induce a significantly larger motion displacement for a floating body than just one high wave.

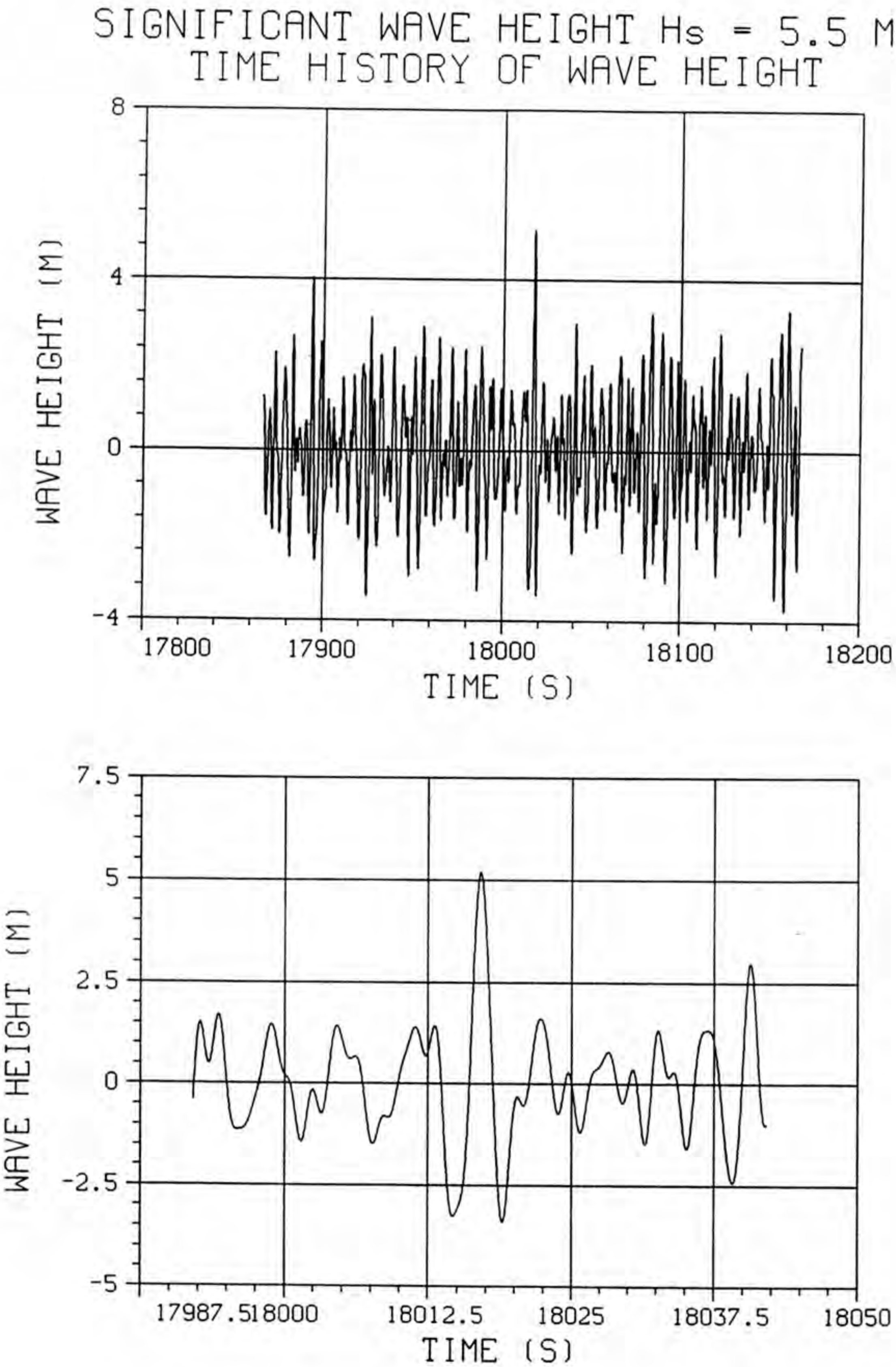


Fig. 5.1 Two short sequencies of simulated irregular waves.

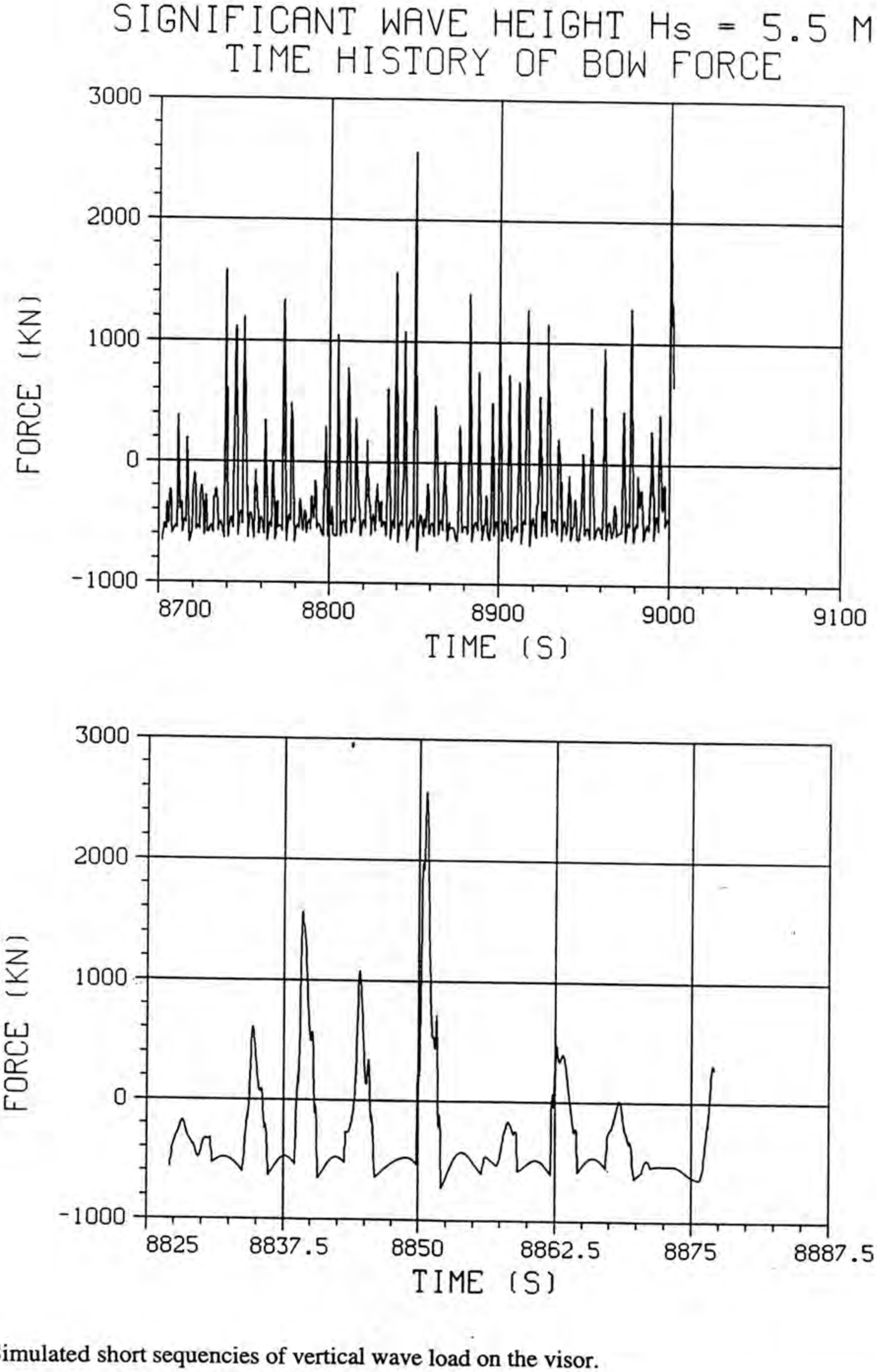
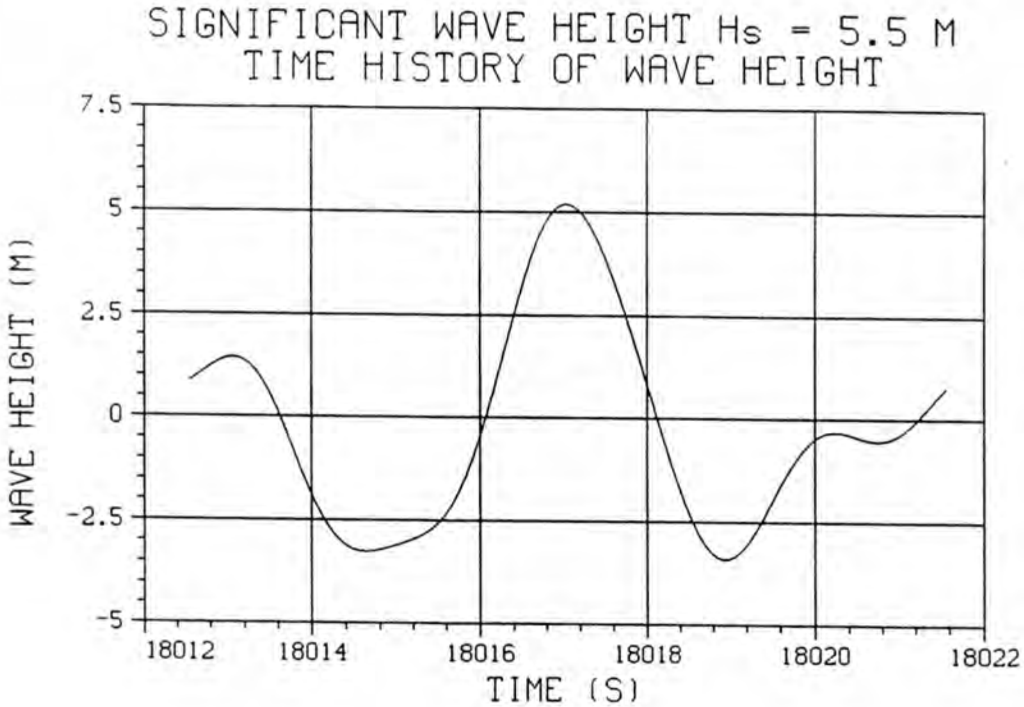


Fig. 5.2 Simulated short sequencies of vertical wave load on the visor.



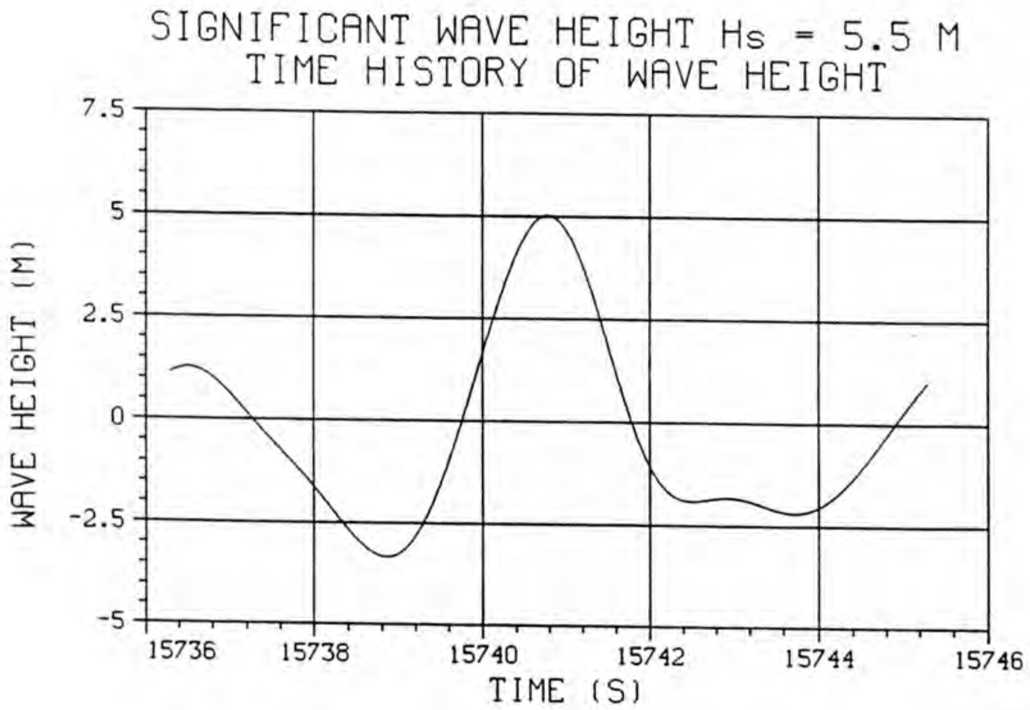


Fig. 5.3 Two high individual waves which excited significantly different loads on the visor in head seas at 15 kn speed. The wave in the upper plot excited a vertical force of 9 800 kN while the lower wave excited a force below 5 200 kN.

The amplitude of vertical relative motion at the time of the highest loads on the visor is about 6 m when the significant wave height is 4 m. A decrease in speed slightly increases the relative motion at the visor. A change of heading from head to bow seas has a similar effect on the relative motion. In the 5.5 m high waves, the relative motion amplitude associated with maximum loads is about 8 m. This means that the bow will be submerged approximately to the level of the foredeck including the bow wave height of about 1 m at 15 knots speed. The height to the foredeck from the baseline is 14.3 m. The bow submergence in the lower seastate at the time of high visor loads is about 12 m. On the basis of Figure 3.5, this is just below the draft where the volume of the visor starts to increase quickly. At a draft of 12.5 m, the visor volume is about 150 m^3 while the volume of the visor up to a draft of 15 m is about 400 m^3. Due to the strong increase of the visor area and volume upwards it may be assumed that the resultant of the wave load on the visor acts close to the water surface. Also the water particle velocities are highest on the wave surface.

In a six hours long simulation, the distribution of the load peaks has typically a long tail, i.e. a few highest peaks are significantly higher than all the other (Figures in Appendix 2). It is common that over 99 % of the peaks are smaller than half of the maximum. The distributions of wave maxima and minima (crests and troughs, respectively) in Figures A2.1 - A2.3 have a distictly different look than the load peak distribution.

Figure 5.8 shows the probability of exceedance curves for three different 36 hours simulations in bow seas at a heading of 150 degrees. The forward speed has been 15 knots and the modal period 8 s in all cases. The simulations are for the significant wave heights of 4 and 4.5 m. The effect of bow wave height has been investigated by assuming bow waves of 1 and 1.5 m heigh in the 4 m high waves. In fact, 0.33 m must be added to these nominal bow wave heights due to the actual stern trim of the vessel which has not been taken into account in predicting the bow submergence.

The significant wave height has a very strong effect on the vertical component of the visor load. The half a meter, or the 12.5 % increase in the wave height increases the wave load by over 40 %. By increasing the significant wave height from 4.0 to 5.5 m in head seas at 10 kn speed, increases the vertical loads threefoald (Figs. 5.4 and 5.6). This indicates that the loads are approximately proportional to the third power of the significant wave height. The effect of wave height is a little smaller at the higher forward speeds than at 10 knots speed. On the other hand, it seems that the highest loads roughly follow the submerged volume of the visor which is about 150 m^3 and 350 m^3 at the incidents of maximum loads when the significant wave heights are 4 and 5.5 m, respectively. In the numerical predictions, the shape of the real visor has been approximated by body which has less volume and area low down than the original one. This may have some effect on the results.

The behaviour of the bow wave in sea conditions when the vessel is heaving and pitching is not well known. The approximation of the bow wave effect at 15 knots speed by a 1.33 m high wave which is superposed on the incoming wave is a crude approximation. However, the effect of the bow wave height on the predicted forces is much less than the effect of the significant wave height. Assuming a bow wave height of 1.83 m instead of 1.33 m increases the vertical load on the visor by about 20 % when the significant wave height is 4 m or 5.5 m (Figs. 5.8 and 5.7, respectively).

Due to the larger wave-induced motions in bow seas than in direct head seas the loads on the visor are higher at 150^o heading than in head waves (Figs. 5.4 and 5.8). The difference is about 20 % at the level of an 1 to 10 000 exceedance probability in 4 m high seas. An increase of the modal wave period from 8 to 8.5 s slightly increases the loads in head seas at 15 knots speed (Figs. 5.4 and 5.5).

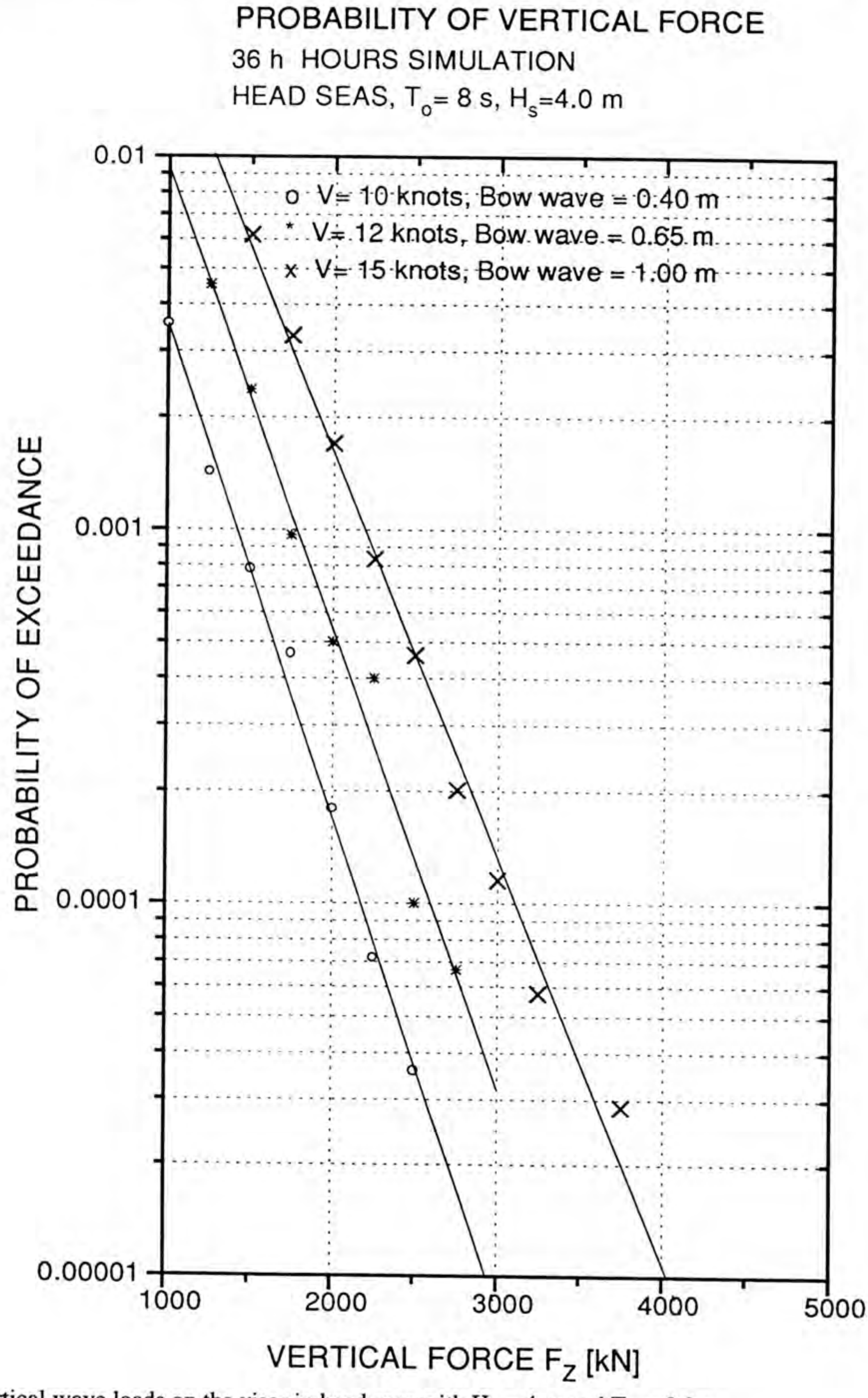


Fig. 5.4 Vertical wave loads on the visor in head seas with $H_S = 4$ m and $T_O = 8.0$ s.

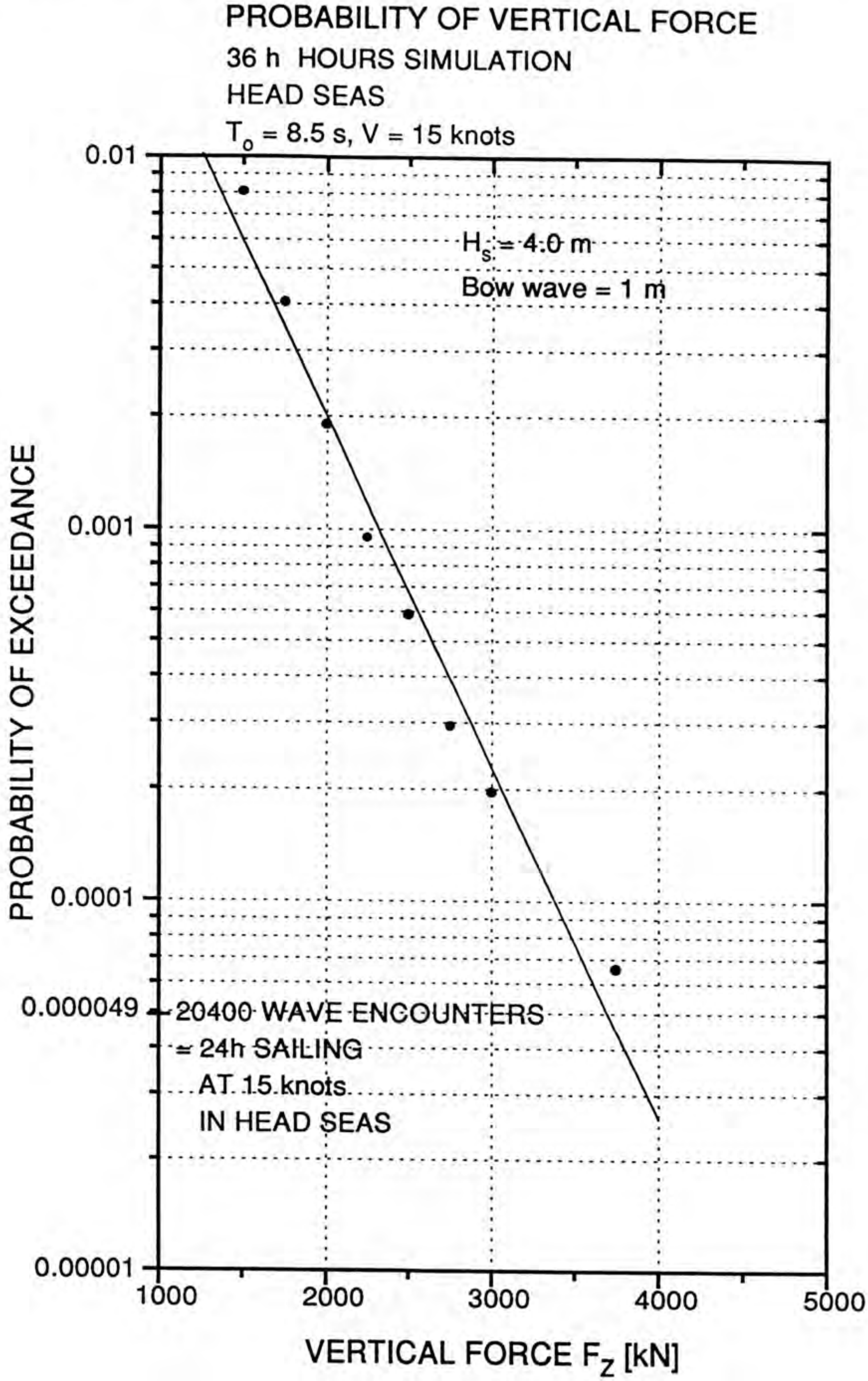


Fig. 5.5 Vertical wave loads on the visor in head seas with $H_S = 4$ m and $T_O = 8.5$ s.

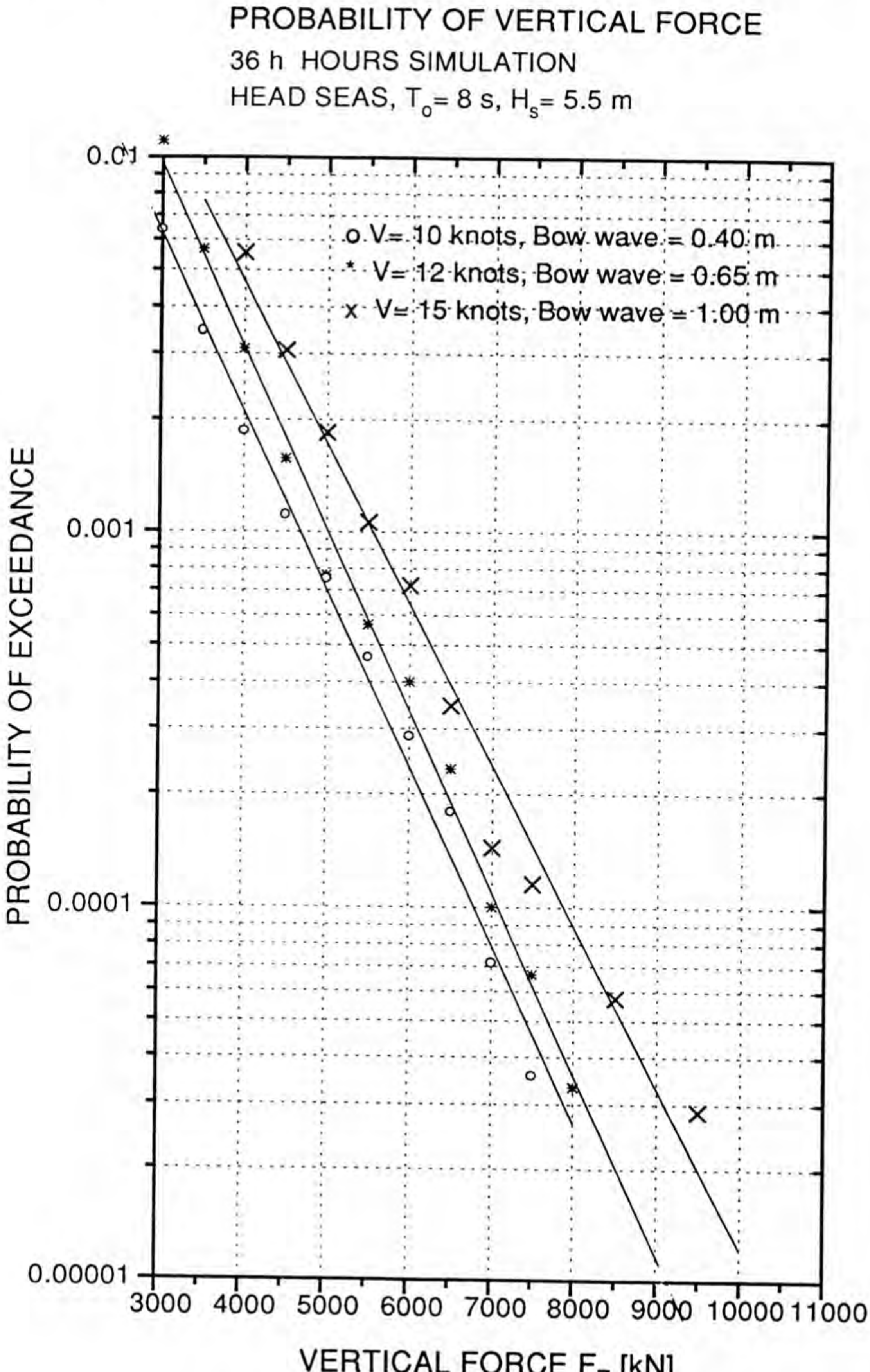


Fig. 5.6 Vertical wave loads on the visor in head seas with $H_S = 5.5$ m and $T_O = 8.0$ s.

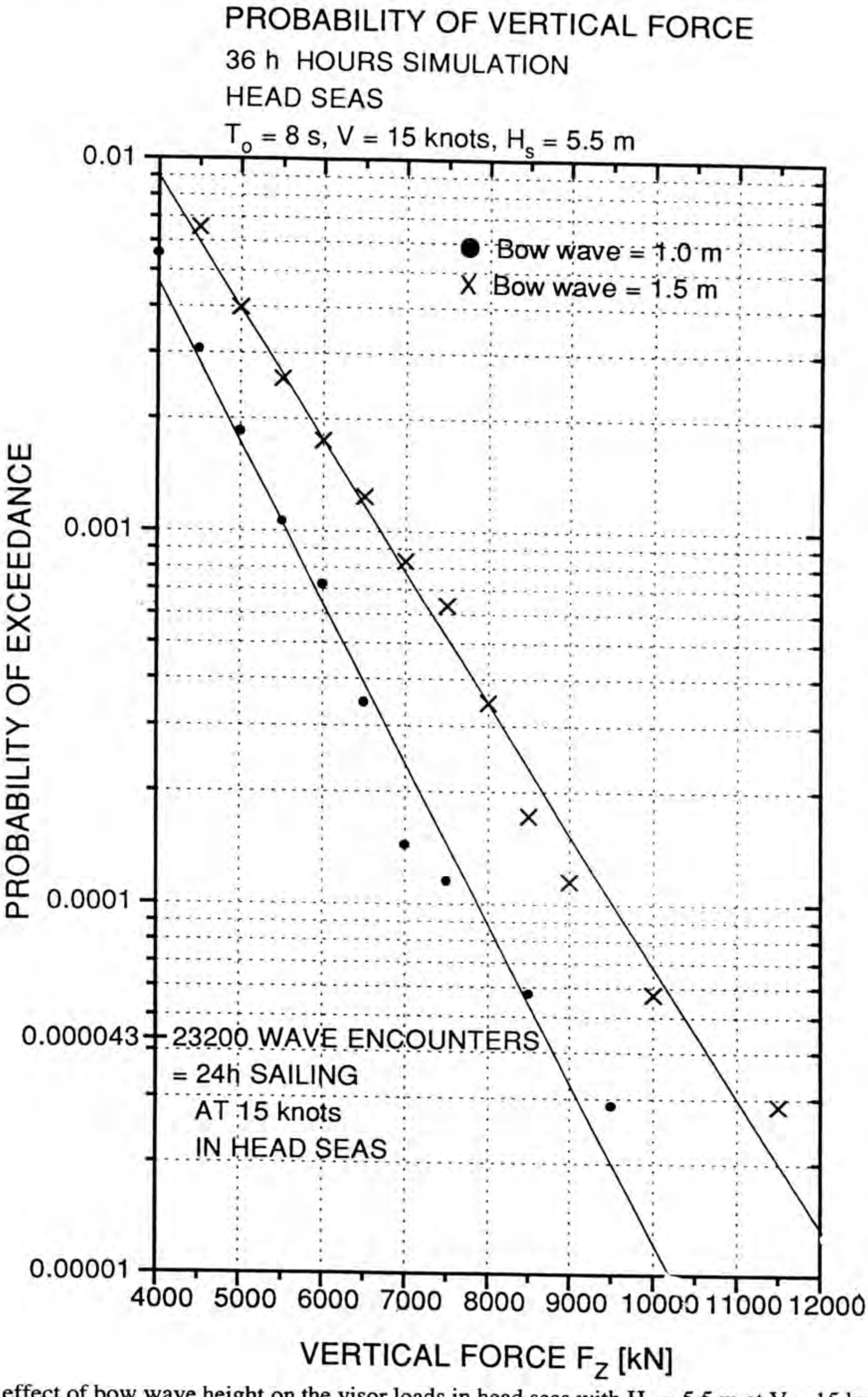


Fig. 5.7 The effect of bow wave height on the visor loads in head seas with $H_S = 5.5$ m at $V = 15$ kn.

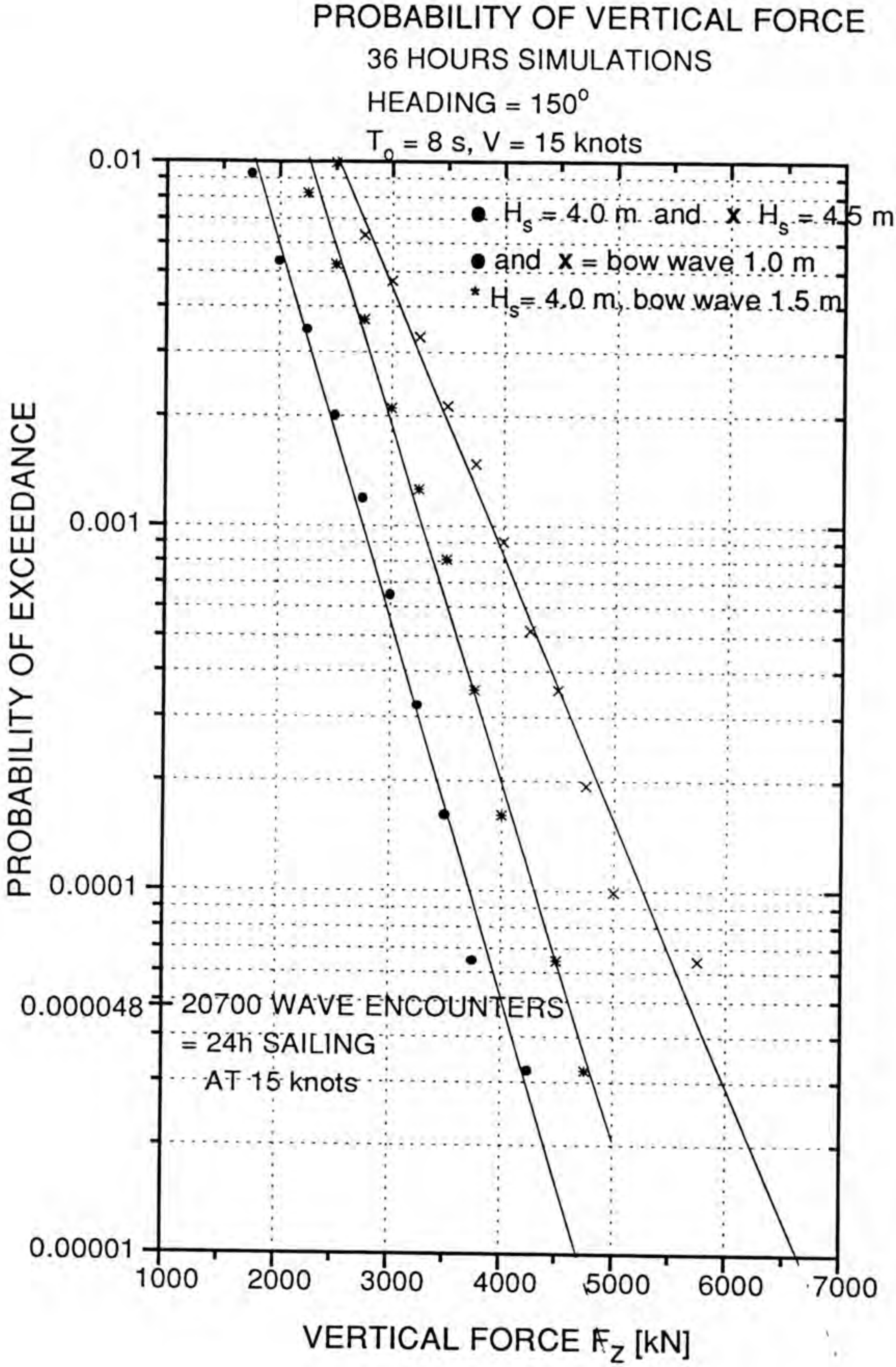


Fig. 5.8 Vertical wave loads on the visor in bow oblique seas with H_S = 4 m and 4.5 m.

The following table gives a summary of the vertical visor loads from different simulations.

Table 5.1 Vertical loads on the bow visor.

Heading [deg.]	Bow wave height [m]	Speed [kn]	H_s [m]	T_0 [s]	Vertical visor load Exc. prob. 10^{-3}	Vertical visor load Exc. prob. 10^{-4}
Head seas, 180	1.0	15	4.0	8.0	2 200 kN	3 100 kN
Head seas	1.0	15	4.0	8.5	2 300 kN	3 400 kN
Head seas	0.65	12	4.0	8.0	1 750 kN	2 600 kN
Head seas	0.4	10	4.0	8.0	1 400 kN	2 150 kN
Head seas	0.4	10	5.5	8.0	4 700 kN	6 750 kN
Head seas	0.65	12	5.5	8.0	5 000 kN	7 100 kN
Head seas	1.0	15	5.5	8.0	5 500 kN	7 900 kN
Head seas	1.5	15	5.5	8.0	6 700 kN	9 500 kN
Bow seas, 150	1.0	15	4.0	8.0	2 750 kN	3 700 kN
Bow seas	1.0	15	4.5	8.0	3 900 kN	5 300 kN
Bow seas	1.5	15	4.0	8.0	3 400 kN	4 300 kN

Figure 5.9 summarizes the effects of forward speed and significant wave height on the visor load in head seas at the exceedance probability levels of 10^{-3} and 10^{-4}. The results in the figure show that in the lower seastate the loads increase approximately linearly with the forward speed of the vessel. At 15 knots speed, the vertical load is about 50 % larger than at 10 kn speed when the significant wave height is 4.0 m. In the higher seastate, the visor load increases by about 20 % when the speed increases from 10 to 15 knots. In this case the assumption of a 1.33 m high bow wave at 15 knots speed may be too low since the bow submerges deep down, much deeper than in the lower seastate. If a bow wave height of 1.83 m is assumed at 15 knots speed when H_s = 5.5 m, the wave load raises by 40 % as the speed goes up from 10 to 15 knots. The behaviour of the bow wave and its effect on the loads should be included in the numerical solution.

5.1 Comparison with the systematic model tests by SSPA

After the MV Estonia accident, SSPA has conducted an extensive, systematic series of model experiments where the wave loads on five different bow visors have been measured. The ship models represent passenger ferries which have almost equal main dimensions as MV Estonia. The main difference between MV Estonia and the SSPA ship models is that MV Estonia had V-type sections at the visor while the models of SSPA have U-type sections. In addition, the bow visor starts closer to the waterline in the SSPA models than in MV Estonia. In spite of these and some other minor differences in the hull form, it is interesting to compare the numerical predictions for MV Estonia to the experimental results of SSPA. Qualitatively the simulated and the measured records of visor loads in irregular head seas in Fig. 5.10 resemble quite a lot each other.

Figure 5.11 compares the vertical wave load on the bow visor of MV Estonia with experimental results of SSPA for the Model No. 1 in regular head waves. The wave length has been 1.2L. The predictions are for 10 and 15 knots speeds while the model tests have been carried out at speeds corresponding to 7, 10, 14 and 19 knots in full scale. The results for MV Estonia follow quite well the same trend with increasing wave height as the experimental results, but the numerical results are larger than the experimental at the same speed. At 10 knots speed, the predicted loads on the bow visor of MV Estonia are close to the test results at 14 knots speed. A partial explanation may be that high up MV Estonia had a wider bow flare than Model No. 1 and in regular waves, close to heave and pitch resonance, the simulated motions were violent.

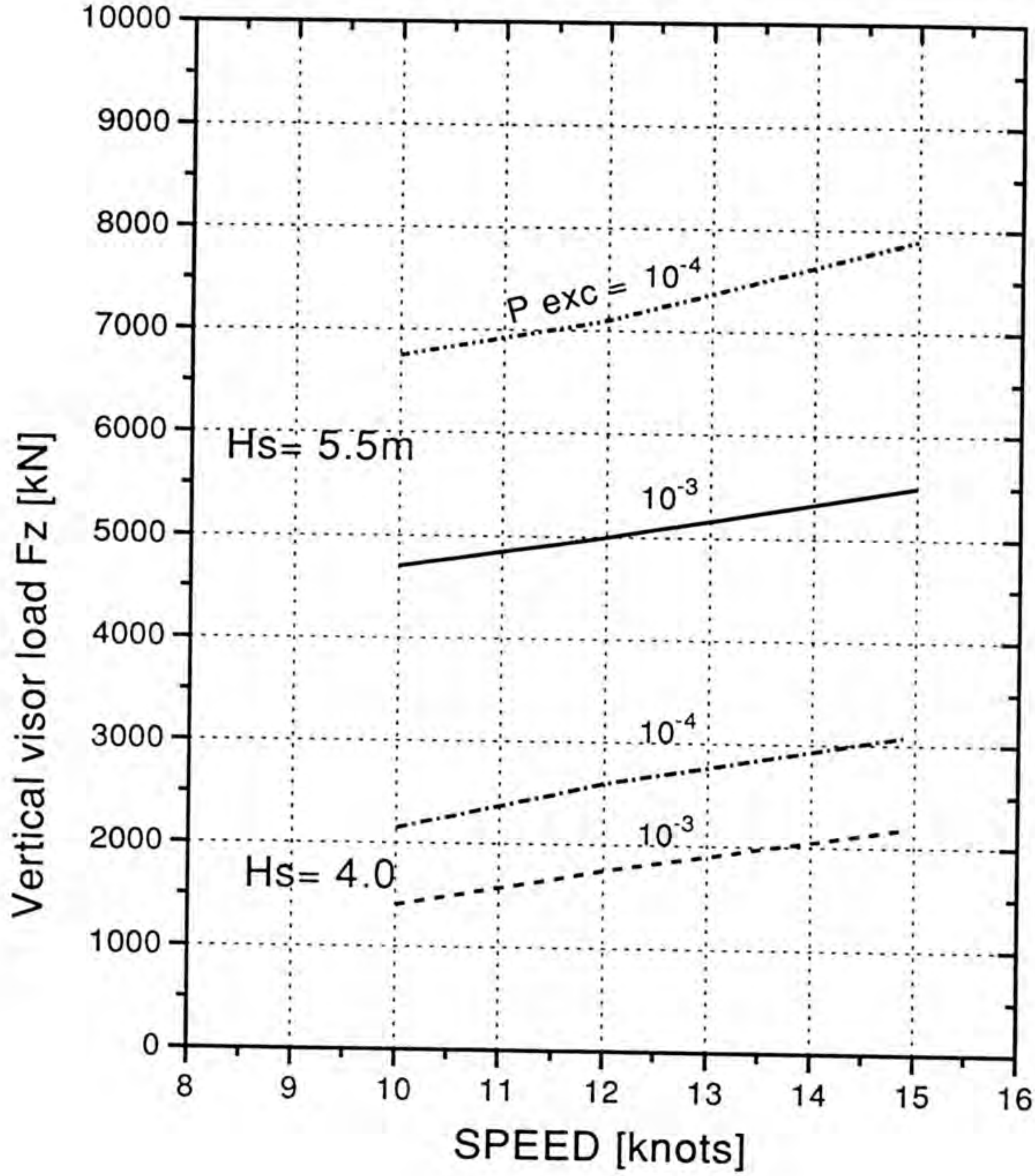
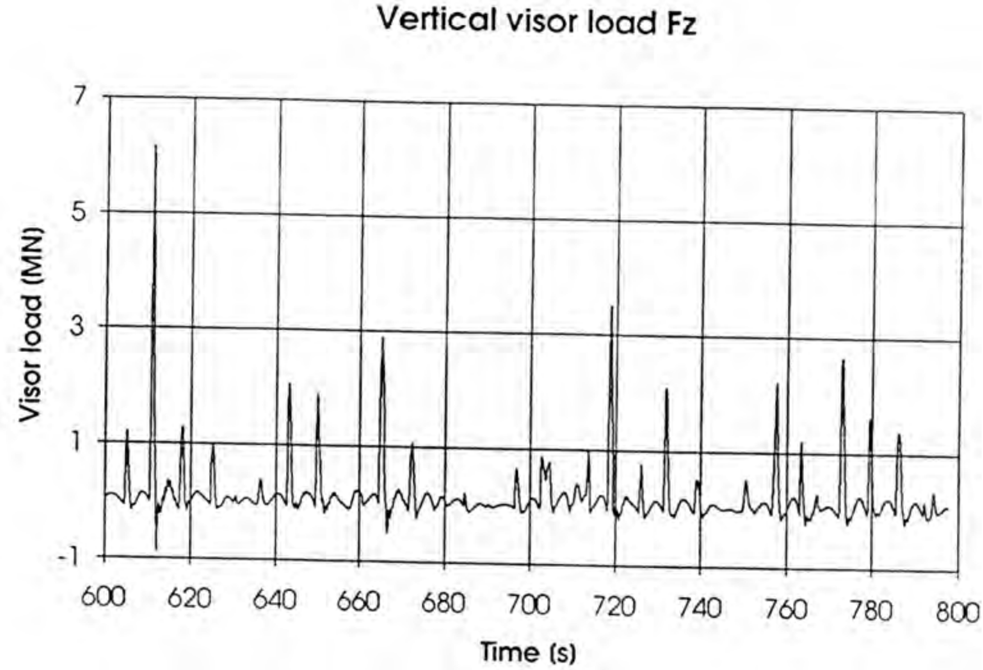


Fig. 5.9 The effect of wave height and speed on the loads of MV Estonia's visor in head seas.

SSPA MODEL EXPERIMENTS



VTT SIMULATIONS

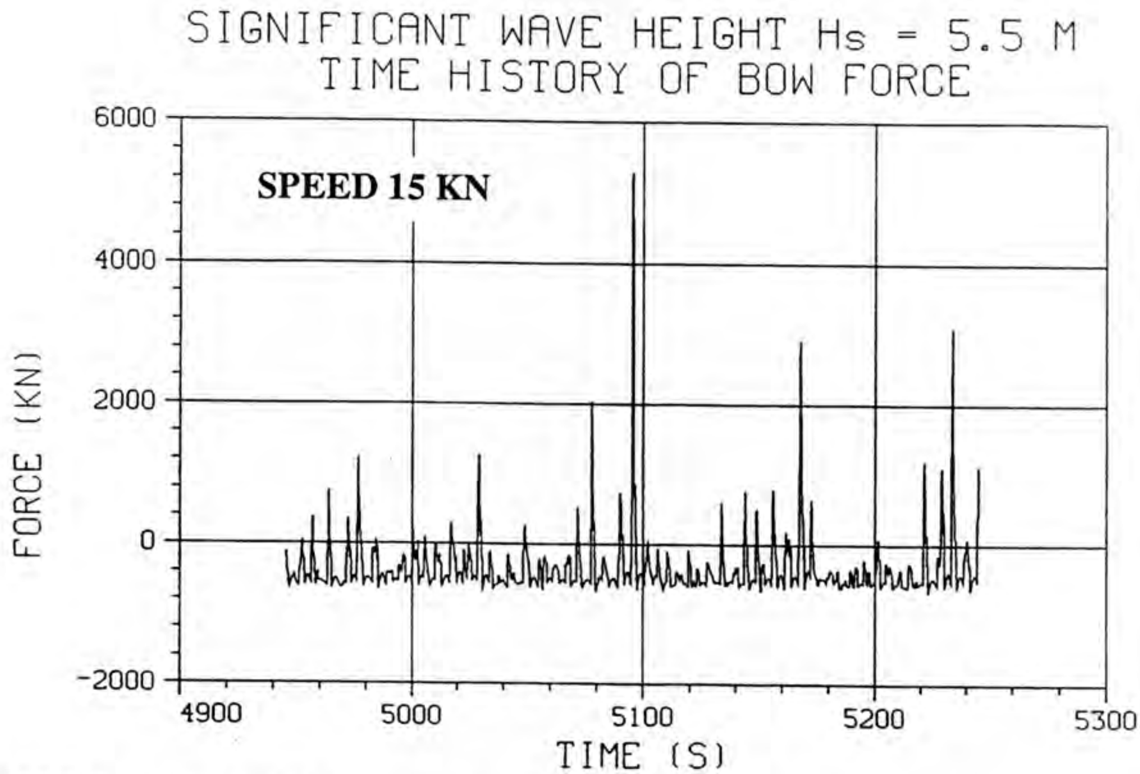


Fig. 5.10 Experimental (SSPA) and simulated records of visor loads in head seas, Hs = 5.5.

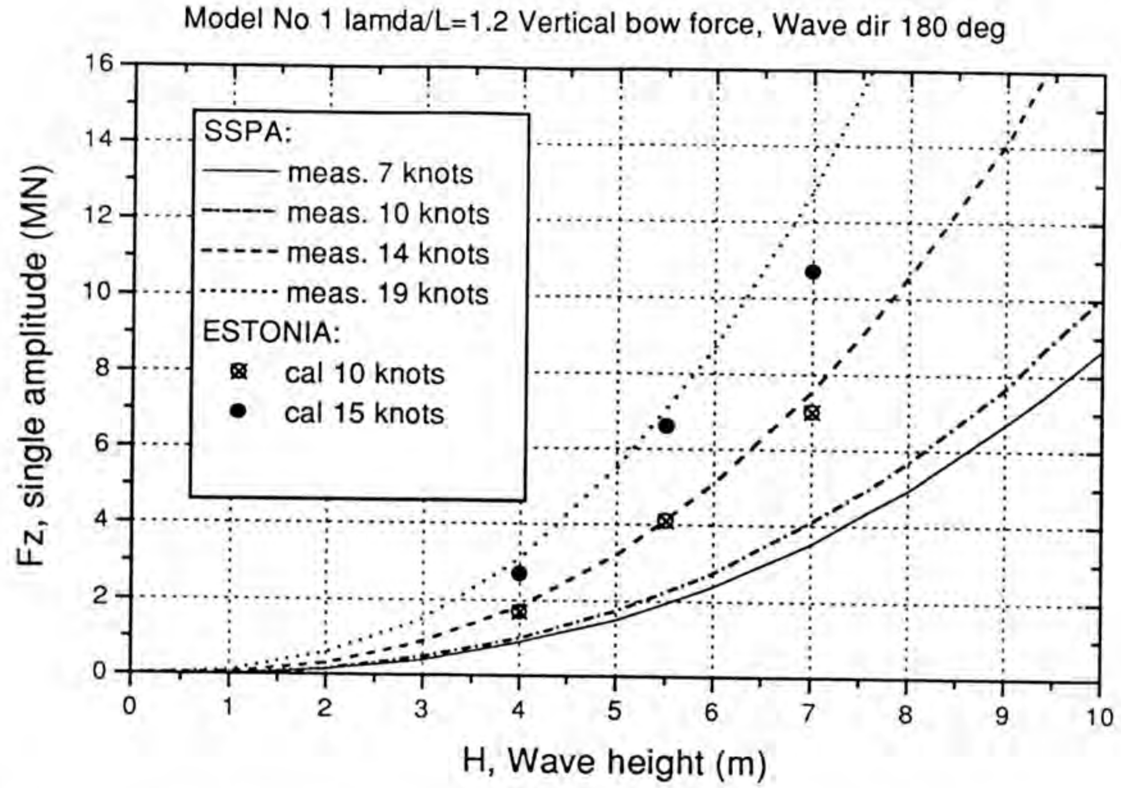


Fig. 5.11 Simulated and experimental (SSPA) vertical visor loads in regular head waves.

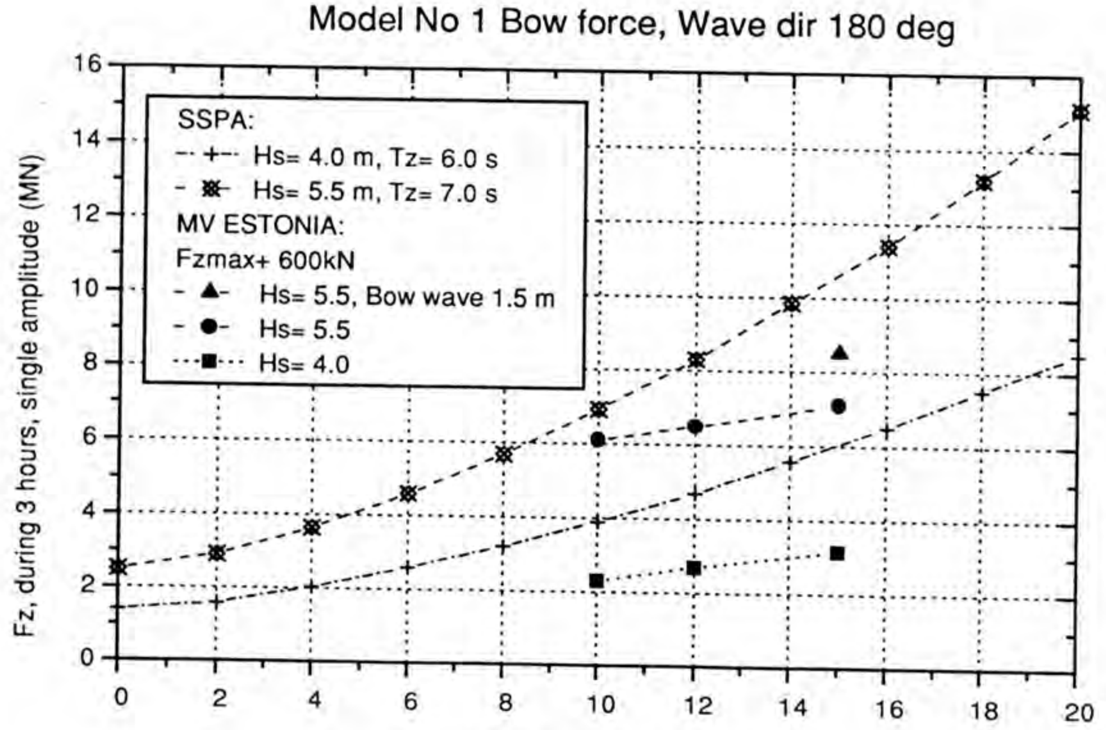


Fig. 5.12 Simulated and experimental (SSPA) vertical visor loads in irregular head seas.

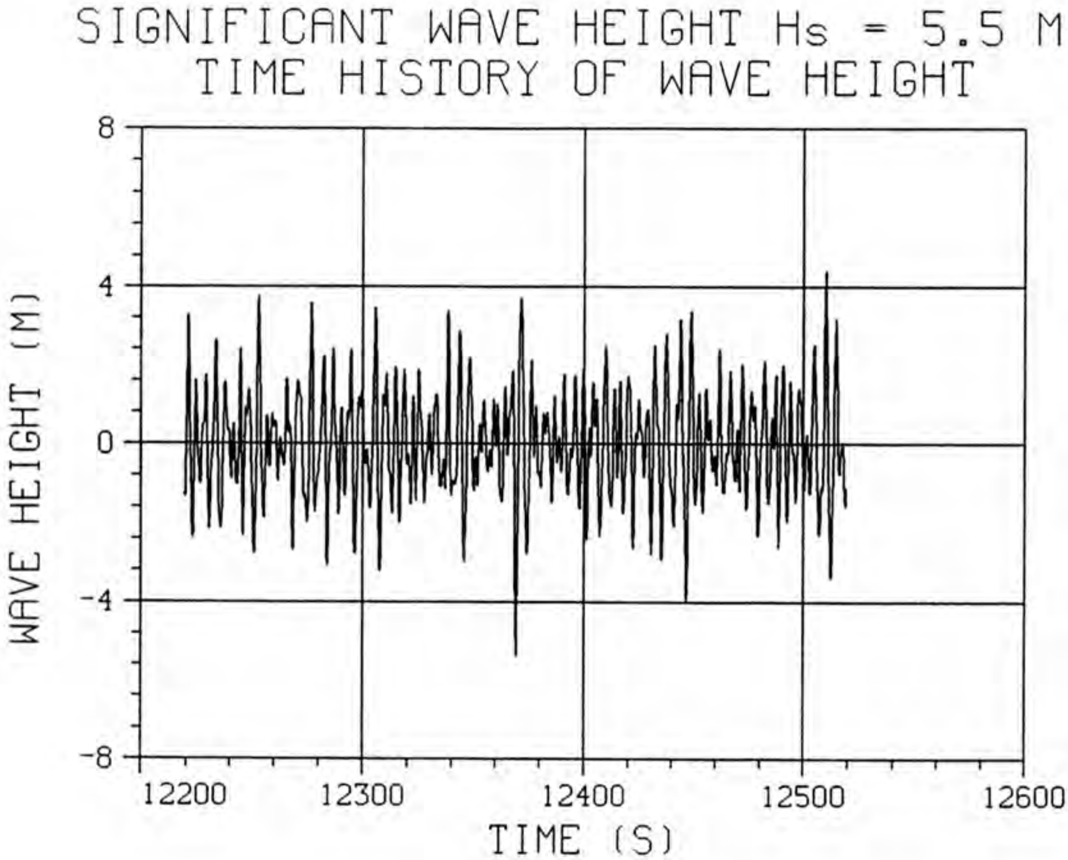
In irregular head seas the simulated wave-induced motions of MV Estonia were not so violent as in high regular waves. This may have contributed to the surprising result that in irregular seas the numerical results are significantly below the model tests of SSPA. Figure 5.12 compares the results of MV Estonia to the maximum vertical visor force of Model No. 1 during 3 hours. The model test results have been extrapolated from an about one hour (full scale) long measurement to a time span of 3 hours. The results for MV Estonia correspond to the exceedance probability of 1/2 500 in Figures 5.4 and 5.6. MV Estonia encountered from 2 300 to 2 900 waves in head seas in three hours depending on the forward speed according to Table 4.2. The weight of the visor, 60 tons, has been added to the simulated results since the static situation was considered as zero level in the model tests (see Fig. 5.10).

If only the largest values measured during one hour of testing time are compared to the largest simulated values, regardless of statistics, the correlation is much better than in Fig. 5.12. This together with the comparison in regular waves (Fig. 5.11) and the strong dependence of the visor loads on the wave height suggest that the irregular wave trains in the simulations and in the model experiments may have different statistics although they have the same significant wave height. A comparison of short wave time histories representing seas with $H_S = 5.5$ m in the simulations and in the model experiments (Fig. 5.13) indicates that the crest heights of the experimental waves may be larger than the heights to wave troughs measured from the still water, zero level. In the experiments, minus sign indicates wave surface level above the still water surface while the opposite sign convention has been used in the simulations.

One wave record from the experiments containing about 150 waves was analysed more in detail. The peak distribution of wave single amplitudes and the level distribution are presented in Fig. 5.14. Both distributions show that the wave record includes more high crests than deep troughs. Figure 5.15 confirms that the probability of wave crest amplitude exceeding certain high level is significantly higher than the trough amplitude exceeding the same level. The exceedance probability curve of crest amplitudes differs considerably from the Rayleigh distribution which the low wave troughs follow. The simulated waves follow the Rayleigh distribution (Fig. 5.16).

Two 16 minutes long wave time histories mesured by MTL with a waverider buoy south of Bogskär in December 1982 and in January 1983 have been analysed after the MV Estonia accident to compare the wave crest and trough height distributions with the Rayleigh distribution. Figures 5.17 and 5.18 show that both the crest and trough distributions correlate well with the Rayleigh distribution. However, the wave time history measured in December 1982 contains one exceptionally high wave crest. This crest which is about 3.7 m high while the significant height is 3.3 m differs significantly from the Rayleigh distribution. In certain storm conditions, so called episodic waves which have a height of about $2.4H_s$ have been observed (Buckley, 1983), but it is not known whether this kind of waves appear in the Baltic. Andrew & Lloyd (1980) measured wave-induced motions of two British frigates in severe head seas on a full scale trial south-west of Ireland and found that the wave-induced motions follow quite well the Rayleigh distribution.

VTT SIMULATIONS



SSPA MODEL EXPERIMENTS

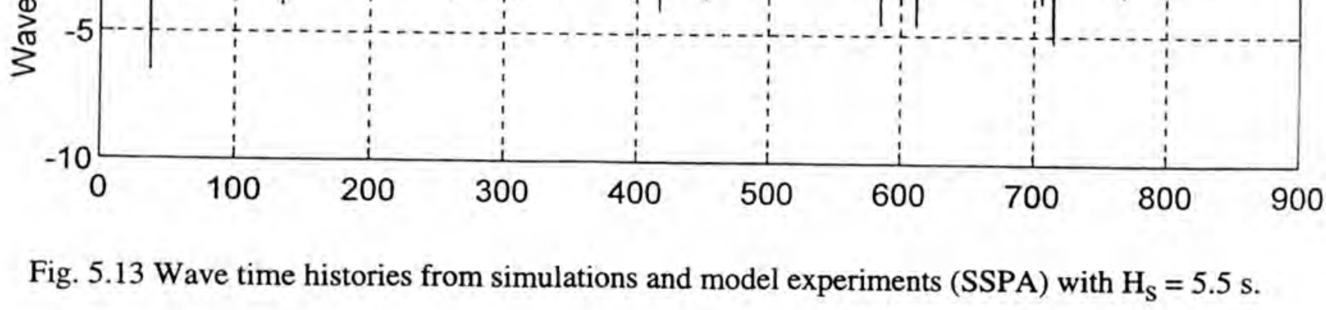
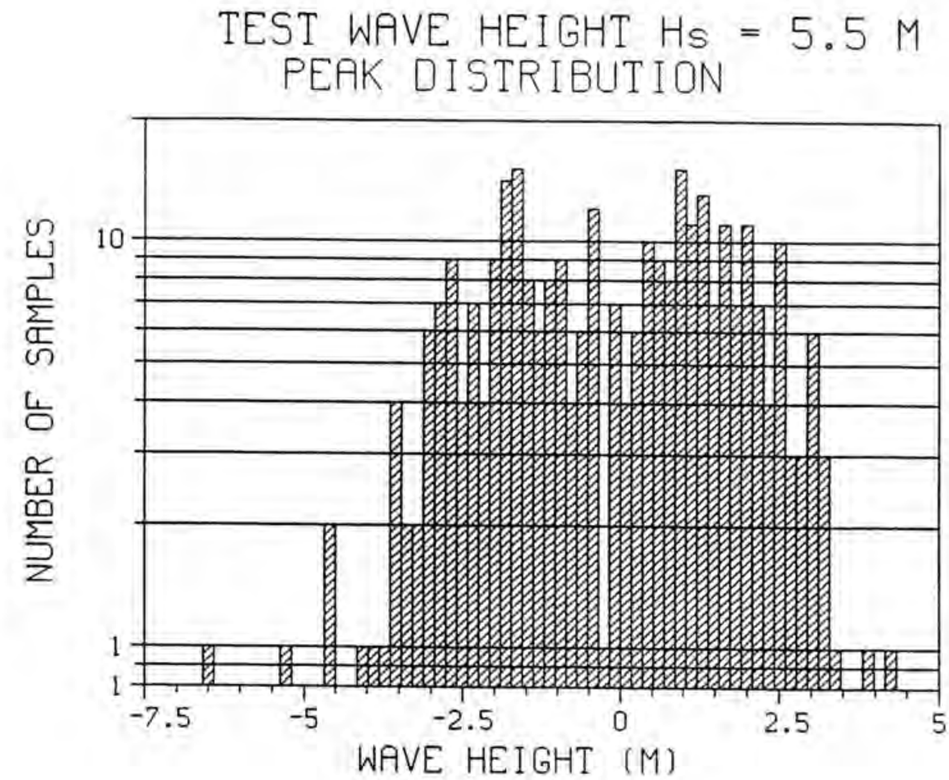


Fig. 5.13 Wave time histories from simulations and model experiments (SSPA) with H_S = 5.5 s.



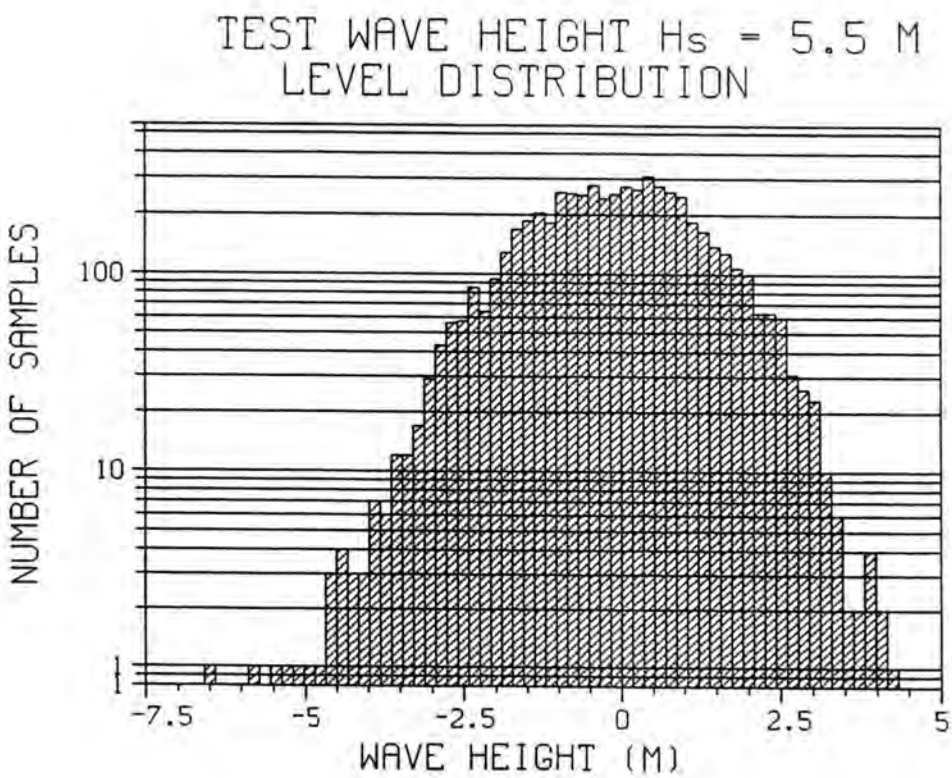


Fig. 5.14 Peak and level distributions of a wave record from the model tests by SSPA.

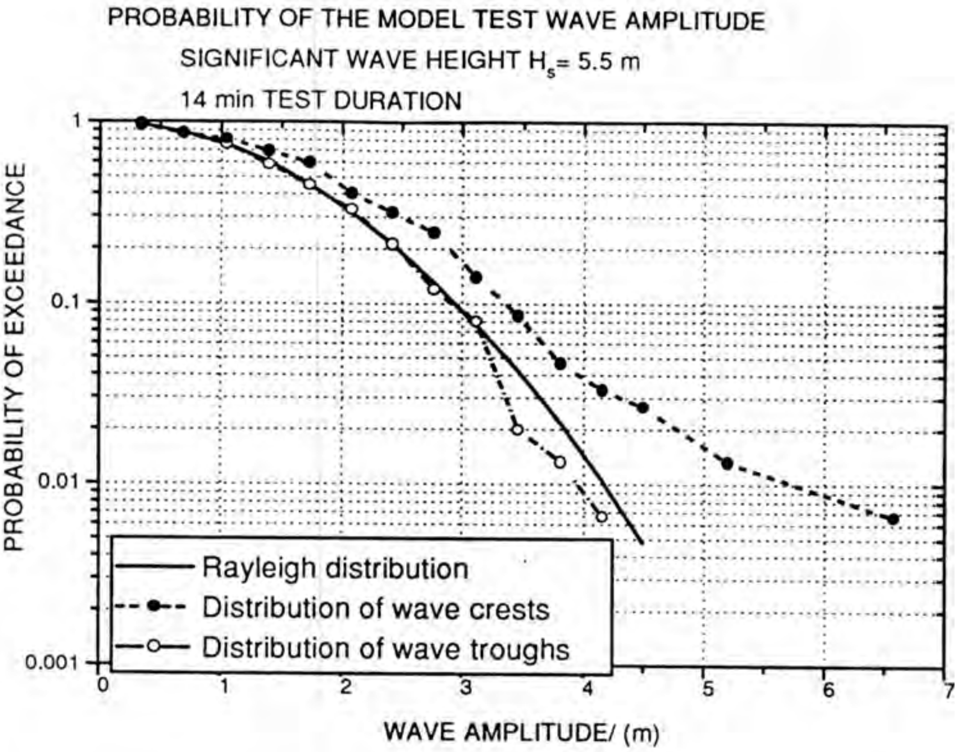


Fig. 5.15 Exceedance probabilities of wave crest and trough amplitudes from model tests by SSPA compared to the Rayleigh distribution.

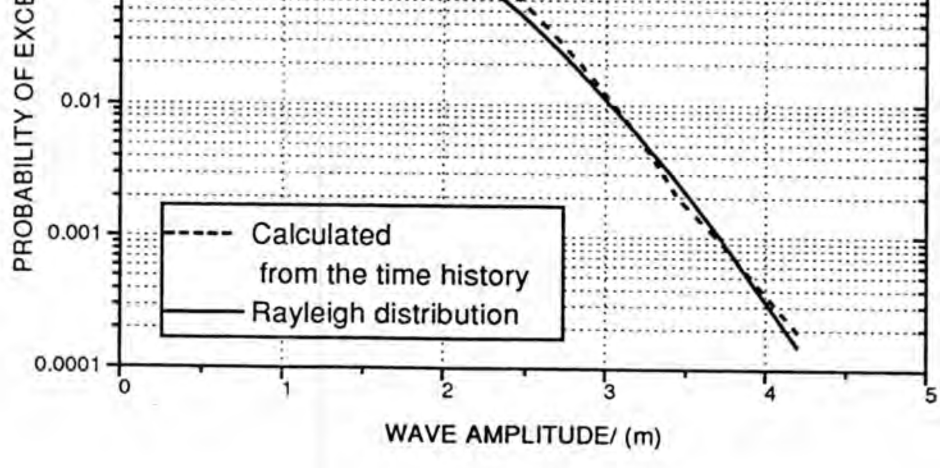


Fig. 5.16 Exceedance probabilities of wave amplitudes of a simulated wave record compared to the Rayleigh distribution.

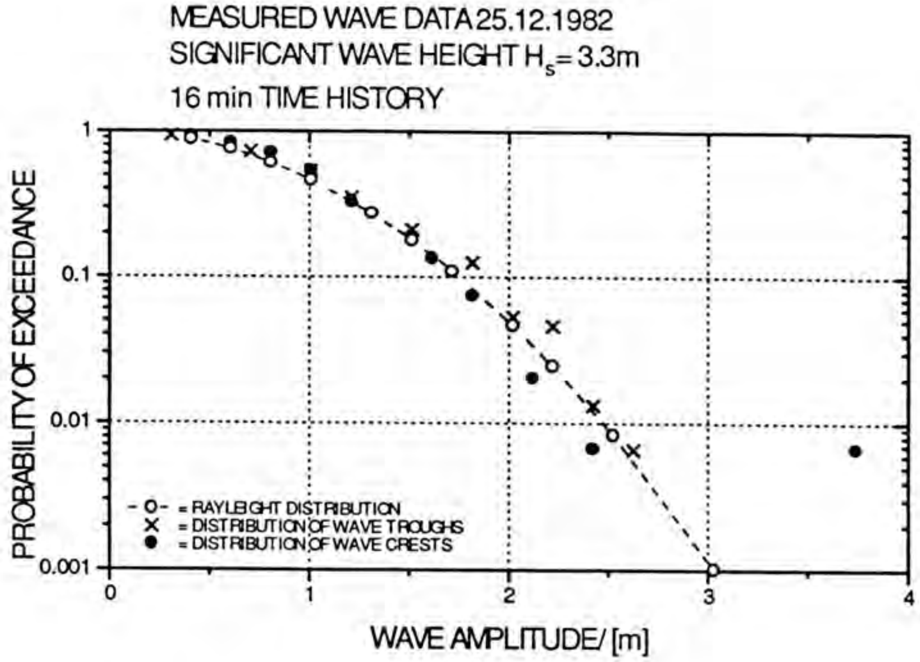


Fig. 5.17 Distribution of wave crest and trough amplitudes measured in December 1982 south of Bogskär compared to the Rayleigh distribution.

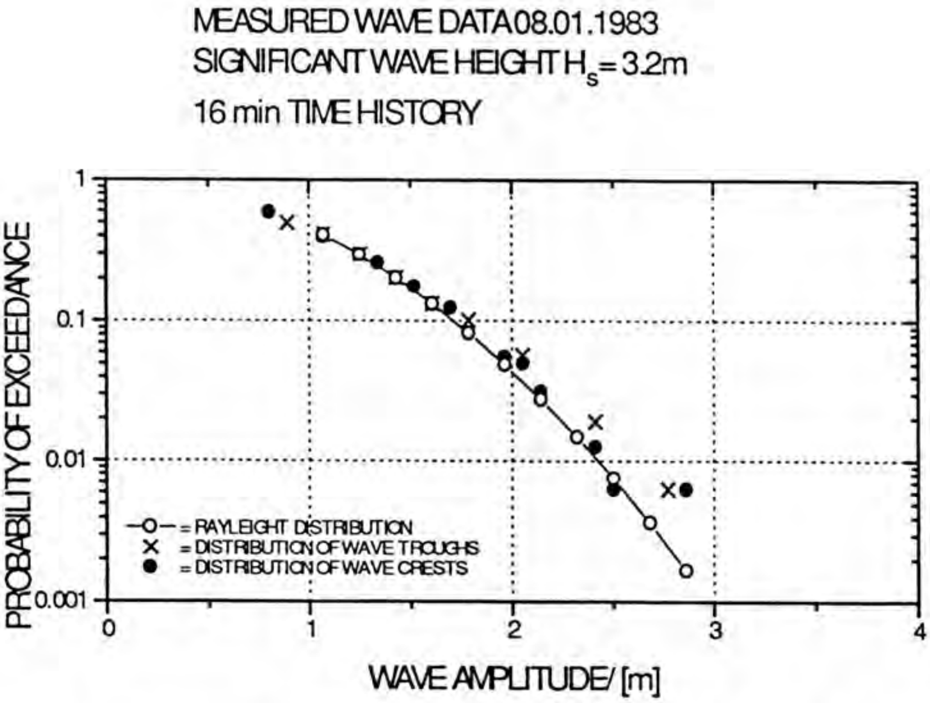


Fig. 5.18 Distribution of wave crest and trough amplitudes measured south of Bogskär in January 1983 compared to the Rayleigh distribution.

5.2 Comparison with experiments with the model of MV Estonia

Model tests with a model of MV Estonia have been carried out by SSPA to measure the wave-induced loads on the bow visor. The tests and the results have been reported in the SSPA Report 7524 dated 1995-12-05 and in the Appendix to the report. The test program included runs in regular and irregular head and bow waves at speeds 10, 15 and 19 knots. The significant wave heights used with JONSWAP spectra were 4, 4.5 and 5.5 m.

The maximum measured vertical force component on the visor has been compared to the simulated vertical force having a probability of exceedance corresponding to the measurement time in the model experiments. The following table shows the relevant experimental results in irregular seas and the simulated results corresponding to the test conditions which are also given in the table.

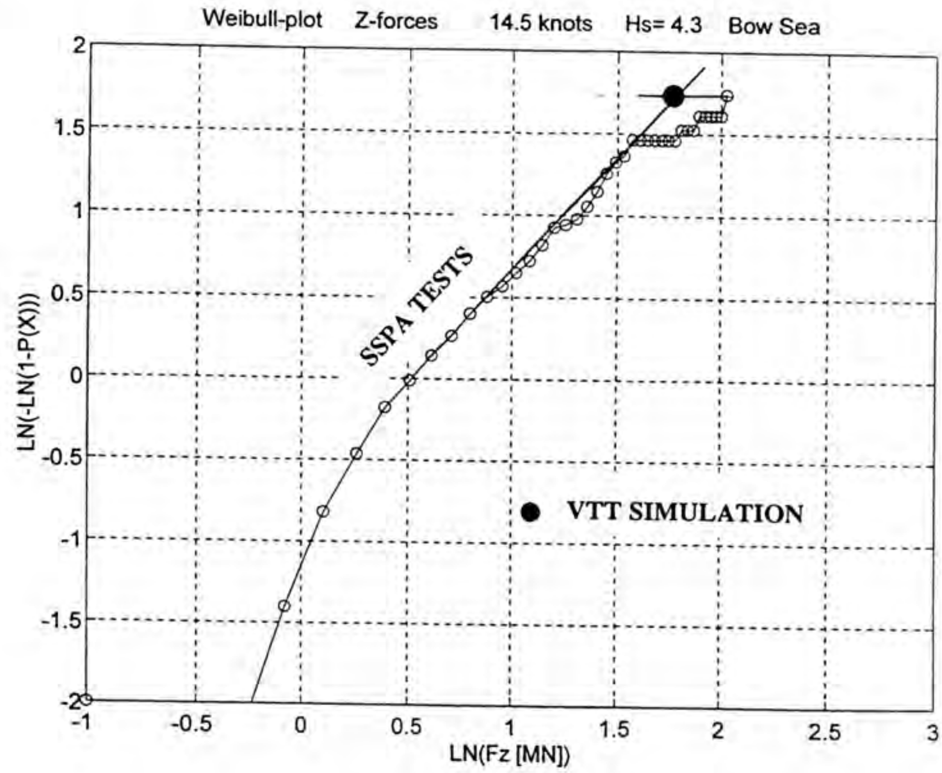
Table 5.2 A comparison of simulated and experimental vertical wave loads on the visor.

SSPA runs	Head.	V [kn]	H_s [m]	Measur. time [s]	Wave enc. VTT	F_z max. meas. SSPA	F_z est. meas. SSPA	F_z sim. VTT
4-5	Head	10.0	3.787	1 922	414	1.817 MN	1.8 MN	1.7 MN
6-31	Head	15.0	3.945	19 161	5 145	6.214 MN	6.2 MN	3.5 MN
34,35,42	Head	10.0	5.233	3 582	771	6.265 MN	5.4 MN	5.0 MN
36,37,41	Head	15.0	5.367	2 345	630	5.939 MN	5.9 MN	5.6 MN
7-13	Head	14.86	4.096	1 649	443	4.980 MN	2.9 MN	2.4 MN
67-116	Bow	14.54	4.512	10 672	2 557	7.400 MN	5.9 MN	5.1 MN

Table 5.2 gives the run numbers specified in the SSPA report, measured average forward speed, V, and significant wave height, H_s, total measurement time, and the number of wave encounters in the VTT simulations corresponding to the measurement time. F_z max. is the maximum vertical force component on the visor measured during the experiments at the particular speed, heading and significant wave height. In the SSPA report, the given force is defined as the nominal force since it has been corrected for the difference in mass of the model visor and the full scale visor. However, the weight of the visor has not been included in the vertical force. Thus, the weight of the visor, 0.6 MN, has been added to the simulated forces given in the table.

The simulated forces F_z sim. have been estimated from the probability of exceedance curves in Figures 5.4, 5.6 and 5.8. The forces correspond to the exceedance probabilities of 1/(number of wave encounters), for instance, in bow seas at 14.5 kn speed the exceedance probability has been 1/2 557 = 0.00039. If the maximum force measured during the experiments differs considerably from the general trend of the lower peak force values expressed in the form of a Weibulll-diagram, the general trend has been extrapolated and an estimate F_z est. has been read from the extrapolation line. This has been made in three cases of which examples are in Figure 5.19.

As expected, the simulated vertical forces are smaller than the measured forces. The difference cannot be explained by viscous effects which are of the order of 0.01 MN. Also the computed significant relative motions and velocities agree well with the measured data (Report VTT VALC53) so that a discrepancy in the simulated and experimental wave-induced motions seems to be not a source of the difference. The correlation of the numerical predictions is better with the estimated experimental value than with the measured maximum value. However, if the maximum measured value follows the general trend, the correlation with the numerical prediction is quite good with the exception of the head sea case at 15 kn, runs 6 - 31, H_s = 3.945 m. For instance, at 15 kn speed in head seas with a significant height of 5.367 m the maximum measured value is 5.9 MN while the corresponding force from the simulations is 5.6 MN.



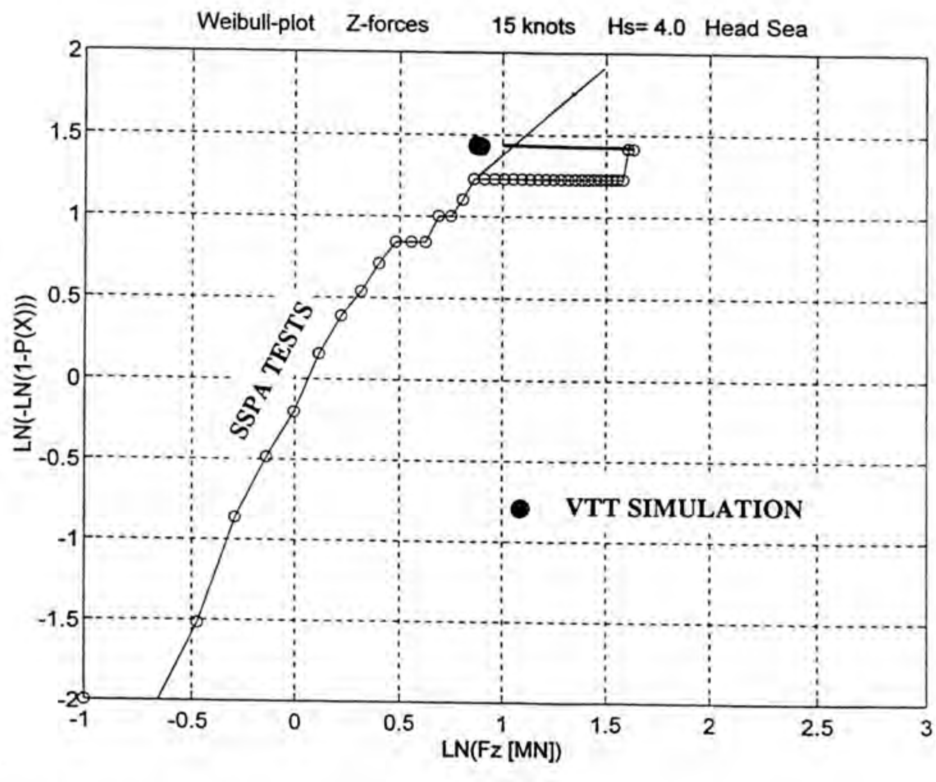


Figure 5.19 Extrapolation of measured data and a comparison with simulated results.

The maximum vertical force measured during the runs 6 - 31 in the towing tank at 15 kn speed, 6.2 MN, is significantly higher than the simulated value of 3.5 MN although the maximum follows quite well the general trend of the lower measured peak values. A partial explanation may be that the wave time histories in runs 6 - 31 have included some quite extreme wave crests and the distribution of high wave crest amplitudes differs considerably from the Rayleigh distribution like in Figure 5.15. The maximum measured wave crest amplitude has been 7.012 m which is rather extreme when the significant wave height is 3.945 m. It must be noted that the highest forces are not excited by the highest wave crests, for instance, during the runs 6 - 31 the maximum force is due to a 5.3 m high crest. However, it may be anticipated that if the wave crest heights are extreme also those wave characteristics which are significant for high loads on the visor may be extreme.

To understand better the correlation of high visor loads with ship motions and characteristics of waves, Table 5.3 below shows a summary of experimental wave and response maximum values.

Table 5.3 Experimental wave and response maximum values.

SSPA runs	Head.	V [kn]	H_s [m]	H max [m]	H crest max. [m]	Rel. mot. max. bow down [m]	Rel. vel. max. bow down [m]	F_z max. meas. SSPA
4-5	Head	10.0	3.787	6.33	4.197	5.69	6.77	1.817 MN
6-31	Head	15.0	3.945	8.19	7.012	7.60	10.65	6.214 MN
34,35,42	Head	10.0	5.233	9.55	7.056	7.41	9.22	6.265 MN
36,37,41	Head	15.0	5.367	9.07	6.587	6.94	12.09	5.939 MN
7-13	Head	14.86	4.096	8.84	6.145	7.41	7.22	4.980 MN
67-116	Bow	14.54	4.512	8.40	5.894	7.59	10.94	7.400 MN

Table 5.3 indicates that the maximum vertical force correlates better with the maximum crest amplitude measured upwards from the calm water level than with the maximum relative motion or velocity amplitude in the bow down motion. The correlation with crest height is also better than with the maximum crest-to-trough wave height, H max. Though the observed correlation may be just a chance, the ratios of the maximum measured vertical force to the square of maximum crest amplitude are given in the following table.

Table 5.4 Experimental ratio of the maximum force to maximum crest height squared.

SSPA runs	Head.	V [kn]	H_s [m]	H max. [m]	H crest max. [m]	F_z max. meas. SSPA	$F_z$max./ (H crest)^2
4-5	Head	10.0	3.787	6.33	4.197	1.817 MN	0.103
6-31	Head	15.0	3.945	8.19	7.012	6.214 MN	0.126
32-33	Head	19.0	4.036	7.29	5.418	8.523 MN	0.290
34,35,42	Head	10.0	5.233	9.55	7.056	6.265 MN	0.126
36,37,41	Head	15.0	5.367	9.07	6.587	5.939 MN	0.137
38-40	Head	19.0	5.289	9.55	7.260	8.148 MN	0.155
7-13	Head	14.86	4.096	8.84	6.145	4.980 MN	0.132
34-46	Bow	9.86	4.207	8.08	5.084	2.373 MN	0.092
67-116	Bow	14.54	4.512	8.40	5.894	7.400 MN	0.213
48-55	Bow	10.0	5.338	9.55	6.189	7.318 MN	0.191
56-66	Bow	15.1	5.286	10.05	6.914	10.846 MN	0.227

It is once again stressed that the maximum wave crest given in Table 5.4 did not cause the maximum vertical force given in the same table though there seems to be some correlation between them. The

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table seems to indicate that speed has some effect on the vertical visor load, i.e. the ratio of the force to the crest height squared increases with increasing speed. A change of heading from head to bow seas increases clearly the force ratio. Respectively, the wave-induced motions are clearly larger in bow seas than in the head seas while a speed increase has a modest effect on the motions as the results in the report VTT VALC53 show. It is surprising to see in Table 5.4 that in head seas at 19 kn speed a larger maximum force has been measured in the seastate with H_s = 4.036 m than in the seastate with H_s = 5.289 m. The explanation may be statistics since in the lower seastate the maximum force differs very significantly from the Weibull fit through the lower values. If a value corresponding to the measured maximum is read on the extrapolation line, a vertical force of about 4.5 MN is obtained. This force divided by the square of crest height gives 0.153 which is very well in line with the other values.

5.3 Wave loads on the bow visor of MV Estonia during the last voyage

During the last voyage of MV Estonia, the significant wave height rose to near 4 m about one hour before the accident, or at about midnight Finnish time. During this one hour, the vessel encountered about 1 000 waves. Thus, it is quite likely that the maximum vertical load exceeded the value corresponding to the exceedance probability of 1/1000. There is a chance of 1 to 10 that during one hour the extreme load was larger than the value corresponding to the exceedance probability of 1/10 000. The extreme load increases by about 1 000 kN with a decrease of the exceedance probability from 10^{-3} to 10^{-4}.

Due to the approximations involved in the numerical method, it is believed that the extreme load values may be larger in reality than the simulated values. The simplified form of the visor acts in this direction in lower seas and the lack of non-linear, breaking waves in the simulated wave time histories has a similar effect. Due to the wind shift south the seas may have been short-crested and quite confused which increases wave-induced motions and wave loads on the visor. Taking this into account it seems quite well possible that MV Estonia hit in bow seas at a speed of 15 knots a wave which generated on the visor a vertical load exceeding 5 000 kN, even 6 000 kN at a somewhat smaller exceedance probability. The numerical predictions show an approximately linear relationship between the vertical visor load and the forward speed of the vessel.

The numerical predictions give only the vertical component of the wave load on the visor. To determine also the visor opening moment around the hinges, the horizontal force component, the point of application and the direction of the total force have to be estimated. The predictions by the SHIPFLOW-program and the shape of the visor suggest that the horizontal load component is approximately equal to the vertical component which has been confirmed by the model experiments. It seems reasonable to assume that the acting point of the total load has been at or somewhat below the vertical centre of buoyancy of the submerged part of the visor close to the stem. The total force has thus been acting at a height of about 11.5 m above the baseline, or 6 m above the design waterline of T = 5.5 m. On the basis of the visor geometry, the force resultant has been acting in a direction which is nearly perpendicular to the stem. These assumptions result in a moment arm of about 3 m and a total opening moment around the hinges of over 20 MNm.

The significant wave height has a strong effect on the bow flare loads as already noted by Gran et al. (1976). According to the Finnish Institute of Marine Research the uncertainty in the estimate of the significant wave height is about 0.5 m. The numerical predictions indicate that a change of H_s by 0.5 m may change the vertical load on the bow visor of MV Estonia by 1000 to 1 500 kN. In head seas with H_s = 5.5 m at a speed of 15 kn, the vertical visor load may exceed 10 000 kN.

5 CONCLUSIONS

The vertical component of the wave load on the bow visor of MV Estonia has been simulated in irregular head and bow seas by a numerical method based on the so called non-linear strip method and momentum consideration. The method is practical and seems to give reasonable results in spite of the simplifying assumptions involved in the method. The simplifications probably decrease the numerical visor load values. This has been taken into account before making the final load estimates. The method has not been fully validated but in some cases the results for MV Estonia have been compared with results of model tests with some other hull forms and with a model of MV Estonia. The comparison of numerical predictions with experimental results of MV Estonia is encouraging though the different factors contributing to high visor loads are not clear.

The numerical predictions indicate that the vertical component of the wave load on the bow visor of MV Estonia may quite well have exceeded 5 000 kN or even 6 000 kN at a somewhat smaller probability in the sea conditions of the accident night. The results of the numerical predictions supplemented by some rough estimates of the direction and acting point of the load resultant suggest a visor opening moment around the hinges of over 20 MNm.

The very strong dependence of the visor loads on the wave height and even on the wave shape adds uncertainty in the results. This dependence arises partly from the wide flare of the bow visor of MV Estonia. The dependence of the vertical visor load on the forward speed of the vessel is not nearly so strong as on the significant wave height. The load on the bow visor of MV Estonia seems to be approximately directly proportional to the forward speed over a speed range relevant on the accident night.

The behaviour of the "steady" bow wave when the bow submerges deeply is not well known. In the numerical predictions, the bow wave height estimated by a non-linear numerical method in calm water has simply been superposed to the vertical relative motion at bow. Assuming a higher bow wave increases the loads. The behaviour of the bow wave should be part of the numerical solution.

The irregular seas used in the simulation have been generated by applying the linear superposition principle. This means that the wave crests and troughs are symmetrical with respect to the still water level and the crest and trough amplitudes follow the Rayleigh distribution. In reality in rough sea conditions, the wave troughs get flatter and the wave crests sharper resulting finally to wave breaking. This increases the number of high wave crest amplitudes and decreases the number of deep throughs. The result is evidently an increase in the magnitude and probability of high wave loads on the bow visor. Wave groups of successive high waves act also in this direction by inducing large motion displacements to the vessel. These are problems which require further study.

REFERENCES

Buckley, W. H. 1983. A study of extreme waves and their effects on ship structure. Ship Structure Committee Report SSC-320, U.S. Coast Guard, Washington, D. C. 82 p.

Chiu, F. & Fujino, M. 1991. Nonlinear prediction of vertical motions of a fishing vessel in head sea. Journal of Ship Research, Vol. 35, No. 1, March, pp. 32 - 39.

Faltinsen, O. M. 1990. Sea loads on ships and offshore structures. Cambridge University Press, Great Britain, 328 p.

Garrison, C. J. 1974. Hydrodynamics of large objects in the sea. Journal of Hydronautics, Vol. 8, No. 1, January, pp. 5 - 12.

Gran, S., Olsen, H. & Tellsgård, F. 1976. Hull response to hydrodynamic forces on bow flare. Norwegian Maritime Research, No. 3, pp. 29 - 40.

Greenhow, M. 1987. Wedge entry into initially calm water. Applied Ocean Research, Vol. 9, No. 4.

Greenhow, M. & Yanbao, L. 1987. Added mass for circular cylinders near or penetrating fluid boundaries - review, extension and application to water-entry, -exit and slamming. Ocean Engineering, Vol. 14, No. 4, pp. 325 - 348.

Hooft, J. P. 1970. Oscillating wave forces on small bodies. International Shipbuilding Progress, Vol. 17, No. 188.

Kagemoto, H., Fujino, M. & Okabe, T. 1995. Motions and safety of floating bodies in a wave group. Transactions of the West-Japan Society of Naval Architects, No. 89, March, pp. 91 -102.

Kahma, K., Pettersson, H., Myrberg, K. & Jokinen, H. 1995. Estimated wave conditions and currents during the last voyage of M/S Estonia. Finnish Institute of Marine Research.

Karppinen, T. 1975. Wave-induced motions of semisubmersible drilling rigs. nstm'75 meeting of the Nordic naval architects, Helsinki University of Technology, Finland, 58 p.

de Kat, J. O. & Paulling, J. R. 1989. The simulation of ship motions and capsizing in severe seas. SNAME Transactions, Vol. 97, pp. 139 - 168.

Kalske, S. T., Karppinen, T. O. & Matusiak, J. E. 1985. Arctic mobile drilling structures in waves. 17th Offshore Technology Conference, Paper No. 5033, Houston, May, pp. 107 - 117.

Larsson, L. 1993. Resistance and flow predictions using the SHIPFLOW code. 19th WEGEMT School, Nantes.

Larsson, L., Broberg, L., Kim, K.-J. & Zhang, D.-H. 1990. A method for resistance and flow prediction in ship design. SNAME Transactions, Vol. 98, pp. 495 - 535.

Matusiak, J. & Rantanen, A. 1986. Digital simulation of the non-linear wave loads and response of a non-rigid ship. Proc. CADMO'86, Washington DC, p. 211 - 222.

Newman, J. N. 1977. Marine Hydrodynamics. MIT Press, Cambridge, Massachusetts, 402 p.

Payne, P. R. 1981. The vertical impact of a wedge on a fluid. Ocean Engineering, Vol. 8, No. 4, pp. 421 - 436.

Raff, A. I. 1972. Program SCORES - Ship structural response in waves. Ship Structure Committee Report SSC-230, U.S. Coast Guard Headquarters, Washington D.C. 63 p.

Sundell, T. 1995. MV Estonia accident investigation. Forces on the bow visor due to stationary flow. VTT Manufacturing Technology, Report VALC55, Espoo, January.

Trosch, A.W. & Kang, C.-G. 1988. Evaluation of impact loads associated with flare slamming. SNAME Spring Meeting/STAR Symposium, Pittsburgh, Pennsylvania, June, pp. 117 - 132.

Yamamoto, Y., Fujino, M. & Fukasawa, T. 1980. Motion and longitudinal strength of a ship in head sea and the effects of non-linearities. Naval Architecture and Ocean Engineering, Vol. 18, pp. 91 - 100.

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SUPPLEMENT No. 409

Huss Mikael: Wave loads on visor attachments.

MV ESTONIA Accident Investigation. Internal report 1995 - 1997.

MV ESTONIA Accident Investigation
Internal Report
1995-1997

Wave loads on visor attachments

by
Mikael Huss

Introduction

The distribution of wave induced forces at the attachments of the bow visor has been estimated by using equilibrium equations and assumptions of relative distribution and direction of forces. The external loads have been taken from an estimated range of maximum wave forces and moments during the last 30 minutes before the accident, and are based on the model test at SSPA Maritime Dynamic Laboratory, (MDL).

1 Estimate of maximum wave loads for the accident condition

A probable range of maximum forces and moments for the accident condition has been evaluated from the MDL test for 150° heading, 14.5 knots and a (measured) significant wave height of 4.51 m. The evaluation has been done in three steps:

- Approximate probability distribution curve fit in the figures of SSPA report 7524-appendix

- Calculation of maximum loads during 30 minutes of exposure for a confidence interval of 90% based on the approximate distributions

- A reduction by 30% on forces and 50% on moment levels to make them correspond to a significant wave height of 4.0-4.1 m as is now assumed to be the most probable condition at the time of the accident.

Probability distribution of measured wave loads

The measured dynamic wave forces and moments about the hinge axis/centreline position are presented in SSPA Report 7524 as curves of ln(-ln(exceedance probability) versus ln(load level). A linear curve fit have been made to these figures which equals an assumption of Weibull-distributed load levels. The numerical simulations performed at VTT indicates that this assumption is valid for the vertical forces even down to very low levels of probability. This also holds for the measured forces from model tests. However, the upper tail of the measured wave induced moments seem to deviate from an ordinary Weibull distribution. This can partly be explained by the non-linearity between forces and moments due to the visor geometry, but there could also bee some influence from the wave conditions generated at the tests, where some of the larger waves were extremely steep with significantly higher crests than troughs. The highest values of the Y-moment (opening moment) have therefore been disregarded in the linear curve fit.

The SSPA plots with the corresponding linear curve fit are shown in Figures 1.1-1.5. The Z-moment distribution was not possible to evaluate directly from this test series.

A summary of the parameters of the fitted distributions is given in the table, Figure 1.6.

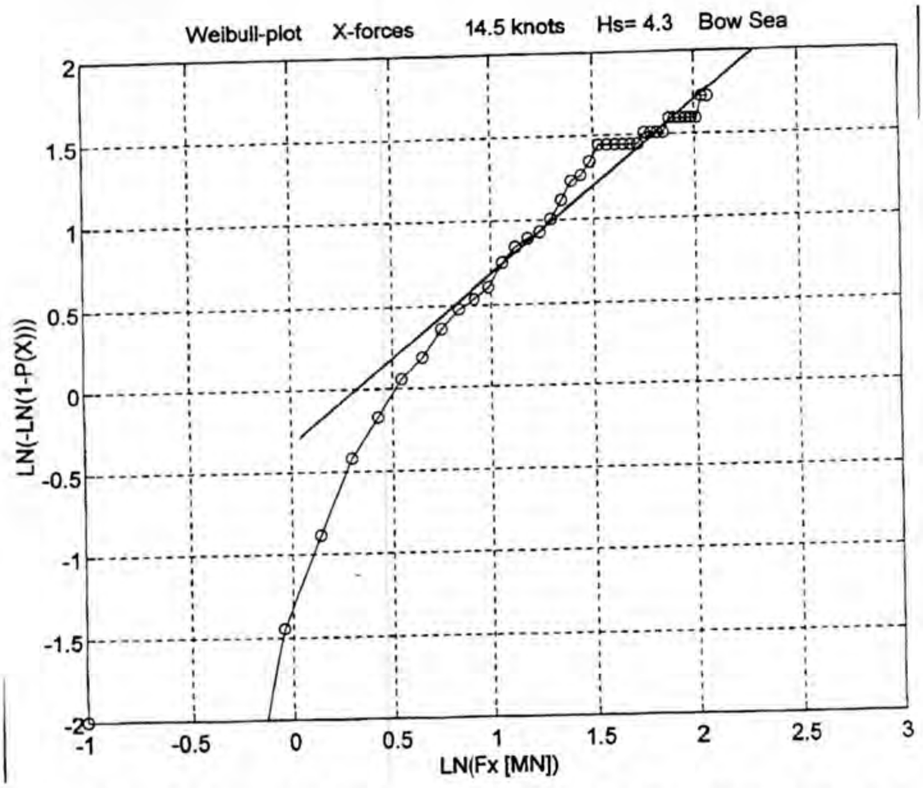

Figure 1.1 X-forces as measured and with Weibull-distribution curve fit

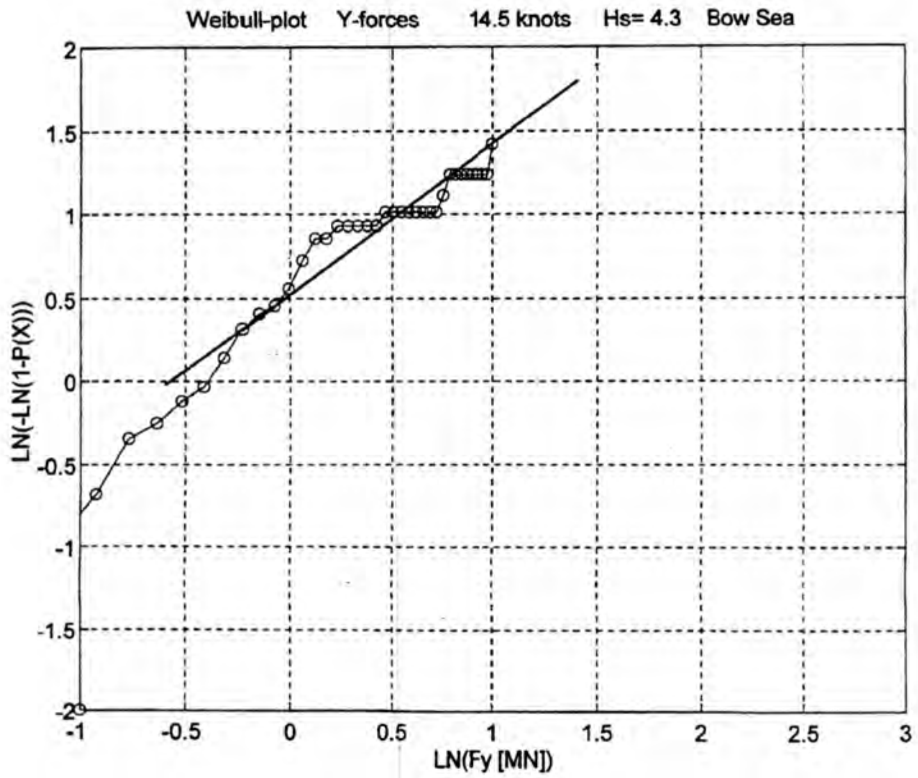

Figure 1.2 Y-forces as measured and with Weibull-distribution curve fit

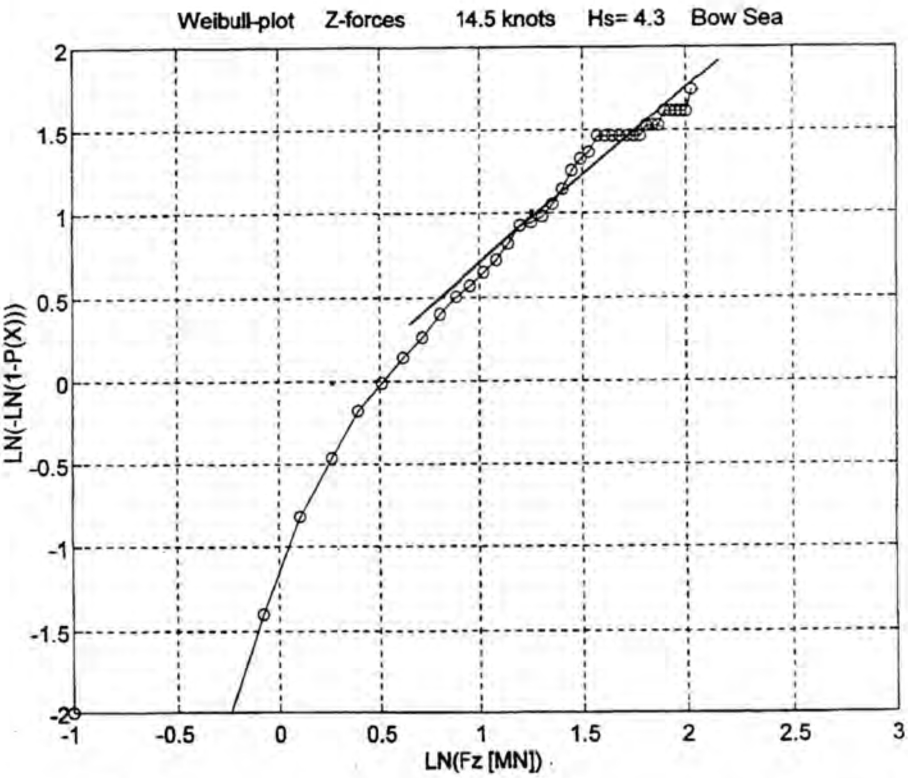

Figure 1.3 Z-forces as measured and with Weibull-distribution curve fit

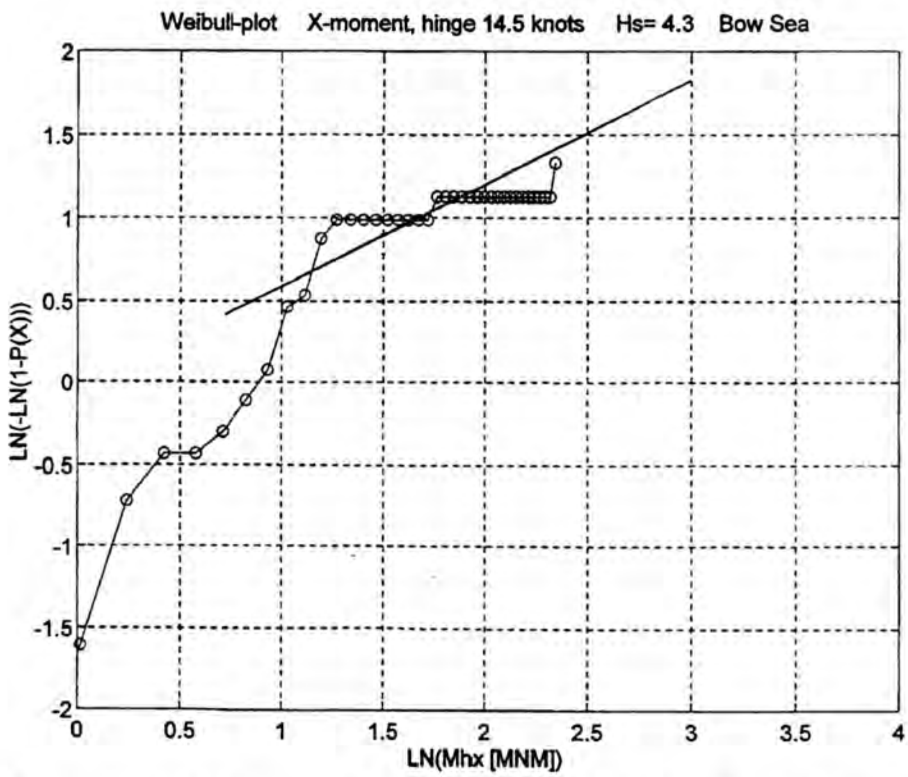

Figure 1.4 X-moments as measured and with Weibull-distribution curve fit

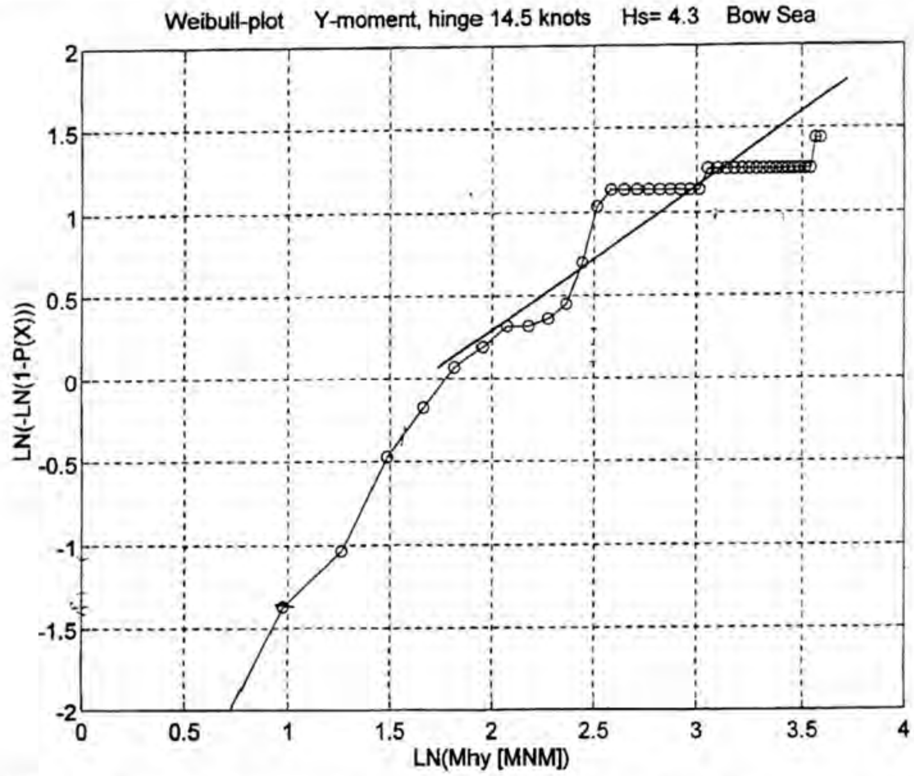

Figure 1.5 Y-moments as measured and with Weibull-distribution curve fit

Exceedance distributions and extreme value distributions for model test condition

The cumulative probability distributions corresponding to the linear curve fit of Figures 1.1-1.5 is expressed as:

$$F(x) = 1 - e^{-(x/b)^k}$$

where b and k are the parameters of the Weibull distribution.

The risk r to exceed a certain level x_r among n values is expressed by an extreme-value distribution defined from the basic cumulative distribution:

$$r = 1 - (F(x_r))^n$$

and the extreme level associated with a certain risk can be written

$$x_r = b(-\ln(1-(1-r)^{\frac{1}{n}}))^{\frac{1}{k}}$$

The estimated range of maximum wave loads are here based on 30 minutes of exposure and on risk levels 0.05 - 0.95. The number of cycles n have been taken from the model test results by taking one sixth of the measured cycles during the 3h test series.

Load type	Cumulative prob. distr.		no. of	Maximum value during 30 minutes		
			load peaks	Exceedance	Most	Exceedance
[MN]	Weibull parameters			probability	Probable	probability
[MNm]	b	k	n	0.95		0.05
X-force	1.41	1.04	50	3.85	5.23	9.01
Y-force	0.58	0.93	11	0.85	1.49	3.53
Z-force	1.40	1.05	53	3.86	5.20	8.86
X-moment	1.00	0.60	8	1.28	3.39	14.88
Y-moment	5.11	0.81	11	7.97	15.04	40.71
Z-moment	not possible to evaluate from the report					

Figure 1.6 Summary of load level distributions for the model test condition Hs = 4.5 m

The k-parameter is a good indication of the degree of non-linearity. If the forces would have been linear to the relative motion between bow and wave surface, then k would have been around 2 (Rayleigh-distributed forces). The low number of load peaks and the low k-value gives for the chosen time and confidence interval a very wide span for the different load components and especially the moments. This illustrates clearly the large uncertainty in any estimate of the actual maximum wave load at the time of the accident.

Correction due to difference in wave height in tested and actual condition

The significant wave height was measured to 4.51 m during the long test series in bow sea at MDL. The actual wave condition at the time of the accident was according to the meteorological institutes lower, with Hs 4.0-4.1 m. It is very difficult to estimate the influence from wave height in this narrow range, 4.05-4.51 m, based on the different model tests. Instead is here used the results from the numerical simulations at VTT, since they include bow wave conditions with both 4.0 and 4.5 m significant wave height. For all simulated probability levels, the reduction on Z-force was about 25%. For comparable conditions in head sea, the model tests gave larger reductions than the simulations. Here is therefore used as a rough estimate a reduction of 30% on all forces to compensate for the difference in wave height between model test condition and the accident condition.

The reduction on moments have been estimated from the correlation between Z-forces and Y-moments according to Figure 1.7. The diagram includes the 13 highest forces and moments measured during the 3 h long model test series. For the Z-force levels in the range of 4-10 MN, a reduction with 30% will give an approximate reduction of about 50% on the moments. This reduction has here been used for all moments.

Figure 1.8 shows the range of probable maximum forces and moments for the accident condition. The Z-moment range has been estimated only based on the maximum measured value.

It must be noted that when these values are used in the analysis of the visor attachment loads, Z-force and Y-moments are reduced with the weight of the visor (about 0.6 MN and 3.0 MNm)

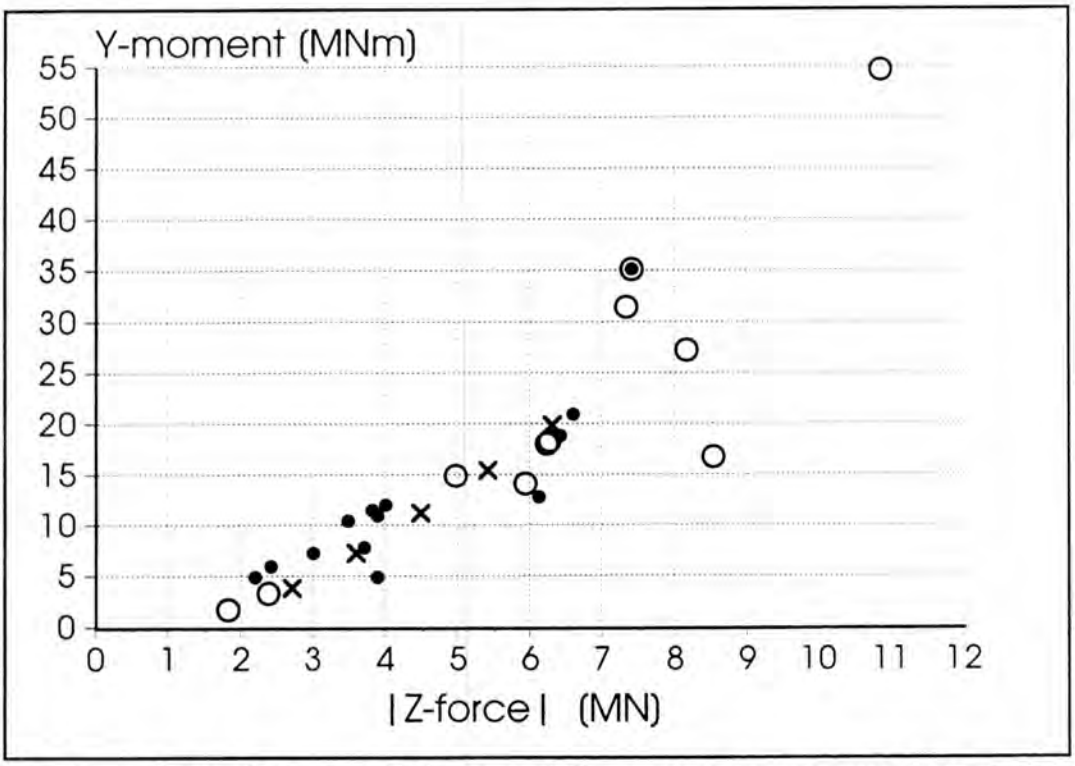

Figure 1.7 Correlation between Z-force and Y-moment, as measured at model tests
Filled spots show the 13 highest wave loads in Hs = 4.5m/V = 14.5 kn
Rings shows the single highest value from all different test series.
The 5 cross show the example load levels A-E as defined on page 9

Load type [MN] [MNm]	Maximum value during 30 minutes		
	Exceedance probability 0.95	Most Probable	Exceedance probability 0.05
X-force	2.7	3.6	6.3
Y-force	0.6	1.0	2.5
Z-force	2.7	3.6	6.2
X-moment	0.6	1.7	7.4
Y-moment	4.0	7.5	20.0
Z-moment	0.5	1.0	2.5

Figure 1.8 Summary of estimated load level distributions for the accident condition, Hs = 4.0-4.1 m

2 Reaction forces on visor attachments

The possible distribution of reaction forces at the attachments of the bow visor has been studied by using equilibrium equations and assumptions of relative distribution and direction of forces.

2.1 Equations of equilibrium

The same direction of coordinates as used by SSPA is used here, i.e. x–forward, y–starboard and z–downwards. The origin of the system is placed at the deck hinge axis and CL-plane. Coordinates and notation of reaction forces are given in Figure 2.1 on the next page. In total 10 reaction forces at 5 different positions are considered.

The equations of equilibrium are formulated for 5 degrees of freedom, x-,z-forces and x-,y-,z-moments. Reaction forces in y-direction are not included because the levels of external y-forces (Fy) are relatively small, and because Fy are also possibly taken by the locating horns in addition to the attachments. However, the "yawing" Z-moment, (Mz) induced by external Fy is of importance and accounted for in the equations.

The "twisting" X-moment (Mx) about longitudinal axis is partly taken as y-, and partly as z-reaction forces at the attachments. Therefore, only half of Mx is considered in the equations below. This rough assumption is not critical for the results.

The lifting actuators are not considered to develop any reaction forces as long as the visor is kept in position by intact hinges and locks.

The equilibrium equations become:

<u>x-forces:</u>

$$(Rx_{hp}+Rx_{hs}) + (Rx_{sp}+Rx_{ss}) + Rx_a + Fx = 0$$

<u>z-forces:</u>

$$(Rz_{hp}+Rz_{hs}) + (Rz_{sp}+Rz_{ss}) + Rz_a + Fz + W = 0$$

(W is weight of visor)

<u>x-moments:</u>

$$(-Rz_{hp}+Rz_{hs})\cdot y_h + (-Rz_{sp}+Rz_{ss})\cdot y_s + Rz_a\cdot y_a + Mx/2 = 0$$

(Mx/2 assumed taken by y-forces)

<u>y-moments:</u>

$$(Rx_{sp}+Rx_{ss})\cdot z_s - (Rz_{sp}+Rz_{ss})\cdot x_s + Rx_a\cdot z_a - Rz_a\cdot x_a + My - W\cdot x_g = 0$$

<u>z-moments:</u>

$$(Rx_{hp}-Rz_{hs})\cdot y_h + (Rx_{sp}-Rx_{ss})\cdot y_s - Rx_a\cdot y_a + Mz = 0$$

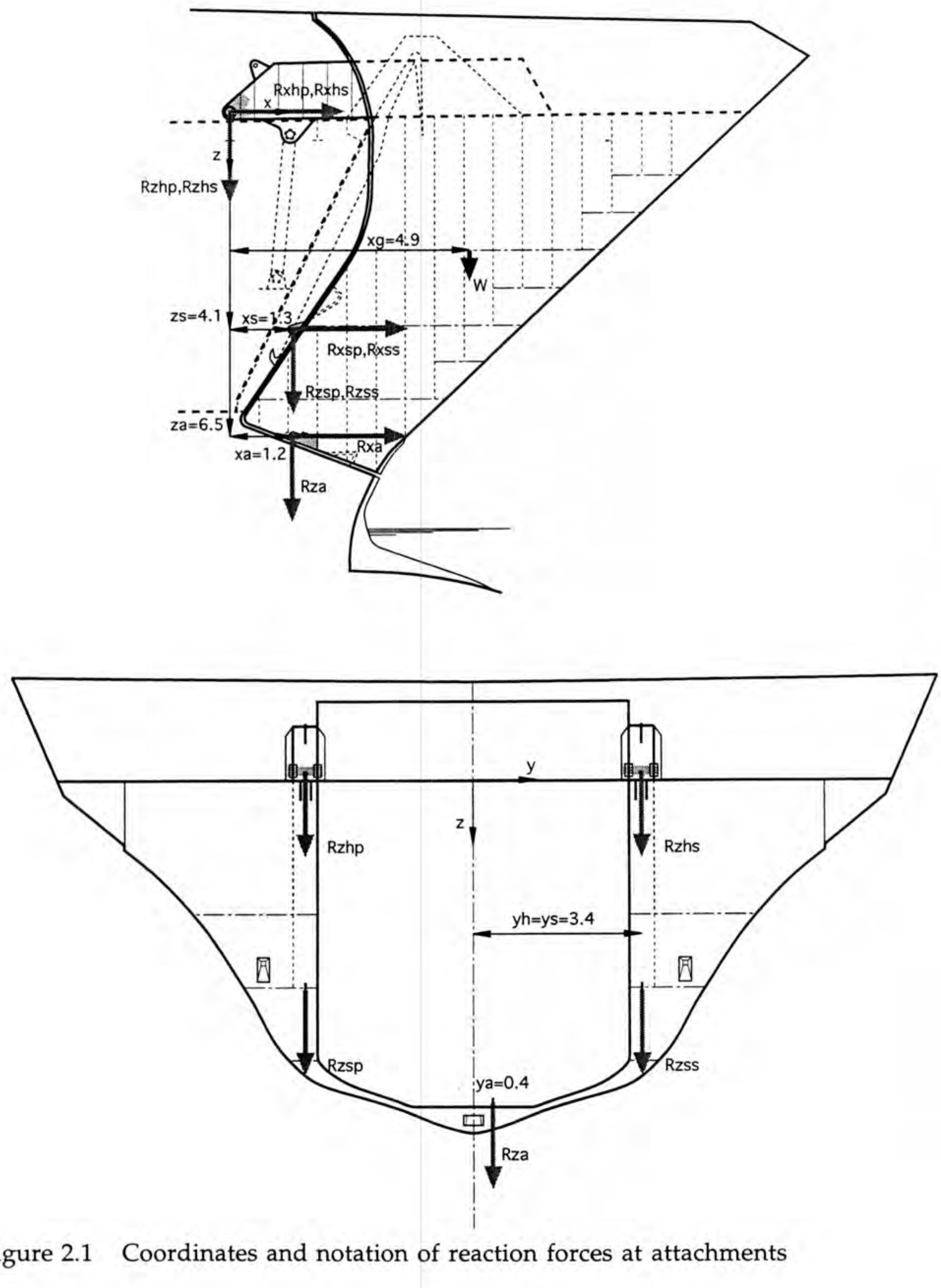

Figure 2.1 Coordinates and notation of reaction forces at attachments

2.2 Complementary equations

To solve for the ten unknown reaction forces it has been necessary to formulate five more conditions. Two are related to the geometry, and used here as fixed conditions. The direction of total reaction force in side locks and in the Atlantic lock have been assumed to be perpendicular to the hinge axis. This assumption is not critical since only the opening moment My is causing resultant tension in side and Atlantic locks.

$$(Rx_{sp}+Rx_{ss}) = -(x_s/z_s)\cdot(Rz_{sp}+Rz_{ss})$$

$$Rx_a = -(x_a/z_a)\cdot Rz_a$$

The last three conditions are related to to the stiffness and play in the system of attachments. They have been formulated as the relative distribution of moments taken by hinges and side locks for Mx and Mz, and by side locks and Atlantic lock for My. The influence of these conditions have been studied separately.

$$(-Rz_{hp}+Rz_{hs})\cdot y_h = (hsmx/(1-hsmx))\cdot(-Rz_{sp}+Rz_{ss})\cdot y_s$$

$$(Rx_{sp}-Rx_{ss})\cdot z_s - (Rz_{sp}-Rz_{ss})\cdot x_s = (samy/(1-samy))\cdot(Rx_a\cdot z_a - Rz_a\cdot x_a)$$

$$(Rx_{hp}-Rz_{hs})\cdot y_h = (hsmz/(1-hsmz))\cdot(Rx_{sp}-Rx_{ss})\cdot y_s$$

where hsmx = (Mx taken by hinges)/(Mx taken by hinges and side locks)
samy = (My taken by side locks)/(My taken by side locks and Atl. lock)
hsmz = (Mz taken by hinges)/(Mz taken by hinges and side locks)

2.3 Typical combinations of wave induced forces

The range of maximum wave force components considered has been covered by the following five typical cases A-E (also shown in Figure 1.7):

Load level:	A	B	C	D	E	
Resultant force:	3.9	5.2	6.5	7.9	9.2	[MN]
Components:						
Fx	-2.7	-3.6	-4.5	-5.4	-6.3	[MN]
Fy	0.6	1.0	1.5	2.0	2.5	[MN]
Fz	-2.7	-3.6	-4.5	-5.4	-6.3	[MN]
Mx	0.6	1.7	3.1	5.0	7.4	[MNm]
My	4.0	7.5	11.3	15.5	20.0	[MNm]
Mz	0.5	1.0	1.5	2.0	2.5	[MNm]

The different levels represent the estimated extreme value distribution in which level A has an exceedance probability of 95%, B is the most probable maximum and E has an exceedance probability of 5%. It is not certain that these force components will act simultaneously, but it is here considered as a sufficient assumption for the average conditions.

2.4 Results

The critical attachments in bow sea is the side lock on the wave encountered side, in this case the port side lock, and the Atlantic lock. The load carrying capacity of port side lock has been estimated by Rahka, VTT, to 1.2 MN, and the capacity of the Atlantic lock to 1.5 MN. However, calculations by Metsaveer, TTU, indicate the possibility of a significantly lower capacity for the Atlantic lock, somewhere in the range 0.8 - 1.4 MN dependent on the ultimate strength of the weldments. In the figures here is used a conservative assumption that the upper estimate is the critical value

The most critical of the complementary conditions is the percentage of opening moment My carried by side locks and Atlantic lock respectively. Figures 2.2-2.3 show the resultant reaction force in port side lock and Atlantic lock as function of the load level and the load distribution. When more than 40% of the opening moment is assumed taken by the side locks, the port side lock will be the first to fail. Due to the relative stiffer upper part of the visor and the high position of the wave forces centre of action, it is reasonable to assume that most of the opening moment will be taken by the side locks. Figure 2.4 shows an example of a critical load distribution assuming 67% of My carried by the two side locks, and Mx,Mz shared equally between hinges and side locks.

Figure 2.5 shows the influence of Mx, Mz distribution between hinges and side locks.

Figure 2.6 shows the influence of force centre of action. The moments My and Mz are varied by 20% with regard to the resultant force level. This variation is about the same as have been found from the model tests as shown in the previous Figure 1.7.

In conclusion, it can be estimated that the first failure of the port side lock will occur in a wave impact with a resultant force level of at most 7.0-8.5 MN. According to the previous estimate of wave load extreme value distribution, this corresponds to a failure probability of 10-25% during 30 minutes of exposure with a speed of 14.5 knots in a sea state with a significant wave height of 4.0–4.1 m.

Figures 2.7-2.8 show the reaction forces at starboard side lock and Atlantic lock when the port side lock has failed. It is not possible to ascertain which of the remaining locks that will be the second to fail. The capacity of the the starboard side lock has been estimated by different calculations to be at most 1.6 MN. It is also a possibility that the port side deck hinge will fail second due to the more downwards directed reaction force. In general the necessary wave load is about equal or slightly larger for any subsequent failure as for the initial failure. Figure 2.9 gives two examples of possible subsequent failure conditions after the port side lock has failed. The wave load level is here chosen as the same as in Figure 2.4.

2.5 Discussion

A reasonable accurate estimate of the relative stiffness of the visor and its attachments could only be obtained by a detailed finite-element analysis. However, since the play in the attachments and the actual distribution of dynamic wave pressure still would be undetermined, a FE-model is here judged to be of limited value.

The presented analysis is to bee seen as a qualitative illustration of the load distribution. All attachments are assumed working effectively and the wave load levels given for the initial failure is therefore possibly somewhat over-estimated. On the other hand, the analysis also shows that the necessary load level to fail the complete attachment system is not changing much even if one of the locks is considered ineffective or failed.

The failure sequence and approximately equal load level of initial and secondary failures are to some extent verified by the damage found at the various visor attachments of the near sister ship DIANA II in January 1993.

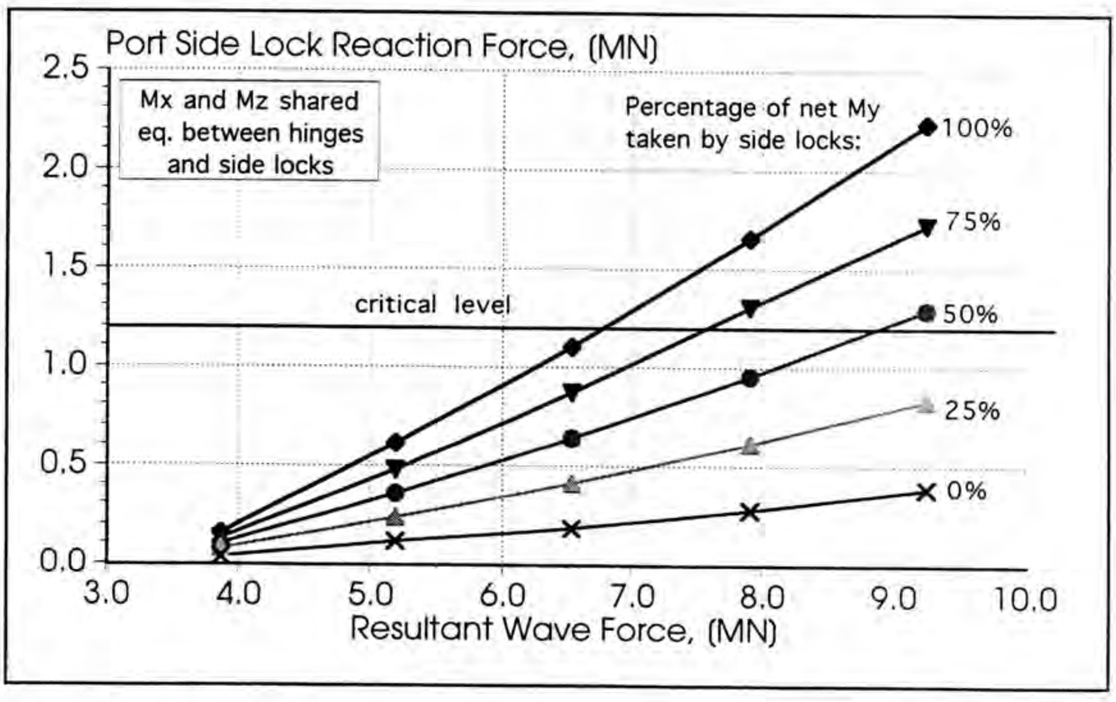

Figure 2.2 Port side lock reaction as function of wave force and My distribution between locks. All attachments intact

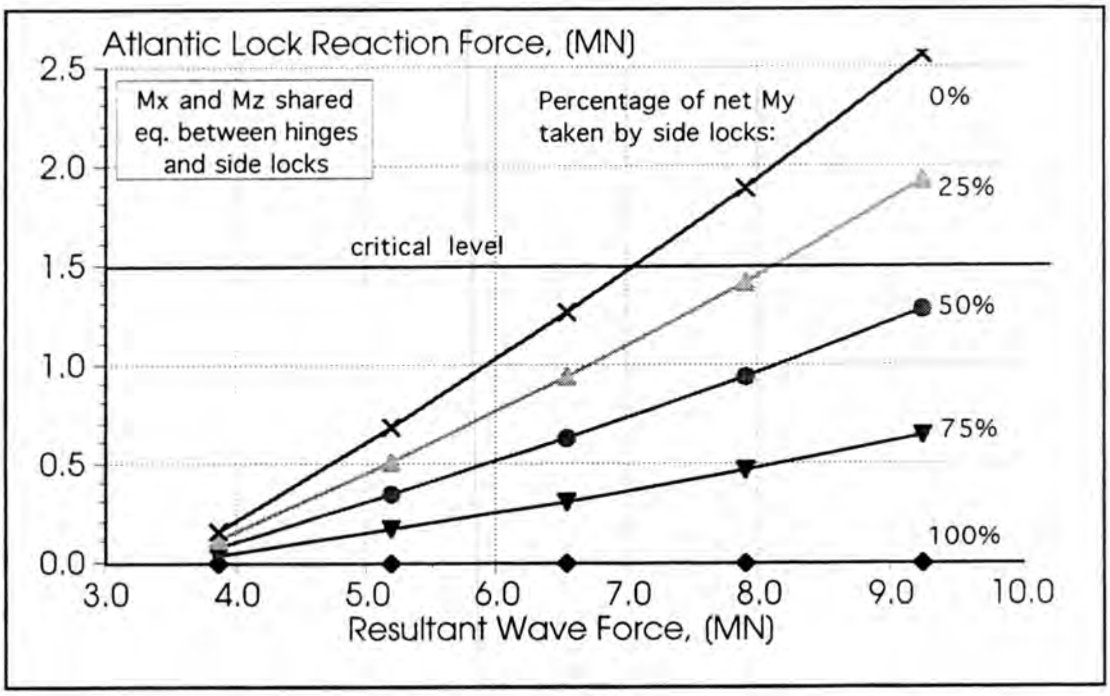

Figure 2.3 Atlantic lock reaction as function of wave force and My distribution between locks. All attachments intact

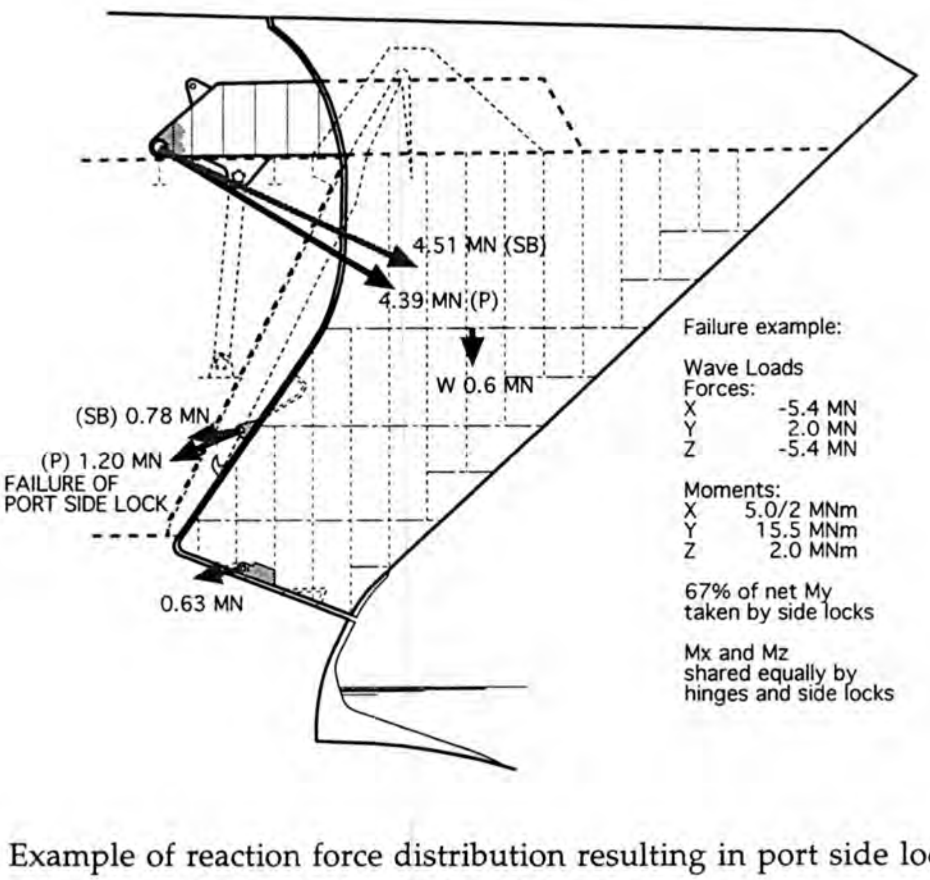

Figure 2.4 Example of reaction force distribution resulting in port side lock failure

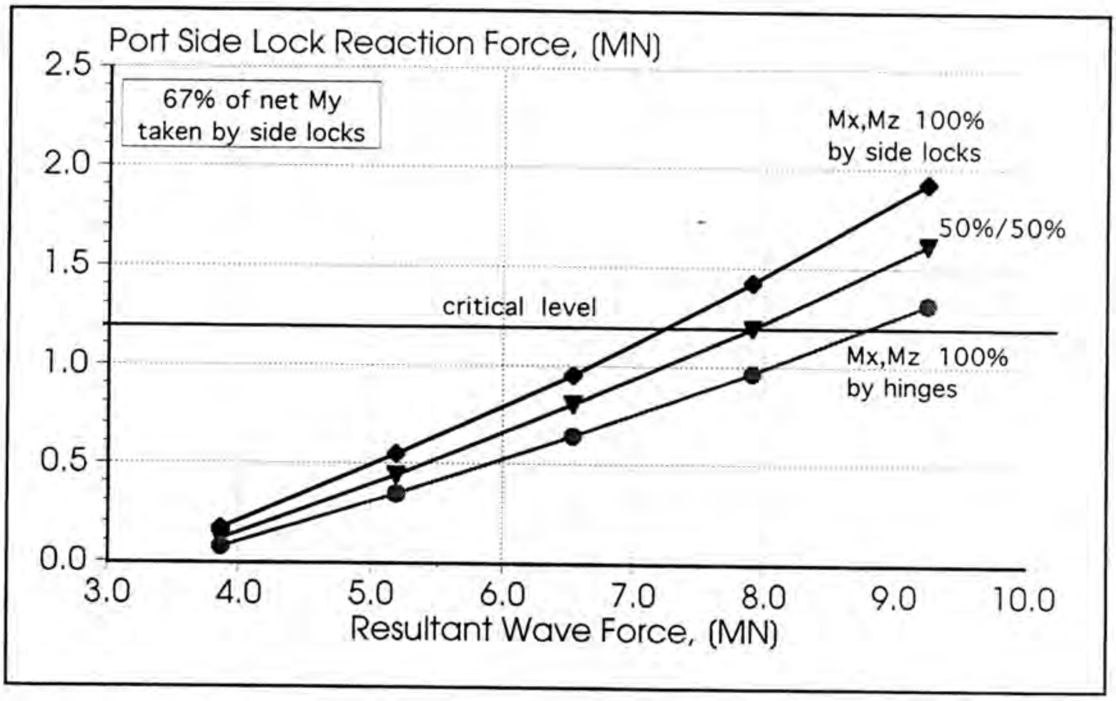

Figure 2.5 Example of influence from Mx,Mz distribution between hinges and side locks

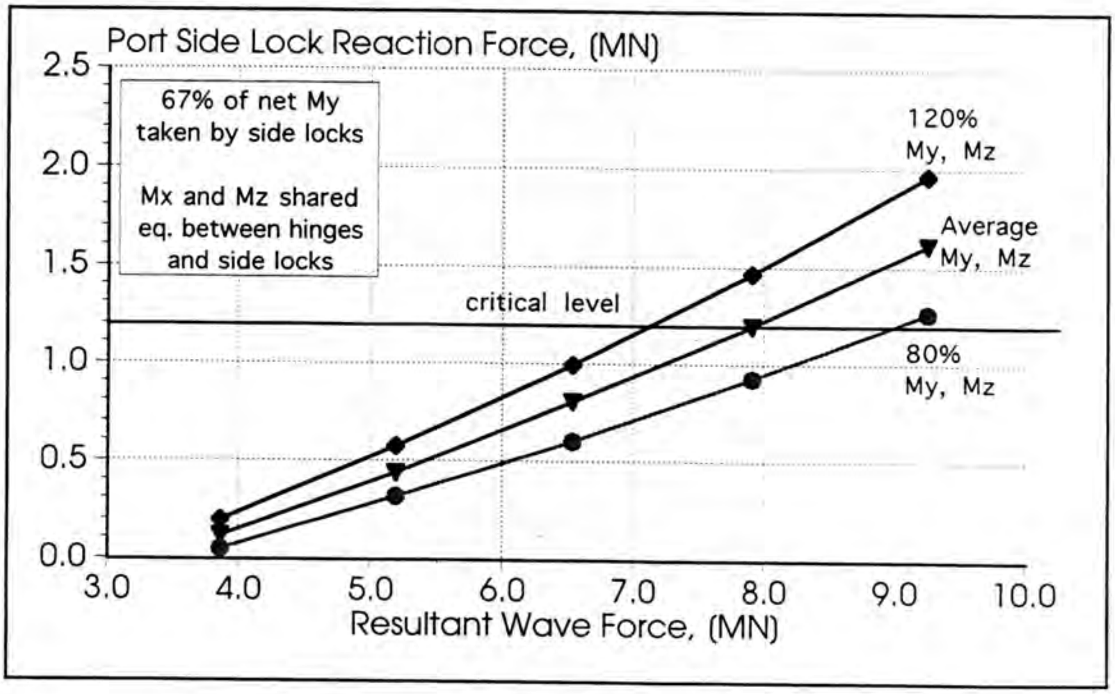

Figure 2.6 Example of influence from variation in My,Mz level

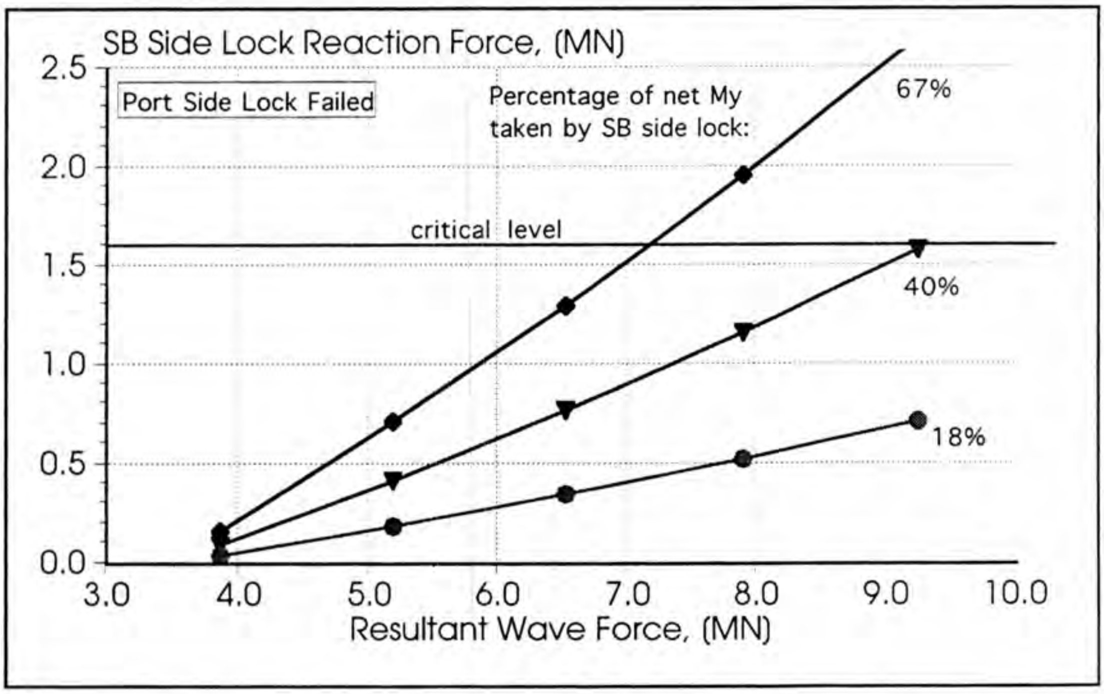

Figure 2.7 Reaction in starboard side lock after port side lock has failed

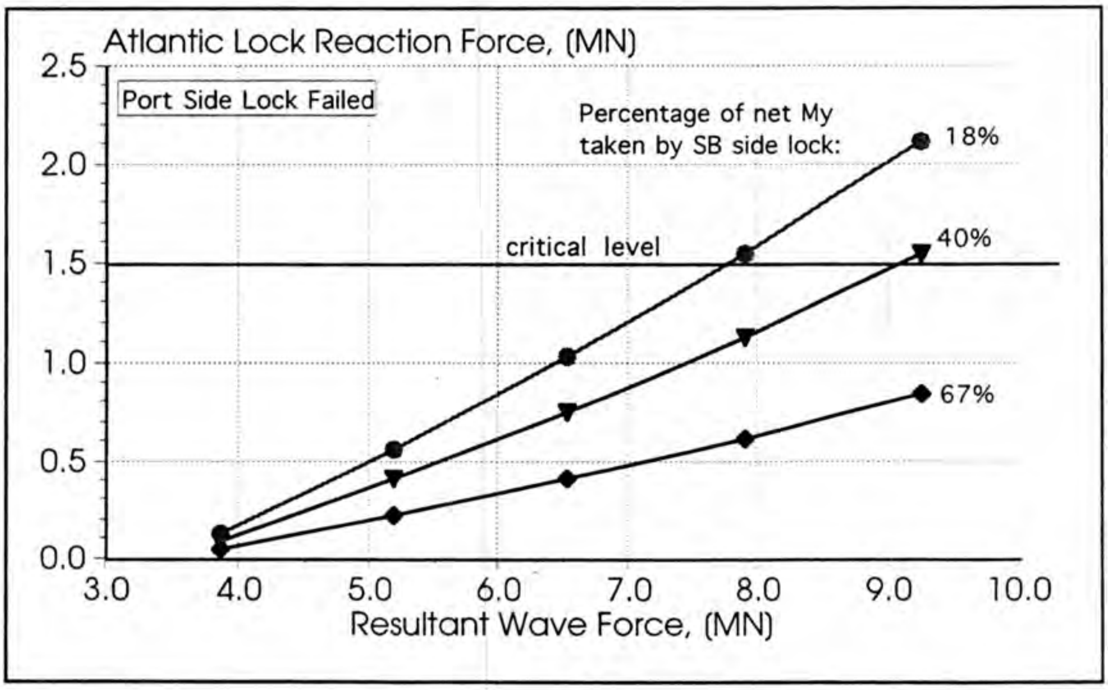

Figure 2.8 Reaction in Atlantic lock after port side lock has failed

SUPPLEMENT No. 410

Trägårdh Peter:

Model test with M/S ESTONIA. Sea loads on bow visor and yawing behaviour due to heel.

SSPA Maritime Consulting. Report 7524.

Gothenburg 1995.

EX 3(5)

STATENS HAVERIKOMMISSION
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SSPA

MARITIME CONSULTING

REPORT

Subject	Report
Model tests with M/S Estonia **Sea loads on bow visor and yawing behaviour due to heel.**	7524 Project manager Peter Trägårdh
Customer/Contact Statens Haverikommission Box 12538, 102 29 STOCKHOLM Börje Stenström	Author Peter Trägårdh Date 1995-12-05
Order Fax dated 1995-05-18	Code of classification

Summary

Model tests with a self-propelled model of M/S Estonia have been carried out in both the towing tank and the Maritime Dynamics Laboratory (MDL) in order to study the wave induced loads on the bow visor. At the tests in the towing tank the model was free to heave, trim and roll and the model speed was equal to the towing carriage while in MDL the model was completely free to move in all 6 degrees of freedom and controlled by an autopilot.
As an example the maximum expected wave and response during abt 3 hours in irregular bow sea with a significant wave height Hs= 4.3 m at a speed of 14.5 knots, which have been claimed to be the most probable condition preceding the accident, can be derived from these tests. Thus the highest wave would be 8.4 m, the upward vertical force 7.4 MN and opening deck hinge moment 35.4 MNm.

Some tests were carried out in order to study the yawing behaviour at different heel angles. The ship did not yaw as would be expected due to the curved waterline at heel, i.e. to port at a starboard heel. This could be explained by the negative pressures forward of the two propellers running with the same thrust creating steering forces that are larger than and opposite to those created by the unsymmetric curved waterline at heel.

SSPA Maritime Consulting AB

Jim Sandkvist

Peter Trägårdh

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Contents

SSPA MARITIME CONSULTING

1. Introduction

Model tests with a model of M/S Estonia have been carried on behalf of Statens Haverikommission (Board of Accident Investigation) in Stockholm. The purpose of the tests was to measure the wave induced loads on the bow visor in different waves and speeds at head and bow seas.
The yawing behaviour caused by the heeling of the ship due to water flooding was also studied.

The test program was decided in co-operation with a SHK representative who also was present at the tests in SSPA Maritime Dynamics Laboratory (MDL). The main object was to get a good statistical basis for estimation of actual loads on the bow visor. The most effective way was to run a long (abt 5 hours full scale time) head sea condition in the towing tank, a reasonable long (abt 3 hours) bow sea condition in MDL and further shorter conditions in both tanks.

2. Model test data

Model tests were carried out in SSPA towing tank on June 19-20 and in MDL on June 28 - July 1. Main data for test conditions (full scale data):

Ship Model			2758-A
Scale			1:35
Length, Lpp		(m)	137.40
Beam		(m)	23.59
Draft			
moulded	forward	(m)	5.17
	aft	(m)	5.61
Displacement		(m^3)	11930
		(tonnes)	12050
Block coefficient		(-)	0.683
LCB		(% aft L/2)	4.85
GM (corr)		(m)	1.17
Rudder	No of rudders		2
	Height	(m)	4.0
	Area, tot/rud	(m^2)	10.85
	- , mov/rud	(m^2)	8.75
	- , tot	(% of L·T)	2.90
Propeller	No of propellers		2
	No of blades	(-)	4
	Diameter	(m)	4.200
	Pitch Ratio	(-)	0.868
	Model No		P1757 (left and right rotating outward)

Photos, body plan and contours of the model is given in figs 1-5. The model was fitted with bilge keels, duck-tail, bow and rudder ice knifes, controllable rudders and a separate bow visor attached to the model with a six-component balance (fig 6).

3. Wave tests in the towing tank

At the tests in the towing tank the model was free to move in heave, roll and pitch. Although self-propelled the model was connected to the carriage with a towing rod including a x-force gauge. The propeller rpm was calibrated to give zero towing force in calm water. Thus the measured force gives some information about the added resistance in head waves. The speed of the model was constant during the test and the same as the carriage.

However the main object of the tests was to measure forces and moments on the bow visor caused by the wave impact. The wave profile was measured both some distance ahead of the model where the waves are undisturbed by the model and the tank walls but also abt 4 m beside the model at the same longitudinal position as the forward perpendicular (FP) thus providing information for calculation of relative motion as the vertical motion at FP was measured. In addition the vertical acceleration at FP was measured.

The following table gives the test program. In order to get desired amount of statistical bases several test runs were carried out in irregular sea. For the analysis the time series of measuring parameters for all runs for each test condition were added together.

Tests in SSPA towing tank on June 19-20 1995

Run 4-5	Irregular head sea	Hs= 4.0 m - Tp= 8.0 s,	10 knots	
6-31	Irregular head sea	Hs= 4.0 m - Tp= 8.0 s,	15 knots	
32-33	Irregular head sea	Hs= 4.0 m - Tp= 8.0 s,	19 knots	
34-35	Irregular head sea	Hs= 5.5 m - Tp= 8.0 s,	10 knots	
36-37	Irregular head sea	Hs= 5.5 m - Tp= 8.0 s,	15 knots	
38-40	Irregular head sea	Hs= 5.5 m - Tp= 8.0 s,	19 knots	
41	Irregular head sea	Hs= 5.5 m - Tp= 8.0 s,	15 knots	
42	Irregular head sea	Hs= 5.5 m - Tp= 8.0 s,	10 knots	
46	Regular head sea	H = 4.0 m - T = 9.3 s,	10 knots	(λ/L= 1.0)
47	Regular head sea	H = 4.0 m - T = 9.3 s,	15 knots	(λ/L= 1.0)
48	Regular head sea	H = 4.0 m - T = 9.3 s,	19 knots	(λ/L= 1.0)
49	Regular head sea	H = 4.0 m - T = 8.0 s,	10 knots	(λ/L= 0.74)
50	Regular head sea	H = 4.0 m - T = 8.0 s,	15 knots	(λ/L= 0.74)
51	Regular head sea	H = 4.0 m - T = 8.0 s,	19 knots	(λ/L= 0.74)

Irregular waves of JONSWAP spectrum.

4. Wave tests in MDL

At the tests in MDL the model was completely free to move in all six degrees of freedom, self-propelled and controlled by an autopilot. An X-Y-positioner (measuring arm) is the only link between the carriage and the model. The deviation in position between model and carriage are fed into a steering computer which controls the carriage to "hunt" the model. The measuring arm also provide measuring signals for calculation of all 6 DoF motions and from this the vertical motion at FP could be calculated.

The propeller rpm was adjusted to give the desired mean speed during the test run.
The wave profile was measured at a position abt 2 m starboard of the model (leeward side), longitudinally adjusted so that the wave meets the FP of the ship at the same time. Thus the relative motion could be calculated as the difference between the wave height and the vertical motion at FP.

The following table gives the test program. In order to get desired amount of statistical bases several test runs were carried out in irregular sea. For the analysis the time series of measuring parameters for all runs for each test condition were added together.

Tests in SSPA Maritime Dynamics Laboratory on June 28-30

Run	7-13	Irregular head sea	Hs= 4.0 m - Tp= 8.0 s,	15 knots
	15	Regular head sea	H = 4.0 m - T = 8.0 s,	15 knots (λ/L= 0.74)
	18	Regular bow sea	H = 4.0 m - T = 8.0 s,	15 knots (λ/L= 0.74)
	20	Regular bow sea	H = 4.0 m - T = 8.0 s,	10 knots (λ/L= 0.74)
	22	Regular bow sea	H = 6.0 m - T = 8.0 s,	15 knots (λ/L= 0.74)
	34-37	Irregular bow sea	Hs= 4.0 m - Tp= 8.0 s,	10 knots
	39-40	Irregular bow sea	Hs= 4.0 m - Tp= 8.0 s,	10 knots
	45-46	Irregular bow sea	Hs= 4.0 m - Tp= 8.0 s,	10 knots
	48-55	Irregular bow sea	Hs= 5.5 m - Tp= 8.0 s,	10 knots
	56-66	Irregular bow sea	Hs= 5.5 m - Tp= 8.0 s,	15 knots
	67-116	Irregular bow sea	Hs= 4.3 m - Tp= 8.3 s,	14.5 knots

Irregular waves of JONSWAP spectrum is used as it is representative for the relatively shallow water of the actual area of the Baltic sea and for a relatively young storm with the energy concentrated around the peak period Tp. It generally means more severe (conservative) response that the more commonly used Pierson-Moskowitz or ITTC spectrum.
It should also be noted that all tests have been run in long-crested sea which generally give more conservative response but also is considered as more representative for a young storm.

5. Manoeuvring tests in MDL

The background for running manoeuvring tests was a theory that the starboard heel angle caused by the water flooding of the ro/ro deck would make the ship yaw to port regardless of the autopilot trying to keep course by compensating with a starboard rudder angle. This yawing was expected to be explained by the unsymmetric curved waterline profile of the hull due to heel.

Due to practical testing reasons the weights used instead of water to heel the ship had to be placed on the port rail thus providing a port heel angle. The following static heel angles were achieved with weights placed on the port rail:

Scale		Heel
model	full	angle
5 kg	214 ton	8.7°
10 kg	428 ton	15.3°
15 kg	643 ton	21.5°
20 kg	857 ton	27.2°
22.5 kg	965 ton	30.3°

Manoeuvring tests at an initial speed of 14.5 knots:

Run no
23: 5 kg at L/2 - autopilot in calm water
24: 10 kg at L/2 - autopilot in calm water
25: 15 kg at L/2 - autopilot in calm water
26: 15 kg at L/2 - zero rudder in calm water
27: 20 kg at L/2 - zero rudder in calm water
29: 15 kg at L/2 - autopilot in bow sea -150°
30: 15 kg at L/2 - zero rudder in bow sea -150°
31: 15 kg aft - zero rudder in calm water
32: 15 kg at L/2 - initial rudder at 30° put to zero in calm water
38: 15 kg at L/2 - zero rudder in calm water - only starboard propeller running
41: 15 kg at L/2 - zero rudder in calm water - only starboard propeller running
42: 15 kg at L/2 - zero rudder in calm water - only port propeller running
43: 0 kg at L/2 - zero rudder in calm water - only port propeller running

From runs 23-25 it could be concluded that there was no problem for the autopilot to maintain a straight course using only moderate rudder angles. Thus it was decided to lock the rudder in a position that provided the most straight course in calm water without heel, i.e. starboard 1.8 deg called zero rudder. Runs 26-27 gave a clear indication that the ship turned the unexpected way, i.e. port heel gives port yaw. The tests in waves with autopilot confirmed the good steering behaviour in calm water and with zero rudder the ship turned to port just as before.
There was no significant change of behaviour if the weights were place as far aft as possible (cf run 26 and 31).

At run 32 the test started with a starboard rudder angle just to initiate a starboard turn. After put to zero rudder the yaw rate decreased and probably it would have turned port if the dimension of the basin had been large enough.
By stopping the port propeller the port yawing was increased (cf runs 26, 38 and 41).
At runs 41-43 the initial speed was reduced to 12 knots, i.e. the approximate steady speed with one propeller running at the same rpm as corresponding to 14.5 knots with both propellers.
By stopping starboard propeller the ship turned the other way (run 42) but not at all as much as with port propeller stopped (cf run 41 and 42).
Time traces from all manoeuvring tests are given in the appendix [1] to this report and as an illustration runs 23-24 are given here (fig 19-20).

6. Results and conclusive remarks

Definitions of co-ordinate system, motions and wave direction are given in fig 11. Note that the height of the wave crest is negative and that negative relative motion means decreasing free-board. Standard statistics of relevant parameters from all tests are given in the appendix to this report [1]. Note that the period Tz is the zero-crossing period of encounter and that amplitudes marked with * means single amplitudes and ** double amplitudes. Time series and Weibull diagrams of relevant parameters and tests are also given in [1] but some examples are included here (fig 12-16).

The Weibull diagram is a special form of showing a statistical distribution and is a straight line with an inclination of 2.0 for a Rayleigh distribution which seems to be the case for the waves. For the forces and especially the moments the inclination is smaller and the highest values fall out of line probably because of too low statistical occurrence.

The measured Z-force has been corrected for the difference in mass of the model visor (2.98 kg corresponding to 127.8 ton in full-scale) and the full-scale visor (53.0 ton) to a nominal value, called Z-force nom. Also the pure dynamic wave load, Z-force dyn, has been calculated. The measured moments have been transformed to the deck hinge of the visor (Yh-moment) which also is corrected for the mass difference.
It should be noted that the weight of the visor is not included in the Z-force.

Time series of relative motion, X and Z-forces and Yh-moment are given for the most probable condition (14.5 knots in bow waves of Hs= 4.3 m and Tp= 8.3 s) in fig 13 . Note the very similar X and Z-forces (fig 13 c and d) with the upwards negative force peaks. From fig 13 e it is obvious that the opening positive deck hinge moment peaks do not occur as frequently as the vertical force peaks while the relative motion (fig 13 b) has the same frequency as the encountering wave.

In the tables below the maximum values from the Weibull diagrams are read. No of encounters have been calculated from ln(-ln(1-P(x))) where P(x) is the probability for a certain value to be exceeded. Hm is the height of the largest following crest and trough.

Towing tank tests - irregular sea

Dir	Hs	Speed	Waves		Rel mot (neg)		Z-force		Yh-moment	
			No	Hm	No	(m)	No	MN	No	MNm
180	4.0	10	357	6.33	301	-5.69	77	-1.8	178	1.8
180	4.0	15	3914	8.19	3018	-7.60	538	-6.2	55	18.2
180	4.0	19	301	7.29	211	-5.70	51	-8.5	14	16.8
180	5.5	10	662	9.55	538	-7.41	119	-6.3	38	18.5
180	5.5	15	459	9.07	392	-6.94	151	-5.9	55	14.2
180	5.5	19	424	9.55	301	-7.84	151	-8.1	45	27.5

Max values recalculated to the same probability level corresponding to 1618 wave encounters meaning Prob= ln(-ln(1-P(x))) =2.0 where (1-P(x))=1/1618 and which have been calculated proportionally with respect to no of encounters of each parameter and extrapolated (interpolated) in the Weibull diagrams:

Dir	Hs	Speed	Waves		Rel mot(neg)		Z-force		Yh-moment	
			Prob	Hm	Prob	(m)	Prob	MN	Prob	MNm
180	4.0	10	2.0	7.02	1.977	-6.02	1.767	-2.5	1.901	1.4
180	4.0	15	2.0	7.68	1.964	-7.38	1.687	-4.6	1.139	12.0
180	4.0	19	2.0	8.19	1.951	-7.20	1.725	-5.9	1.464	28.0
180	5.5	10	2.0	10.05	1.972	-9.55	1.736	-6.2	1.511	22.5
180	5.5	15	2.0	9.55	1.978	-8.95	1.837	-7.0	1.662	21.4
180	5.5	19	2.0	10.31	1.952	-9.42	1.850	-10.0	1.638	39.6

MDL tests - irregular sea

Dir	Hs	Speed	Waves		Rel mot (neg)		Z-force		Yh-moment	
			No	Hm	No	(m)	No	MN	No	MNm
180	4.0	15	363	8.84	301	-7.41	62	-5.0	5	14.9
150	4.0	10	363	8.08	301	-6.68	71	-2.4	45	3.4
150	5.5	10	363	9.55	301	-8.50	71	-7.3	17	31.6
150	5.5	15	363	10.05	251	-8.51	71	-10.8	20	54.8
150	4.3	14.5	1618	8.40	1280	-7.60	301	-7.4	67	35.4

Max values recalculated to the same probability level corresponding to 1618 wave encounters meaning Prob= ln(-ln(1-P(x))) =2.0 and extrapolated in the Weibull diagrams (fig 15-16):

Dir	Hs	Speed	Waves		Rel mot (neg)		Z-force		Yh-moment	
			Prob	Hm	Prob	(m)	Prob	MN	Prob	MNm
180	4.0	15	2.0	8.62	1.974	-6.42	1.727	-3.8	1.133	17.0
150	4.0	10	2.0	8.51	1.974	-7.68	1.750	-2.9	1.668	3.6
150	5.5	10	2.0	12.18	1.974	-9.92	1.750	-7.9	1.465	44.5
150	5.5	15	2.0	11.72	1.949	-9.31	1.750	-11.7	1.502	43.5
150	4.3	14.5	2.0	8.40	1.968	-7.60	1.742	-7.4	1.436	35.4

The maximum expected response (single amplitude) during 1618 wave encounters (abt 3 hours) have been plotted versus ship speed in fig 18. There do not seem to be a clear connection between relative motion/velocity, vertical force on visor and deck hinge moment, which is quite surprising. From the video recordings from the tests it seems likely that high deck hinge moment is in some way connected to a steep high wave hitting the visor high up. This explains why the highest vertical forces do not occur at the highest vertical motion and velocity and that high vertical forces can occur without causing large hinge moments.
Thus the maximum expected upward vertical force during 3 hours would be 7.4 MN and opening deck hinge moment 35.4 MNm for the most probable condition, i.e. 14.5 knots in bow irregular sea Hs= 4.3 m. However this does not occur due to the highest wave (Hm= 8.4 m) but for a wave of 6.5 m height as could be seen in the time series (fig 13-14).

Complete results from the tests in regular waves are given in the appendix and in fig 17 the most interesting results are plotted. Note that the distribution of peak values has not been calculated for the deck hinge moments from the towing tank tests. The reason is that the peak moments from the waves are very small and hardly becomes an opening moment (positive). For the worst case (run 22: 15 knots in bow sea with H= 6.0 m and T= 8.0 s) the opening deck hinge moment was only 2.1 while the closing moment was 3.3 MNm (fig 31d in the Appendix).
As an example time series from one test are given in fig 12.

The results from these model tests are similar to what could be expected in view of tests of bow loads on ro/ro ships carried out on behalf of the Swedish Shipowners' Association [2].

Manoeuvring tests

Generally a ship with a starboard heel angle should turn to port due to the change of the symmetric waterline profile of the hull to a unsymmetric curved waterline. This phenomena is sometimes called 'the banana effect' and is not very strong.
The 'unexpected' turning behaviour at the tests that were carried out here is probably caused by the negative pressures created in front of each forward working propeller. The horizontal components of these pressures acting on the V-formed sections of the aftbody cancel each other due to symmetry at zero heel, but at a starboard heel the component on the port side increases and on the starboard side decreases. The steering effect of this is likely to dominate over 'the banana effect'.

However it should be noted that these tests were carried out without any wind, which probably would have had a larger effect than 'the banana effect' on the ship making it to turn towards the wind as long as the speed was high enough. At zero speed the ship would have drifted with mainly beam wind and sea.

7. References

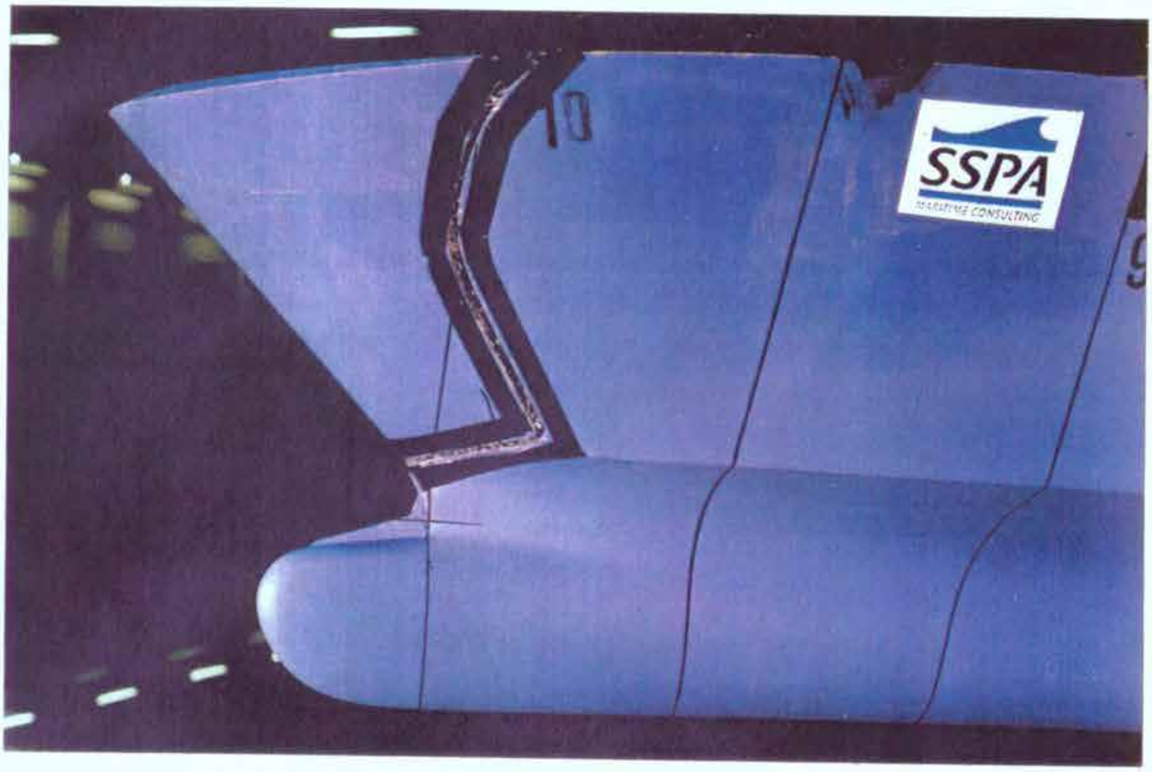
[1] P Trägårdh "Model tests with M/S Estonia - Appendix"
SSPA Report 7524-Appendix, 1995-09-20

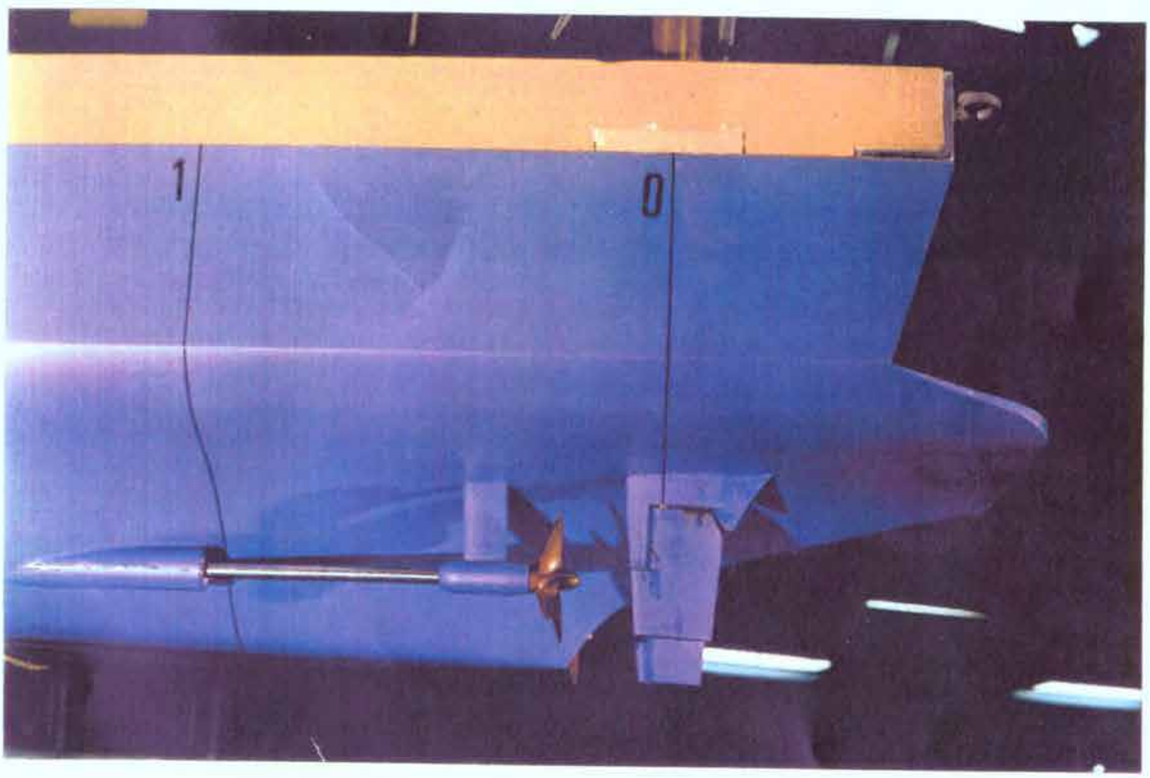
[2] J Lundgren "Bow Loads on Ro/Ro Ships - Visor forces on five different bow shapes
Model tests in regular waves and irregular seas"
SSPA Report 7315-1 , Preliminary report from 7 March 1995

8. Figures

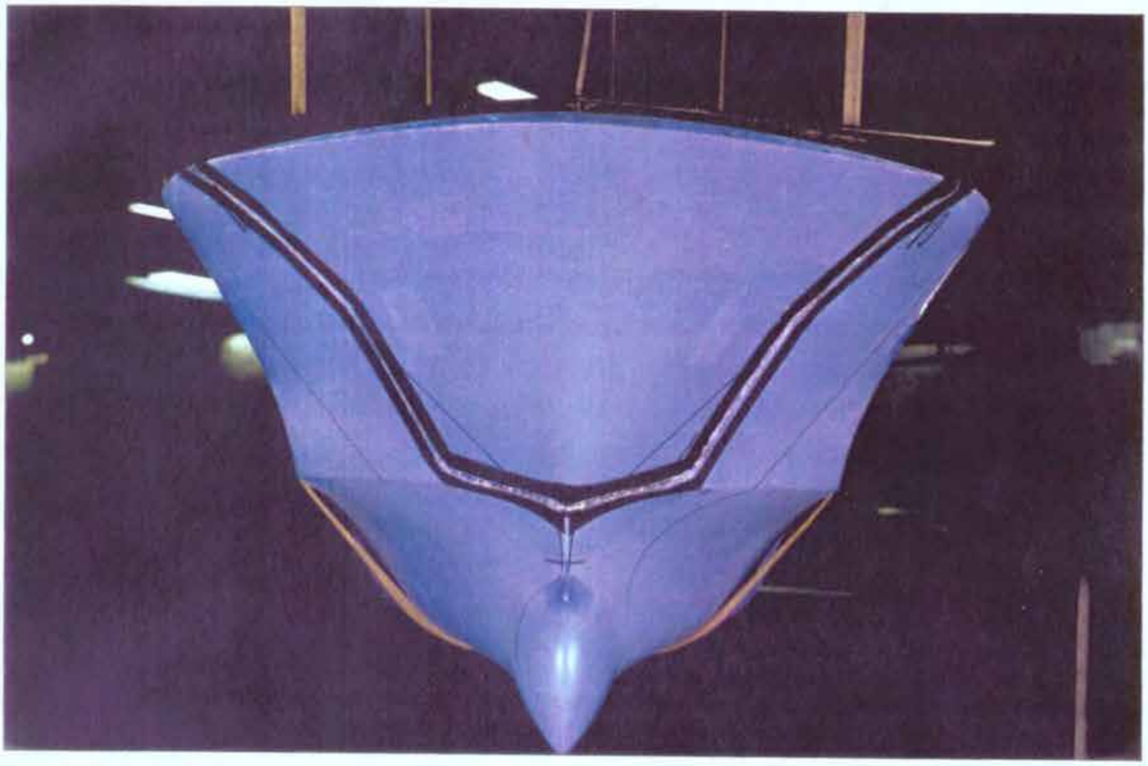
SSPA MARITIME CONSULTING	M/S Estonia SHIP MODEL 2758-A	Fig 1 Report 7524

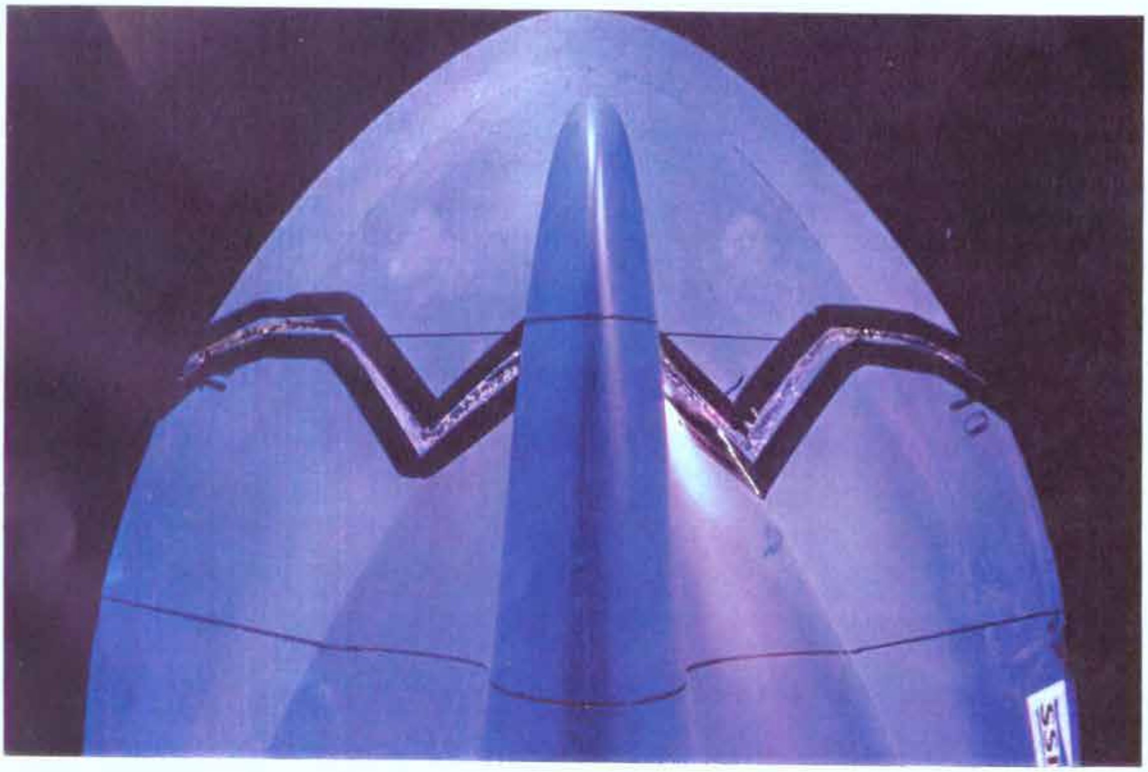
SSPA MARITIME CONSULTING	M/S Estonia SHIP MODEL 2758-A Forward and aft contours	Fig 2 Report 7524





SSPA MARITIME CONSULTING	M/S Estonia SHIP MODEL 2758-A Bow with visor	Fig 3 Report 7524



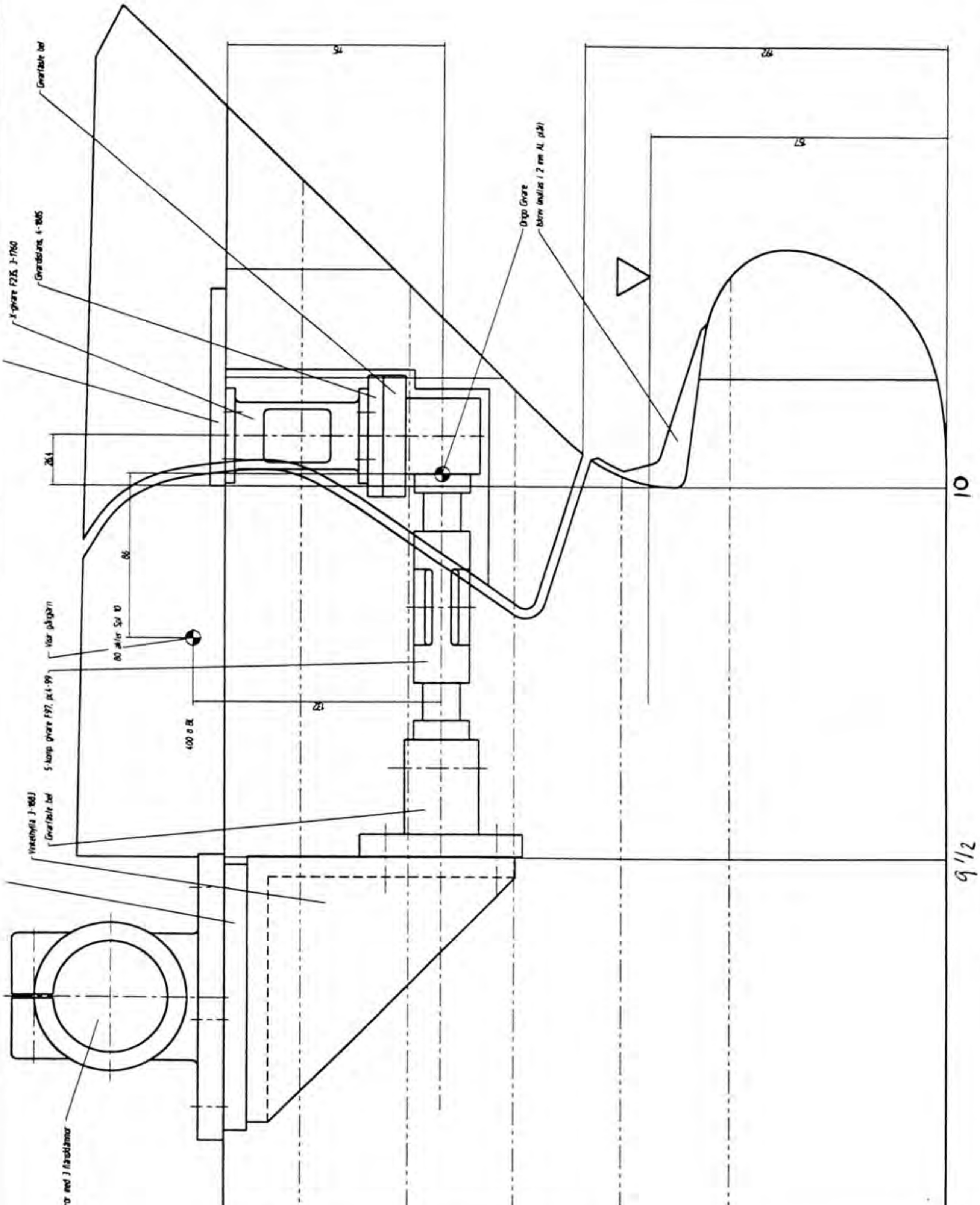


SSPA MARITIME CONSULTING

M/S Estonia

Bow visor
Arrangement for 6-comp balance

Fig	4
Report	7524



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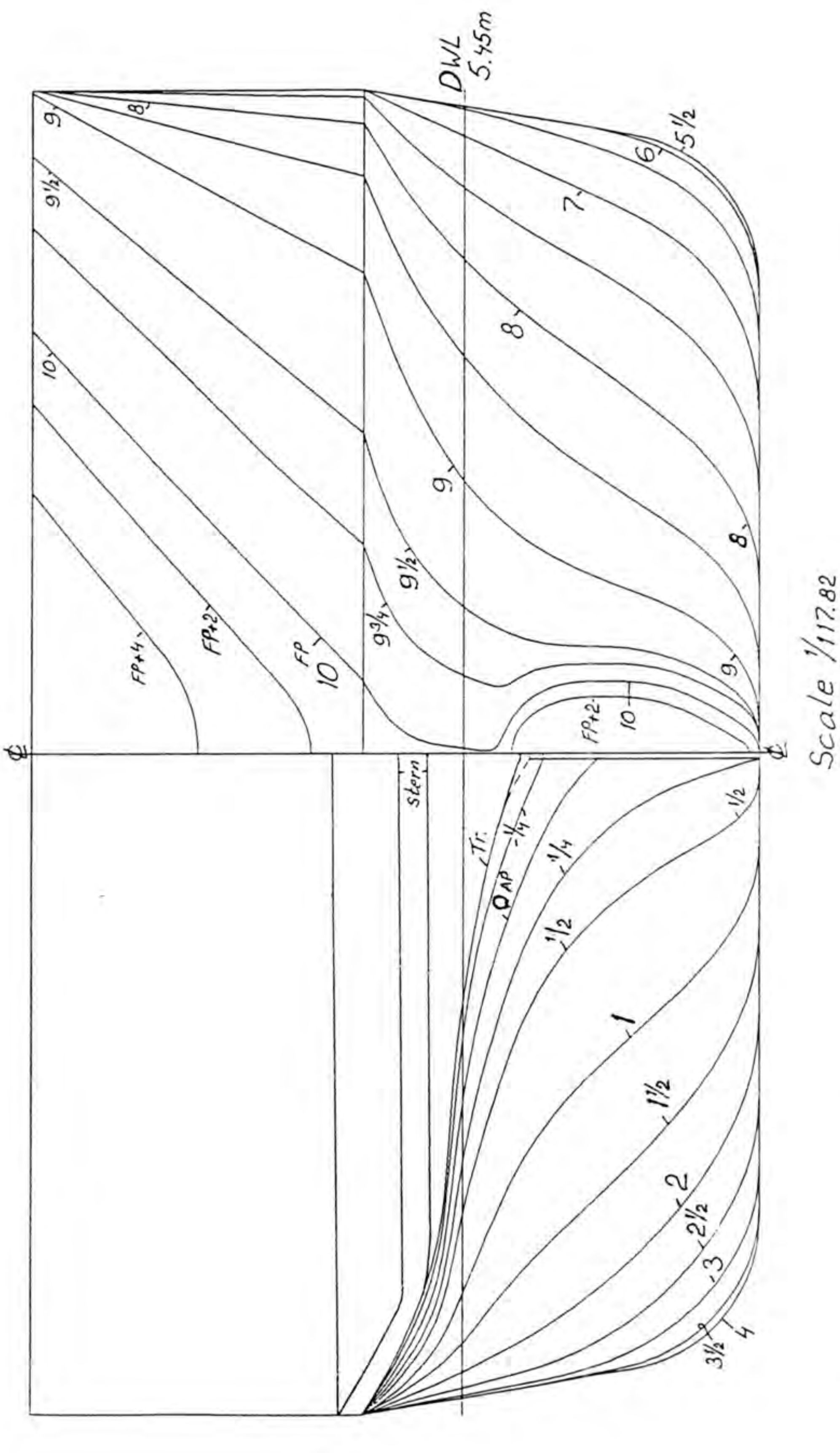
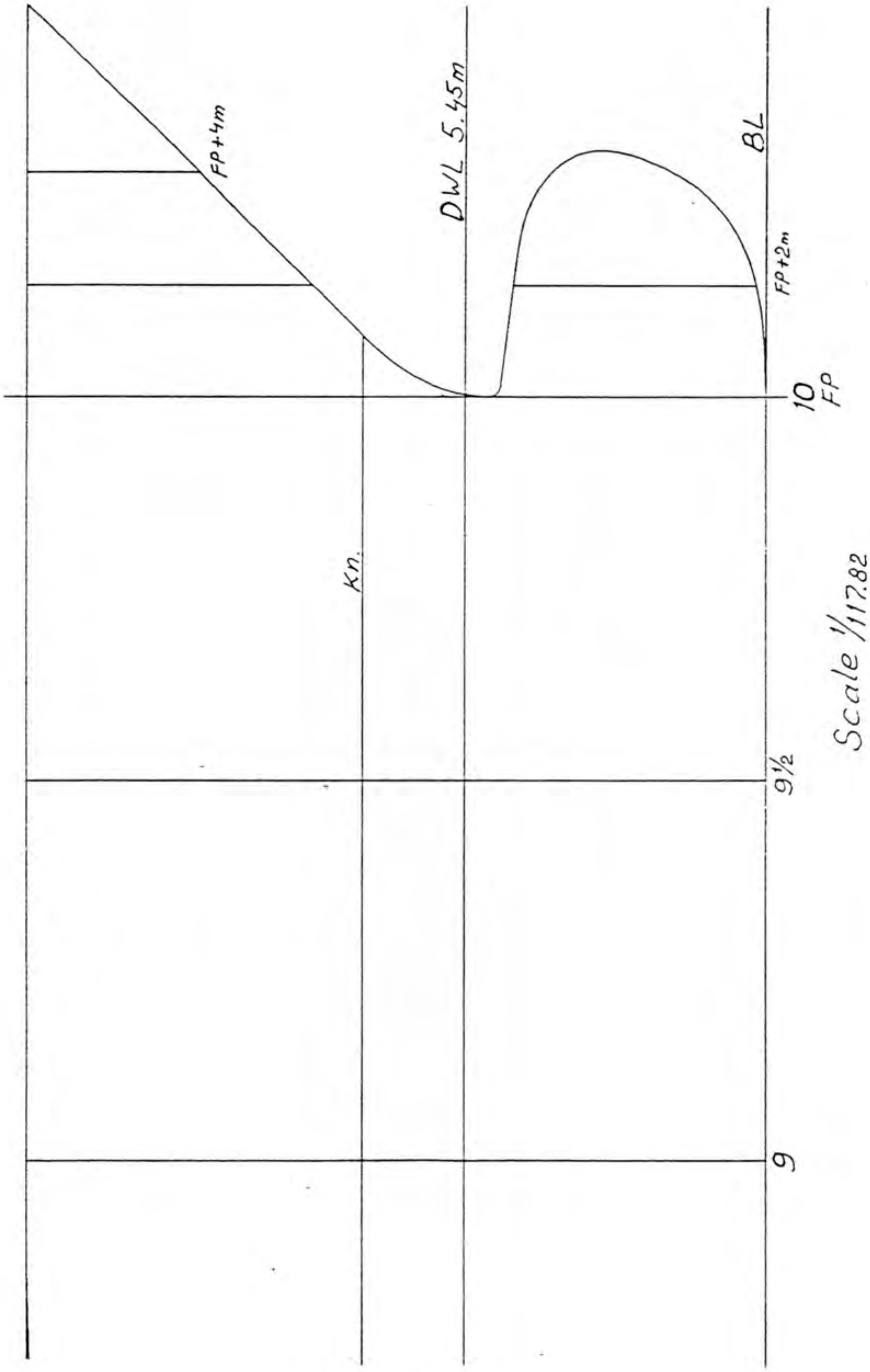
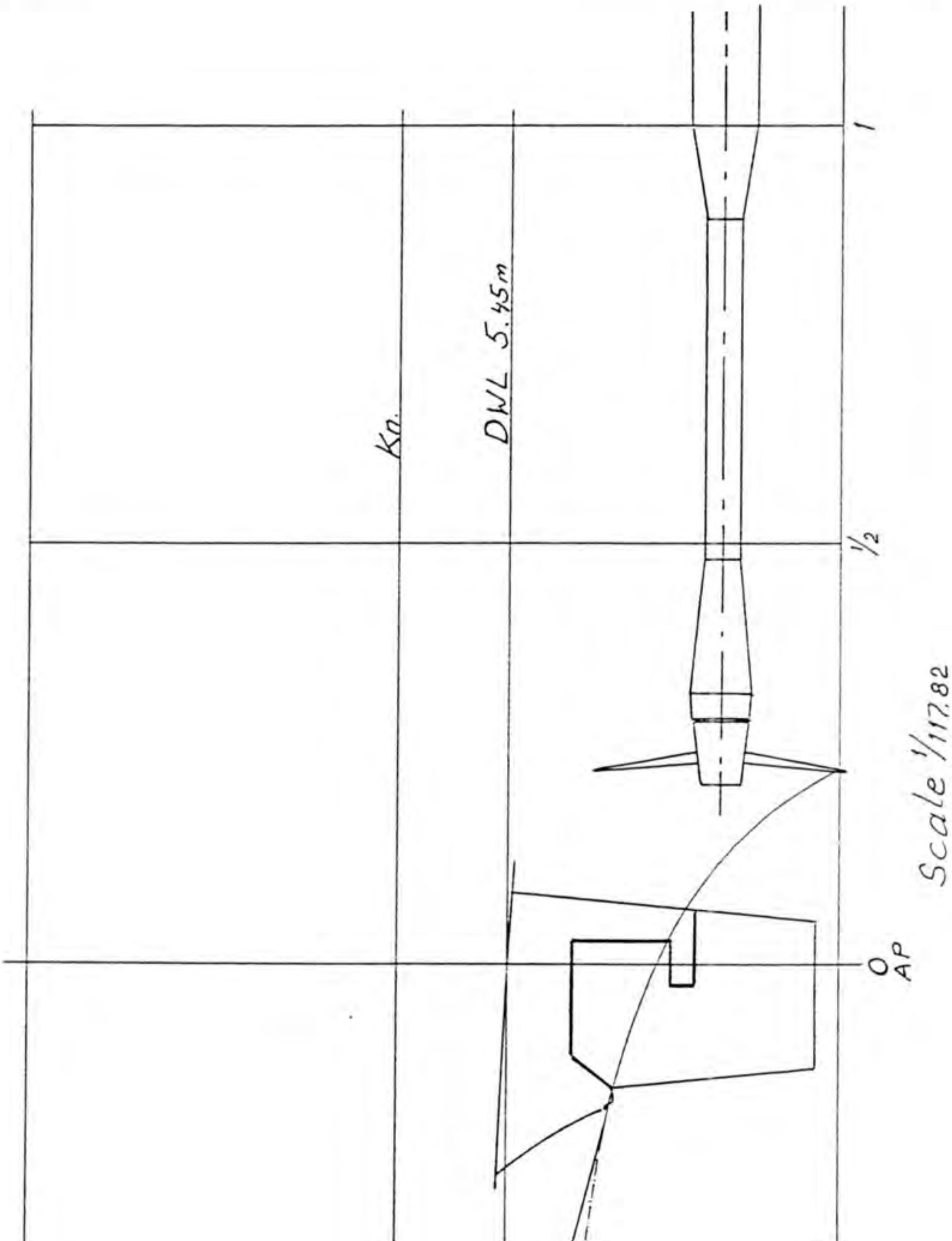
M/S Estonia Ship model 2758-A BODY PLAN	Fig 5 Report 7524



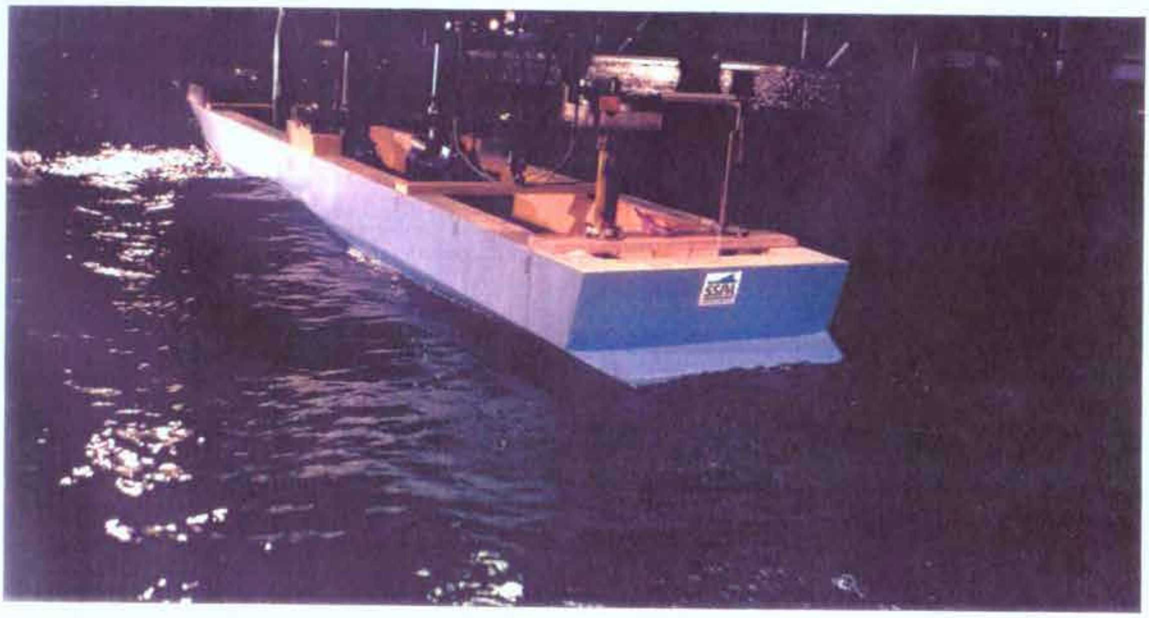
SSPA MARITIME CONSULTING	M/S Estonia Ship model 2758-A CONTOUR forward	Fig 6a Report 7524



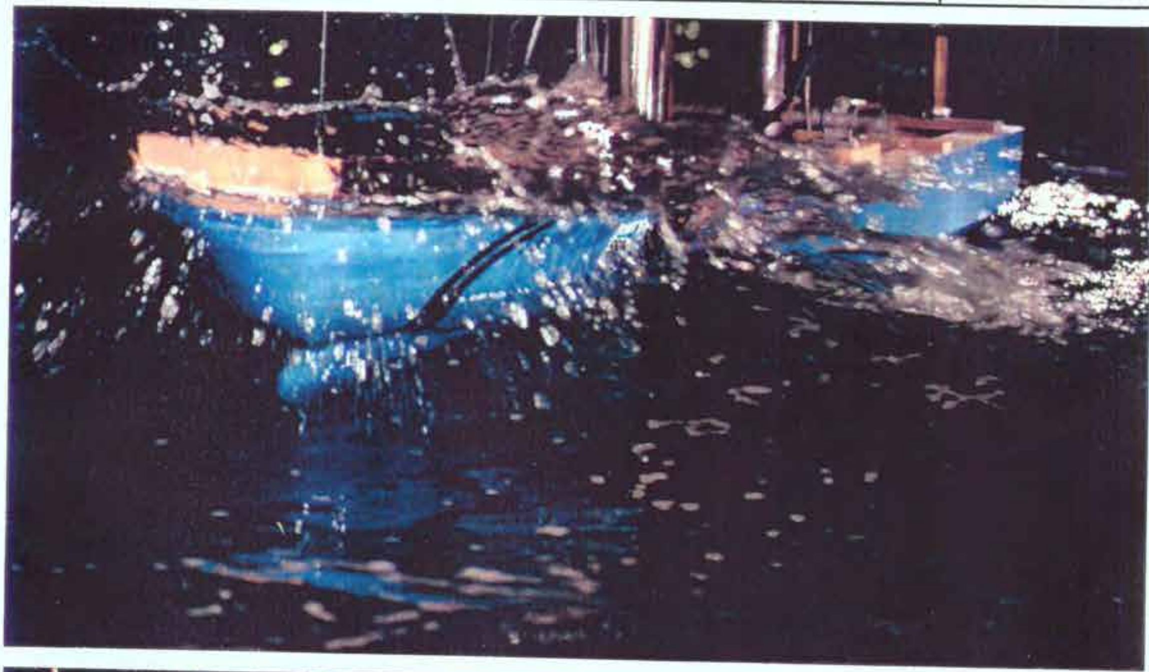
SSPA MARITIME CONSULTING	M/S Estonia Ship model 2758-A CONTOUR aft	Fig 6b Report 7524



SSPA MARITIME CONSULTING	M/S Estonia Test in towing tank Speed 15.0 knots in head sea Hs= 4.0 m	Fig 7 Report 7524



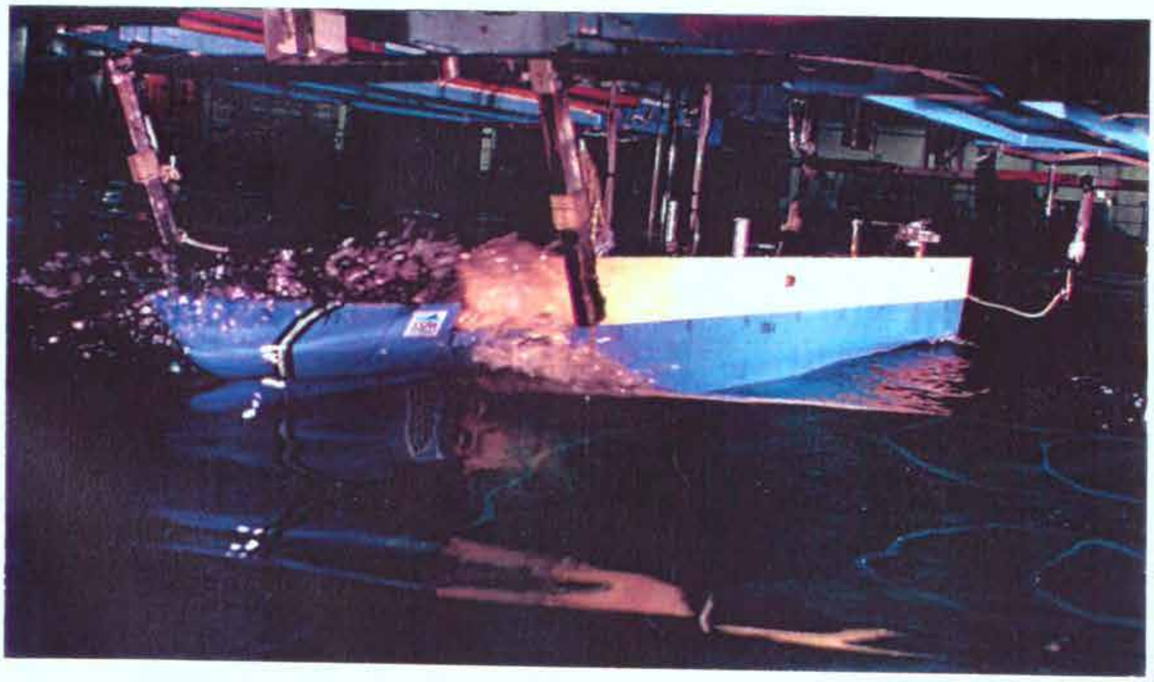
SSPA MARITIME CONSULTING	M/S Estonia Test in towing tank Speed 15.0 knots in head sea Hs= 4.0 m	Fig 8 Report 7524



Model at rest

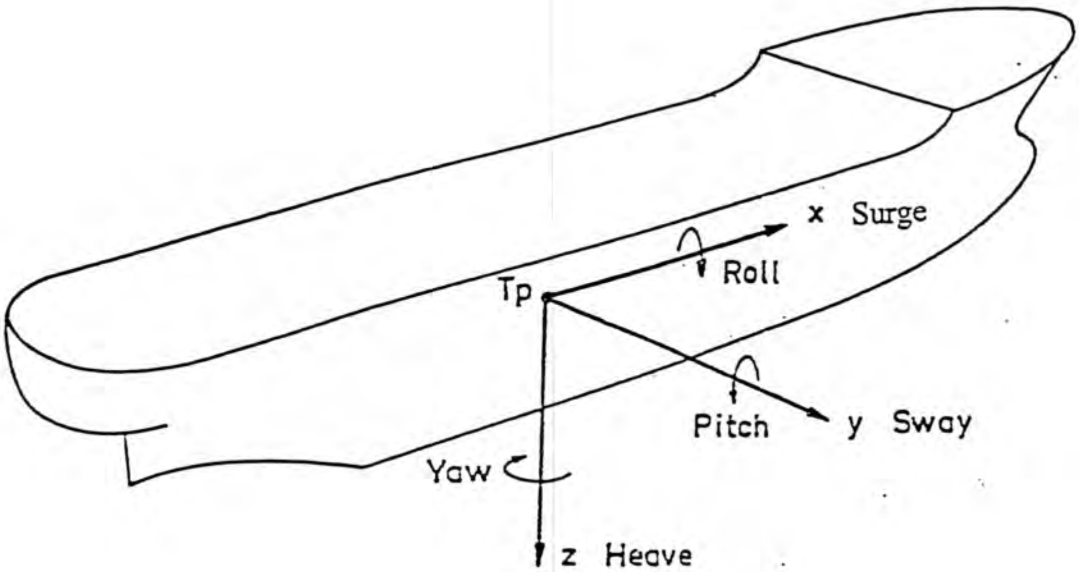
Speed 10.0 knots in bow sea Hs= 5.5 m

Speed 15.0 knots in bow sea Hs= 5.5 m

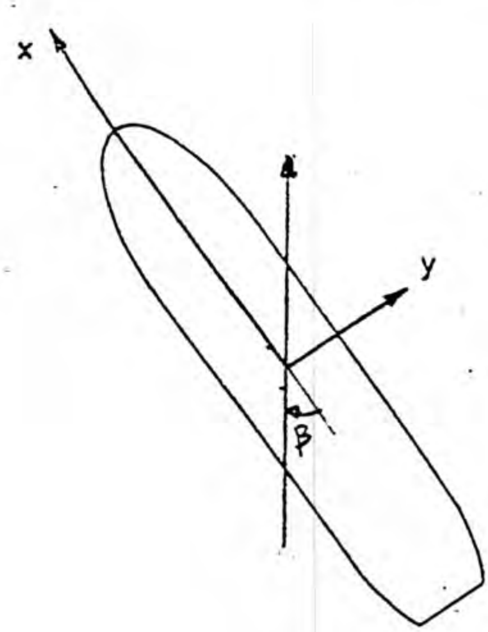


Speed 14.3 knots in bow sea Hs= 4.3 m

SSPA MARITIME CONSULTING	M/S Estonia Definitions of motions and wave direction	Fig 11 Report 7524

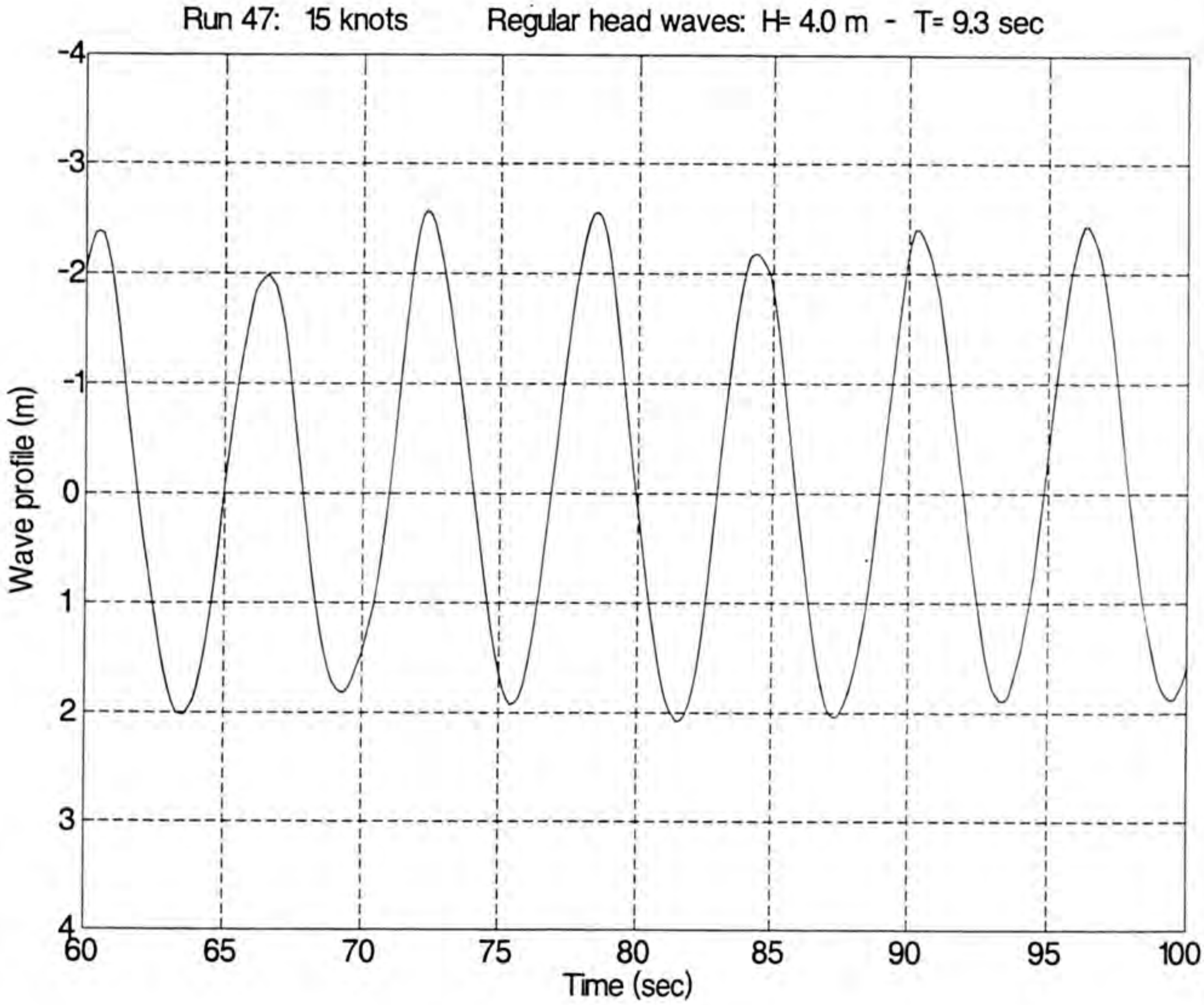


Definition of motions



Definition of wave direction

SSPA MARITIME CONSULTING	M/S Estonia Encountering wave profile Towing tank tests in regular waves Speed 15.0 knots	Fig 12a Report 7524



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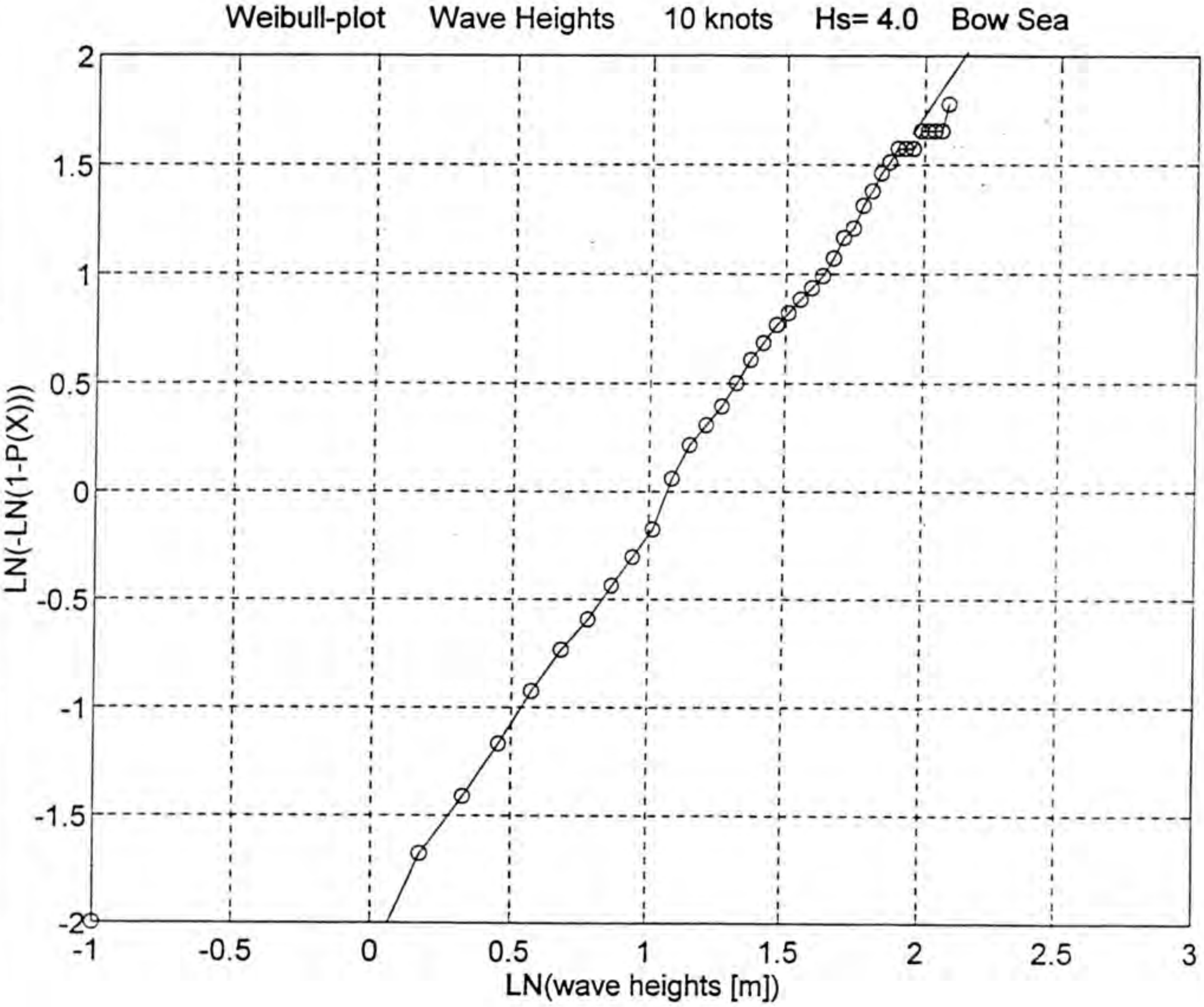
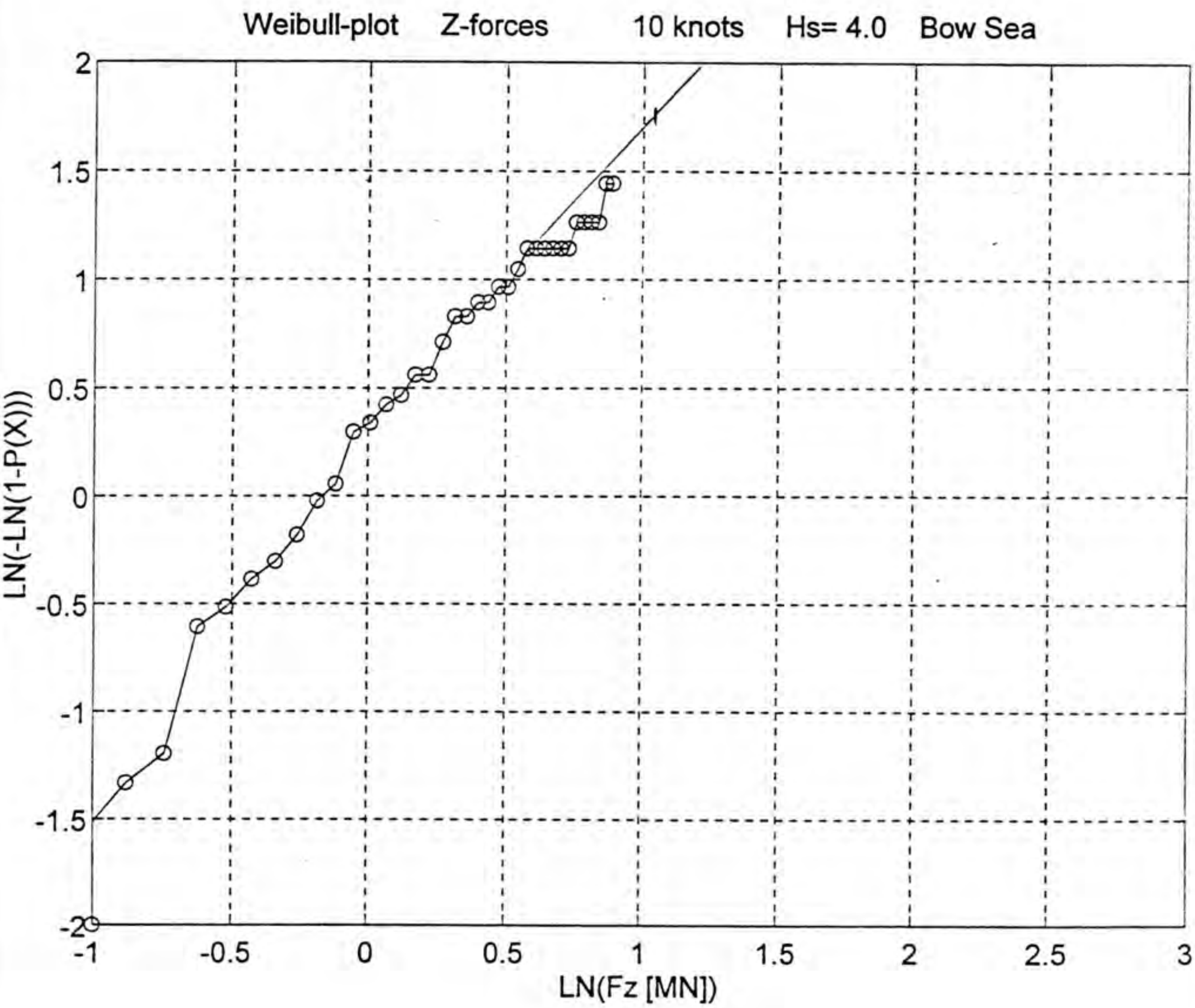
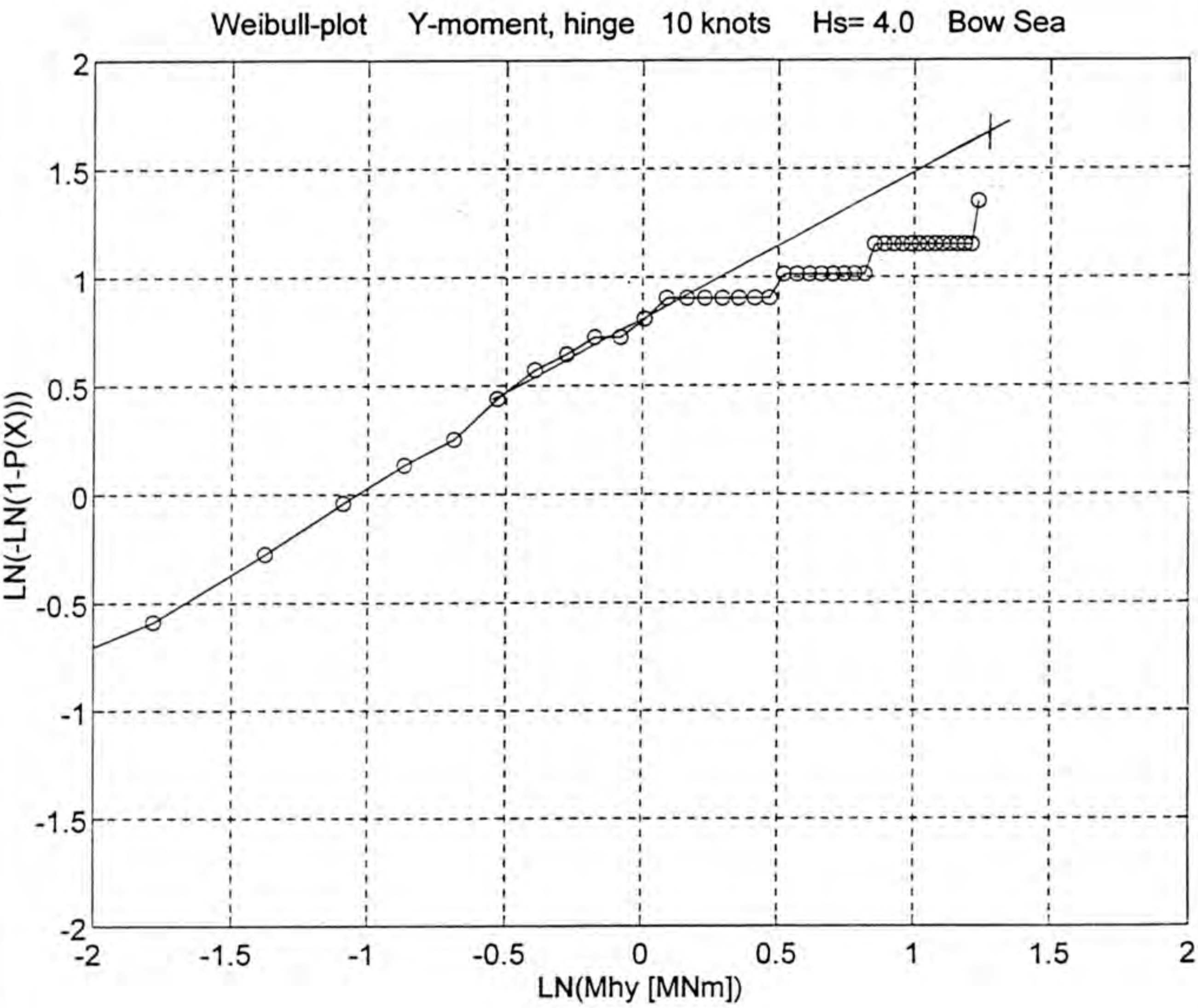
SSPA MARITIME CONSULTING	M/S Estonia MDL tests in irregular sea Weibull diagram from run 34-46: Wave height Speed 10 knots in bow sea Hs= 4.0 m	Fig 15a Report 7524



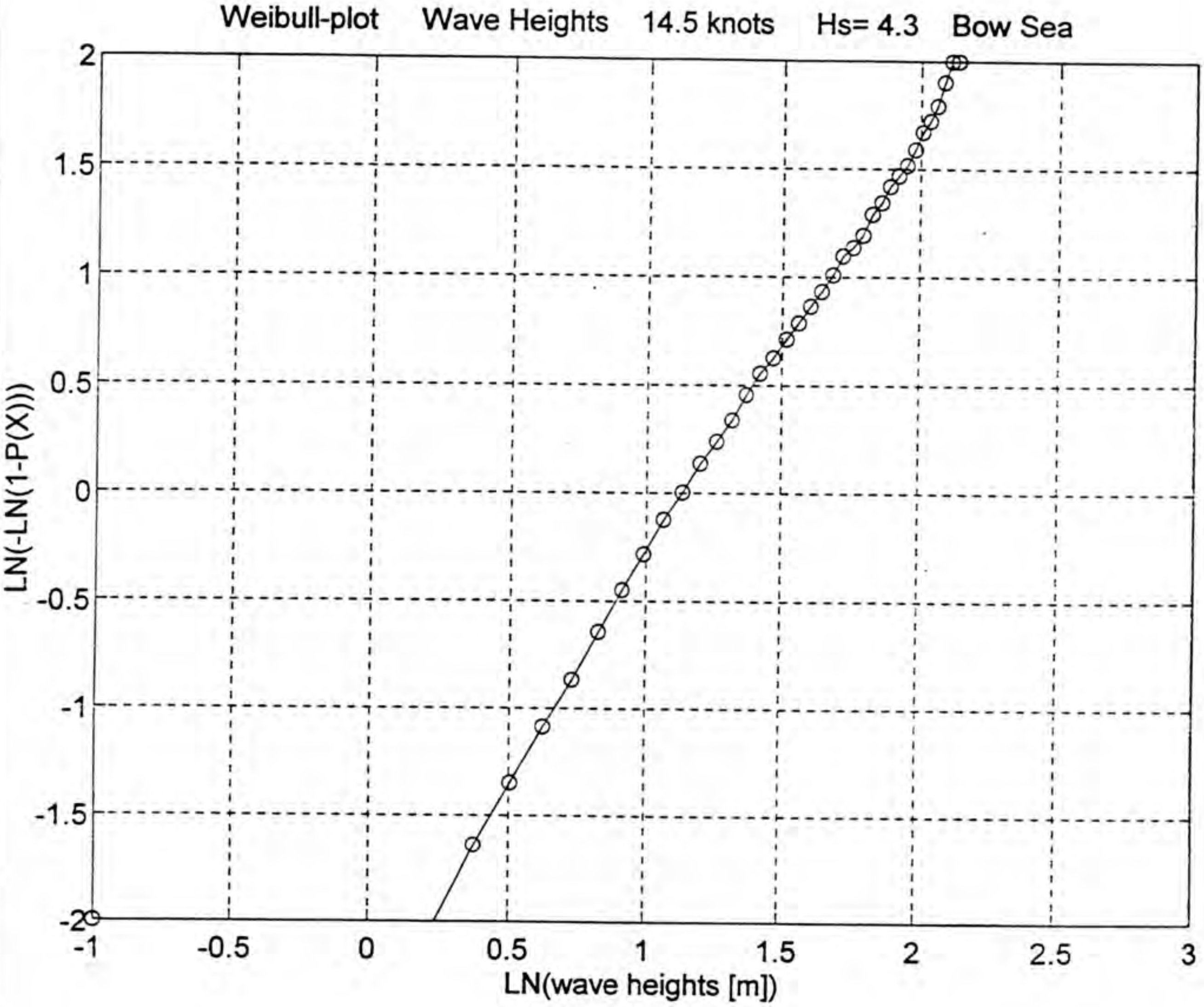
SSPA MARITIME CONSULTING	M/S Estonia MDL tests in irregular sea Weibull diagram from run 34-46: Vertical (Z) force on visor Speed 10 knots in bow sea Hs= 4.0 m	Fig 15b Report 7524



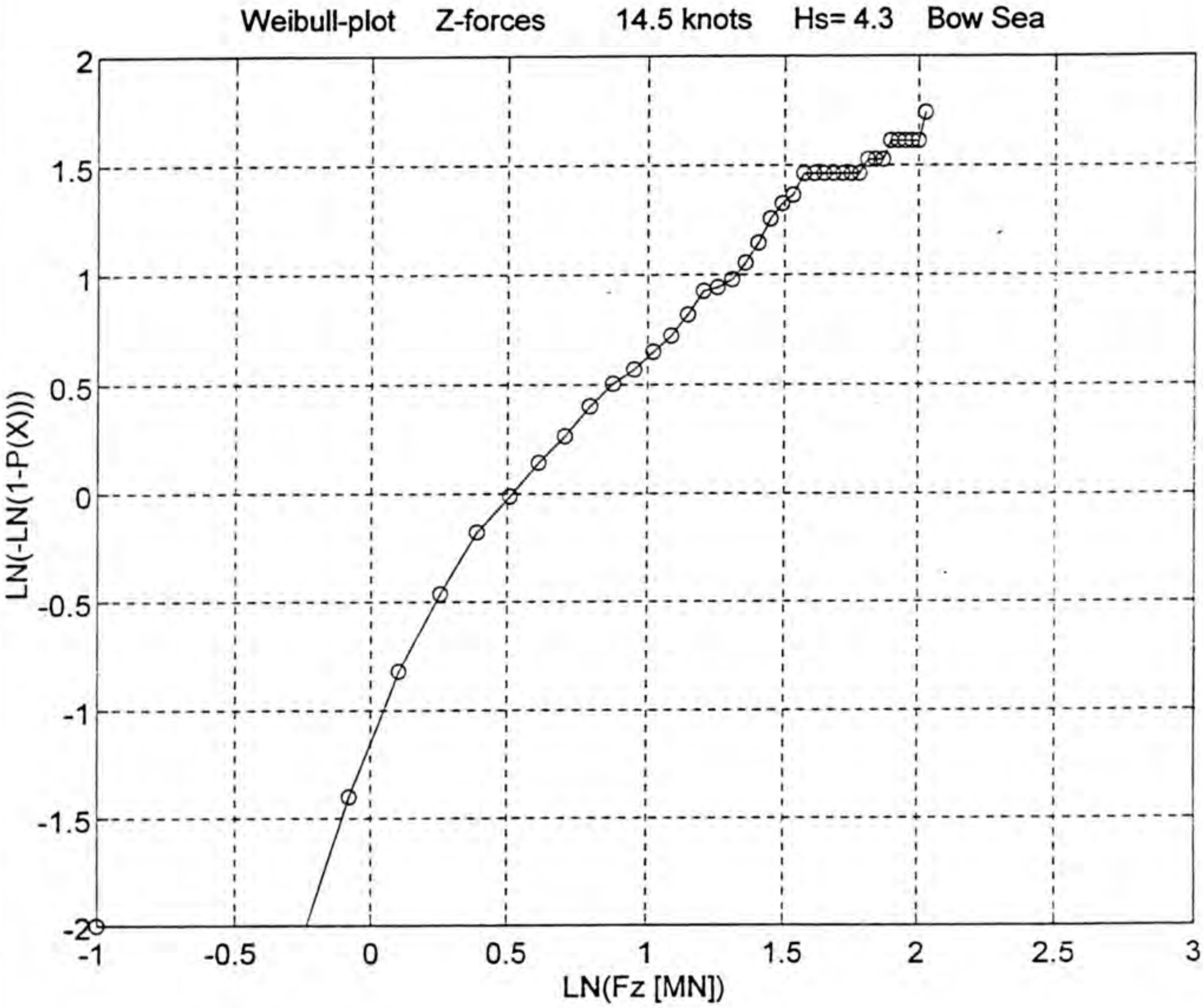
SSPA MARITIME CONSULTING	M/S Estonia MDL tests in irregular sea Weibull diagram from run 34-46: Deck hinge (Yh) moment Speed 10 knots in bow sea Hs= 4.0 m	Fig 15c Report 7524



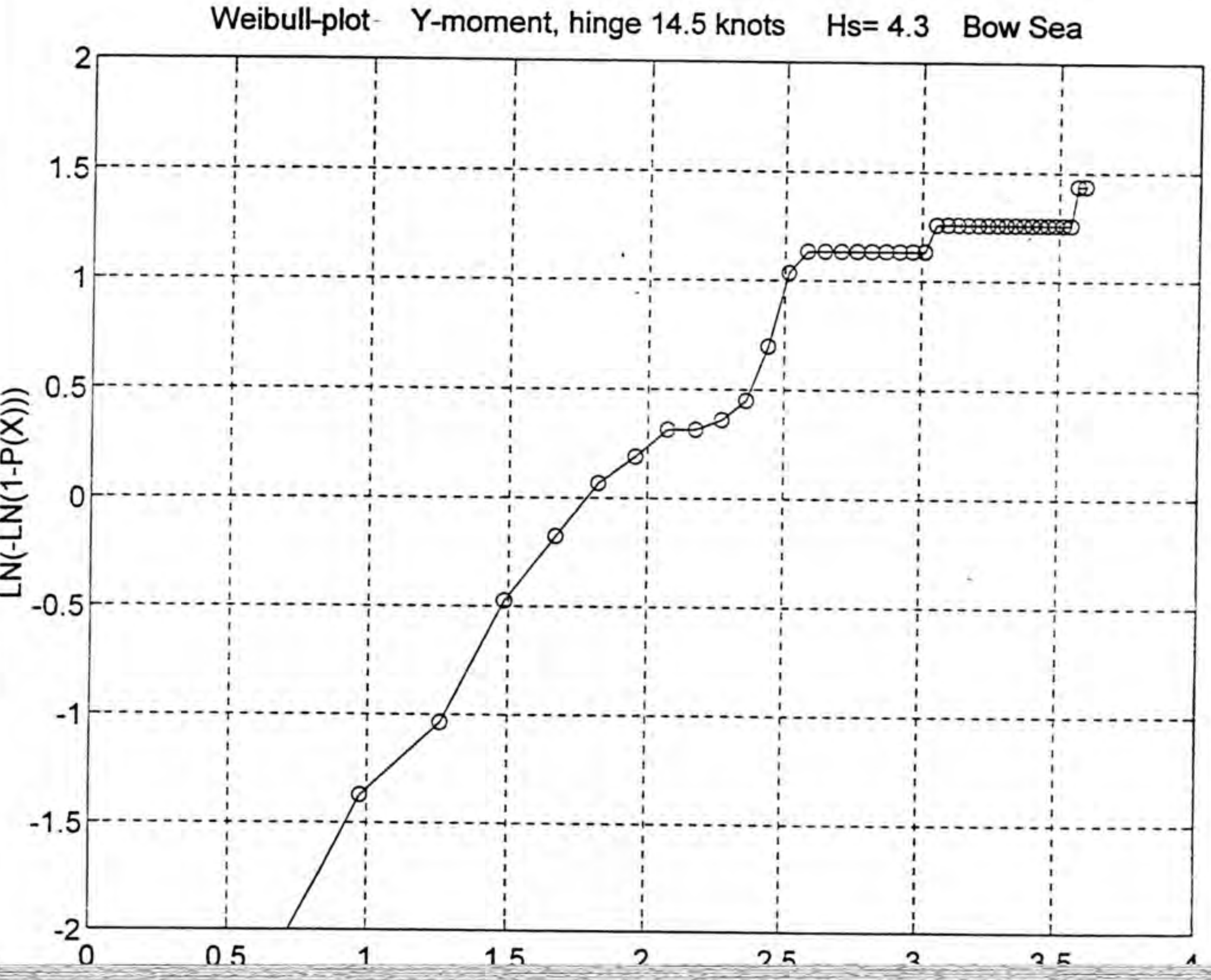
SSPA MARITIME CONSULTING	M/S Estonia MDL tests in irregular sea Weibull diagram from run 67-116: Wave height Speed 14.5 knots in bow sea Hs= 4.3 m	Fig 16a Report 7524



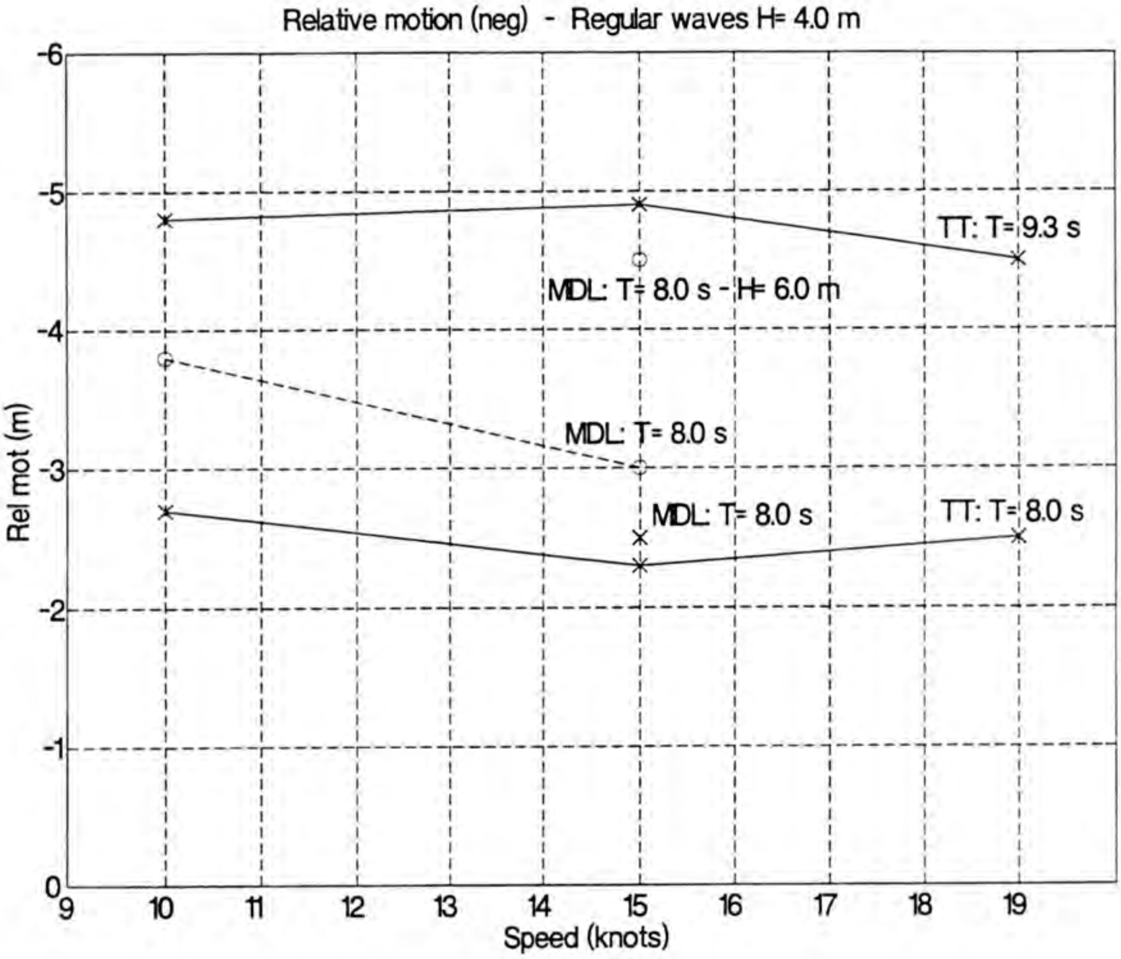
SSPA MARITIME CONSULTING	M/S Estonia MDL tests in irregular sea Weibull diagram from run 67-116: Vertical (Z) force on visor Speed 14.5 knots in bow sea Hs= 4.3 m	Fig 16b Report 7524



SSPA MARITIME CONSULTING	M/S Estonia MDL tests in irregular sea Weibull diagram from run 67-116: Deck hinge (Yh) moment Speed 14.5 knots in bow sea Hs= 4.3 m	Fig 16c Report 7524



SSPA MARITIME CONSULTING	M/S Estonia Relative Motion from model tests in regular waves	Fig 17a Report 7524



TT: towing tank
MDL: Maritime Dynamics Laboratory

x: head sea
o: bow sea

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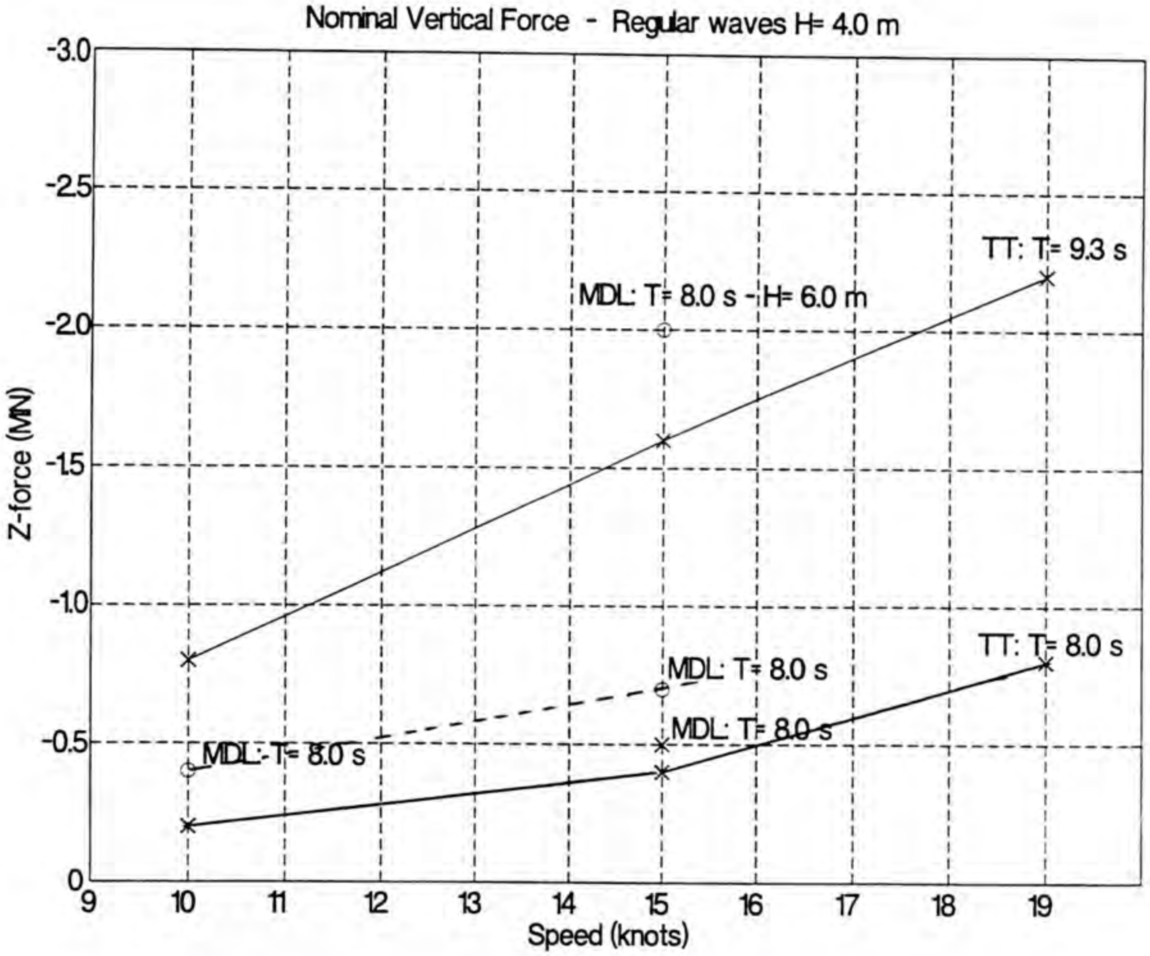
M/S Estonia

Vertical Force on Visor
from model tests in regular waves

Fig 17b	
Report 7524	



TT: towing tank
MDL: Maritime Dynamics Laboratory

x: head sea
o: bow sea

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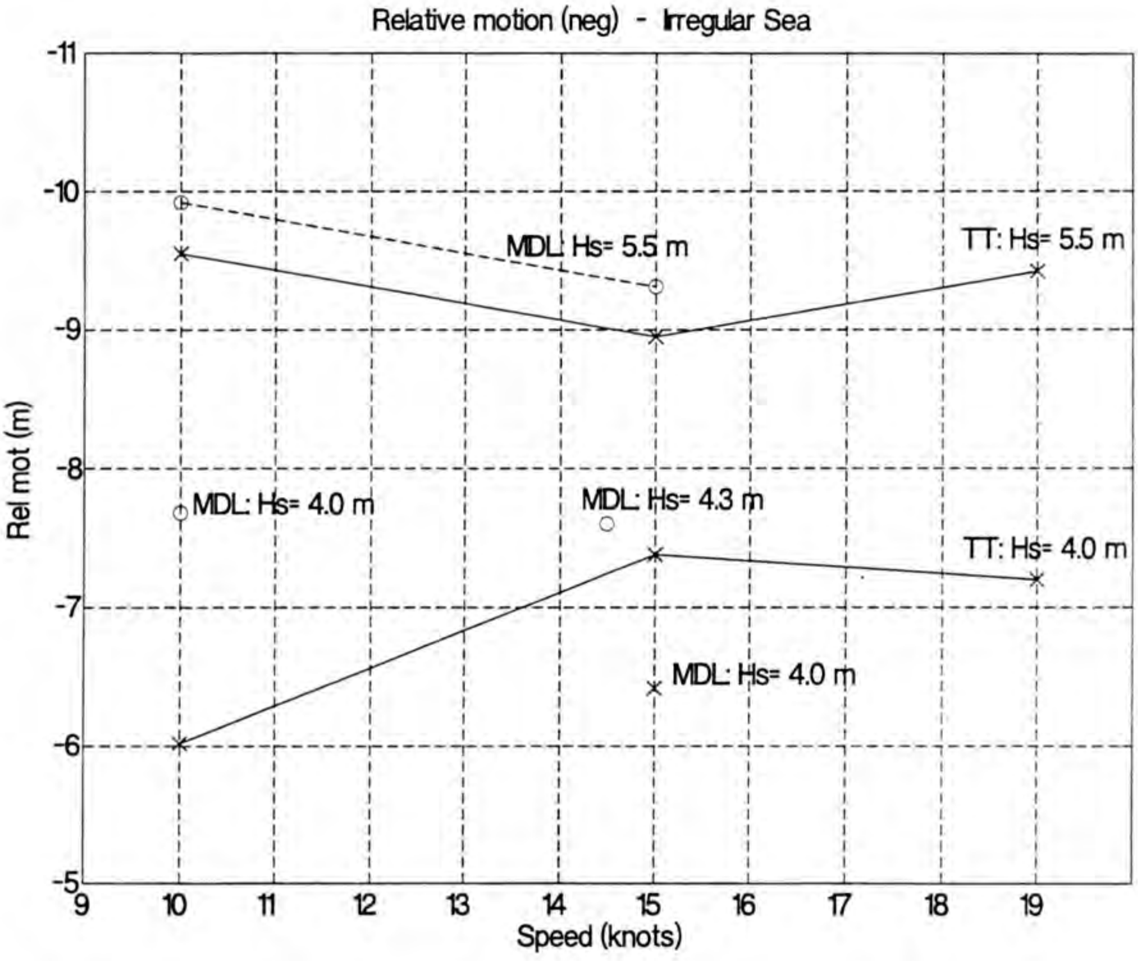
M/S Estonia
Maximum Expected Relative Motion
during 3 hours (1618 wave encounters)
in irregular sea

Fig	18a
Report	7524



TT: towing tank
MDL: Maritime Dynamics Laboratory

x: head sea
o: bow sea

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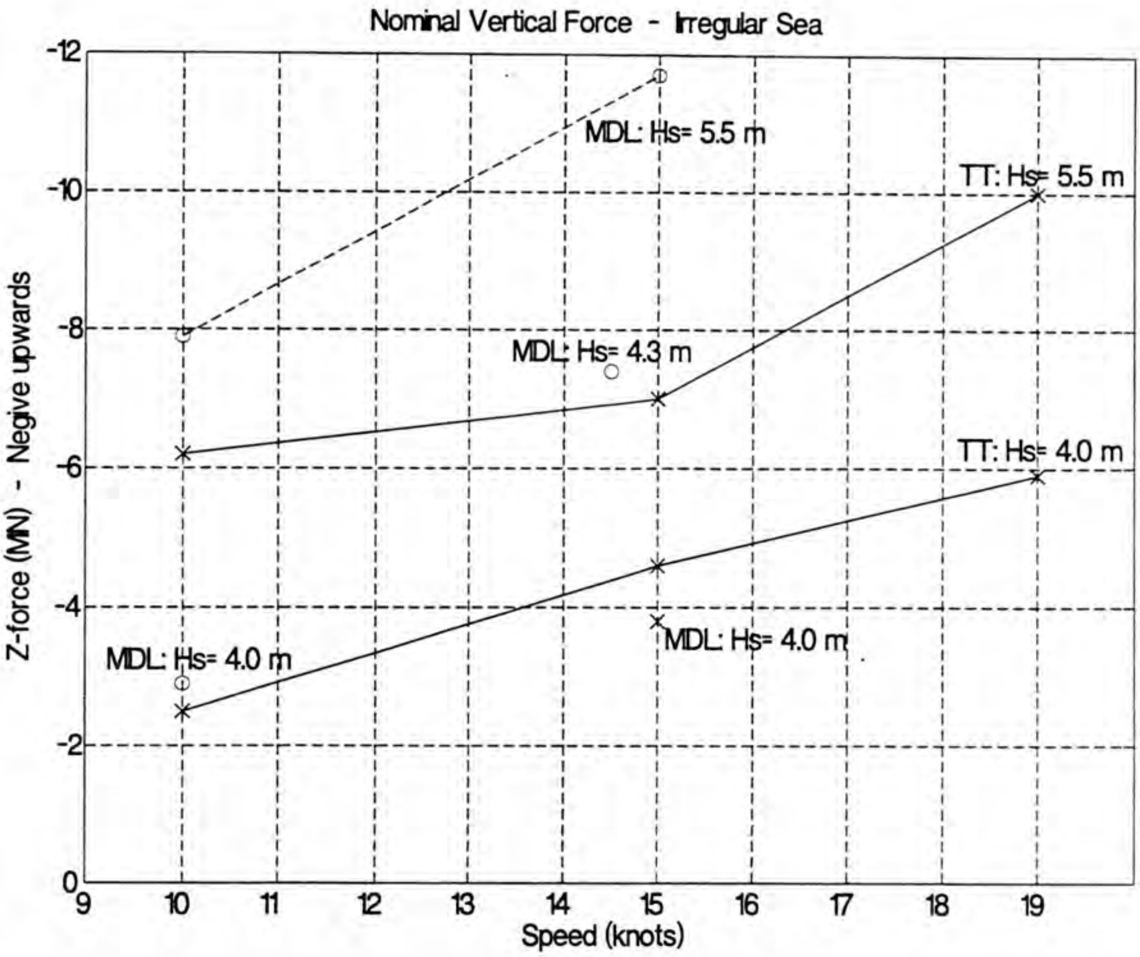
M/S Estonia
Maximum expected Vertical Force on Visor
during 3 hours (1618 wave encounters)
in irregular sea

Fig 18b

Report 7524



TT:	towing tank		x:	head sea
MDL:	Maritime Dynamics Laboratory		o:	bow sea

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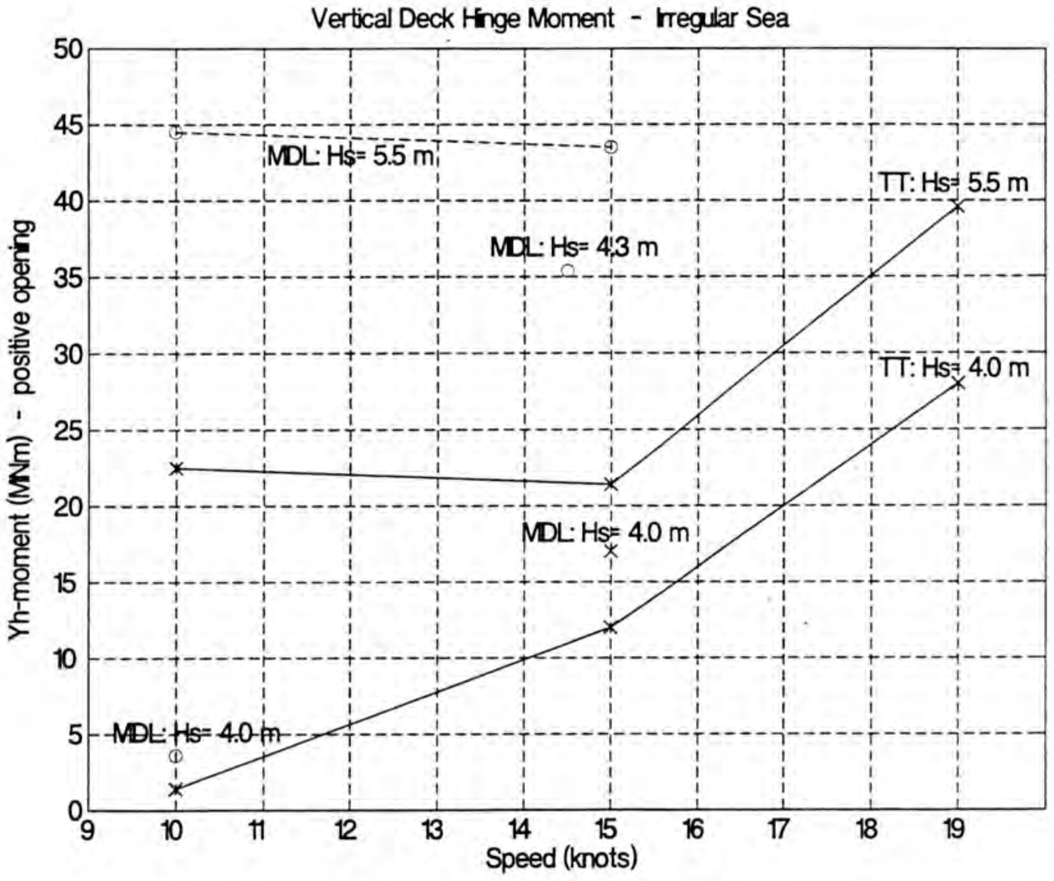
M/S Estonia
Maximum expected Deck Hinge Moment (Yh) during 3 hours (1618 wave encounters) in irregular sea

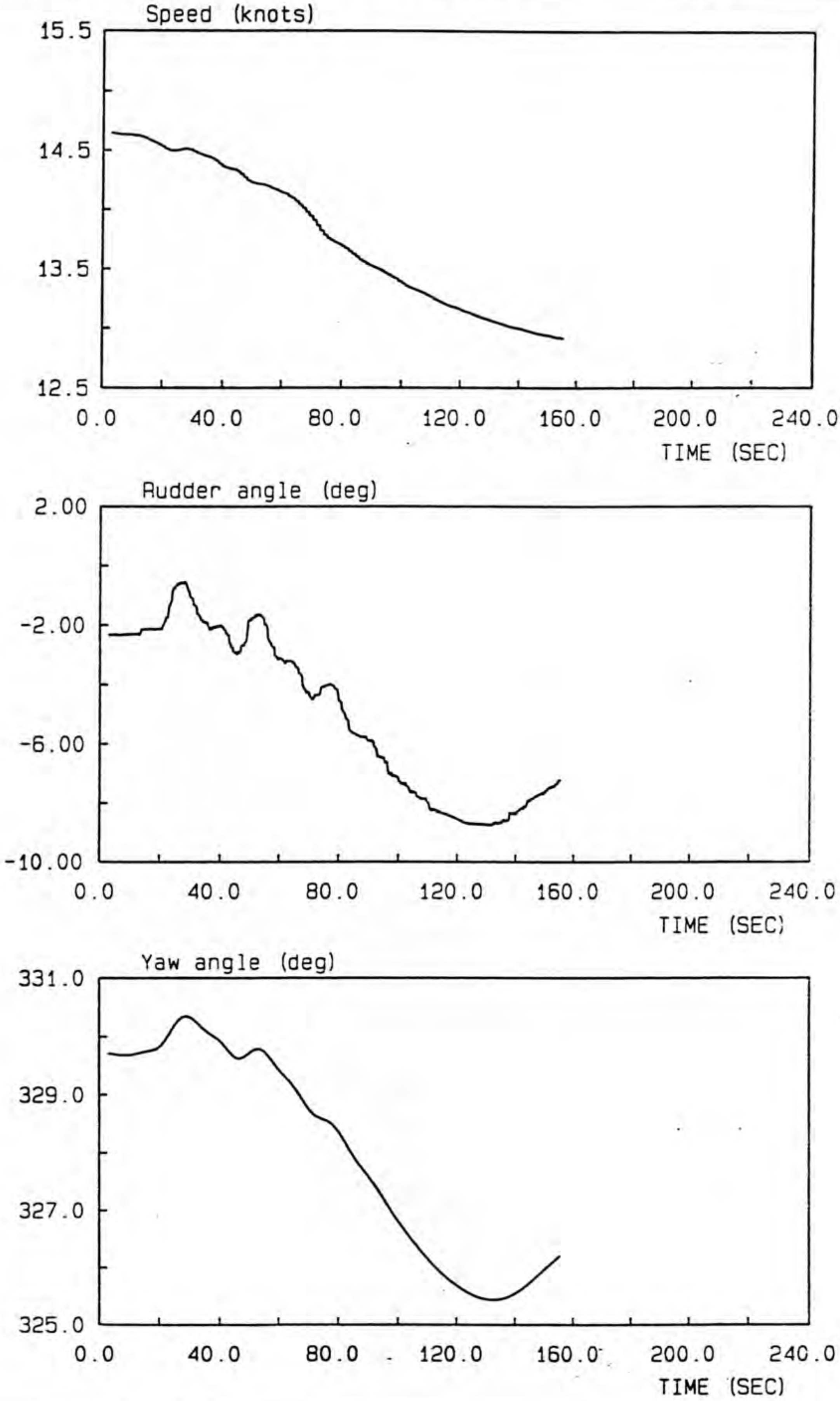
Fig 18c
Report 7524



TT: towing tank
MDL: Maritime Dynamics Laboratory

x: head sea
o: bow sea

SSPA MARITIME CONSULTING	M/S Estonia Manoeuvring test in calm water Run 25: Heel angle 21.5 deg Speed 14.5 knots - autopilot	Fig 19a Report 7524

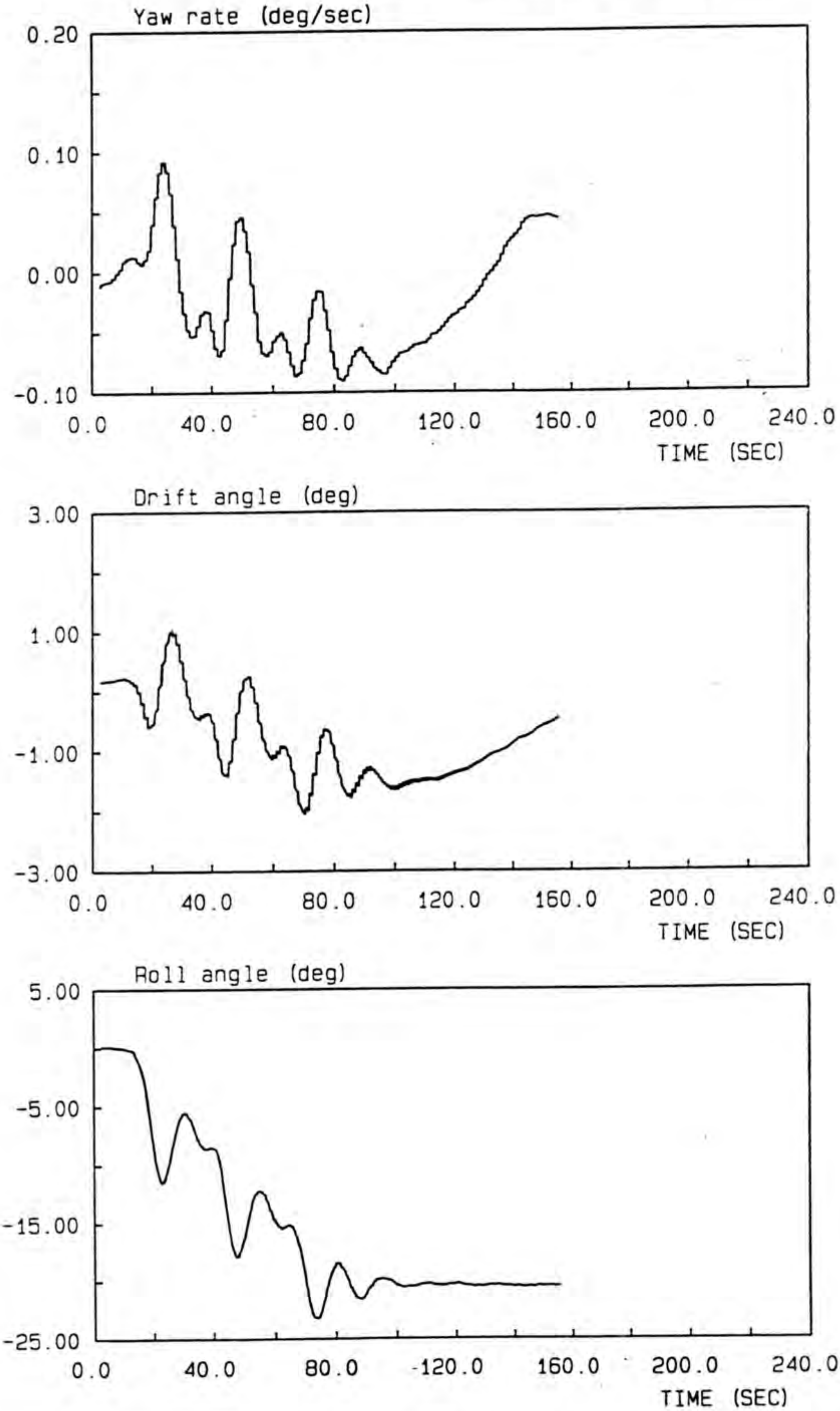


SSPA MARITIME CONSULTING

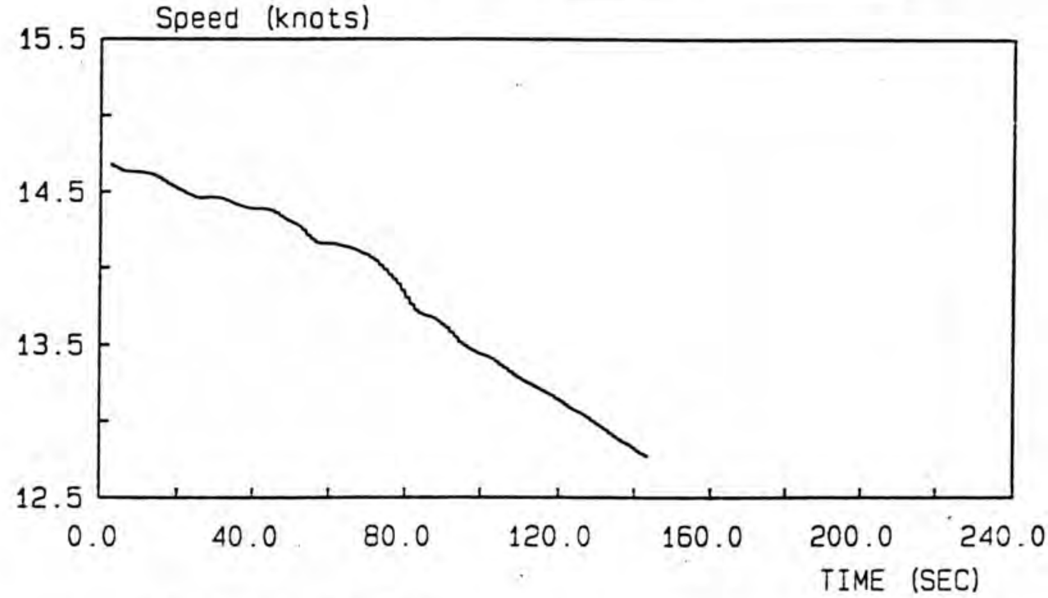
M/S Estonia

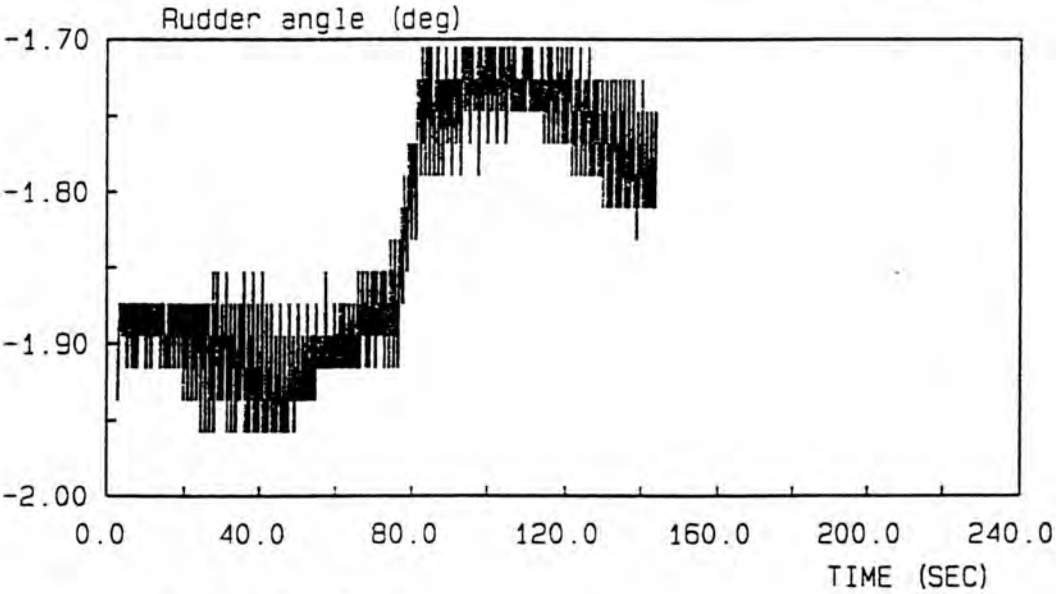
Manoeuvring test in calm water
Run 25: Heel angle 21.5 deg
Speed 14.5 knots - autopilot

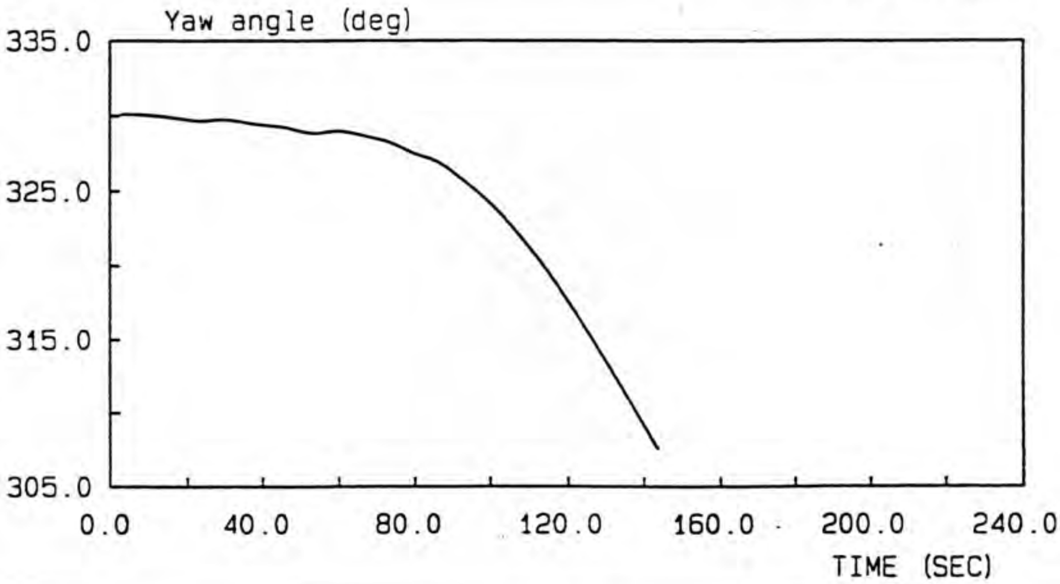
Fig 19b
Report 7524



SSPA MARITIME CONSULTING	M/S Estonia Manoeuvring test in calm water Run 26: Heel angle 21.5 deg Speed 14.5 knots - zero rudder	Fig 20a Report 7524







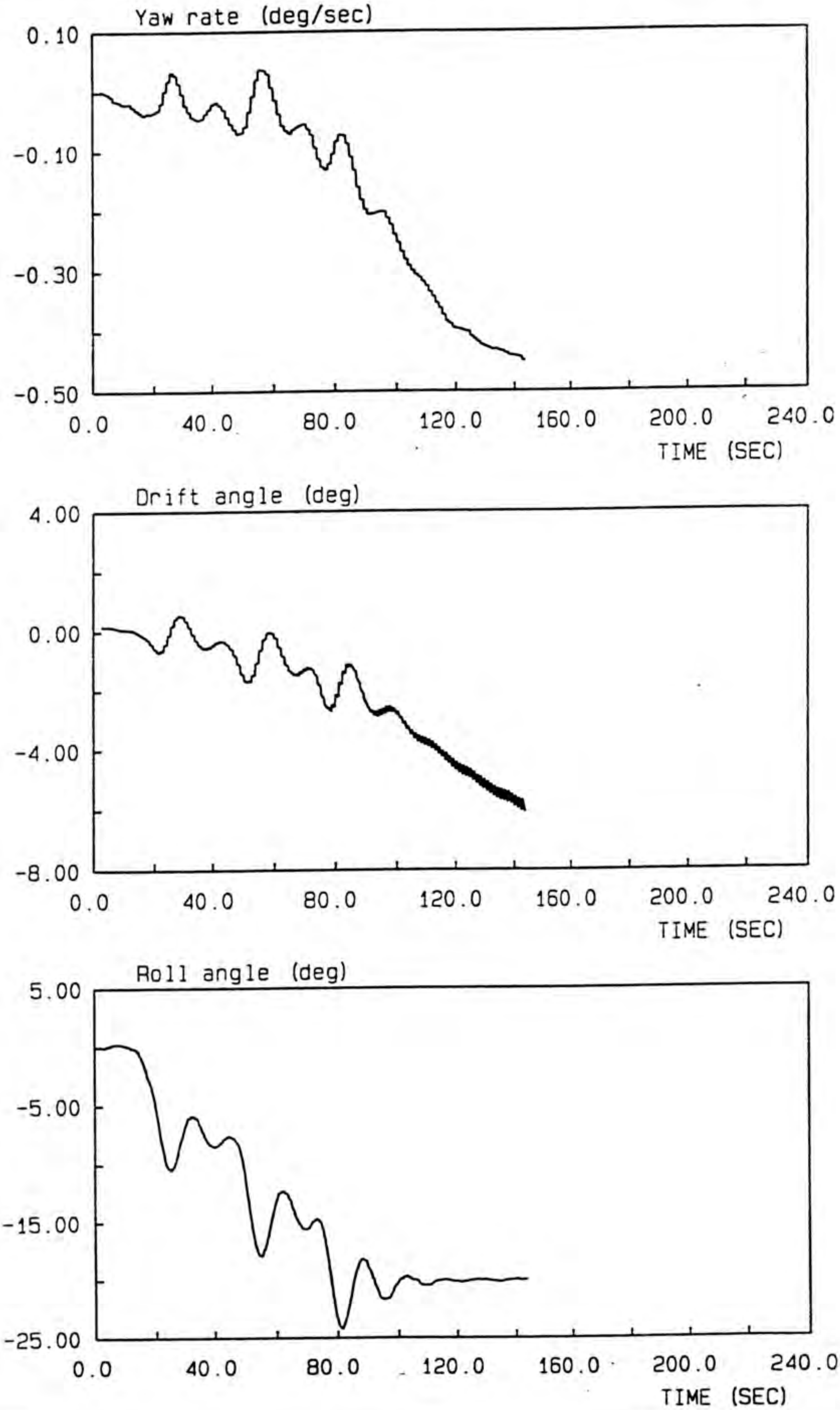
SSPA MARITIME CONSULTING

M/S Estonia

Manoeuvring test in calm water
Run 26: Heel angle 21.5 deg
Speed 14.5 knots - zero rudder

Fig 20b

Report 7524



SUPPLEMENT No. 411

Sundell Tom:

MV ESTONIA Accident Investigation. Forces acting on the bow visor due to stationary flow.

Technical Report VALC55.

VTT Manufacturing Technology.

Espoo 1995.

MV ESTONIA ACCIDENT INVESTIGATION

FORCES ACTING ON THE BOW VISOR DUE TO STATIONARY FLOW

CONFIDENTIAL

TECHNICAL REPORT VALC55

Tom Sundell

Espoo, January 1995

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MV ESTONIA ACCIDENT INVESTIGATION
FORCES ACTING ON THE BOW VISOR DUE TO STATIONARY FLOW

Tom Sundell

Päivitys raporttiin nro - Update to report no.	Hyväksynyt - Approved by

Julkisuus - Availability statement — Määräpäivä - Until date

[] B (Julkinen - Public) [X] C (Luottamuksellinen - Confidential) [] C (Salainen - Secret)

Abstrakti, sisällysluettelo, tms. - Abstract, list of contents etc.

Abstract

A Non-Linear free-surface panel method code was used to compute the flow around the hull of MV ESTONIA. The aim of this study was to evaluate the steady hydrodynamic forces acting on the bow visor, caused by a stationary axial fluid velocity, on the bow part of the hull. The hydrodynamic force on the bow visor was computed at different drafts and speeds. The studied cases correspond to situations where the ship is forced to a given position and advancing at constant speed without any vertical motion.

Five different draughts were computed. The design draught of 5.50 meters with even keel and four draughts where the trim was -0.9 degrees. The submergence of the bow was 5.5, 7, 9, 11 and 13 meters. The flow velocities corresponds to the full-scale speeds of 10.0, 15.0 and 20.0 knots.

The steady vertical hydrodynamic lift seems to vary almost linearly with the visor submergence whereas the velocity seems to have an large effect on the forces. In the steady state situation the bow wave grows to an impressive height. A large bow wave increases both buoyancy and hydrodynamic forces significant. To what extent this bow wave grows in real sea-way has a large effect on the total force.

CONTENT

1. INTRODUCTION

A Non-Linear free-surface panel method code was used to compute the flow around the hull of MS ESTONIA. The aim of this study was to evaluate the steady hydrodynamic forces acting on the bow visor, caused by a stationary axial fluid velocity. The hydrodynamic force on an approximation of the bow visor was computed at different drafts and speeds.

2. THE COMPUTATIONS

The non-linear panel method code SHIPFLOW was used in these computations. The panel number of the model varied from 2600 to 3300, depending on draft and speed. The number of panels representing the visor varied between 50 to 450 panels depending on the draft. The geometry of hull-visor junction was simplified accordion to the figure in Appendix I and constant pressure over each panel was used. By integrating this pressure force over the visor surface, the total steady hydrodynamic force acting on the visor was determined. In the non-linear computations the integration is carried out over the total vetted surface of the visor, including the par wetted by the bow wave. To estimate the effect of the bow wave on the visor loads finally some computations using a linear theory was made. In this computation the undisturbed water-surface is taken as the symmetry plane and no effect of the bow wave is taken into account.

Five different draughts were computed. The design draught of 5.50 meters with even keel and four draughts where the trim was -0.9 degrees. The submergence of the bow was 5.5, 7, 9, 11 and 13 meters. The flow velocities correspond to the full-scale speeds of 10, 15.0 and 20 knots.

The studied cases correspond to situations where the ship is forced to a given position and advancing at constant speed without any vertical motion. The theory used in these computations does not model the breaking of waves (breaking bow wave) neither time dependent effects. For these reasons, the results, especially the numerical values of the forces, should be used with care.

3. RESULTS

The pressure force on the bow visor and it's horizontal (FX) and vertical (FZ) components at different bow submergence when the velocity is 15.0 knots is shown in Fig. 1. These result are obtained using the non-linear theory and include the effect of the bow wave.

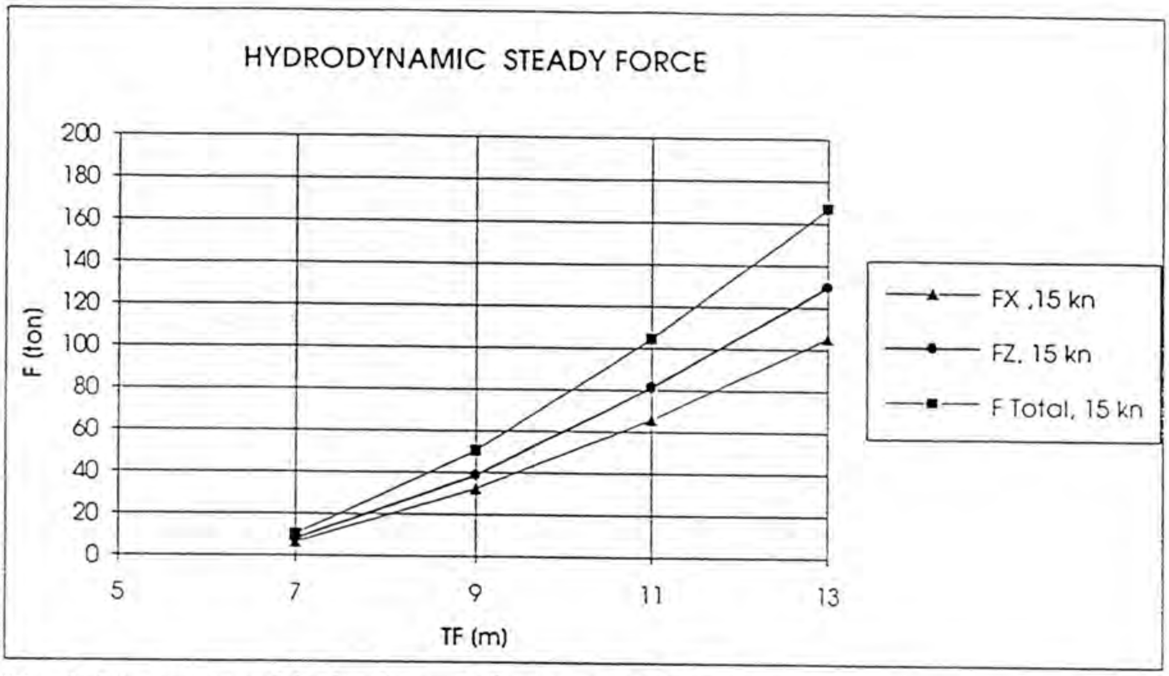


Fig. 1. *The computed hydrodynamic forces on the bow visor.*

As seen in the figure the forces seem to vary almost linearly with the bow submergence.
The effect of flow velocity is seen in Fig. 2. The force velocity coupling is larger than $F \propto V^2$.

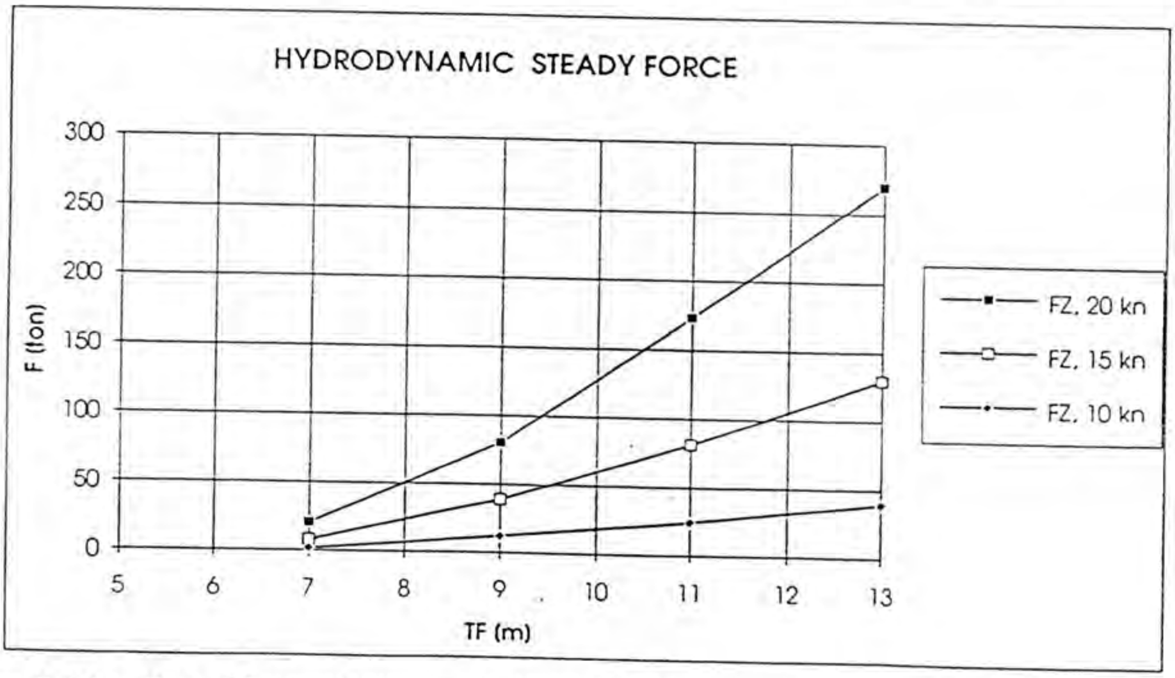


Fig. 2. *The effect of flow velocity on the vertical force*

The swellup or bow wave height for the different submergence when the speed is 10.0 15.0 and 20 knots is shown in Fig. 3. In reality the bow wave will brake and it is questionable to what extent if it has time to grow to these heights in a dynamic situation.

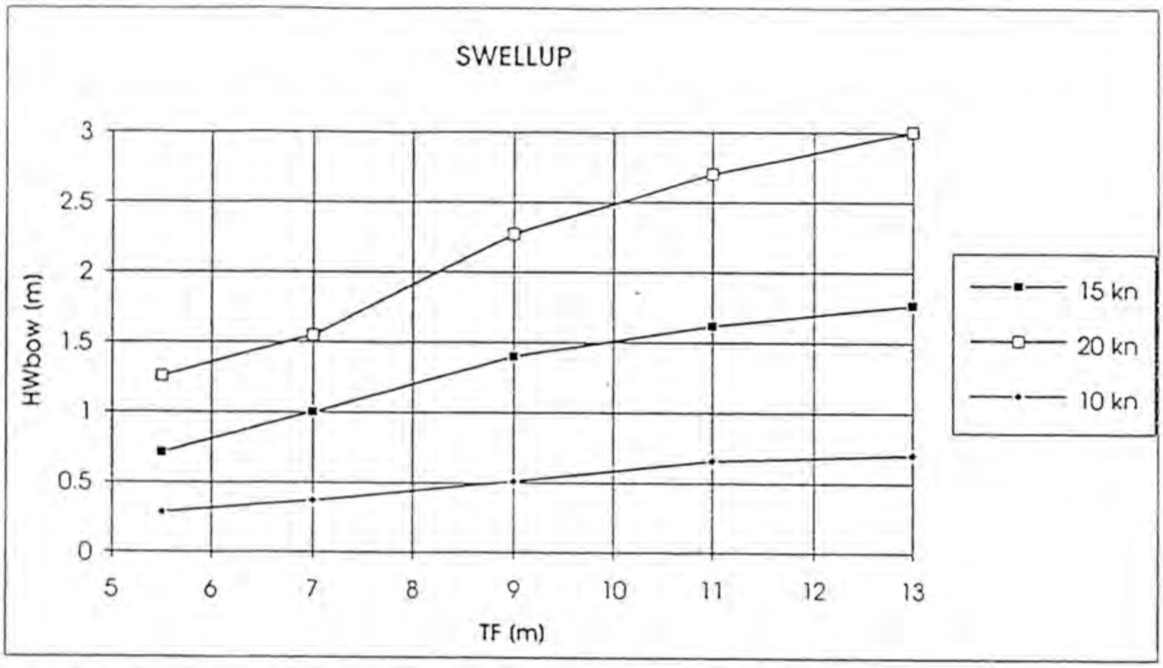


Fig. 3. *The bow wave height as a function of submergence and speed*

The submergence of the visor and the swellup in the bow results in a large hydrostatic force. In Fig. 4 the hydrostatic lifting force is plotted as a function of bow submergence. The volume shown in this figure is based on the actual visor geometry not the approximation used in the flow computations.

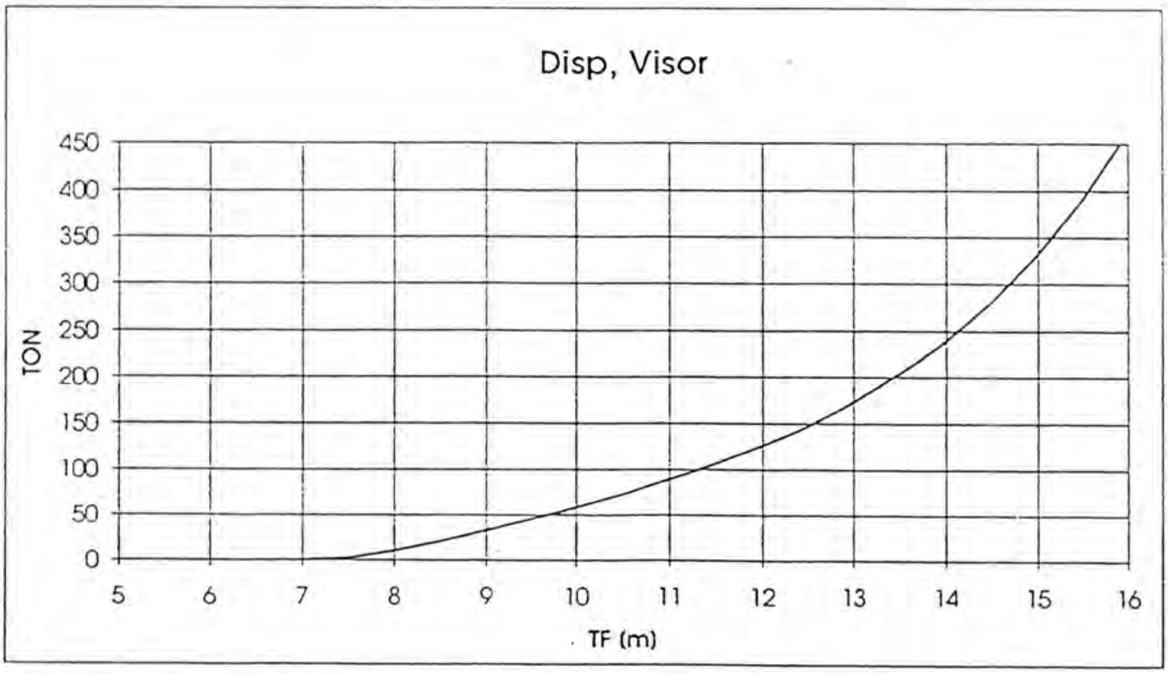


Fig. 4 *The hydrostatic lift of the visor as a function of bow-submergence*

Combining the data of figures 2,3 and 4 it is possible to estimate the approximate total vertical force in stationary flow. The estimate in Fig 5 is somewhat conservative, as the submergence of the visor is taken simply as a sum of the bow draft and swellup. In reality the maximum swellup is a local value, also the breaking of the bow wave would probably decrease the bow wave height.

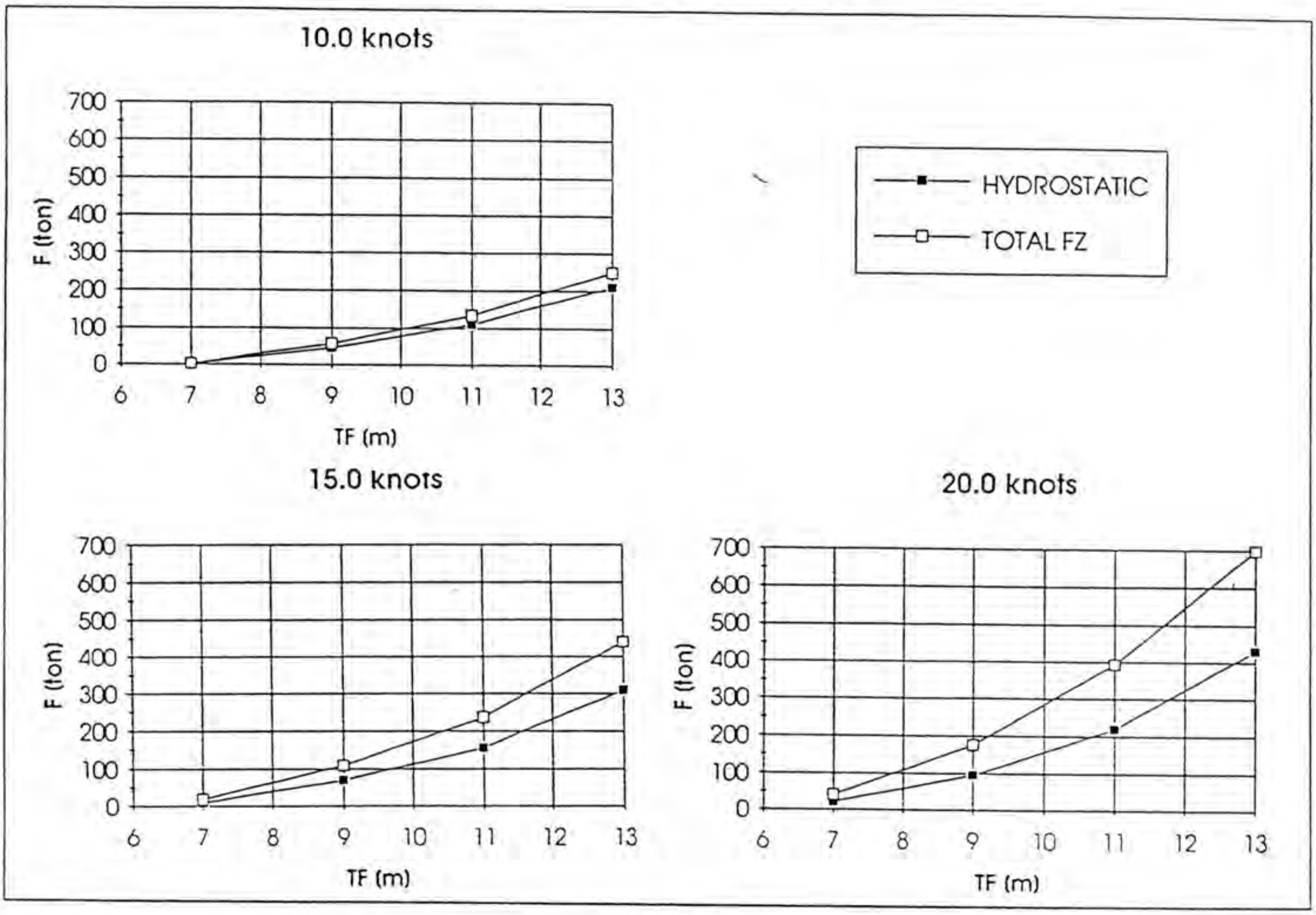


Fig. 5. *The total steady vertical force, including both hydrodynamic and -static forces*

In the most severe case when the visor is completely submerged the total computed vertical force is up to 700 tons.

As it is doubtful to what extent the dynamic swellup will develop some results without the bow wave is also presented. In these results the undisturbed free-water surface is taken as a symmetry plane and no swellup is taken into account. The computed hydrodynamic lift for the linear and non-linear cases is plotted in Figure 6.

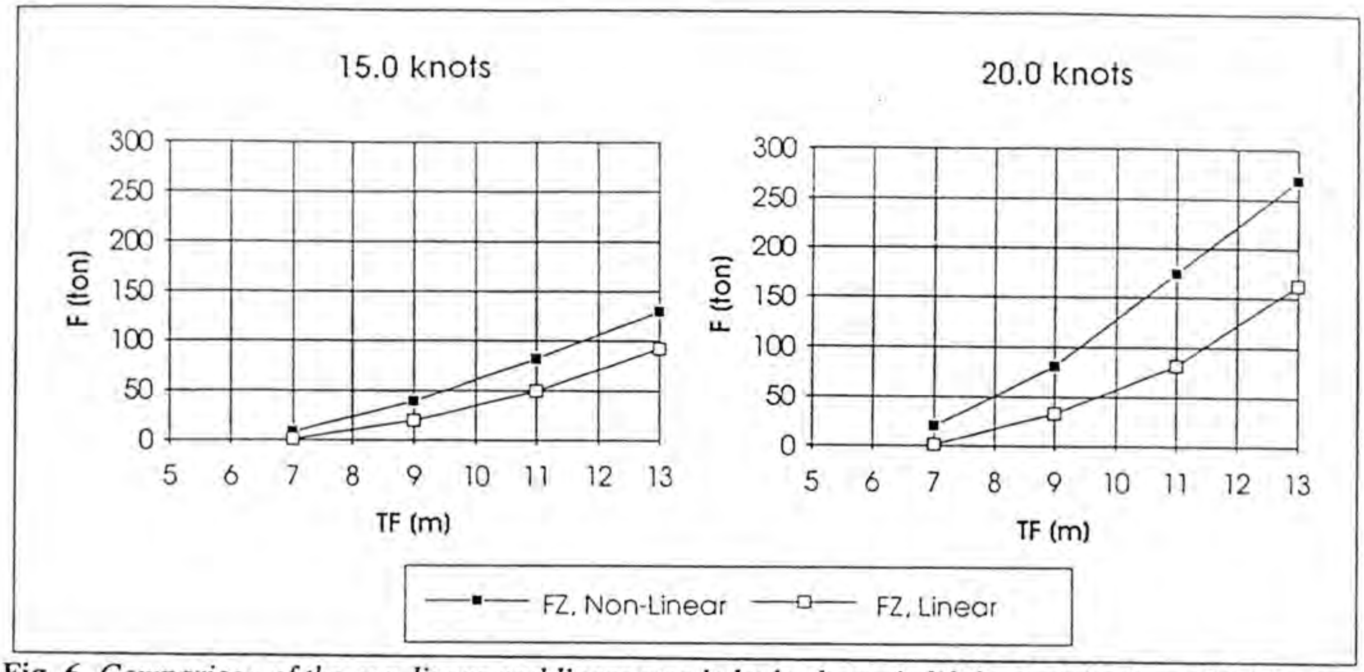


Fig. 6. *Comparison of the non-linear and linear steady* <u>*hydrodynamic*</u> *lift for both 15.0 and 20.0 knots*

The bow wave increases in size with speed and thus also the difference between the linearly and non-linearly computed vertical hydrodynamic forces. The size of the bow wave also affects the displaced volume greatly. The effect of overlooking the bow wave is shown in Figure 7.

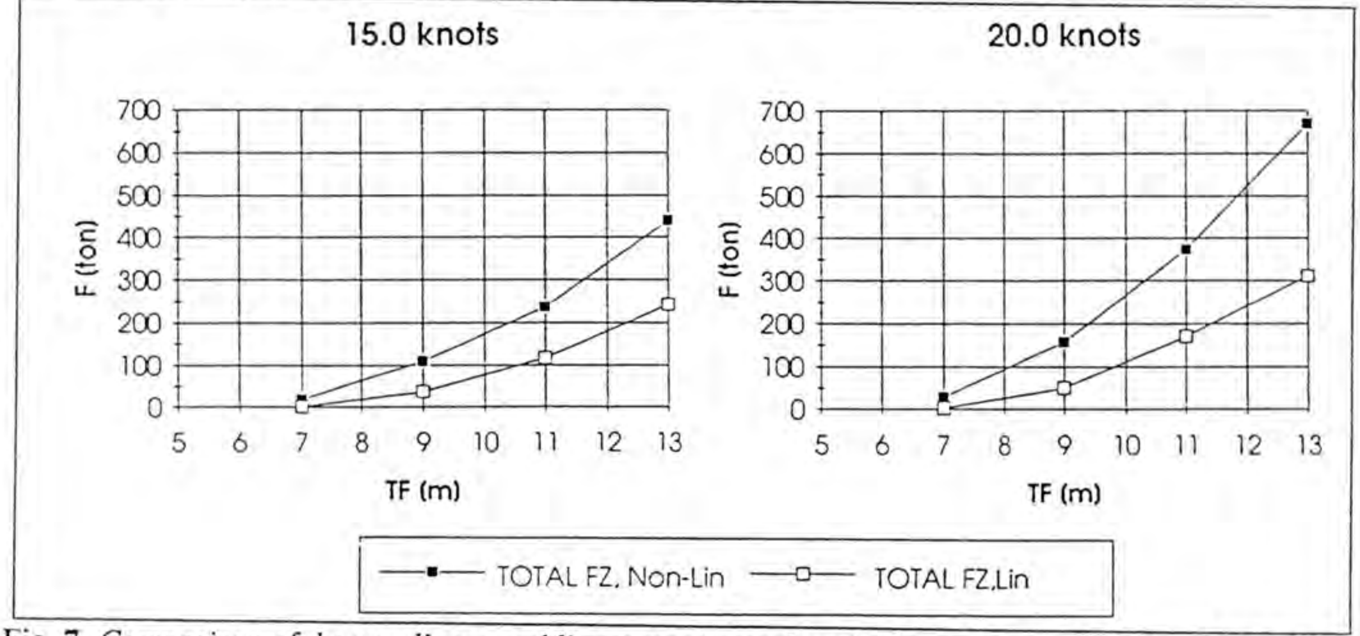


Fig. 7. *Comparison of the non-linear and linear steady* <u>*total*</u> *vertical force for both 15.0 and 20.0 knots*

From the linearly computed results for vertical force a simple equation can be derived for the hydrodynamic lift.
A lift coefficient,

$$C_{Lift} = \sqrt{\frac{T_v}{T_{DWL}}} \cdot \frac{F_{Lift}}{\frac{1}{2}\rho \cdot T_v \cdot U^2},$$

is defined, where T_v is the submergence of the visor, T_{DWL} is the design draught, U^2 is the flow velocity and ρ the density of the water.

The term, $\sqrt{\frac{T_v}{T_{DWL}}}$ is a scaling factor without any physical background.

The force F_{Lift} (Newtons) seems to follows well the line,

$$F_{Lift} = \sqrt{\frac{T_{DWL}}{T_V}} \cdot \frac{1}{2} \cdot \rho \cdot U^2 \cdot T_v^2 \cdot C_{Lift}.$$

The obtained value for the lift coefficient of the MV ESTONIA visor is: CLift=0.81

4. DISCUSSION

There are some central findings of this study that should be considered when estimating the forces on the visor.

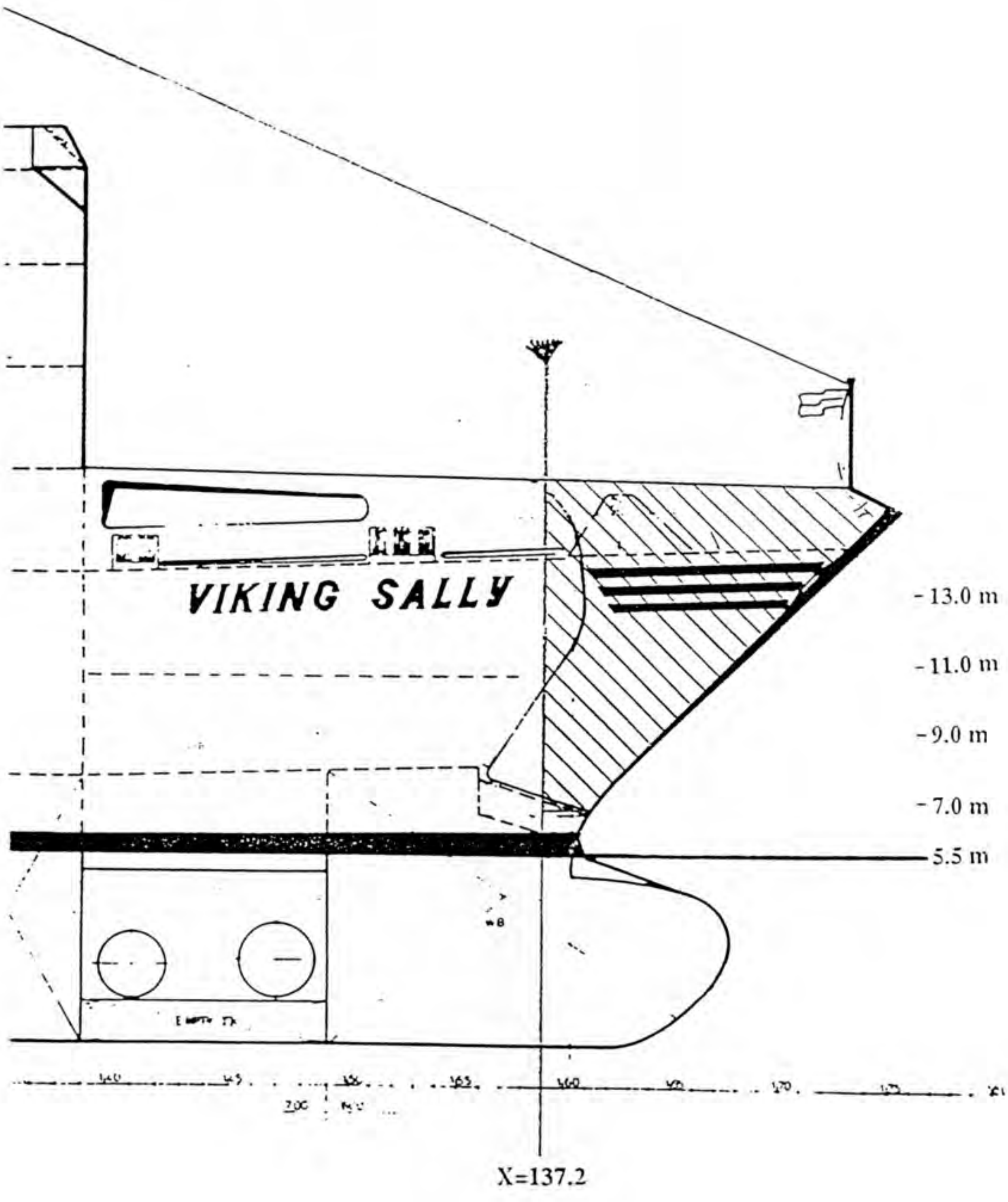
The computation indicates a nearly linear growth in the hydrodynamic steady forces with increasing visor submergence. If the pressure would be constant over the whole visor surface the force would vary approximately quadratic with the submergence. However the pressure value varies along the visor surface, attaining its highest value at the stagnation point near the water surface and in its vicinity and decreasing when moving aft and down. This high-pressure area covers a proportionally larger part of the visor for smaller submergence. Pressure distributions on the visor at bow submergence of 9 and 13 meters are shown in Appendix II.

The strong effect of the speed on the hydrodynamic lift is also interesting. Without the effect of the free-surface, the force would vary quadratic with speed. However as the bow wave grows with speed, affecting the flow and increasing the submerged area for a given draft significantly, the force will grow faster. In this case the force seems to vary with $V^{2.5-2.8}$.

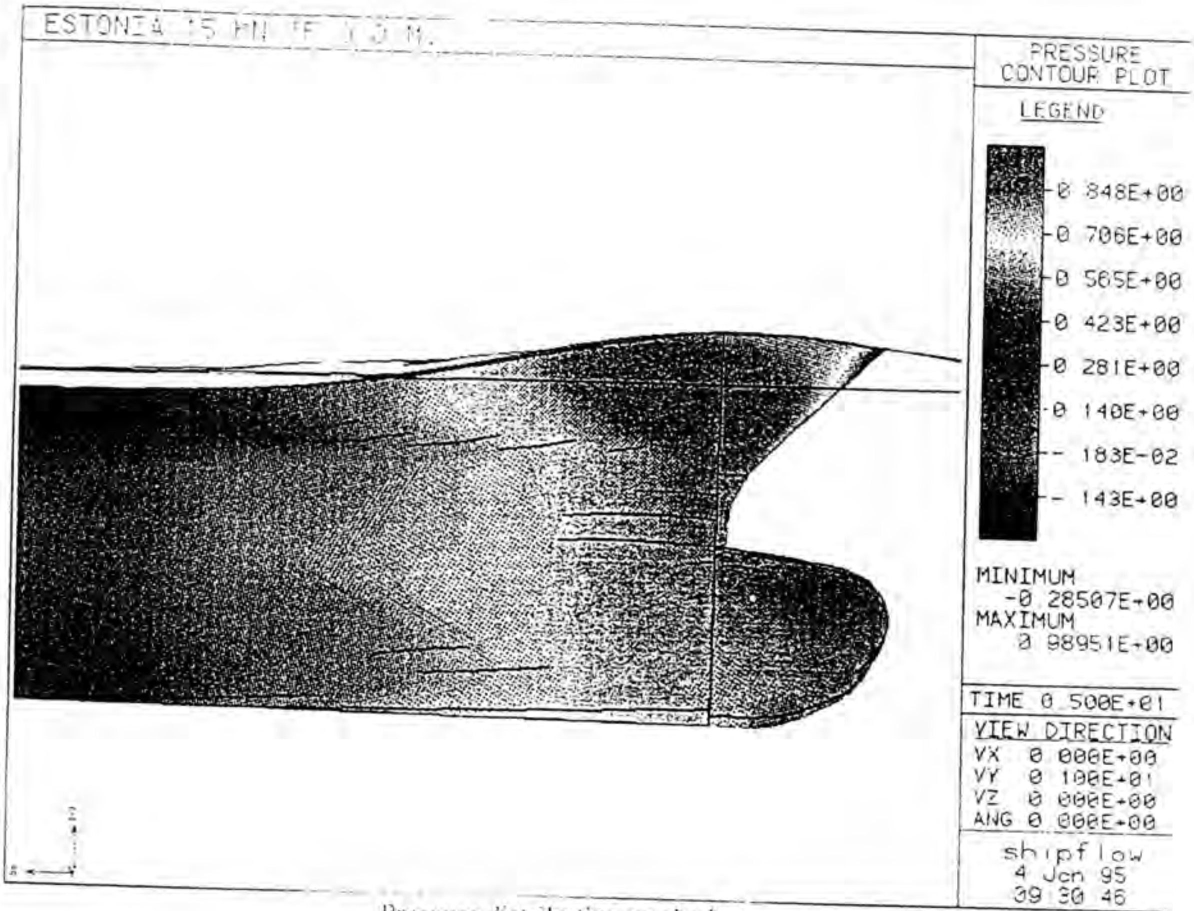
As the swellup is a function of speed the hydrostatic force is also affected by speed. The computations indicate a bow wave height up top 3.0 meters, in the most sever condition. In some cases the increase of submergence due to the bow wave could more than double the displaced volume of the visor.

The results also show how important a right estimation of the bow wave height is. The effect of the bow wave is especially important in cases, as MV ESTONIA, where both buoyancy and submerged areas increases quickly upwards. This dynamic swellup is an important field for further research.

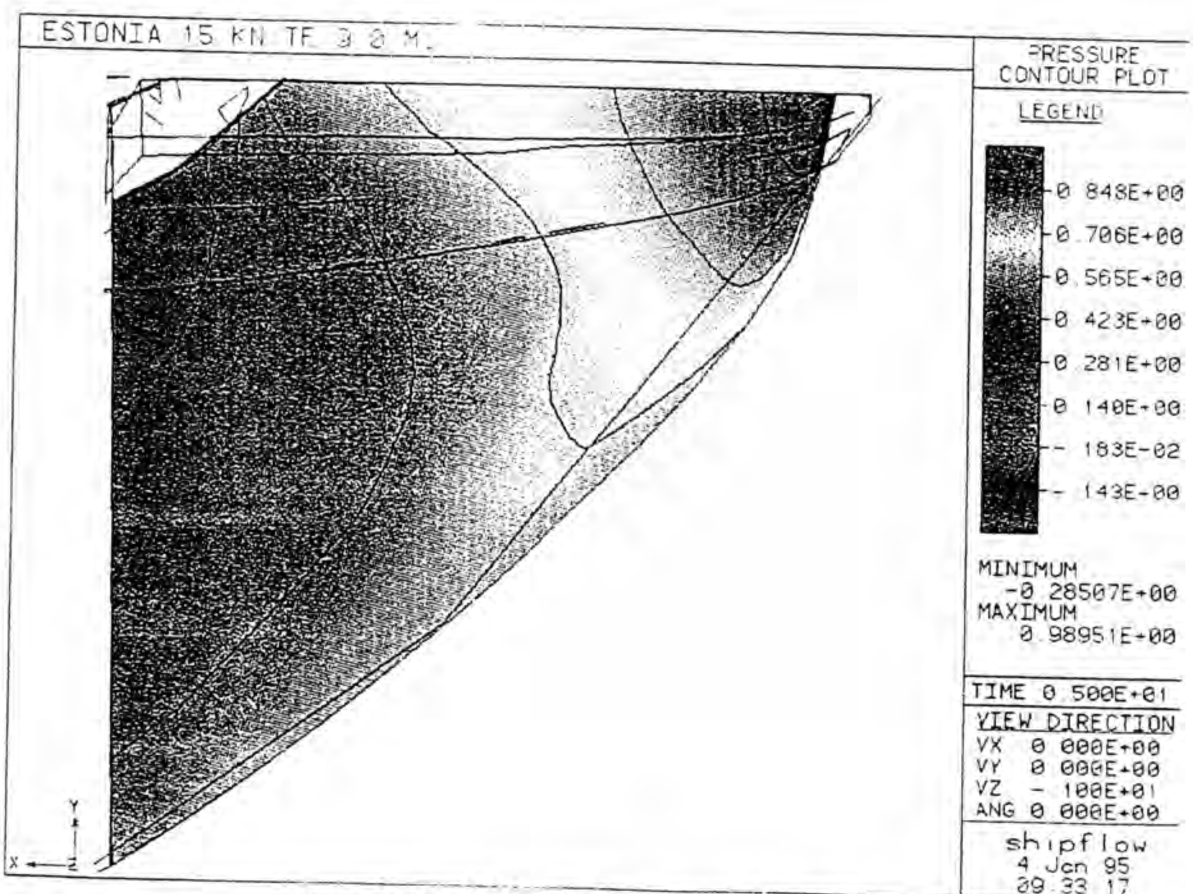
Although the performed computations include many simplifications of the time dependent situation where the vessel operates in severe conditions it seems as the steady hydrodynamic lift generated by the steady axial flow is of considerably magnitude. This force is of course strongly dependent of the bow geometry and should not be neglected in the cases of wide bow and large overhangs. In the case of MS ESTONIA this vertical force could grow up to 200 tons or 40 % of the design load in the most sever conditions.


VIKING SALLY
- 13.0 m
- 11.0 m
- 9.0 m
- 7.0 m
5.5 m
X=137.2

SPEED: 15.0 knots, TF: 9.0 m

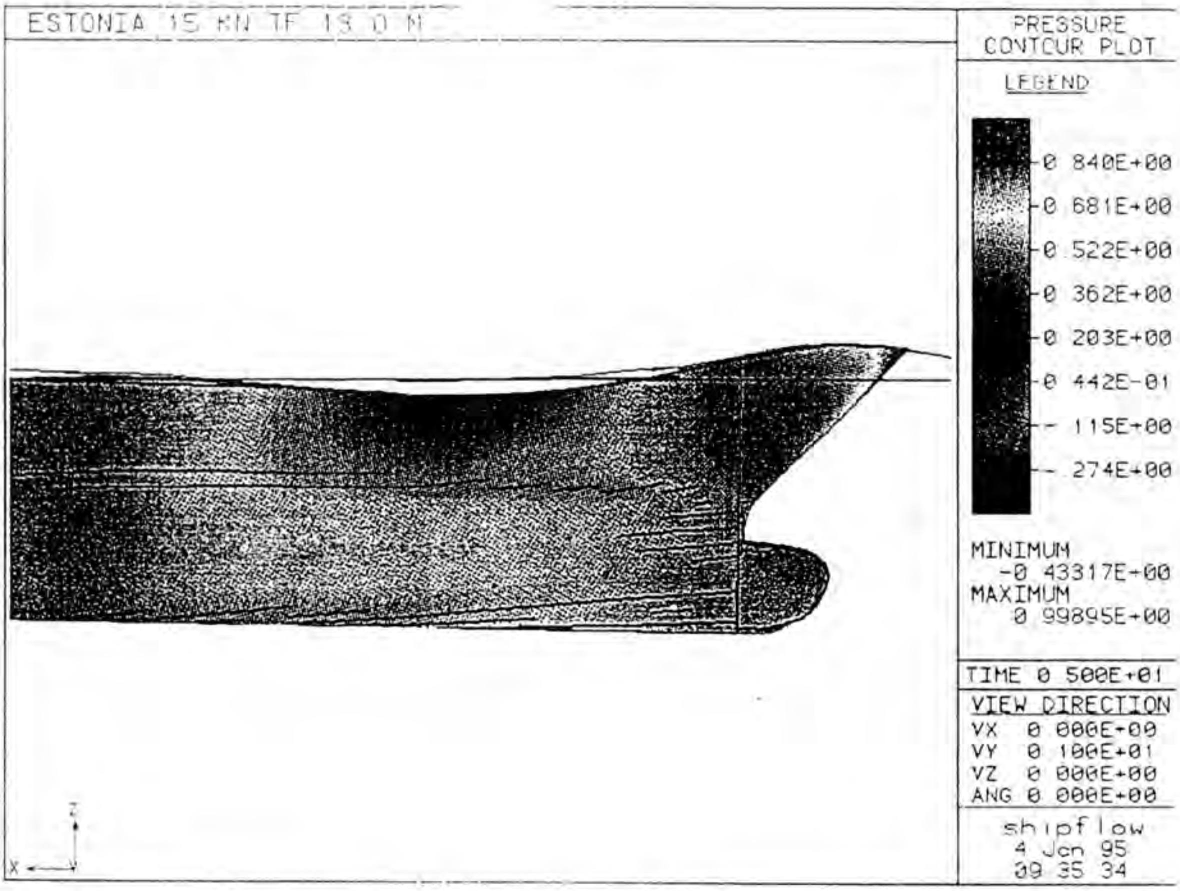


Pressure distribution on the bow

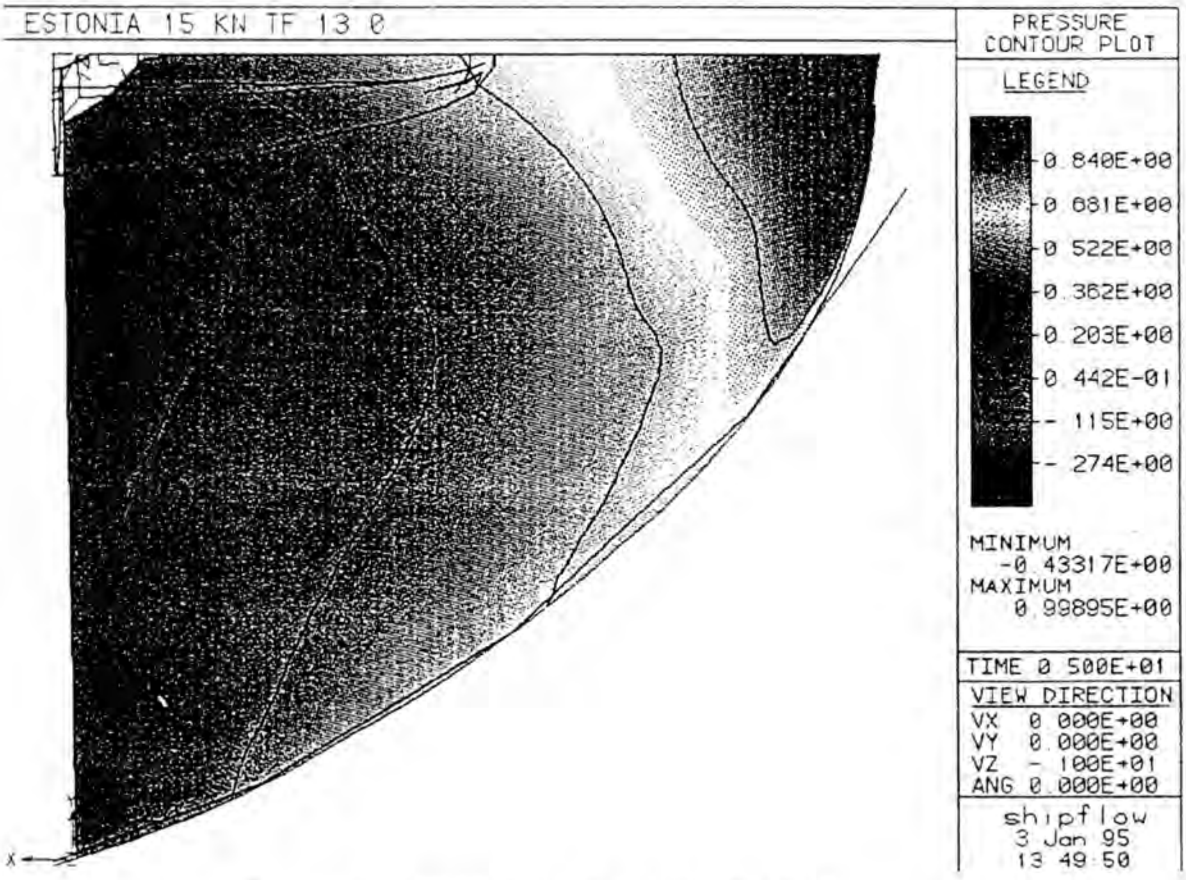


Pressure distribution on the visor, seen from above

SPEED: 15.0 knots, TF: 13.0 m



Pressure distribution on the bow



Pressure distribution on the visor, seen from above

SUPPLEMENT No. 412

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Technical Report VALC106.

VTT Manufacturing Technology.

Espoo 1995.

MV ESTONIA ACCIDENT INVESTIGATION

Numerical predictions of wave-induced motions

CONFIDENTIAL

TECHNICAL REPORT VALC53

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Espoo, December 1995

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Abstrakti, sisällysluettelo, tms. - Abstract, list of contents etc.

Abstract

Wave-induced motions of MV Estonia have been predicted in irregular seas at different headings and speeds by applying the strip method and the linear superposition principle. The numerical results have been compared to experimental data from model tests carried out by SSPA. Conclusions are based on the present estimate of the sea state, speed and heading at the time of the accident. The numerical results indicate that heavy bottom slams or incidents of green water on foredeck were unlikely during the last voyage of MV Estonia. Spray and smaller amounts of water came certainly to the deck and the vessel obtained flare impacts. The rigid body vertical accelerations of the vessel were before the accident near the passenger comfort limit which means that 10 to 20 % of the passengers may have been seasick (vomiting).

CONTENTS

1 INTRODUCTION

Wave-induced motions of MV Estonia have been predicted in irregular seas by applying the linear superposition principle. The superposition principle assumes that the ship responses in irregular seas may be determined by summing the ship responses to a large number of regular sinusoidal waves making up the irregular seaway. Response amplitude operators, or ship responses (heave, roll, pitch, vertical accelerations etc) in regular waves with unit amplitude have been determined by the SCORES-program (Raff, 1972) based on the strip theory.

In the strip theory, the hydrodynamic forces are first determined on two-dimensional ship sections and the total forces are obtained by integrating the sectional forces over the ship length. The method has been validated in numerous comparisons with model and full scale results. Numerical predictions have been made for different ship speeds, headings and wave periods to study their effect on the motions. The results are discussed from the point-of-view of passenger comfort, deck wetness and bottom slamming. The wave impact forces on the bow visor of MV Estonia have been determined by a time domain simulation method and are reported in the report VTT VALC106.

2 CONDITIONS

2.1 Sea states

Numerical predictions of wave-induced motions in long-crested irregular waves were made in four sea states using both the JONSWAP and the ISSC wave spectrum formula given in Appendix 4. The wave spectrum shows the wave energy distribution versus frequency. In the JONSWAP spectrum, the wave energy is concentrated over a narrower frequency band than in the ISSC spectrum. The significant wave height, H_s, was in all cases 4.0 m and the modal wave periods, T_0, or the periods corresponding to the spectrum peak were 7.0, 7.8, 8.5 and 9.5 s.

The present estimate of the sea state during the MV Estonia accident is 4 m significant height and 8 s modal period. Estimates of the modal period and the significant wave height were obtained from the Finnish, Swedish and German institutes of marine research, MTL, SMHI and DW, respectively. Table 2.1 gives their predictions determined by numerical models at the accident site at 02 Finnish time 28 September 1994, i.e. about one hour after the accident.

Table 2.1 Estimates of wave conditions at 02 28.9.1994 at the site of the accident.

Institute	H_s [m]	T_0 [s]	T_1 [s]	Mean dir. [deg.]
MTL, Finland	4.4	8.2		260
SMHI, Sweden	4.2	8.5	7.2	218 - 233
DW, Germany	4.3	8.3	7.0	218

In the table, T_1 is the mean wave period. SMHI gives both the wave direction corresponding to the peak frequency (first) and the direction of the shortest waves which is the same as the wind direction. MTL and SMHI have also made estimates of the wave conditions before and after the accident. A summary of these estimates is in Table 2.2.

Table 2.2 A summary of wave conditions before and after the accident.

Institute	Position	Time	H_s [m]	T_0 [s]	Mean dir.
MTL	59 25, 22 35	27.9, 23.00	3	7	260
SMHI	59 27, 22 50	27.9, 23.00	2.5	6.7	250 - 185
MTL	Accident site	28.9, 01.00	4.0	7.8	260
MTL	Accident site	28.9, 01.30	4.2	8.0	260
MTL	Accident site	28.9, 08.00	5.0	8.7	270
SMHI	Accident site	28.9, 08.00	5.1	9.5	236 - 272

The estimates of the significant wave height by the different institutes agree remarkably well. The Finnish MTL has assumed in predicting the mean wave direction that the wind shift to south on the 27.9 did not last long enough to change the direction of the major wave components. This conclusion is based on their wave observations on the northern part of the Baltic. The experience of MTL is that the mean error in the predicted significant wave height is about 0.5 m, in the wave period about one second and in the wave direction about 10 degrees.

All the wave estimates are for deep water. Numerical predictions by MTL show that the significant wave height may increase significantly in shallow water due to wave focusing (Kahma et al. 1995). If waves with significant wave height 4 m and modal period 8 s enter an area were the waterdepth is around 20 m, the significant wave height may increase to 6 m while the period remains approximately constant. At the same time, statistics of the waves change so that a large part of the waves will have heights near the significant height. However, the maximum wave height will not increase respectively and remains approximately on the same level as with the original 4 m significant height.

The Finnish Lion, about 25 nautical miles west from the MV Estonia accident site, is an example of a shallow area were the significant wave height will increse in suitable weather conditions. The Finnish National Board of Navigation has analysed soundings in a sector reaching over 10 nautical miles east from the wreck of MV Estonia. The area covers the probable route of MV Estonia before the accident. The minimum waterdepth measured was 52 m which indicates that there cannot be sites shallower than about 40 m between the sounding lines. Thus, shallow waterdepth did not have an effect on the wave formation when the lockings of the bow visor of MV Estonia were broken. It may be assumed that the significant wave height was about 4 m and the modal period about 8 s at the time of the accident.

The following table shows a summary of the wave spectra in the numerical predictions and gives the relevant parameters used in forming the spectra.

Table 2.3 Summary of wave spectra.

Modal period T_0 [s]	JONSWAP Wind speed [m/s]	ISSC Mean period T_1 [s]
7.0	38.1	5.40
7.8	22.2	6.01
8.5	14.4	6.55
9.5	8.3	7.33

The mean period of an ISSC spectrum is linked to the modal period by $T_1 = 0.771T_0$. The predictions at different wave periods show the effect of wave period on the wave-induced motions of MV Estonia. According to the linear superposition principle motions such as heave, pitch, vertical acceleration and vertical relative motion are directly proportional to the significant wave height at a fixed value of wave period. Thus, the predicted significant motion amplitudes, which are for H_s = 4.0 m, may easily be scaled for other values of significant wave height.

In addition to the predictions in long-crested seas, wave-induced motions were also computed in short-crested seas with a modal period of 7.8 s. The cosine-square spreading function was used.

Short-term wave statistics may be determined by applying the Rayleigh distribution in the same way as statistics of ship responses in a seaway. The probabilities of individual wave heights and ship response amplitudes exceeding certain levels are discussed in Section 3.

2.2 Speeds and headings

The numerical predictions were made for the vessel speeds of 7, 12, 15 and 17 knots. The present estimate of the forward speed of MV Estonia just before the accident is about 15 knots which is based on witness accounts. The wave-induced motions were determined at the headings to waves of 180° (head seas), 150° and 120°. MV Estonia encountered the waves probably slightly to the port from direct head seas though there are estimates which indicate that the heading may have been closer to beam seas.

2.3 Definition of the vessel hull form

Figure 2.1 shows the body plan and lines of MV Estonia. In the numerical predictions, the vessel hull form was defined by 11 and 21 sections. The number of sections had an insignificant effect on the wave-induced motions. Lewis-forms were used in defining the section shapes. Table 2.4 presents a summary of the main particulars of MV Estonia.

Table 2.4 Main particulars of MV Estonia.

	Symbol	Dimension	Value
Length over all	L_{oa}	m	155.4
Waterline length	L_{wl}	m	144.8
Length betw. perp.	L_{pp}	m	137.4
Beam mld, A deck	B	m	24.2
Waterline beam	B_{wl}	m	23.6
Draught at aft. perp.	T_a	m	5.75
Draught at forw. perp.	T_f	m	5.25
Trim, positive by stern		m	0.50
Displacement	∇	m^3	12 243
Longitudinal CG from aft. perp.	LCG	m	63.7
Vertical CG	KG	m	10.50
Transverse metacentric height	GM_T	m	1.28
Roll radius of gyration	k_{xx}	m	8.96
Pitch radius of gyration	k_{yy}	m	36.2
Depth to stemhead	D	m	10.0

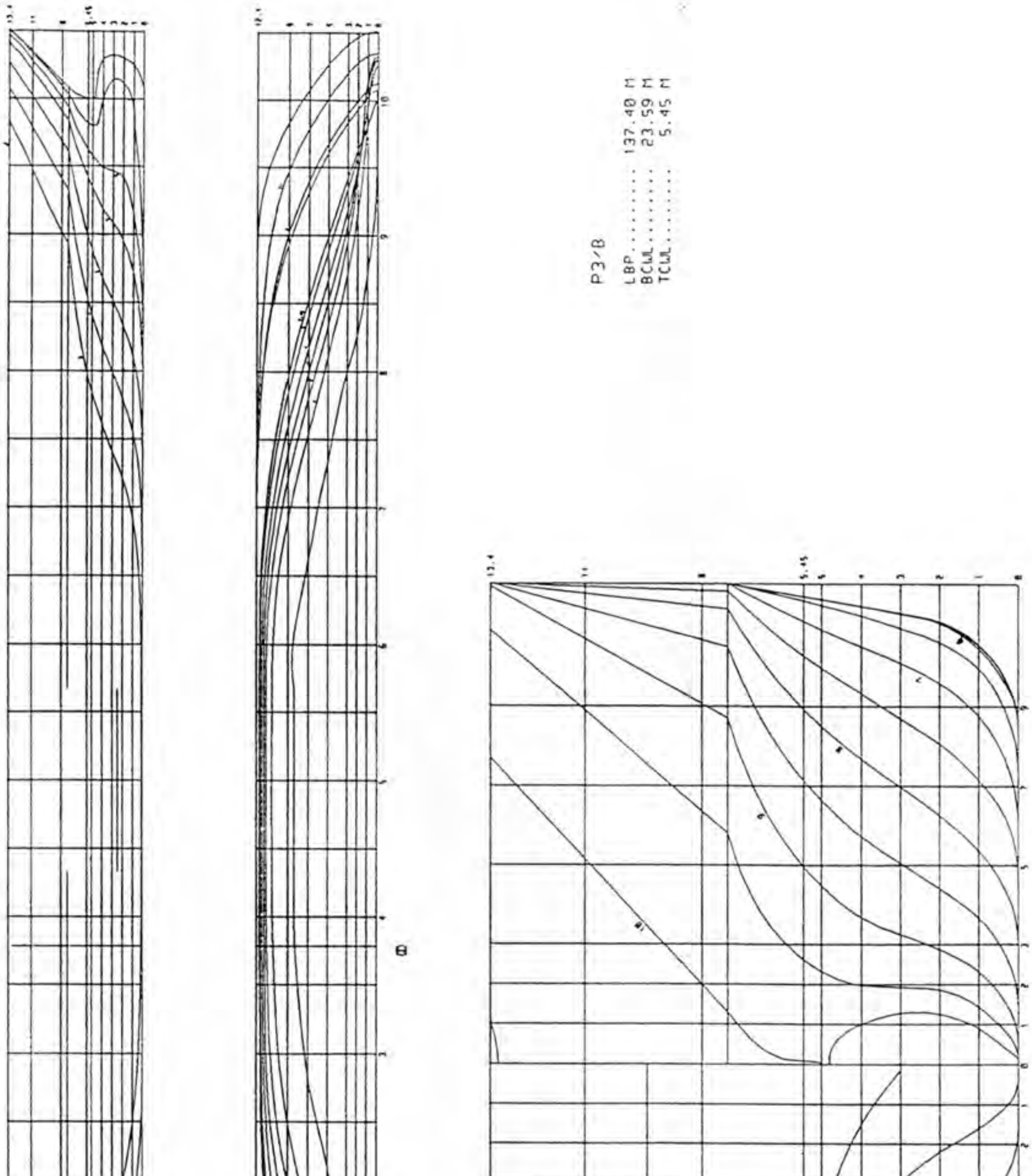

Fig. 2.1 Body and lines plan of MV Estonia.

The numerical predictions are for a vessel mean draught of 5.5 m and an aft trim of 0.5 m, i.e. the draft at the forward perpendicular was 5.25 m and at AP 5.75 m. The displacement of 12 365 tons at a water density of 1.01 $tons/m^3$ and the longitudinal centre of gravity were taken from hydrostatic calculations by the NAPA-program. After the predictions had been made, the load condition of MV Estonia during the accident trip was estimated as 12050 tons and 0.435 aft trim. The fore and aft draughts are respectively 5.172 m and 5.607 m. The difference between the actual and the assumed loading condition is so small that it has hardly any effect on the wave-induced motions.

Standard values of $0.25L_{wl}$ and $0.38B_{wl}$ were used for the longitudinal and transverse radius of gyration, respectively. The transverse metacentric height was set to 1.3 m while the actual value was 1.17m. All but one of the stations for which predictions were made are on the centre line. The roll motion and the transverse metacentric height have no effect on the results on the centre line. The roll motion of MV Estonia was small since the damping fins were out. However, the transverse metacentric height had an effect on the list of the vessel at later stages of the accident. Also the actual location of the centre of gravity differed a little from the assumed value. The final estimated values are: LCG = 63.85 m and KG = 10.62 m. A summary of the input data is given in Appendix 3.

2.4 Predicted responses

In addition to heave, pitch and roll, vertical acceleration has been determined at six stations: the stemhead on the Centre Line (CL), bow visor on the side, construction frame 8.5 (CL), bridge (CL), midship (CL) and aftship (CL). The vertical motion relative to wave surface has been predicted at the three foremost stations. The longitudinal and transverse coordinates of the six stations measured from the after perpendicular and the centre line, respectively, are given in the following table.

Table 2.5 Stations.

Station	Dist. from AP [m]	Dist. from CL [m]
Stemhead # 10 2/3	146.50	0
Bow visor # 10 1/4	140.84	6.08
# 8 1/2	116.79	0
Bridge	111.40	0
Midship	68.70	0
Aftship	10.00	0

Since only motions in the vertical plane were considered, the results apply on any deck at the specific station.

3 RESULTS

The results are given as significant amplitudes in tabular form in Appendix 1. The most important results are also shown in graphical form in Appendix 2.

The significant response amplitude, or the mean of the one third highest response amplitudes is given by:

Significant amplitude = 2(Root Mean Square value) = 2RMS while the mean of the one tenth of highest amplitudes is given by:

$$x_{1/10} = 2.55 \text{ RMS}$$

The significant wave height, respectively, is given by 2(significant amplitude) = 4RMS where RMS is the Root Mean Square value of the wave time history.

The probabilities of the response amplitude exceeding a specific value, z, in a short, a few hours long time interval may be estimated by the Rayleigh distribution:

$$P[x_o > z] = e^{-(\frac{z^2}{2RMS^2})}$$

For instance, the following exceedance probabilities are obtained.

Table 3.1 Exceedance probabilities according to the Rayleigh distribution.

Response amplitude	Probability of exceedance
RMS	0.6065
2RMS	0.135
2.55RMS	0.0387
4RMS	0.0003355

The table shows that there is a 13.5 % probability that the response amplitude will be larger than the significant amplitude. Thus, approximately one wave in ten waves is higher than the significant wave height. Approximately one response amplitude of 25 oscillations is larger than the mean of the one tenth highest amplitudes. As a rule of thumb is often used that the maximum amplitude during a few hours is twice the significant amplitude, or 4RMS which is exceeded approximately at a probability of 1/3000. The wave encounter period of MV Estonia during the accident night was 3.5 to 4.5 seconds so that MV Estonia encountered 3000 waves in 3 to 4 hours.

In every wave train including 3 000 individual waves with a significant height of 4 m, there is a good chance that one of the waves is higher than 8 m. At a probability of 1/3 000 the first or any other of the waves may be higher than 8 m. There are an infinite number of different wave trains which have the same significant height, spectrum and wave statistics.

The most probable extreme response amplitude in N oscillations, or wave encounters may be estimated by the formula:

$$X = RMS\sqrt{2\ln N}$$

The previous formula gives for instance the following results.

Table 3.2 Most probable extreme values.

Number of oscillations, N	Extreme value
100	3.035RMS
1 000	3.717RMS
3 000	4.002RMS
10 000	4.292RMS

The most probable extreme value in 3 000 oscillations, about 4RMS, agrees of course well with the probability of an individual response amplitude exceeding the value 4RMS. The probability of the extreme value exceeding the most probable value is quite high: 63.2 %. The most probable extreme value does not increase quickly with N, the number of oscillations, or wave encounters due to the logarithmic dependence on N. The statistics in Tables 3.1 and 3.2 explain quite well why 4RMS is often used as a rule of thumb for the maximum individual response or wave amplitude.

The results in the Appendices show in general that the modal wave period and the heading to waves have a stronger effect on the responses than the forward speed of the vessel within the wave periods and headings considered here. The significant motion amplitudes increase with increasing wave period and when the heading to waves changes from head seas towards beam seas. Respectively, the responses are larger in short-crested seas than in long-crested seas with the exception of the heading 120°. It seems thus that during the accident night in nearly head seas MV Estonia was more or less running through the waves. The situation was different if MV Estonia had a heading closer to beam seas. The results stress the importance of accurate estimates for the wave period, wave direction and the course of the vessel. The waves may have been quite confused and short-crested due to the wind shift during the day.

3.1 Comparison with numerical predictions and model tests by the SSPA

The significant amplitudes of the responses predicted by SSPA with a similar method as VTT agree very well with the Finnish results. The significant amplitudes at the highest value of modal wave period T_0 = 9.5 s are a little higher in the predictions by VTT when the results using the JONSWAP wave spectrum are compared to the VTT and SSPA results obtained by using the ISSC spectrum formula. The JONSWAP spectrum is narrower than the ISSC spectrum and close to resonance the vessel responses are larger when the energy in the waves is concentrated over a narrow band of frequencies near the resonance frequency. At the three shorter wave periods, the spectrum shape has little effect on the responses.

The following two tables compare the significant motion amplitudes predicted by VTT to experimental results obtained by SSPA in head and bow seas at 15 kn speed. The results by SSPA are from the APPENDIX to the SSPA Report 7524, dated 1995-11-05. The significant motion amplitudes in tables 3.3 and 3.4 have been divided by the significant wave amplitude, $H_s/2$, to make it possible to compare tests at different values of significant wave height. The nominal value of modal wave period has been 8 s. For this particular value of modal period, the results of VTT have been determined by linear interpolation between the results for T_o = 7.8 and 8.5 s.

Table 3.3 A comparison of numerical and experimental motions in head seas with T_o = 8 s at 15 kn.

	SSPA towing tank		SSPA MDL	VTT strip theory
Sign. ampl./(H_s/2)	H_s = 4 m	H_s = 5.5 m	H_s = 4 m	
Heave LCG	0.213	0.219	0.200	0.185
Pitch	0.546	0.609	0.410	0.484
Rel. motion #10	1,560	1.646	1.409	1.457
Rel. velocity #10	1.887	1.899	1.776	2.040
Vert. acc. visor	0.881	0.986	0.740	0.830
Vert. acc. L/2	0.306	0.325	0.260	0.238

Table 3.4 A comparison of numerical and experimental motions in bow seas with $T_o = 8$ s at 15 kn.

	SSPA MDL		VTT strip theory
Sign. ampl./(H_s/2)	$H_s = 4.3$ m	$H_s = 5.5$ m	
Heave LCG	0.310	0.310	0.238
Pitch	0.660	0.658	0.619
Rel. motion #10	1.819	1.851	1.645
Rel. velocity #10	2.002	2.038	2.096
Vert. acc. visor	1.111	1.137	1.059
Vert. acc. L/2	0.355	0.369	0.284

The numerical results show in general good correlation with the experimental results. In bow seas, the predictions by the strip theory are slightly below the test data with the exception of the relative vertical velocity which is about 5 % higher than in the tests. In particular, heave and the vertical acceleration at midship are underpredicted by the strip theory also in head seas where the other numerical results excluding the relative vertical velocity fall between the experiments in the towing tank and the Maritime Dynamics Laboratory (MDL).

The experimental results at different values of significant wave height confirm also in this case the validity of the linear superposition principle, i.e. the significant response amplitudes at the same wave period are linear with regard to the significant wave height.

3.2 Vertical accelerations

At the bow visor of MV Estonia, the significant amplitude of vertical acceleration was 2 - 2.5 m/s^2 and the largest amplitudes were about 0.4g just before the accident assuming that the heading to waves of the vessel was about 150 degrees, speed 15 knots, significant wave height about 4 m and the modal wave period 8 s. This acceleration level is roughly half of the level when masters of cargo vessels start to consider a manoeuvre to reduce the accelerations and about two thirds of the corresponding limit on Ro-Ro cargo vessels including the cross-channel car-ferry ms Roi Baudoin from the sixties (Karppinen, 1987).

Figure 3.1 compares the significant vertical accelerations on board MV Estonia to vertical accelerations masured on board some other vessels and to the ISO 2631/3 (1985) motion sickness standard which is based on the limiting Motion Sickness Incidence (MSI) of 10 % amongst the passengers. The corresponding limiting significant vertical acceleration level is 1.0 m/s^2. On the bridge and in the forward cabins of MV Estonia, the significant vertical acceleration was about 1.5 m/s^2 which is somewhat high from the point-of-view of passenger comfort. About 20 % of the passengers in the foremost cabins may have felt seasick. On the other hand, people tolerate higher vertical accelerations without getting seasick when they are laying in bed than when standing or sitting.

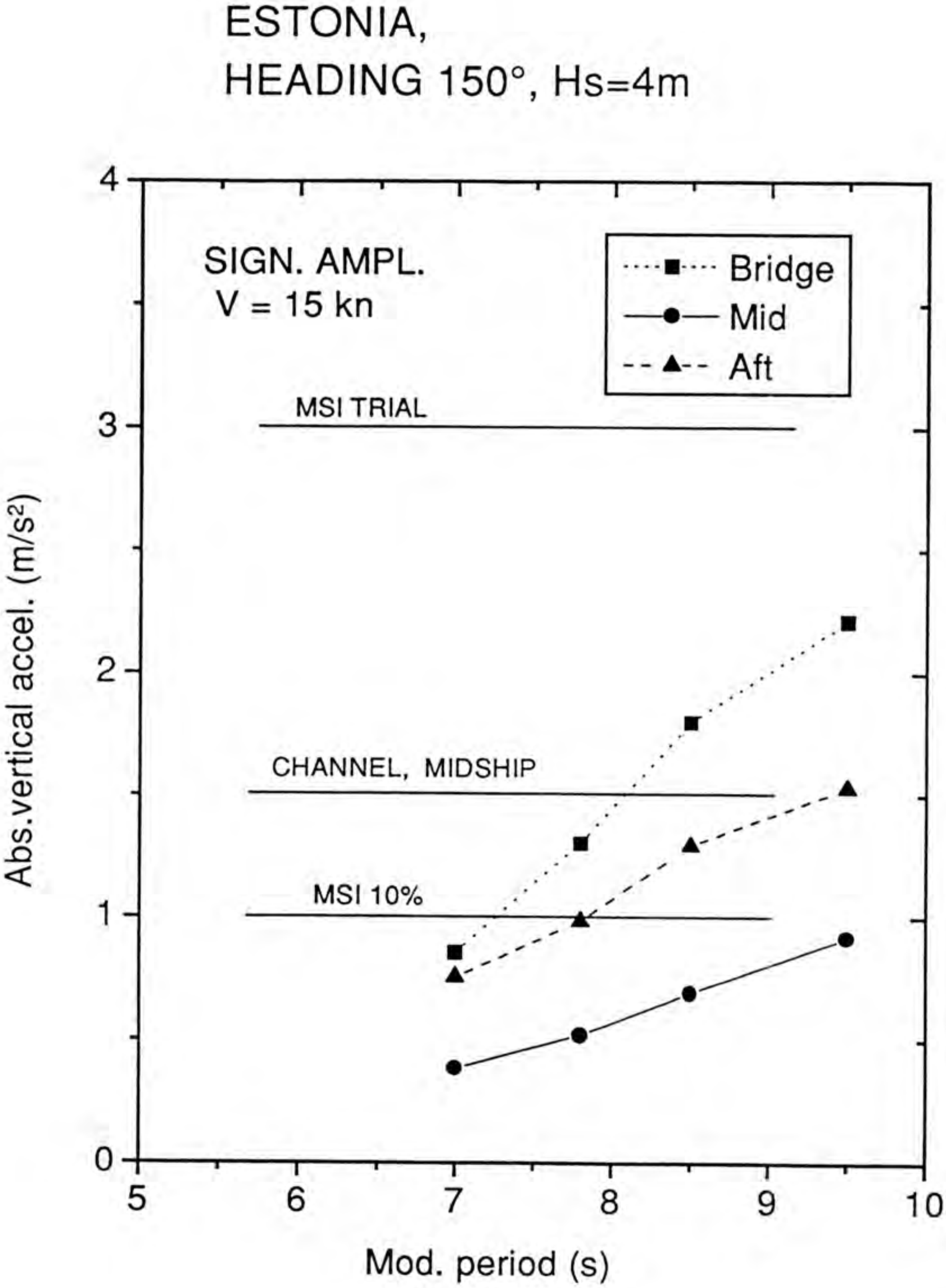

Fig. 3.1 Vertical accelerations on board MV Estonia compared to some other results.

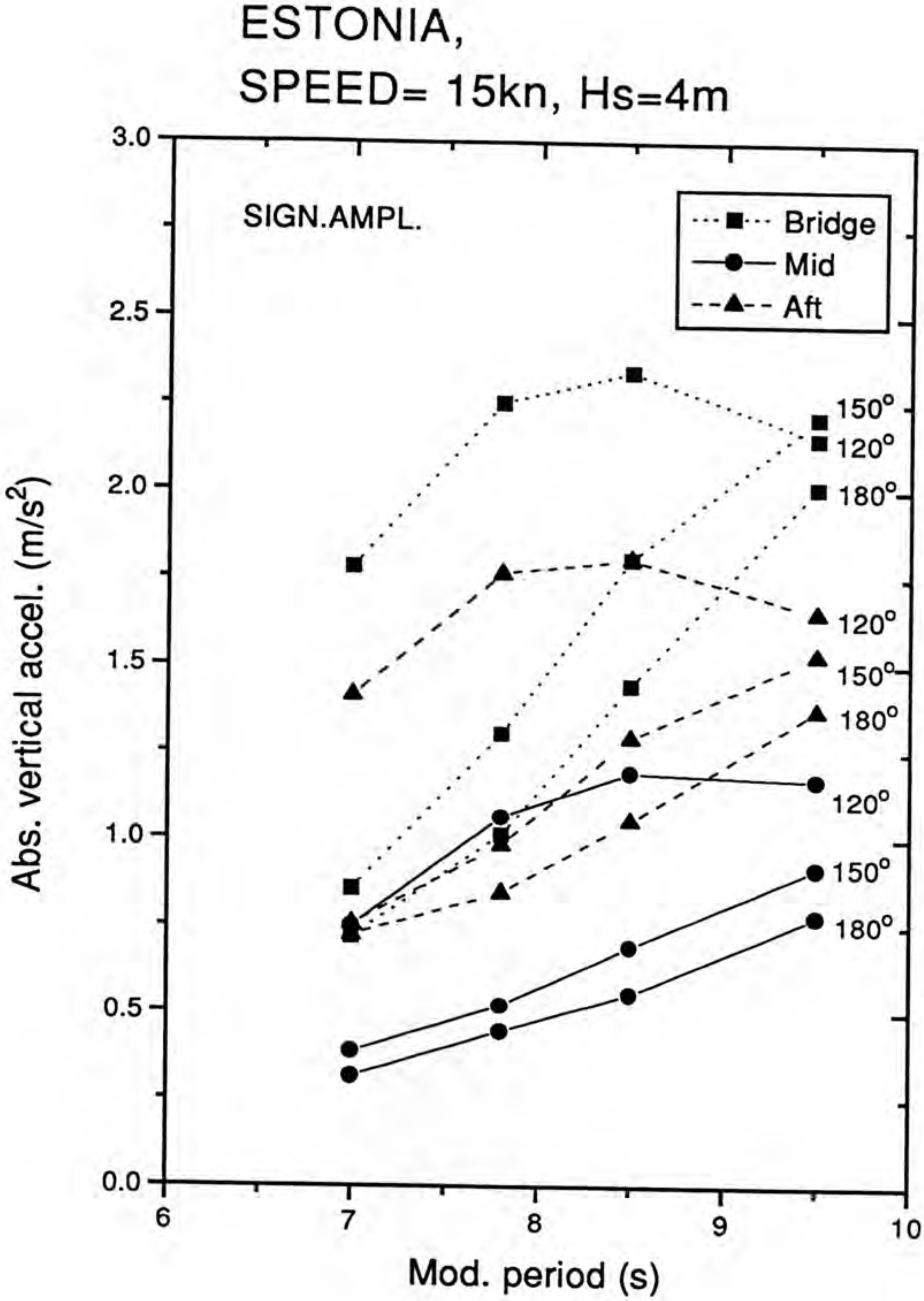

Fig. 3.2 The effect of heading on the vertical acceleration. JONSWAP spectrum.

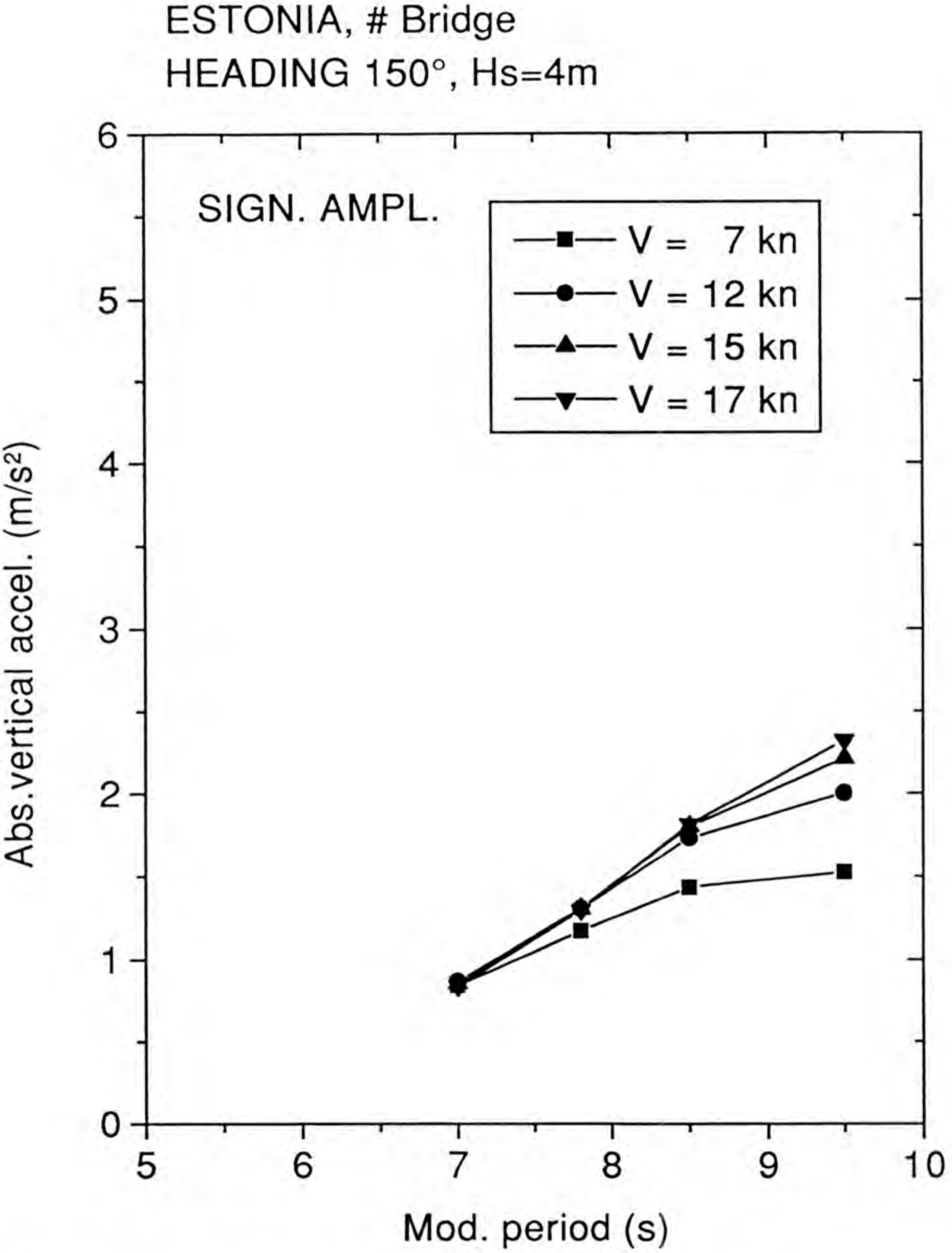

Fig. 3.3 The effect of speed on the vertical acceleration on the bridge in bow seas.

At midship, the acceleration level of about 0.7 m/s^2 significant amplitude was just perceptible and not many people should have felt symptoms of seasickness. At aftship in the cafeteria and restaurant spaces, the significant vertical acceleration was near the ISO 2631/3 limit of 1.0 m/s^2 when about 10 % of standing or sitting people unused to ship motion are seasick (vomiting) after an exposure of two hours. Thus, with regard to the passenger comfort the wave-induced motions of MV Estonia on the accident night after midnight Finnish time were near the comfort limit which is significantly below survival conditions. Before midnight, when the significant wave height was under 3 m, the vertical accelerations on board MV Estonia were at least 25 % lower than just before the accident.

Lawther and Griffin (1986) report on Channel crossings when the significant vertical acceleration at the centre of the ship has been 1.1 - 1.5 m/s^2 and 25 - 35 % of the passengers on board have been seasick (vomiting). Significant vertical acceleration amplitudes of 1.2 - 2.2 m/s^2 have been measured in the foreship on board ms Silja Symphony during a scheduled voyage from Helsinki to Stockholm in heavy bow seas (VTT Report VALC138 dated 12.9.1995). Ikeda and Shirazawa (1994) have observed MSI ratios of 20 to 40 % on board Japanese passenger/car ferries when the significant vertical acceleration has been 2 to 4 m/s^2.

During a seasickness trial on board a fast Norwegian passenger catamaran (Karppinen et al. 1993), the significant vertical acceleration amplitude in the passenger compartment was 3 m/s^2. Two trial runs were conducted with about 100 passengers on board on each trial. On both runs, about 20 % of the passengers were seasick (vomiting) after half an hour of exposure. The frequency of vertical motion during the tests was about 0.4 Hz which is higher than on board MV Estonia. People tolerate larger vertical accelerations without getting seasick at higher frequencies.

If MV Estonia was running in near head seas as assumed, a change of heading or reduction of forward speed would have had only a moderate effect on the vertical acceleration level (Figures 3.2 and 3.3). With a change of heading from bow seas towards beam seas, the accelerations would have increased while by dropping the speed to 7 knots the vertical acceleration level on the bridge would have decreased from about 1.5 m/s^2 to 1.3 m/s^2. In following seas, the vertical accelerations would of course have been significantly lower.

3.3 Vertical relative motion at bow

The vertical relative motion is defined as the vertical ship motion relative to the vertical motion of the wave surface. The relative motion is obtained as the difference between the absolute rigid body vertical motion of the ship and the vertical motion of the undisturbed wave. If the amplitude of the vertical relative motion exceedes the freeboard at bow, there will be green water on deck.

The significant amplitude of the vertical relative motion at the bow visor of MV Estonia was according to the predictions 3 - 4 m. The freeboard to the car deck was about 2.0 m, to the upper edge of the ramp about 7.0 m and to the stemhead about 9.5 m (Figure 3.4). The stationary bow wave may be assumed to reduce these freeboards by 1 m though it is not clear whether the bow wave height should be taken into account.

The predicted vertical relative motion does not include the effect of dynamic swell-up which is difficult to estimate. The dynamic swell-up may increase the vertical relative motion by 30 to 50 %. In full scale, the dynamic swell-up gives rise to spray which by the action of wind comes to the foredeck. It is not well known what is the effect of dynamic swell-up on the green water on deck.

The following table gives probabilities of the water level exceeding certain heights at the bow. The exceeedance probabilities are given for both 3 m and 4m significant amplitude of relative motion. The freeboards include the effect of an one metre high bow wave.

Table 3.3 Probabilities of relative motion at bow exceeding certain levels.

Level and freeboard [m]	Exceedance prob. r_S = 3.0 m	Exceedance prob. r_S = 4.0 m
Car deck, FB = 1.0	0.801	0.882
Ramp, FB = 3.0	0.135	0.325
Ramp, FB = 4.5	0.0111	0.0796
Ramp upper edge, FB = 6.0	0.000335	0.0111
Stem, FB = 7.5	$3.7\ 10^{-6}$	0.000884
Stemhead, FB = 8.5		0.000120

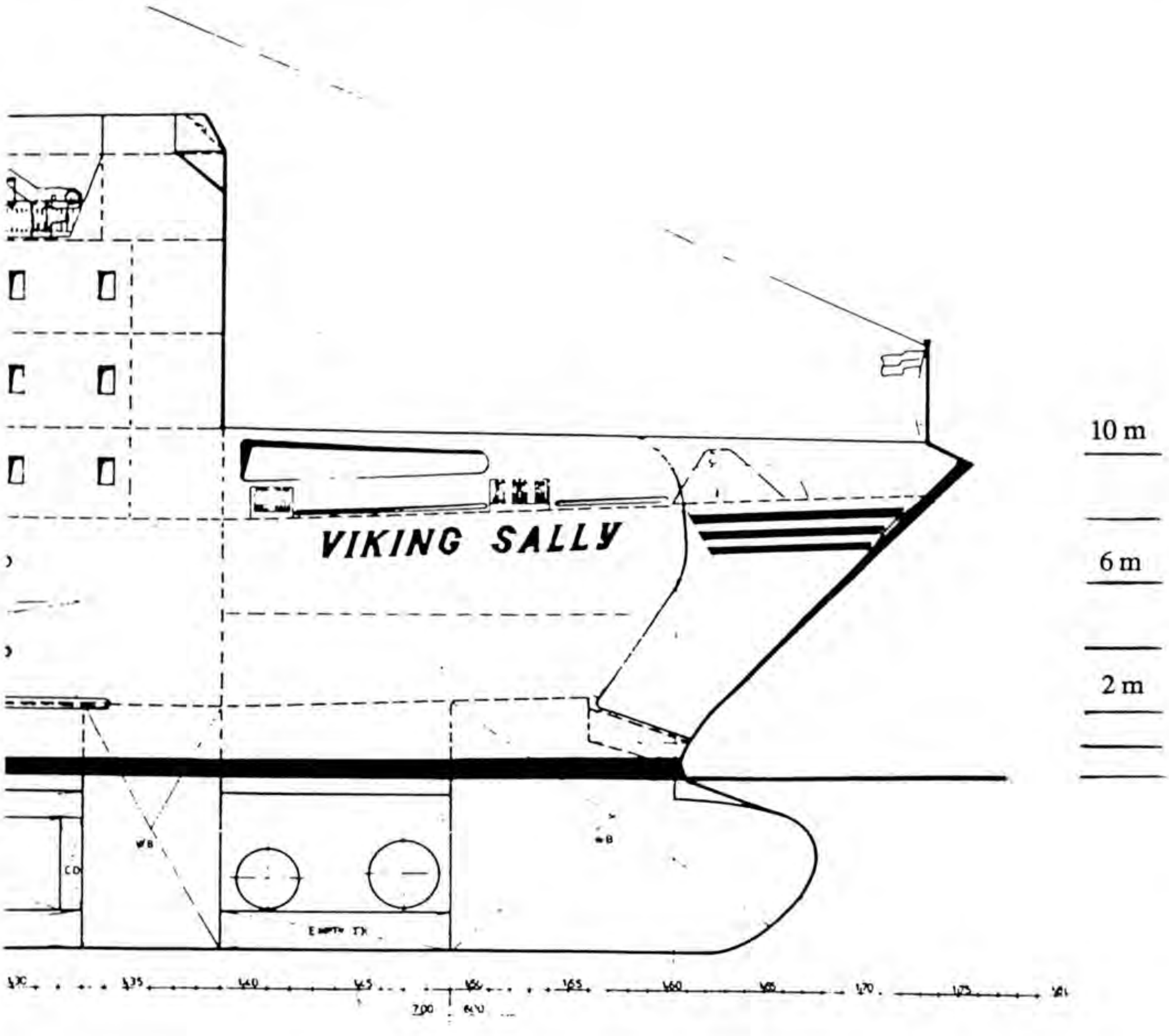

Fig. 3.4 Bow of MV Estonia.

The water level at bow rose in practice nearly at every wave encounter above the car deck level. One wave in hundred, or about once in five minutes the wave surface reached the level of the upper edge of the ramp opening from where there was still 2.5 m freeboard to the stemhead. With these waves, spray and some water came to the foredeck. The probability of relative motion exceeding the stemhead was about 1/10 000. Thus, it is possible that more water came to the foredeck a few times during the accident voyage.

The probability of ship bottom coming out of water at the station 8 1/2 was about 1/1 000 and the probability of a bottom slam about 1/2 000 using Ochi's formula for the critical re-entry velocity. Thus, MV Estonia may have obtained a bottom slam during the accident voyage. In general, the critical slamming probability when cargo ships reduce speed or change course seems to be over 0.01 (Karppinen & Aitta, 1986).

The probability of a flare impact during the accident voyage must have been significantly higher than the bottom slamming probability. The knuckle at the bow is about 2 m above the waterline and there the deadrise angles of the sections are small, about 20 degrees. If Ochis's critical re-entry velocity is applied with a freeboard of 2 m, a probability of about 0.1 is obtained for flare impacts. However, Ochi's formula gives in this case probably too low values for the re-entry velocity. The impact probability decreases quickly with increasing critical re-entry velocity.

3.4 Vertical relative velocity

The vertical relative velocity seems to be not so sensitive to changes in the modal wave period as the other responses. The significant amplitude at the bow visor of MV Estonia has been 4 to 4.5 m/s. The most probable extreme amplitude in 1 000 wave encounters has been about 8 m/s and in 10 000 near 10 m/s.

According to the drop tests by Yamamoto et al (1985) the maximum pressure on the flare part may be expressed as $k\ 0.5\ \rho\ V^2$ where V is the vertical velocity and k a constant the value of which depends on the flare angle. MV Estonia had at the bow visor a flare angle of about 45^o for which roughly $k = 2$. This value with $V = 9$ m/s gives a maximum pressure of 8 ton/m^2 which is more than the design pressure but much less than the 50 ton/m^2 which has been reported in some cases. These very high pressures are local and may be explained by high, local water particle velocities in waves breaking nearly in the normal direction on the hull surface or being entrapped under an overhanging bow flare.

4 CONCLUSIONS

The rigid body vertical accelerations of MV Estonia during the accident voyage after midnight Finnish time were near the passenger comfort limit which corresponds to about 10 % of the passengers seasick (vomiting). From the point-of-view of passengers, the trip was uncomfortable. The conditions on board MV Estonia before the accident were probably similar to conditions which have been observed on board other passenger ferries in heavy weather in general. At the bow of MV Estonia, the vertical accelerations were about two thirds of the level when Ro-Ro cargo vessels decrease speed or change heading to reduce the wave-induced motions of the vessel. The bow of MV Estonia did not probably submerge to the waves, i.e. no events of green water on the foredeck, but certainly spray and smaller amounts of water came to the deck. There were not many heavy bottom slams but the number of flare impacts must have been significantly higher.

REFERENCES

Ikeda, Y. & Shirazawa, H. 1994. A study on evaluation of seakeeping performance for passenger ships (2nd Report) - Measurements of ship motions and vomiting ratio of passengers. J. Kansai Soc. N. A. Japan, No. 222, September.

ISO 2631/3. 1985. Evaluation of human exposure to whole-body vibration - Part 3: Evaluation of exposure to whole-body z-axis vertical vibration in the frequency range 0.1 to 0.63 Hz. International Organization for Standardization, Switzerland. 4 p.

Kahma, K., Pettersson, H., Myrberg, K. & Jokinen, H. 1995. Estimated wave conditions and currents during the last voyage of M/S Estonia. Finnish Institute of Marine Research.

Karppinen, T. 1987. Criteria for seakeeping performance predictions. nstm 87, Helsinki, VTT, Espoo. 31 p.

Karppinen, T. & Aitta, T. 1986. Seakeeping performance assessment of ships. nstm 86, Stockholm, VTT, Espoo. 91 p.

Karppinen, T., Kyyrö, K. & Hellevaara, M. 1993. Passenger comfort and seakeeping performance of fast ferries. RINA Int. Seminar on High-Speed Passenger Craft, London, June.

Lawther, A. & Griffin, M. J. 1986. The motion of a ship at sea and the consequent motion sickness amongst passengers. Ergonomics, Vol. 29, No. 4.

Raff, A. I. 1972. Program SCORES - Ship structural response in waves. Ship Structure Committee Report SSC-230, U.S. Coast Guard Headquarters, Washington D.C. 63 p.

Yamamoto, Y., Iida, K., Fukasawa, T., Murakami, T., Arai, M. & Ando, A. 1985. Structural damage analysis of a fast ship due to bow flare slamming. International Shipbuilding Progress, Vol. 32, No. 369, May.

Appendix 1

Tables

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Appendix 1 : Table A.1

JONSWAP, HEADING 180°   Significant amplitudes

	SPEED (kn)	HEAVE (m) LCG	ROLL (°)	PITCH (°)	REL. VERTICAL MOTION (m) 10 2/3	10 1/4	8 1/2	REL. VERTICAL VELOCITY (m/s) 10 2/3	10 1/4	8 1/2	ABS.VERTICAL ACCEL. (m/s^2) 10 2/3	10 1/4	8 1/2	ABS.VERTICAL ACCEL. (m/s^2) Bridge	Mid	Aft
To=7.0s	7	0.290	0	0.680	2.48	2.58	2.27	3.26	3.39	3.19	1.19	1.12	0.819	0.754	0.362	0.788
	12	0.216	0	0.562	2.28	2.37	2.27	3.71	3.83	3.82	1.18	1.10	0.802	0.737	0.331	0.750
	15	0.191	0	0.494	2.20	2.28	2.24	4.03	4.14	4.17	1.15	1.08	0.782	0.718	0.314	0.723
	17	0.179	0	0.452	2.16	2.23	2.21	4.25	4.35	4.40	1.12	1.05	0.765	0.702	0.305	0.709
To=7.8s	7	0.396	0	1.010	3.05	3.07	2.49	3.36	3.43	3.03	1.41	1.32	0.985	0.911	0.441	0.823
	12	0.339	0	0.921	2.82	2.86	2.55	3.71	3.80	3.63	1.56	1.46	1.090	1.000	0.443	0.839
	15	0.328	0	0.840	2.68	2.72	2.51	3.93	4.02	3.92	1.57	1.48	1.100	1.010	0.445	0.843
	17	0.326	0	0.785	2.60	2.64	2.47	4.09	4.17	4.11	1.56	1.47	1.090	1.010	0.449	0.849
To=7.8s	7	0.516	0.297	1.40	3.59	3.53	2.64	3.75	3.72	3.07	1.95	1.83	1.360	1.250	0.514	1.020
short	12	0.530	0.232	1.27	3.38	3.33	2.74	4.04	4.02	3.63	2.15	2.02	1.510	1.390	0.582	1.070
crested	15	0.542	0.204	1.17	3.21	3.17	2.72	4.18	4.17	3.89	2.17	2.04	1.530	1.410	0.616	1.100
	17	0.546	0.188	1.10	3.11	3.07	2.68	4.28	4.27	4.04	2.16	2.03	1.520	1.410	0.634	1.120
To=8.5s	7	0.440	0	1.48	3.83	3.75	2.75	3.73	3.71	3.01	1.83	1.72	1.260	1.160	0.441	0.953
	12	0.456	0	1.39	3.62	3.59	2.95	4.06	4.1	3.67	2.18	2.05	1.520	1.400	0.519	1.020
	15	0.474	0	1.29	3.40	3.40	2.92	4.18	4.23	3.94	2.24	2.11	1.570	1.440	0.553	1.050
	17	0.486	0	1.21	3.26	3.27	2.88	4.25	4.32	4.10	2.25	2.12	1.570	1.450	0.576	1.080
To=9.5s	7	0.555	0	2.08	4.72	4.46	2.84	4.11	3.95	2.80	2.19	2.06	1.500	1.370	0.447	1.130
	12	0.690	0	2.06	4.86	4.66	3.31	4.76	4.64	3.61	2.85	2.68	1.980	1.830	0.652	1.280
	15	0.771	0	1.97	4.76	4.59	3.45	4.98	4.89	4.00	3.11	2.93	2.180	2.010	0.777	1.370
	17	0.813	0	1.90	4.63	4.50	3.48	5.07	4.99	4.20	3.21	3.03	2.260	2.090	0.850	1.450

Appendix 1 : Table A.2

JONSWAP, HEADING 150°   Significant amplitudes

	SPEED (kn) LCG	HEAVE (m)	ROLL (°)	PITCH (°)	REL. VERTICAL MOTION (m)			REL. VERTICAL VELOCITY (m/s)			ABS.VERTICAL ACCEL. (m/s^2)			ABS.VERTICAL ACCEL. (m/s^2)		
					10 2/3	10 1/4	8 1/2	10 2/3	10 1/4	8 1/2	10 2/3	10 1/4	8 1/2	Bridge	Mid	Aft
To=7.0s	7	0.327	0.288	0.811	2.73	2.70	2.36	3.34	3.34	3.14	1.30	1.21	0.909	0.841	0.413	0.774
	12	0.268	0.208	0.704	2.52	2.51	2.36	3.71	3.71	3.68	1.34	1.26	0.937	0.865	0.393	0.760
	15	0.253	0.174	0.631	2.42	2.41	2.32	3.96	3.96	3.98	1.33	1.25	0.925	0.854	0.385	0.754
	17	0.244	0.155	0.582	2.36	2.35	2.29	4.13	4.14	4.17	1.31	1.22	0.908	0.838	0.380	0.753
To=7.8s	7	0.412	0.289	1.330	3.56	3.48	2.71	3.71	3.66	3.13	1.83	1.72	1.270	1.170	0.457	0.926
	12	0.408	0.212	1.200	3.28	3.22	2.79	3.95	3.92	3.68	2.02	1.91	1.410	1.300	0.497	0.959
	15	0.417	0.180	1.090	3.08	3.03	2.73	4.07	4.05	3.92	2.02	1.91	1.410	1.300	0.518	0.981
	17	0.420	0.162	1.010	2.96	2.92	2.68	4.15	4.14	4.06	1.99	1.88	1.390	1.290	0.528	0.994
To=7.8s short	7	0.723	0.393	1.460	3.57	3.54	2.56	3.71	3.68	2.95	2.07	1.94	1.460	1.350	0.625	1.110
	12	0.748	0.344	1.340	3.40	3.38	2.67	3.99	3.97	3.47	2.27	2.14	1.610	1.500	0.705	1.170
	15	0.761	0.331	1.250	3.26	3.24	2.65	4.12	4.11	3.71	2.30	2.17	1.640	1.520	0.747	1.210
	17	0.765	0.328	1.180	3.16	3.15	2.63	4.20	4.20	3.86	2.29	2.16	1.640	1.520	0.769	1.230
To=8.5s	7	0.498	0.285	1.830	4.40	4.23	2.89	4.17	4.04	3.05	2.27	2.13	1.560	1.430	0.475	1.130
	12	0.583	0.211	1.730	4.27	4.13	3.17	4.55	4.45	3.73	2.70	2.55	1.880	1.730	0.620	1.220
	15	0.625	0.180	1.610	4.05	3.94	3.18	4.63	4.55	4.01	2.80	2.64	1.960	1.800	0.690	1.290
	17	0.641	0.162	1.570	3.88	3.78	3.15	4.66	4.59	4.15	2.81	2.65	1.960	1.810	0.724	1.340
To=9.5s	7	0.699	0.325	2.200	4.88	4.62	2.78	4.22	4.03	2.71	2.42	2.26	1.660	1.520	0.511	1.240
	12	0.864	0.240	2.280	5.15	4.91	3.27	4.93	4.74	3.49	3.10	2.91	2.160	2.000	0.756	1.410
	15	0.967	0.206	2.200	5.15	4.93	3.47	5.22	5.04	3.88	3.39	3.20	2.390	2.210	0.915	1.530
	17	1.020	0.186	2.130	5.08	4.87	3.53	5.35	5.18	4.10	3.53	3.33	2.500	2.320	1.010	1.620

Appendix 1 : Table A.3

JONSWAP, HEADING 120° · Significant amplitudes

	SPEED (kn)	HEAVE (m) LCG	ROLL (°)	PITCH (°)	REL. VERTICAL MOTION (m) 10 2/3	10 1/4	8 1/2	REL. VERTICAL VELOCITY (m/s) 10 2/3	10 1/4	8 1/2	ABS.VERTICAL ACCEL. (m/s^2) 10 2/3	10 1/4	8 1/2	ABS.VERTICAL ACCEL. (m/s^2) Bridge	Mid	Aft
To=7.0s	7	0.575	0.436	1.72	4.22	4.06	2.83	4.54	4.35	3.30	2.78	2.60	1.92	1.76	0.612	1.37
	12	0.623	0.348	1.49	3.93	3.77	2.89	4.64	4.44	3.69	2.82	2.64	1.96	1.81	0.715	1.40
	15	0.629	0.307	1.35	3.72	3.57	2.85	4.65	4.45	3.85	2.76	2.59	1.93	1.78	0.749	1.41
	17	0.624	0.284	1.26	3.58	3.44	2.81	4.65	4.46	3.94	2.70	2.54	1.89	1.75	0.761	1.41
To=7.8s	7	0.858	0.543	2.14	4.60	4.49	2.74	4.57	4.44	2.98	3.04	2.83	2.10	1.94	0.751	1.55
	12	0.969	0.438	1.99	4.62	4.50	3.01	4.95	4.81	3.50	3.34	3.13	2.36	2.18	0.962	1.68
	15	1.010	0.390	1.88	4.53	4.40	3.08	5.08	4.92	3.74	3.42	3.21	2.43	2.25	1.060	1.76
	17	1.020	0.362	1.80	4.44	4.31	3.10	5.13	4.97	3.88	3.44	3.23	2.45	2.27	1.110	1.81
To=7.8s short crested	7	1.000	0.608	1.55	3.40	3.38	2.28	3.45	3.43	2.58	2.17	2.04	1.56	1.45	0.765	1.21
	12	1.030	0.720	1.43	3.31	3.29	2.41	3.68	3.66	2.99	2.34	2.20	1.69	1.58	0.846	1.27
	15	1.040	0.946	1.35	3.22	3.20	2.42	3.77	3.76	3.18	2.36	2.23	1.72	1.61	0.889	1.31
	17	1.050	1.200	1.30	3.15	3.14	2.41	3.83	3.82	3.29	2.36	2.23	1.72	1.61	0.913	1.33
To=8.5s	7	1.070	0.639	2.27	4.40	4.32	2.48	4.16	4.06	2.60	2.89	2.68	2.01	1.86	0.796	1.53
	12	1.210	0.521	2.20	4.62	4.54	2.83	4.66	4.56	3.13	3.31	3.10	2.36	2.19	1.040	1.69
	15	1.280	0.467	2.12	4.66	4.58	2.98	4.89	4.78	3.41	3.50	3.28	2.51	2.34	1.190	1.80
	17	1.320	0.436	2.06	4.66	4.57	3.05	5.02	4.91	3.57	3.59	3.37	2.59	2.42	1.270	1.88
To=9.5s	7	1.310	0.775	2.24	3.86	3.80	2.10	3.49	3.41	2.15	2.53	2.35	1.79	1.65	0.792	1.40
	12	1.430	0.636	2.22	4.13	4.08	2.42	3.95	3.88	2.59	2.95	2.75	2.12	1.98	1.020	1.55
	15	1.520	0.577	2.18	4.25	4.20	2.59	4.20	4.13	2.84	3.16	2.96	2.30	2.15	1.170	1.65
	17	1.570	0.541	2.15	4.31	4.27	2.69	4.35	4.28	2.99	3.29	3.09	2.41	2.26	1.270	1.73

Appendix 1 : Table A.4

ISSC, Heading 180°

Significant amplitudes

	SPEED (kn) LCG	HEAVE (m)	ROLL (°)	PITCH (°)	REL. VERTICAL MOTION (m)			REL. VERTICAL VELOCITY (m/s)			ABS.VERTICAL ACCEL. (m/s²)			ABS.VERTICAL ACCEL. (m/s²)		
					10 2/3	10 1/4	8 1/2	10 2/3	10 1/4	8 1/2	10 2/3	10 1/4	8 1/2	Bridge	Mid	Aft
To=7.0s	7	0.265	0	0.714	2.49	2.54	2.25	3.42	3.50	3.36	1.11	1.05	0.765	0.704	0.316	0.681
	12	0.218	0	0.623	2.34	2.39	2.26	4.01	4.09	4.07	1.16	1.10	0.803	0.739	0.310	0.662
	15	0.203	0	0.556	2.25	2.30	2.23	4.38	4.45	4.48	1.15	1.08	0.795	0.732	0.304	0.650
	17	0.196	0	0.512	2.20	2.25	2.21	4.64	4.70	4.74	1.13	1.07	0.781	0.719	0.301	0.646
To=7.8s	7	0.343	0	1.100	3.08	3.06	2.43	3.51	3.55	3.20	1.43	1.34	0.982	0.903	0.370	0.811
	12	0.342	0	1.030	2.96	2.96	2.54	4.03	4.08	3.88	1.65	1.55	1.140	1.050	0.410	0.834
	15	0.355	0	0.953	2.84	2.85	2.53	4.32	4.38	4.25	1.70	1.60	1.180	1.090	0.435	0.850
	17	0.363	0	0.899	2.76	2.77	2.51	4.52	4.57	4.48	1.71	1.61	1.200	1.100	0.452	0.866
To=7.8s short crested	7	0.479	0.283	1.340	3.40	3.33	2.50	3.70	3.66	3.15	1.78	1.67	1.230	1.140	0.452	0.951
	12	0.518	0.220	1.260	3.31	3.25	2.63	4.15	4.12	3.76	2.02	1.90	1.410	1.300	0.534	0.998
	15	0.545	0.193	1.180	3.20	3.15	2.63	4.38	4.36	4.08	2.08	1.96	1.460	1.350	0.583	1.030
	17	0.558	0.178	1.120	3.12	3.07	2.62	4.53	4.51	4.28	2.10	1.98	1.480	1.370	0.611	1.060
To=8.5s	7	0.426	0	1.420	3.57	3.47	2.54	3.63	3.62	3.05	1.66	1.56	1.140	1.040	0.403	0.908
	12	0.470	0	1.380	3.54	3.46	2.75	4.16	4.16	3.75	2.01	1.89	1.400	1.290	0.489	0.971
	15	0.511	0	1.310	3.44	3.39	2.79	4.42	4.43	4.10	2.14	2.02	1.500	1.380	0.548	1.010
	17	0.536	0	1.250	3.36	3.31	2.78	4.58	4.60	4.32	2.19	2.07	1.540	1.420	0.588	1.050
To=9.5s	7	0.724	0	2.290	4.06	3.86	2.60	3.72	3.63	2.83	1.86	1.75	1.280	1.170	0.433	1.000
	12	0.657	0	1.790	4.18	4.00	2.92	4.30	4.23	3.53	2.36	2.22	1.640	1.510	0.574	1.100
	15	0.731	0	1.740	4.15	4.00	3.03	4.57	4.51	3.89	2.57	2.43	1.810	1.670	0.675	1.180
	17	0.778	0	1.690	4.10	3.96	3.07	4.73	4.68	4.11	2.68	2.53	1.900	1.750	0.744	1.240

Appendix 1 : Table A.5

ISSC, HEADING 150° Significant amplitudes

	SPEED (kn) LCG	HEAVE (m)	ROLL (°)	PITCH (°)	REL. VERTICAL MOTION (m)			REL. VERTICAL VELOCITY (m/s)			ABS.VERTICAL ACCEL. (m/s^2)			ABS.VERTICAL ACCEL. (m/s^2)		
					10 2/3	10 1/4	8 1/2	10 2/3	10 1/4	8 1/2	10 2/3	10 1/4	8 1/2	Bridge	Mid	Aft
To=7.0s	7	0.290	0.238	0.909	2.80	2.75	2.35	3.51	3.50	3.31	1.35	1.26	0.929	0.855	0.351	0.745
	12	0.274	0.173	0.810	2.63	2.60	2.38	3.99	3.99	3.94	1.45	1.36	1.010	0.927	0.366	0.744
	15	0.274	0.145	0.733	2.52	2.49	2.35	4.28	4.28	4.28	1.45	1.36	1.010	0.929	0.374	0.749
	17	0.271	0.129	0.680	2.44	2.42	2.32	4.48	4.49	4.51	1.43	1.34	0.992	0.915	0.377	0.754
To=7.8s	7	0.394	0.264	1.320	3.43	3.33	2.53	3.69	3.64	3.17	1.70	1.60	1.170	1.080	0.408	0.899
	12	0.433	0.193	1.240	3.32	3.24	2.66	4.15	4.10	3.80	1.97	1.85	1.370	1.260	0.481	0.945
	15	0.463	0.163	1.160	3.21	3.13	2.67	4.38	4.34	4.12	2.04	1.92	1.420	1.320	0.528	0.981
	17	0.476	0.146	1.100	3.11	3.05	2.65	4.53	4.50	4.32	2.05	1.93	1.440	1.330	0.554	1.010
To=7.8s short crested	7	0.662	0.373	1.370	3.36	3.30	2.42	3.64	3.61	3.03	1.88	1.76	1.320	1.220	0.555	1.020
	12	0.698	0.326	1.290	3.28	3.24	2.55	4.04	4.02	3.59	2.09	1.97	1.480	1.370	0.637	1.070
	15	0.720	0.313	1.210	3.19	3.15	2.56	4.25	4.23	3.88	2.15	2.03	1.530	1.420	0.686	1.110
	17	0.731	0.310	1.160	3.12	3.09	2.55	4.39	4.37	4.06	2.17	2.04	1.550	1.440	0.715	1.140
To=8.5s	7	0.507	0.288	1.640	3.87	3.72	2.61	3.81	3.72	3.03	1.93	1.81	1.330	1.220	0.445	1.000
	12	0.585	0.212	1.580	3.86	3.73	2.84	4.30	4.22	3.67	2.31	2.17	1.610	1.490	0.567	1.090
	15	0.641	0.180	1.500	3.78	3.66	2.89	4.53	4.46	4.00	2.45	2.31	1.720	1.590	0.648	1.150
	17	0.670	0.162	1.440	3.70	3.59	2.90	4.66	4.59	4.19	2.50	2.36	1.760	1.630	0.697	1.190
To=9.5s	7	0.682	0.336	1.960	4.22	4.02	2.61	3.84	3.71	2.79	2.09	1.96	1.440	1.320	0.482	1.090
	12	0.792	0.248	1.940	4.36	4.17	2.94	4.40	4.27	3.45	2.59	2.43	1.810	1.670	0.652	1.210
	15	0.873	0.212	1.880	4.35	4.17	3.05	4.65	4.53	3.78	2.80	2.64	1.980	1.830	0.769	1.300
	17	0.922	0.191	1.830	4.31	4.15	3.09	4.79	4.67	3.97	2.90	2.74	2.060	1.910	0.844	1.360

Appendix 1 : Table A.6

ISSC, HEADING 120° Significant amplitudes

	SPEED (kn)	HEAVE (m) LCG	ROLL (°)	PITCH (°)	REL. VERTICAL MOTION (m) 10 2/3	10 1/4	8 1/2	REL. VERTICAL VELOCITY (m/s) 10 2/3	10 1/4	8 1/2	ABS.VERTICAL ACCEL. (m/s^2) 10 2/3	10 1/4	8 1/2	ABS.VERTICAL ACCEL. (m/s^2) Bridge	Mid	Aft
To=7.0s	7	0.584	0.431	1.53	3.70	3.57	2.55	4.11	3.95	3.19	2.35	2.19	1.63	1.50	0.562	1.17
	12	0.647	0.343	1.39	3.57	3.45	2.63	4.36	4.20	3.60	2.46	2.30	1.75	1.59	0.679	1.22
	15	0.670	0.303	1.29	3.46	3.35	2.63	4.48	4.33	3.81	2.46	2.31	1.74	1.61	0.734	1.26
	17	0.676	0.280	1.23	3.38	3.27	2.62	4.56	4.41	3.94	2.45	2.30	1.74	1.61	0.762	1.28
To=7.8s	7	0.798	0.520	1.83	3.99	3.87	2.55	4.15	4.01	3.00	2.58	2.40	1.79	1.65	0.655	1.32
	12	0.889	0.419	1.71	3.96	3.85	2.71	4.45	4.31	3.43	2.79	2.61	1.97	1.82	0.819	1.41
	15	0.931	0.374	1.62	3.90	3.79	2.76	4.59	4.45	3.65	2.85	2.68	2.03	1.89	0.905	1.47
	17	0.952	0.348	1.56	3.84	3.74	2.77	4.67	4.53	3.78	2.88	2.70	2.06	1.91	0.955	1.51
To=7.8s short crested	7	0.913	0.579	1.40	3.15	3.12	2.18	3.35	3.33	2.66	1.96	1.84	1.40	1.31	0.689	1.10
	12	0.941	0.692	1.32	3.11	3.08	2.30	3.64	3.62	3.07	2.10	1.98	1.52	1.42	0.759	1.14
	15	0.957	0.930	1.25	3.05	3.03	2.32	3.79	3.77	3.29	2.14	2.02	1.56	1.45	0.801	1.17
	17	0.964	1.180	1.20	3.01	2.99	2.32	3.88	3.86	3.42	2.15	2.03	1.57	1.47	0.826	1.19
To=8.5s	7	0.971	0.605	1.99	4.04	3.94	2.47	4.04	3.92	2.79	2.64	2.45	1.84	1.69	0.706	1.37
	12	1.070	0.492	1.89	4.09	3.99	2.68	4.38	4.25	3.23	2.91	2.72	2.06	1.91	0.893	1.48
	15	1.130	0.442	1.81	4.07	3.97	2.76	4.54	4.41	3.45	3.01	2.82	2.16	2.01	0.999	1.56
	17	1.160	0.413	1.76	4.04	3.95	2.79	4.63	4.51	3.59	3.06	2.87	2.20	2.05	1.060	1.61
To=9.5s	7	1.180	0.734	2.08	3.89	3.81	2.28	3.74	3.64	2.47	2.55	2.37	1.79	1.65	0.737	1.36
	12	1.280	0.602	2.01	4.02	3.94	2.52	4.11	4.00	2.89	2.87	2.69	2.05	1.91	0.936	1.49
	15	1.350	0.545	1.96	4.05	3.97	2.63	4.29	4.18	3.11	3.01	2.83	2.17	2.03	1.050	1.57
	17	1.380	0.510	1.91	4.05	3.98	2.68	4.39	4.28	3.25	3.09	2.90	2.24	2.09	1.130	1.64

Appendix 2

Figures

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SUPPLEMENT No. 413

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MV ESTONIA Accident Investigation. Effect of speed on the visor loads.

Working paper.

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MV ESTONIA ACCIDENT INVESTIGATION

Effect of speed on the visor loads

The effect of forward speed on the visor loads in bow oblique seas (wave direction 150 degrees) is here analysed on the basis of the results of the model experiments and numerical simulations. Only the vertical force component is considered since the experiments show that the horizontal component was always very close to the vertical and the opening moment was proportional to the vertical force, i.e. a larger force indicates a larger opening moment.

The model experiments with Estonia, the extensive systematical series of experiments by SSPA and the simulations show that the vertical force on the visor in head and bow seas over a large speed range is approximately directly proportional to the forward speed. The dependence on speed may be a little weaker but it is hardly stronger. Thus, a linear relationship between the visor force and speed has been assumed. Two exceedance probabilities have been considered: 10^{-3} and 10^{-4} which correspond approximately to one hours and ten hours sailing time, respectively. The significant wave heights, H_s, have been assumed as 4 and 4.5 m.

The following table shows a summary of the vertical visor loads in bow oblique seas at different speeds according to the results of the numerical simulations (VTT Report VALC106, Table 5.1) and the assumption of linear dependence on speed.

Table 1. The vertical wave load on the visor in bow seas.

H_s [m]	Exc. prob.	Speed 7.5 kn	Speed 10 kn	Speed 12 kn	Speed 15 kn
4	10^{-3}	1375 kN	1830 kN	2200 kN	2750 kN
4	10^{-4}	1850 kN	2470 kN	2960 kN	3700 kN
4.5	10^{-3}	1950 kN	2600 kN	3120 kN	3900 kN
4.5	10^{-4}	2650 kN	3530 kN	4240 kN	5300 kN

The forces in the previous table include the effect of the weight of the visor which has been assumed as 589 kN (60 tons). The effect of wave height increase from 4 to 4.5 m is in agreement with the model tests.

To see better the trends with speed and since the load required to break the visor lockings is not exactly known, the load in the conditions where the lockings broke has been given the value of 100 and all the other force values have been scaled accordingly. Thus, the load 2750 kN which has an exceedance probability of 10^{-3} at 15 knots speed in seas with H_s = 4 m has been assigned the value of 100. The next table shows the results in this form.

Table 2. The relative vertical wave load on the visor in bow seas.

H_s [m]	Exc. prob.	Speed 7.5 kn	Speed 10 kn	Speed 12 kn	Speed 15 kn
4	10^{-3}	50	67	80	100
4	10^{-4}	67	90	108	135
4.5	10^{-3}	71	95	113	142
4.5	10^{-4}	96	128	154	193

When the lockings of the visor broke, the Estonia had been sailing about half an hour from the waypoint in increasing bow seas. Before the course change at the waypoint, the loads on the visor had been at least 25 % smaller than after the waypoint, i.e. about 75 using the same scale as in Table 2. Thus, it is reasonable to assume that the load which broke the attachments of the visor was not a very rare extreme load. On the other hand, the ultimate strength of the lockings could not have been below the level of about 75 since then the accident may have happened already before the waypoint. This, however, depends quite strongly on how quickly the significant wave height rose during the last half an hour before the accident. The ultimate strength of the locking system must have been a little smaller than the load which broke the lockings, perhaps about 90.

From the accident site, the Estonia had about 75 nautical miles to Söderarm. The significant wave height was increasing and there were on the way some areas of shallow water where the wave height would probably have been higher than in the surrounding deep water. At 15 kn speed it would have taken 5 hours and at 10 knots 7.5 hours to Söderarm. A large part of this time the significant wave height would have been about or larger than 4.5 m. At speeds more than 10 knots, the maximum loads would have been above the level of 95 according to Table 2. Thus, it can be concluded that at a speed of more than 10 knots in bow seas during the accident night after 01 Finnish time the Estonia had no chance of avoiding the breaking of the lockings.

At a speed of 7.5 knots, it would have taken about 10 hours to Söderarm. The maximum loads on the visor at this speed would most likely have exceeded the level which broke the lockings, if the Estonia had not changed significantly course. The Estonia may have survived in the prevailed bow seas without breaking the lockings at a speed of below 5 knots. The chances of survival would then have been of the same order as in playing the Russian Roulette.

If the lockings of the Estonia had been constructed according to the design calculations, the ultimate strength of the locking system would have been approximately twice the actual strength, or about 180 on the scale of Table 2. Then the Estonia would likely have survived at a speed of about 12 knots but not necessarily at 15 knots.

According to the IACS and BV Rules of 1982 the design load per attachement point for the visor of Estonia would have been about 200 tons instead of the original 100 tons. This means that the ultimate strength of the locking system would have been on the level of 360. The lockings of the visor of Mariella and the lockings of the bow doors of Silja Europa were probably on this or a little higher level. In spite of this, the bow doors of Silja Europa suffered damage during the accident night. The bow doors of Silja Symphony and Serenade were constructed according to even higher design loads and their strength was somewhere above the level of 500 if the same scale as used for Estonia is applicable.