METL / IGSAM / *BEA*mer
PERMANENT COMMISSION OF INVESTIGATION INTO ACCIDENTS AT SEA (CPEM)

TOTAL LOSS OF
THE ITALIAN CHEMICAL TANKER
IEVOLI SUN
IN THE ENGLISH CHANNEL
30 OCTOBER 2000

=**=

CONTRIBUTION TO THE INVESTIGATION

=**=

This report constitutes the French contribution to the investigations carried out on the total loss of the IEVOLI SUN. It has been drawn up, on one hand in the form specified by the provisions of the decree of 20/01/81 concerning technical and administrative investigatory commissions after accidents and incidents at sea and its decree of enforcement of 16/12/97 which created the Marine Accident Investigation Board (Bureau enquêtes accidents / mer) (BEAMER) and a Permanent Commission of Investigation into Accidents at Sea (CPEM), and on the other hand taking into account Resolutions A.849(20) of 27/11/97 and A.884(21) of 25/11/99 of the International Maritime Organization (IMO) on Investigations of Marine Casualties and Incidents, and the United Nation Convention on the Law of the Sea, 1982. These texts allow States which, on account of the risks for their coasts and damage caused thereto, have an interest in knowing the causes of an incident which occurred in international waters to take part in the technical investigation into this incident.

As the IEVOLI SUN was an Italian-registered vessel, operated by Italian nationals, under the command of an Italian master with a crew who were mainly Italian, the necessary contact was therefore made with the competent maritime authorities for investigations after marine casualties in Italy, and with those having the same functions in Great Britain, owing to the location of the sinking.

The relevant information was therefore exchanged among all these authorities in accordance with the provisions of the above-mentioned IMO resolutions. This report will be handed to IMO's Secretary-General's Office as laid down by these resolutions, and, as a contribution, to the Italian authorities in charge of the flag State investigation.

This document sets out the conclusions reached by the CPEM on the circumstances and causes of the total loss of the IEVOLI SUN on 30/10/00. In accordance with the provisions of IMO Resolution A849(20) of 27/11/97 and of the decree of 20/01/81 on investigatory commissions after accidents at sea, the analysis of this sinking has not been carried out in order to establish or impute penal faults or to assess individual or collective civil liability. Its only purpose is to learn from this casualty the lessons which may help to prevent future casualties of the same type. The use of this report for other purposes could therefore lead to erroneous interpretations.

CONTENTS

=**=

OPINIONS AND COMMENTS

=**=

APPENDICES

= ** =

This report was translated from French by Miss Vivien Pearson and Mr Philippe Galvagnon, Senior Lecturers at the Ecole Nationale de la Marine Marchande, Marseilles.

1* REMINDER OF THE CIRCUMSTANCES IN WHICH *IEVOLI SUN* SANK

On 29 October 2000, at about 1230 hours, the chemical tanker *IEVOLI SUN*, proceeding from Fawley (United Kingdom) towards Berre, suffered flooding of the forward spaces and compartments while she was between the Casquets and Ushant.

On 30 October, at about 0130 hours, the ballast tanks were in turn progressively flooded.

As the vessel was heavily down by the head the master requested the assistance of a tug. He then asked for the crew to be evacuated, as the ship was becoming impossible to steer and was likely to sink at any moment.

The crew were winched off by a French Navy helicopter and the vessel was taken in tow, by the stern, by a French salvage tug which proceeded towards a port of refuge in Normandy.

This crossing could not be completed and the vessel finally foundered about 9.5 nautical miles north of the Casquets, in a depth of 60 to 70 metres.

=**=

2* THE OPERATION OF THE VESSEL

The *IEVOLI SUN* was a tanker which could carry oil or liquid chemicals. She was of the *"parcel tanker"* type, still recent and suited for the carriage of various products, including those considered dangerous by IMO regulations. She was operated by a European shipowner within the framework of a relatively large fleet (15 vessels ranging from 5 000 to 40 000 dwt), which was itself part of an international consortium grouping the similar fleets of two other European shipowners. Moreover, chemical carriers are usually operated in pools whose commercial management is performed either by the owners themselves or within consortia of a relatively small number of shipowners. In general there is no uncertainty as to the ownership of these vessels. The consortium within which the *IEVOLI SUN* was commercially operated grouped a few dozen vessels of the same type, used essentially for trade within the European Union on the basis of chartering contracts signed with the major firms of the European chemical industry. All these vessels met the stringent quality criteria of this professional branch (*see* § 4* *below*).

The Commission noted that the vessels of this fleet were regularly inspected by the PSC inspectors of the ports where they called. These inspections have sometimes called attention to various deficiencies on vessels other than the *IEVOLI SUN*, but these were most often minor, did not concern the structure and did not affect the seaworthiness of these vessels (target factors of 21 and 26 for two vessels, negligeable for the others).

The owners of the *IEVOLI SUN* carried out the nautical and technical management of their vessels directly and were ISM *("International Safety Management Code")* certified.

The *IEVOLI SUN* operated mainly between the Mediterranean and the Channel and North Sea ports with:

- **In the South-North direction, complete cargoes of common chemicals (caustic soda in particular)**
- **In the North-South direction, part cargoes grouped together for one or more charterers.**

The Commission found that the chartering conditions were normal, with freight rates sufficiently remunerative to allow the vessel to be maintained and the fleet to be renewed.

It is worth noting that this was the oldest vessel in her owner's fleet (average age eight years); the owner was moreover involved in a considerable, continuous process of modernization and development of his naval material.

Like all the vessels of this fleet, the *IEVOLI SUN* was insured both for the hull (hull insurance) and for civil liability (P&I – *"Protecting & Indemnity club"*) by first-rate underwriters.

The Commission noted that in the management of the consequences of the casualty, the owner of the vessel immediately came forward as such.

=**=

3* THE CARGO

At the time of the accident the vessel was carrying three lots of chemicals, loaded in three different North European terminals (Moerdjik and Peirnis in the port of Rotterdam then Fawley in England) for different Mediterranean ports (Berre, Barcelona, Genoa) for two charterers, subsidiaries of major oil companies and important operators on the petrochemical market:

- **a lot of 3998t of styrene (loaded in Moerdik) ;**
- **a lot of 1027t of methyl ethyl ketone (MEK) (loaded in Fawley);**
- **a lot of 996t of isopropyl alcohol (IPA) (loaded in Rotterdam).**

These three lots took up all the available cargo capacity. These substances are carried regularly by sea in the conditions prescribed by the regulations for this type of goods.

In the series of past and future charters of the *IEVOLI SUN*, this voyage came between two complete voyages carrying caustic soda from Lavera to Immingham for a large French chemical group.

The Commission noted that in the management of the consequences of the casualty, the owners collaborated immediately and as fully as possible with the actions of the French maritime authorities and cooperated fully with the Commission.

=**=

4* THE VESSEL

4.1* Type and characteristics

The *IEVOLI SUN* was a double-hulled vessel which complied with the international regulations in force for vessels of this type (IMO 2). Her main characteristics were as follows:

- **length overall** : **115.65 m;**
- **moulded breadth** : **17.51 m;**
- **draft** : **6.29 m** (reduced to 6.16m at the winter freeboard)**;**
- **depth** : **8.01 m**
- **gross tonnage** : **4 189 grt;**
- **deadweight** : **7 333 dwt** (reduced to 7 075 d w t in Winter North Atlantic)**;**
- **shipyard** : **SOCIETA ESERCIZIO CANTIERI in Viareggio – hull number 768 - 1989.**
- **machinery** : **Main engine WARTSILA VASA (2 960 kW at 720 r p m);**
- **commercial speed** : **13.8 knots;**
- **consumption:**
  - ***12.2 t / day of heavy fuel oil (380 cst),***
  - ***1 t / day of diesel oil during loading,***
  - ***2 t / day of diesel oil during unloading;***

- **bunker capacity:**
  - ***283 m3 for heavy fuel oil,***
  - ***90 m3 for diesel oil;***

- **cargo capacity: 7130 m^3,** 98% of which were chemicals which could be distributed among 16 stainless steel tanks and two stainless steel slop-tanks)**;**
- **ballasting : 3091 m^3** in the fore and aft peak tanks and the 8 U-shaped ballast tanks located between the two hulls and the two L-shaped ballast tanks located between the two hulls below N° 9 cargo tank area. All these tanks were protected by an epoxy coating and each had its own pumping line**;**
- **cargo pumps : 18 *"FRAMO"* submerged pumps each having a rate of 150 m^3 / hr;**
- **ballast pumps : 2 pumps each having a rate of 350m^3/hr.**

The vessel was automated (the engine room was unmanned), the alarms were duplicated in the wheelhouse, in the cabins of the engine officers (chief engineer, second engineer) and in the officers' messroom.

4.2* History

The vessel was built in 1989 by the firm SOCIETA ESERCIZIO CANTIERI of Viareggio, under the control of RINA classification society, according to its regulations, with a view to issuing its first rating fraction 100.A11.

She was under the Italian flag as soon as she was put into service, and has changed neither flag, nor owner, nor classification society but only her name, on 30 September 2000, when from *GENNARO IEVOLI* she became *IEVOLI SUN*, for her owner's own reasons.

4.3* Flag State safety inspections

The Commission asked the Italian authorities to communicate the documents concerning these inspections, but has not received them.

4.4* Classification

The vessel had been classed by the RINA since she was built in 1989.

The vessel had the maximum class:

★ 100 – A – 1.1 – Nav. IL ; Cst (oil chem) ESP

✠ IAQ – 1 ; P. (automation).

The latest certificate was dated 06/12/99 and had been endorsed five times in 2000 after occasional surveys of the hull and/or the engine.

RINA had carried out about sixty surveys of the vessel altogether, including annual surveys, intermediate surveys and the special surveys of 1993/1994 and that of January to June 1999, with drydocking.

During this last survey a scantling measurement had been taken and a complete survey of the hull and the compartments, including the double bottom, carried out without remarks or request for repairs.

The protection of the ballast tanks was considered *"good"* with an *"average"* risk of corrosion.

4.5* Certificates

The following international certificates were almost all issued by RINA, on behalf of the Italian Republic.

a) Load Line

- **International Load Line Certificate : 06/12/99**

b) Solas

- **Cargo Ship Safety Construction Certificate : 06/12/99**
- **Cargo Ship Safety Equipment Certificate (Holland) : 23/10/00**
- **Cargo Ship Safety Radio Certificate : 23/10/00**
- **Unattended Machinery Space Certificate : 06/12/99**

c) Marpol

- **International Pollution Prevention Certificate and supplement : 06/12/99**

d) MSC and MEPC resolutions

- **International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk: 06/12/99**

e) ISM code

- **Initial Safety Management Certificate issued by the Italian Ministry of Transport and Navigation based on an audit by RINA: 19/06/96**
- **endorsed by RINA: 16/06/99**
- **which reexamined it (**new audit**) following the Rotterdam PSC inspection: 23/10/00**

4.6* Port State inspections

4.6.1 INSPECTIONS BEFORE 23/10/00*

These inspections gave rise to a number of recommendations:

25/09/96 – BRUNSBÜTTEL (Germany):

- **Oil Record Book,**
- **charts,**
- **catwalk rails.**

04/03/97 – ROTTERDAM:

- **Oil Record Book,**
- **magnetic compass,**
- **nautical documents,**
- **International Code of Signals,**
- **lifeboat (detention),**
- **liferaft,**
- **opening to engine room.**

12/06/97 – LISBON:

- **manning certificate,**
- **safety plan.**

14/04/99 – AMSTERDAM:

- **emergency lighting,**
- **lifeboats (detention),**

- **nautical documents,**
- **sound and light signals,**
- **lifebuoys,**
- **fire prevention,**
- **electrical installations.**

28/10/99 – RIJEKA (Croatia):

- **manning certificate.**

4.6.2 THE LAST PSC 23/10/00 – ROTTERDAM – DETENTION*

This last inspection brought to light the following points:

- **Safety Radio Certificate out of date,**
- **malfunction of the watertight door closing mechanisms,**
- **charts,**
- **fire safety,**
- **safety in general,**
- **lack of watertightness of liferaft containers,**
- **cracked ports,**
- **leak on the hydraulic system of the crane,**
- **anchor cable in bad condition,**
- **emergency fire pump not operational,**
- **pump room valve (ODME) not working,**
- **non-compliance with the ISM code due to lack of maintenance.**

All of these requirements are quite important, and as some of them concerned the class the RINA surveyor checked that the repairs had been carried out, including that of the guillotine bar stopper; the class was confirmed, but the surveyor requested a new class survey before 15/11/00.

4.7* Inspections by the charterers

4.7.1* INSPECTIONS BY THE CHEMICAL DISTRIBUTION INSTITUTE (CDI)

Since 1995, the purpose of this institute has been to improve the quality and the safety of maritime carriage, in particular by inspecting vessels carrying chemicals.

On these grounds, the *IEVOLI SUN* was inspected three times, the last time being on 11/04/00 at Porto Vesme in the presence of the owner's superintendent.

This inspection gave rise to a report covering:

- **documents,**
- **organization and personnel,**
- **navigation equipment,**
- **anchoring gear,**
- **engine room,**
- **safety,**
- **hygiene,**
- **lifesaving appliances,**
- **pollution prevention,**
- **hull and structure,**
- **accommodation,**
- **cargo tanks,**
- **cargo handling gear,**
- **ballast tanks.**

As the vessel was unloading:

- **the inspection of the hull and the structure was limited to the *"appearance"* of the decks and superstructure (including the forecastle), appearance which seemed *"satisfactory";***
- **neither the cargo tanks, nor the ballast tanks were inspected**

The few recommendations concerned the engine room (ventilation, batteries, leaks, closing of the ballast tank sounding holes, LACK OF CLEANLINESS, electrical and lighting installations), the cut off valves of the foam fire extinguishing system, and a LEAK ON THE BOW THRUSTER HYDRAULIC SYSTEM.

4.7.2 INSPECTION BY* TEXACO *COMPANY WITHIN THE FRAMEWORK OF* "SIRE" *VETTING, IN BARCELONA, ON 30/05/00*

The vessel was again unloading. The structure could not be inspected. It is noted that the last survey of the tanks (class) was in January 1999 and was satisfactory. The crew were obliged to inspect them every six months. On the other hand, there were about 4 to 5 m^3 of fuel oil in the bottom, due to a leak found in the port fuel tank. As usual, the observations made were communicated to the owner who let it be known that he had taken the necessary measures.

4.8* Conclusion – General appraisal

Generally speaking, the vessel seems to have been well monitored by the classification society within the framework of its duties. The many inspections by the port State and by the charterers (who were not however able to examine the structure of the vessel) revealed a number of deficiencies, many of which concerned maintenance.

=**=

5* THE CREW

5.1* Composition

The crew of the *IEVOLI SUN* was as follows:

- **deck officers:**
  - ***a master,***
  - ***a chief mate,***
  - ***a mate,***
  - ***a cadet,***
- **engine officers:**
  - ***a chief engineer,***
  - ***a second engineer,***
- **ratings:**
  - ***a pumpman, also responsible for safety,***
  - ***an assistant engineer,***
  - ***four seamen, including an engineer,***
  - ***a cook,***
  - ***a steward.***

5.2* Qualifications

The Commission noted the following qualifications:

- **the MASTER, aged 48;**

- *held a certificate of competency equivalent to Master, Foreign-going,*
- *30 years of seagoing service,*
- *14 of which as Master (27 command posts),*
- *had been Master of the IEVOLI SUN for one month;*

- **the CHIEF ENGINEER, aged 48 ;**
  - *had held a certificate qualifying him for this function for 15 years,*
  - *27 years of seagoing service (all on tankers),*
  - *eight of which as Chief Engineer,*
  - *had been Chief Engineer on the IEVOLI SUN for one month;*

- **the CHIEF MATE, aged 41;**
  - *held a certificate of competency equivalent to Master, Foreign-going,*
  - *22 years of seagoing service,*
  - *9 of which as Master;*
  - *had been Chief Mate on the IEVOLI SUN for one month;*

- **the PUMPMAN (**Spanish nationality**), aged 58;**
  - *40 years of seagoing service,*
  - *had been pumpman on the IEVOLI SUN for 15 days but had performed the same functions on this vessel for eight months in 1993.*

The Commission considers that the qualifications involved do not call for any particular observations.

=**=

6* THE SEQUENCE OF EVENTS

The following chronological elements come from the log book, the MRCCs' rough books and the interviews that the Commission was able to have with the crew members, owners and charterers.

6.1* The previous voyage

* On 15/10/00, the vessel, proceeding from FOS towards Immingham with a cargo of caustic soda, goes through the Strait of Gibraltar, force 7 head wind, engine on stand by.

* On 17/10/00 at 1430 hours, she rounds Cape Finisterre in Spain (average speed = 12 knots).

* On 18/10/00, at 2230 hours, she passes Ushant (average speed = 12.8 knots).

* On 19/10/00, at 1000, she passes the Casquet Islands (average speed = 12.5 knots).

* On the same day she goes through Dover Strait at 2300 hours.

* On 20/10/00, at 1950 hours, she is alongside in Immingham (average speed = 12.8 knots).

* On 21/10/00, she leaves in the evening for Moerdjik.

* On 22/10/00 at 2348 hours, the *IEVOLI SUN* arrives at the SHELL loading terminal in Moerdjik.

* On 23/10/00 at 0630 hours, the vessel begins to load 4 000 t of styrene for SHELL.

* On 23/10/00 at about 1100 hours, leaking styrene pollutes the harbour water. SHELL has floating booms placed all round the vessel. The leak is from a pipe in the pumproom. When the leak has been repaired loading begins again.

* SHELL'S inspectors blame this leak on a lack of maintenance of the valves and on the crew who it seemed had not set up the valves of the system correctly.

* On 23/10/00 at 1100 hours, the vessel is inspected by the charterers' representatives, and by the Dutch maritime authorities on the grounds of PSC.

* On 24/10/00, at 0130 hours, the vessel has finished loading the styrene.

* On 24/10/00, at 0300 hours, the *IEVOLI SUN* is shifted from the Moerdjik SHELL terminal to the Peirnis SHELL terminal to load the isopropyl alcohol (IPA) for EXXON.

* On 24/10/00 at 1800 hours, the vessel, which has finished loading the IPA, is again shifted to a waiting berth in order to carry out the required repairs.

* On 25 and 26/10/00, the vessel is inspected six times by inspectors of the SHELL group.

* On 26/10/00, the vessel is surveyed by a representative of RINA to make sure that the recommendations concerning the class have been complied with and to perform the remainder of the ISM audit. The class is maintained.

* In the late afternoon, the Dutch maritime authorities put an end to the PSC detention of the *IEVOLI SUN*. SHELL issues the vessel with an acceptance for unloading at their Berre terminal.

* The vessel sails for Fawley at 2000 hours.

* On 27/10/00, the vessel arrives at the Fawley EXXON terminal, at 2200 hours.

* During the call at Fawley, the master carries out the routine check *(ship shore safety check list)* of loading gear. The vessel loaded 1027t of methyl ethyl ketone (MEK).

6.2* The last voyage

* On 28/10/00, the *IEVOLI SUN* leaves Fawley at 1230 hours. On departure, the draft forward is 5.3 metres and the draft aft 6.4 metres. The deadweight is 6 , 600 t (6 , 021 t of cargo, 579 t of bunkers and other consumables), which is below the permitted deadweight, for a load displacement of 8 , 900 t. The vessel is expected to arrive in Berre on 3/11/00 in the late afternoon.

* The master had consulted the weather forecast before leaving and did not consider that it prevented his sailing, which was quite normal as the *IEVOLI SUN*'s navigation was not restricted in any way.

* On the same day, at 2200 hours, the vessel, which is on course 254° heading for the westbound lane of the Casquets TSS, is rolling, pitching and shipping green seas. The wind and the sea are from south-west force 8.

* At 1000 hours, on 29/10/00, on leaving the Casquets TSS, she alters course to 232° to head for the southbound lane of the Ushant TSS. Her speed is 5.3 knots and the wind and sea West/South-West (250°), force 9/10. The vessel is pitching, rolling, shipping green seas and vibrating. From the study of the track plotted by Jobourg MRCC even before she left the TSS, it can be seen that the vessel seemed to be having steering problems.

* At about 1230 hours, a bow thruster room water ingress alarm, *"intermittent"* at first, goes off. The vessel is then 12.3 nautical miles from the end of the CASQUETS TSS.

* The master decides to turn the vessel in order to inspect the forward part.

* He then goes with the chief engineer, the first mate, the pumpman and a seaman to the forecastle where he finds that the store in the forecastle space is flooded.

* He thinks that the water has entered via the spurling pipes, located between the windlasses and the chain lockers, which should be plugged with quick-setting cement, but the cement is no longer there.

* He notices a damaged flexible pipe on the hydraulic systems of the windlasses, which cannot be isolated as the isolating valves are in the flooded store.

* He establishes, on one hand that the store cannot be drained either by the ejector which is out of reach or by the mobile bilge pump (its flow is insufficient and it is dangerous for the crew to use it in heavy weather), and also that the vessel is still slightly down by the stern.

* Nevertheless, in spite of the worsening weather conditions, he considers that the vessel can return to her original course (see below).

* He contacts his company's head office at about 1530 hours. The duty technical superintendent is thus informed of the damage, and also of the fact that the crew consider that the vessel is able to sail. It seems the master then gave instructions for the level in the ballast tanks to be checked at the end of each watch.

* On 30/10/00 at about 0000 hours, the officer on watch notes that the vessel's movements are abnormal and that the forecastle is completely covered by the waves.

* On 30/10/00 at about 0130 hours, the crew observes, on seeing the gauges of the cargo control room, that the forepeak tank and ballast tanks numbers 2 and 3 are completely flooded and that ballast tank N° 4 is starting to fill. The vessel is now heavily down by the head and is listing to port. The pitching decreases. As the propeller is still submerged, the master considers that the vessel can continue to proceed on course 232°, at a speed reduced to 1.7 knots.

* The chief engineer cannot start the unballasting/bilge pumps, due to an electrical fault which he cannot repair.

* At about 0200 hours, the master begins to prepare to abandon ship. The crew is assembled in the wheelhouse.

* At the company's head office in Naples, when the ISM *designated person* is informed, he leaves the assessment of the situation to the master. He indicates that he will contact Corsen MRCC to organize the towing of the ship.

* The crew observes that ballast tank N° 4 has been completely flooded in 40 minutes, followed by ballast tank N° 5 between 0300 and 0330 hours.

* On 30/10/00 at 0408 hours, the master of the *IEVOLI SUN* calls Ushant Traffic Control/Corsen MRCC on the distress frequency 2182 kHz. He gives his position 49°26'N/04°05'W, his course 282°, his speed about 1 knot, and reports that he can no longer control his vessel.

* Then he states that the double bottom tanks are flooded and that he requests assistance.

* At 0414 hours, he sends a VHF/DSC distress call and specifies, via INMARSAT C, that he requests the assistance of a tug for a stern tow.

* At 0428 hours, he tells the MRCC that the situation is unchanged and that he will contact them again if he requires a tug...

* At 0523 hours, he states that the forepeak tank (about 1500 t) is flooded, as well as ballast tanks numbers 2, 3, 4 and 5, which were empty when the vessel left Fawley. He blames this situation on a structural failure. The forward half of the vessel is now underwater. The master repeats his request for a stern tow.

6.3* The rescue of the crew

* On 30/10/00 at 0807 hours, the diver of a French Navy *Super Frelon* rescue helicopter, sent to the scene by Brest Maritime Prefecture after being alerted by the MRCC, is winched onto the vessel.

* At 0822 hours, the winching operation begins.

* At 0847 hours, 12 people have been winched off. The remaining two, the master and the chief engineer, agree to be winched off as well.

* At 0905 hours, all the crew (14 people) have been evacuated. The weather in the area (wind 270° / 40 knots / sea force 6) is indeed so bad that it is feared that it will be impossible to come back to winch off any personnel who may have remained on board.

* Moreover, the intervention team sent by the Maritime Prefecture cannot be winched onto the *IEVOLI SUN* to take the *ABEILLE FLANDRES*' towing line until 1512 hours.

6.4* The towing operation

* At 1647 hours, when the *IEVOLI SUN* is in position 49°17.5'N / 003°50'W and is drifting at 2/2.5 knots to 100°, towards the Channel Islands (Guernsey is 37NM away), a towing line is put across from the *ABEILLE FLANDRES*. The convoy proceeds North-East, hoping to reach Cherbourg or the Bay of the Seine.

* On 30/10/00 at 1905 hours, the convoy is in position 49°27.5'N / 003°25.8'W and is proceeding on course 050° at 5 knots.

* The weather conditions at that time are as follows: wind West/South-West 30 knots reaching 45 knots in gusts; sea force 6/7, visibility 7 NM; swell from West with troughs of 5 to 6 m.

* On 31/10/00 at 0300 hours, the convoy enters the eastbound lane of the Casquets traffic separation scheme at a speed of 2.5 knots, course 075°.

* On 31/10/00 at 0900 hours, responsibility for the operation changes from Brest Maritime Prefecture to that of Cherbourg, in accordance with the instructions in force on this subject.

* At 0700 hours, the convoy is in position bearing 284° from "*Cap de la Hague*" distance 26 NM. It is now proceeding at 3.6 knots, still on course 075°.

6.5* The sinking

* On 31/10/00 at 0800 hours, the tug observes that the forward part of the vessel has sunk 1.5 m deeper since she was taken in tow.

* At 0845 hours, the behaviour of the vessel implies that the sinking is imminent.

* At 0849 hours, the vessel capsizes to starboard and begins to sink by the head.

* At 0905 hours, the vessel is standing on end, with only the rudder blade and the transom plate out of the water. The bow is touching the bottom. The towing line has parted.

* At 0928 hours, the vessel sinks in position 49°52'.3N / 02°23'.8W, ie about 9 NM north of the Casquet Islands, in a depth of 60 - 70 m.

7* TECHNICAL FACTORS CONTRIBUTING TO THE SINKING

7.1* Analysis of the events

7.1.1 THE SAILING CONDITIONS*

a) The weather

Between 28/10, the date when the vessel sailed from Fawley, and 30/10, the date when she was abandoned, the meteorological office broadcast about ten special weather reports (SWR) for “high seas”, Atlantic and West Channel areas.

The SWR are sent to vessels automatically by telex (NAVTEX) every four hours, at the same time as the *“ordinary”* weather reports, which are more detailed.

The observations made by weather buoys in this area, confirmed by those of La Hague signal station, are as follows:

	Barometer	Wind	Sea
28/10 – 1200 hours	1000	180/24 knots	3s/3m
1800 hours	1000	260/50 knots	9s/4m
29/10 – 0000 hours	1006	240/37 knots	10s / 3.8m
0600 hours	1006	270/39	9s/4.4 m
1200 hours	1006	230/31	/4
1800 hours	997	240/50	7s/7m
30/10 – 0000 hours	994	230/46	10s/4.9m
0600 hours	981	250/45	10s/6.2m
1200 hours	987	260/40	9/3.7

The remarks entered in *IEVOLI SUN*'s log book are as follows:

Date / watch.	Course	Wind	Sea	Behaviour of the vessel
29/10 – 0400 hrs	254	225/8/9	225/8	
0800 hours	254	247/9	247/8	
1200 hours	232	247/9	247/9	
*1230 hours				
1600 hours	232	247/9	247/9	Sudden movements-vibrations – Deck submerged.
2000 hours	232	247/9-10	247/9-10	The weather conditions get worse and worse.
30/10 – 0000 hrs	232	247/9-10	247/9.10	Raging sea, on deck.
04H00 hours	232	247/10	247/10	Manœuvring with difficulty.

*** vessel turned, not mentioned**

The officers on watch note strong motion - pitching and rolling – getting worse as the weather conditions deteriorate from 29/10 at 1230 hours – flooding of the forward spaces – to the morning of 30/10 – progressive flooding of the ballast tanks – time when they decrease, as the forward part is underwater.

A car ferry transiting the same area at the same time noted:

- **29/10 wind w/sw force 8 to 10 – sea rough to high .**
- **30/10 wind w/sw force 8 to 9 – sea rough.**

In short, the *IEVOLI SUN* encountered the forecast gale, which, at first sight, was not out of the ordinary for such a ship, remembering again that her navigation was in no way restricted.

But, and this is quite abnormal, she had shipped more than 130t of water in the forward compartments, since 1230 hours on 29/10.

a) Course and speed

From leaving FAWLEY, the vessel always followed the courses planned, even after she left the Casquets TSS, where the course 232° put her almost head on to a sea which was getting rougher and rougher.

As for her speed, it was of course reduced by the heavy weather. Then, at the end and too late, it was reduced to the minimum to heave to.

7.1.2* THE FLOODING OF THE FORWARD SPACES

a) The flooding of the forecastle store

On 29/10 at about 1230 hours, the water ingress alarm in the bow thruster compartment led the crew to inspect the forward part of the vessel, where they observed that the forecastle store was flooded.

This flooding was caused:

- **either by the filling:**
  - ***first of the chain lockers via the spurling pipes, whose sealing cement had disappeared.***

The unusual character of such a method, which in this case is due to the fact that these spurling pipes have no coaming owing to the short height between the cable lifter and the forecastle deck, is to be noted. The crumbling and disappearance of the cement is caused by the movement of the chain in the spurling pipes because of heaving and vibrations.

- ***Then of the store itself via the bitter ends fitted on the deck of the store.***

The Commission noted that flooding had already occurred in this way, on this vessel in 1995, and on others, the lack of watertightness at the bitter ends being caused either by the absence of a device to reduce it, or by a failure of this device, especially if it consisted entirely or partly of cement.

- **Or, especially if the above-mentioned device was still in position and efficient, via the cover located forward of the companionway leading down to the store. The inspection of the wreck showed that this cover was open, its coaming bent, and that of the 5 holding down bolts on the coaming 1 was missing and 3 were in poor condition. Finally, there was a rope fastened inside the cover, which may indicate that it helped to secure it from inside.**

b) The flooding of the bow thruster compartment

As the water ingress alarm in this compartment went off shortly before the flooding of the store was observed, it can be deduced that, as has already happened on similar vessels, the water flooded this compartment progressively via the access door to the companionway to this compartment.

c) Draining

It was not possible to drain these compartments either with the fixed bilge installation (the flooding had made it inaccessible) or with the portable Wildel pump on account of its small rate of flow ($2m^3/h$) and the danger for personnel involved in using it.

b) The flooding of January 1995

The forward compartments of the *IEVOLI SUN* had already been flooded in a similar manner in 1995 (see appendix E).

Among the reasons which allowed the vessel, at the time, to continue her voyage and arrive safely in port, although she had considered a port of refuge, can be noted:

- **the fact that the vessel was five years younger at the time;**
- **that, on the whole, the weather conditions improved shortly after the flooding was discovered, and the normal course made her change from 210° to 180°, ie at an angle of 45° to the sea and wind;**
- **that the crew were able to drain the flooded compartments successively, even if this was a slow process.**

Following what was, for the above reasons, only a minor incident, it appears that covers were fitted on the bitter ends, but these, welded in spots and allowing the bitter ends to be released, were probably not completely watertight.

7.1.3 THE FLOODING OF THE BALLAST TANKS*

On 30/10 at about 0130 hours, the crew notice that the vessel is down by the head to a large extent and that she has become heavier, while the pitching which had until then been severe has decreased noticeably, the forward part being underwater.

The crew then see on the remote level display that the forepeak tank and ballast tanks numbers 2 and 3, which should have been empty, are now full.

Thus 790 t have been added to the 135t, or thereabouts, of water which have entered the store and the bow thruster room, consequently bringing the forward draft from 5.3m (when the vessel left Fawley) to about 8.01m, ie practically level with the freeboard deck.

The crew then see ballast tank N° 4 (437t) fill in 40 minutes, then N° 5 (329t) between 0300 hours et 0330 hours.

The *"draft"* forward is then 9.73m, that is, there is more than a meter of water over the deck both aft of the forecastle and on the forecastle deck.

The question of how this flooding could have occurred and spread progressively from forward to aft led the Commission to have a study carried out. This study is described in § 7.3.

7.2* Observation and technical analysis

7.2.1 OBSERVATION OF THE WRECK*

The French Navy carried out the first exploration of the wreck as early as 1 November 2000.

Supervision and survey operations of the wreck began from 10 November 2000.

They were performed by *NORTHERN PRINCE* by means of a remotely operated vehicle (ROV) of the Explorer 3 type.

Investigations were made difficult by a strong current in the area where the ship sank and by adverse weather conditions to which technical problems were added.

Furthermore, the ROV could not be used beyond sea force 4. Because of this, each inspection period seldom exceeded one hour. They had to be stopped from 14 November to 19 November on one hand because of weather conditions, on the other as a result of the parting of the ROV umbilical.

A total of 5 hours of underwater video were recorded.

The ship is in position 49°52.8N – 002°23.5W. The water depth is about 70 metres.

She is lying on her port side with a list of about 110° and is oriented in direction 240°.

The results of the first investigations were as follows:

- **only the starboard side can be seen properly,**
- **the forecastle sustained heavy damage: bulwark torn off, masts crushed.**
- **The bulb seems to have suffered damage, probably at the time the ship struck the sea bed,**
- **however, no traces of contact with a partly submerged floating object were found,**
- **port and starboard anchors are home as well as the starboard protection grating of the bow thruster,**
- **the windlasses, cables and stoppers are visible,**
- **on the starboard windlass, the chain stopper seems to be unlocked and the casing damaged;**
- **the access door to the forecastle store is closed but on the other hand the hawser store companionway cover is fully open at right angles. Its coaming is bent, as seems to be the cover. Out of five holding down bolts, one is missing and three are in bad condition;**
- **rails are crushed on deck;**
- **two leaks were sighted in the starboard plating in way of frames numbers 46–47. One, quite considerable, comes from a hole from which projects a metal part which is difficult to identify, the other, not so big, was spotted above the first one and is likely to come from a broken weld. These leaks are in way of cargo tank number 8 where a significant staving of the plating, over a large area, can be seen;**
- **the inspection of the keel and the visible part of the port plating lying on the bottom did not show any staving or leak,**
- **on the starboard side, all ballast tank air vents seem to be in position and in good condition;**
- **those on the port side are not visible;**
- **the quality of the video is not good enough to confirm whether the air vent of the forepeak tank is damaged; an aerial photo taken on the morning of 31 October leads us to think that it was still in position;**
- **loading manifolds and piping on deck are bent;**

- **the bridge castle is seriously damaged on the starboard side where crushing of a corner of the bridge can be seen;**
- **the port side of the funnel seems to be lying on the bottom, where many broken fragments are to be seen;**
- **the propeller and the rudder do not seem to have suffered heavy damage.**

It emerges from these investigations that after capsizing when sinking the *IEVOLI SUN* was probably dragged 200 to 250 metres (trace of an impression of the ship's bottom) and eventually lay down on her port side. As for the staving in way of cargo tank N° 8, it might have been caused by an implosion phenomenon.

Further investigations were later conducted with a view to pumping the cargo. They did not produce any new elements, except for finding and recovering the forepeak air vent upper part, which, disconnected from the pipe when the stem landed on the bottom when the ship sank, was lying on the bottom in the vicinity (see §7.2.2.).

*7.2.2*THE IEVOLI SUN'S BALLAST TANK AIR VENTS*

General

As on all vessels of this type, on which you must quickly and almost simultaneously change from loading/unballasting to unloading/ballasting operations and vice-versa, the air vents, which are furthermore situated on the freeboard deck, subject to bad weather, are of the "*automatic closing*" type (by means of balls and/or valves) to prevent sea water from getting into the ballast tanks.

The note drawn up by BEAmer (see appendix D) about these air vents describes their construction and operation. It states the problems met when they become older or corroded, or are excessively maintained; these problems may result in breakage or disappearance of the "*automatic closing*" device.

Moreover, to be efficient, and thus avoid the risk of distortion of the tanks, their diameter must be large enough to cope with the rate of flow of the ballast pumps.

The air vents of the IEVOLI SUN

The *IEVOLI SUN* was fitted with the following air vents:

- **1 forepeak air vent (diameter 250 mm) coming out on the forecastle, on the port bow, close to the bulwark.**
- **2 air vents (diameter 200 mm) coming out forward close to the outer side of ballast tank N° 2, that is to say in an area enclosed by the aft bulkhead of the forecastle and the bulwark which is 3.5 m high at this point and then decreases to reach deck level, aft of ballast tank N° 2.**
- **16 air vents (diameter 200 mm) coming out at the forward part and close to the outer sides of ballast tanks numbers 3, 4, 5, 6, 7, 8 and 9.**

It should be noted that:

- **all ballast tanks from N° 2 to N° 8 are U-shaped, forming a double hull which "*communicates*"; only ballast tank N° 9 is divided in two by a longitudinal central bulkhead;**
- **the construction of these ships causes the strengthening girders (coamings and beams) to be fitted on deck (inverted decks), which hampers considerably the draining of green seas into the sea and favours water confinement on deck;**
- **like other tankers, they have a reduced freeboard because of the small size and number of openings in the freeboard deck (amended Load Line Convention 66).**

Condition of the air vents of the IEVOLI SUN

At first sight, the underwater photos of the wreck show that all starboard air vents seem to be in position, but nothing can be concluded as to the efficiency of their sealing system.

Nevertheless, it must be noted that if there is a lack of watertightness of the upper part of the air vents, the diameter in the head is the same as that in the pipe and that calculations and what the crew observed show that ballast tanks N° 3 and then N° 4 were flooded at a rate of almost 700m3/h, which tends to show that the sealing systems of the two air vents of each of these ballast tanks were disabled.

The port air vents cannot be seen; as the ship was lying on her port side, this part of the deck had sunk into the bottom of the sea.

On the other hand, it was possible to recover and inspect the upper part of the forepeak air vent, which broke off when the bow reached the bottom (see appendix). It had a *“2 ball automatic system”.*

Although the upper part of the head had been opened by the shock on the bottom, it can be noted that, in places, the scantling of the plate was still sufficient, about 3 mm. On the other hand, the bottom of the inner chamber had disappeared, due to corrosion over an area greater than that of the pipe, which made it possible for the balls to fall into the forepeak tank, either intact or broken, as the distance piece between them had broken. Besides, there were no, or no longer, seals on the seats of the openings plugged by the balls, so that the seats rapidly became damaged, without mentioning the indented edges of the bottom of the chamber, due to corrosion, the thicknesses of which were found to be about 0.5mm.

To conclude, this type of air vent is known to be, by nature, subject to stresses which may either break it or destroy the *“automatic sealing system”*, which, even if not visible, has nonetheless the same results.

Failing to have recovered the air vents on the wreck, we can only assume that most of them were in such a condition that, with the head submerged by water retained on the decks and the sinkage of the forward part of the ship, they made it possible for a 350t ballast tank to be flooded within 30 minutes, which corresponds to the total flow of its 2 air vents.

7.2.3* BALLAST SYSTEM – BILGE SYSTEM

Ballast system

It consists of a forepeak tank and 8 U-shaped tanks located in the double bottom and the double hull. Each ballast tank is fed by a dedicated pipe (ND 200) (the same pipe being used for filling and draining the ballast tanks).

The pipes cross the ballast tanks at the bottom. They are fixed on bearing collars lined with a neoprene strip and are fitted with compensators to correct mis-alignments and damp vibrations.

Pipe passages through the bulkheads between the ballast tanks are achieved by means of welded bushes.

The tanks are filled and drained:

- **by 2 centrifugal pumps with a unit flow of 350m3/h, each driven by a hydraulic motor connected to the main cargo hydraulic system;**
- **by a set of butterfly valves controlled by double-acting hydraulic jacks and electro-distributors, fed by a specific hydraulic power unit, separate from those of the pumps, with emergency hand operation of the valves.**

The ballast tanks can also be filled by gravity.

The level in the ballast tanks is monitored by remote-reading gauges from hydrostatic pressure sensors fitted in the tanks and by a LED display on the cargo control room board.

The pumps as well as the valves are installed in a room (pump-room), which can only be entered from outside, and which is located under the main deck, forward of the engine-room at the foot of the accommodation front.

The control systems of the pumps and valves and the indicators of their operational status are located in the cargo control room. It should be noted that further indication of the position of valves is given by the electro-distributor indexes.

If there is no hydraulic pressure, the valves remain as they are (they can no longer be operated below 6 bar). The same holds true in case of failure of the electric supply to the electro-valves.

Bilge system

It consists of 2 systems, one for forward spaces and compartments, the other for aft spaces and compartments.

✓ *Forward system*

- **bow thruster room: drained by water ejector (flow 10m3/h) and by hand pump (Japy type);**
- **forecastle store, chain lockers and cofferdam: drained by hand pump (Japy type) (which can also be used for draining the bow thruster room).**

It should be noted that the means of draining are located inside the compartments they have to drain. It is difficult or even impossible to put them into service when these compartments are flooded.

✓ *Aft system*

- **pump room: drained by water ejector (flow 10m3/h) and by hand pump (Japy type);**
- **engine-room: 2 electric bilge pumps including the general service pump (unit flows 50m3/h and 60m3/h);**
- **steering gear room: drained by water ejector (10m3/h) and hand pump.**

7.2.4* HYDRAULIC SYSTEM

On board *IEVOLI SUN* as on board other chemical carriers, all the pumps (cargo and ballast pumps), the mooring and anchoring gear (windlasses and capstans) as well as cargo handling equipment and the bow thruster are driven by hydraulic motors.

For safety reasons connected with dangerous products, hydraulic energy is used as a power transmission medium and also as a control and monitoring medium.

DESCRIPTION AND OPERATION

The system consists of two hydraulic power units, each driven by a genset by means of a power take off (see appendix B).

It operates as a closed loop, consisting of an HP feed line (230 bar) and an LP return line (10 bar), to which the various hydraulic engines of the following equipment are connected:

- **18 submerged cargo pumps plus one mobile emergency pump;**
- **2 ballast pumps located in the pump room;**
- **1 pump for tank cleaning;**
- **1 bow thruster.**

Each hydraulic power unit consists of a main pump.

The system also includes two booster pumps used to feed the main pumps and two pilot pumps ensuring monitoring and control.

When the ship is loaded, after the hydraulic power unit has been stopped, the pilot pump keeps a minimum pressure of about 5 bar in the return line so as to prevent pollution of the hydraulic system by cargo products.

It should be noted that in the starting procedure of the hydraulic power units, this pump must be put into service first.

The electric control circuits are 220V AC (24 V DC for electro-valves); those dedicated to monitoring and alarm are 24 V DC or 24 V AC.

The management of the hydraulic system is carried out by a PLC (programmable logic controller Mitsubishi KOJ PLC System), which in case of failure is replaced by an emergency override that is manually operated.

Further safety is provided by a loop of emergency stops (2 on deck, 1 in the cargo control room, 1 in the engine control room or in the wheelhouse).

When this safety device operates, it results in a total blackout of the hydraulic system, including pilot pumps, whatever the monitoring/control mode: automatic or override.

It should be noted that only two problems will stop the pilot pumps: low level in the oil tank and emergency stop.

The hydraulic power units are switched on and off from the cargo control room where you can find:

- **the controls for cargo and ballast pumps and for associated valves;**
- **the monitoring/control board of the hydraulic power units where various operation indicators are located as well as sound signals and visual indication of alarms and tripping devices, particularly for emergency stops and oil pressure and level problems in the system.**

There is no alarm duplication of the FRAMO hydraulic system in the wheelhouse and/or in the engine control room. Only alarms concerning the operation of the bow thruster go off in the wheelhouse.

There is no monitoring of the insulation of the 24V circuit dedicated to this system either.

Note: The control system of the loading/discharging valves of the cargo tanks is fed by the same hydraulic power unit as that of the ballasting/unballasting valves. The Commission noted that on the *IEVOLI SUN* this power unit was always working, whereas on other vessels it is stopped when the ship is at sea, or in port without handling cargo.

In port while handling cargo

Loading/unloading operations as well as ballasting/unballasting are carried out from the cargo control room where remote indicators of ballast tank levels are located.

At sea

The hydraulic power units of the FRAMO installation are stopped. Only one pilot pump is still in service when the ship is loaded. It keeps a minimum pressure of about 5 bar in the return line in order to prevent the hydraulic system from being contaminated by cargo products.

ANALYSIS OF THE CASUALTY

Established facts

At about 1400 hours, after it was seen that the forecastle store had been flooded, a *"220V insulation fault"* alarm went off; the chief engineer then disconnected the faulty circuit, probably located forward. While doing so, he checked that the pilot pump was operating and tested the booster pumps but he did not test putting the hydraulic power units into service completely.

At about 2200 hours he made a patrol in the cargo control room and did not notice any alarms on the FRAMO display.

At about 0200 hours, when he wanted to restart the hydraulic power units, he observed that the emergency stop indicator was lit and the pilot pump stopped. In order to restart the installation, he then switched over to the override position, without any result.

While investigating, he noticed that fuses FQ4 of the 24V AC supply circuit were blown. Replacing them gave no result (the new fuses blew as soon as they were put in place).

Likely cause of the damage

As a result of the inspection of technical documentation, hearings of the master and chief engineer, information collected from the shipowner and the maker of the hydraulic installation and inspection of vessels equipped with similar or even identical installations or having belonged to the same owner, the Commission rejected the theory of mere hydraulic failure; the damaged flexible pipe in the hydraulic systems of the windlasses would not have prevented the installation from being restarted.

It considered an electrical fault following flooding of the forecastle store a likely cause for non-restarting of the hydraulic power units.

This assumption is based on the location of bow thruster electric and electronic monitoring and control components in the forecastle store and thruster room: electro-valves, position repeater and particularly the amplifier of the RPM of the thruster with a 24 V AC electrical supply. The latter is located in a box (which is not watertight) fitted on the upper part of the bulkhead located aft of the forecastle store companionway.

This box was filled with water as a consequence of the flooding, causing a short circuit in the 24V AC network, particularly in the supply circuit of the control box EX(i) of the emergency stop loop, hence the blowing of the fuses FQ4. The loss of this supply resulted in the release of relay K1 controlling emergency stops of the hydraulic power units then the release of relay K7 controlling stoppage of the pilot pumps, thus preventing any restarting by the reset sequence of the PLC or by manual override.

This explains the visual alarm signal (and probably the sound signal) of the emergency stop alarm on the FRAMO display, and the stoppage of the pilot pump.

Note: The *"return pipe low pressure"* alarm may go off, if the pilot pump stops.

Flooding of this box is likely to have had further consequences, such as:

- **grounding of one of the poles of the PLC;**
- **probably a short circuit in the 24 V DC network and therefore blowing of fuses FQ3;**
- **the consequence of which was a loss of control of the installation by the PLC.**

Given the extent of the short circuit, the main circuit breaker of line FQ1 may have tripped.

In addition, it is not impossible that flooding of the bow thruster room may have damaged the electric circuit of the electro-valves and positioning cams of the thruster and thus caused the fuses FQ2 of the 24V DC circuit, supplying among other things the engaging electro-valves of the main hydraulic pumps, to blow.

Emergency solutions

The crew, no doubt, identified the origin of the failure but were not able to solve the problem.

The Commission has tried to determine the solutions making it possible for the hydraulic power units to be restarted, which is subject to the pilot pumps restarting first.

Restarting the pilot pumps implied getting rid of the 24V AC short circuit by disconnecting the part of the circuit which was concerned.

One solution would have been to disconnect from the FRAMO board terminal plate the wires supplying the forward part of the monitoring/control system of the thruster, that is to say the RPM amplifier (6 terminals), the electro-valves and positioning cams (10 terminals).

This solution was tested and validated by means of simulation on board a vessel fitted with the same installation.

An alternative troubleshooting solution would have been to connect a supply line directly between the outlet of the 220V AC / 24V AC transformer TR1 and the box EX(i).

Forced starting of the pilot and booster pumps would have been another alternative.

SYNTHESIS

Analysis shows that it would have been possible to restart the installation within a comparatively short time provided that the crew had a good knowledge of the electric circuits and made a correct diagnosis of the failure.

The stress condition of the crew in such circumstances and the ship's movements due to the state of the sea must also be taken into consideration.

The serious consequences of this failure are due to the fact that the circuits are not separate.

While the single loop layout of the hydraulic system has the advantage of being simple and cheaper to install, the disadvantage, when considering the efficiency of operation, is the interdependence of components; failure of one of them is likely to have an effect upon the whole system.

In addition, alarm duplication in the wheelhouse would probably have made it possible for the failure to be detected earlier.

Therefore, this accident revealed the need to improve reliability of the hydraulic system:

- **by preventing an incidence on the operation of the rest of the system of a failure of the thruster or of other equipment connected to the same system;**
- **by reducing the risk of external faults affecting the emergency stop device;**
- **and by making troubleshooting easier.**

7.3* Study of the progressive flooding of the ballast tanks

The sequence of events makes it possible for us to conclude with certainty that the ship sank as a result of progressive flooding of forward tanks as well as seawater ballast tanks, leading to a loss of buoyancy and transverse stability.

Thus, the Commission directed the investigations towards this flooding process and drew up a list of failures which made such flooding possible:

- **ballast system: the valves of the valve chest may have remained open and thus made possible a connection with sea chests or the first compartments which were flooded. However, this scenario does not explain, quite the opposite, why compartments were flooded in turn from forward to aft.**

- **breaking of structural parts of the transverse bulkheads of the ballast tanks. Even if structural damage of the collision bulkhead can just about be considered, it is very difficult to uphold this theory for the ballast tank bulkheads; the breadth of the bulkhead is 1.2m, its scantling very strong and no weakness nor evidence of unusual corrosion was mentioned during overhaul inspections;**
- **flooding of tanks by lack of watertightness of the air vents on the main deck. This flooding may take place by rupture of the pipe fixed to the deck or by lack of watertightness of the upper part of the air vent, which includes ball valves acting as plugs when sea water is shipped on deck. A specific paragraph deals with the structure of this equipment and with failures which may affect its sealing function (see appendix D).**

The Commission concluded that the last theory was the most likely cause of ingress of water into ballast tanks. Consequently, it asked for a study, the purpose of which was to assess whether, given the loaded condition of the ship when she left Fawley and the sea conditions she met, it might be possible to suffer flooding to such an extent that the ship could sink.

This study, which is the subject of the report included in appendix F, involved 3 phases:

- **Assessment of the hydrostatic characteristics of the vessel on a calm sea for loaded conditions corresponding to the successive stages of flooding. Thus we obtain the static and dynamic parameters of transverse stability for worsening conditions of buoyancy. The corresponding waterlines make it possible to assess the distance from the upper part of the air vents to the surface of the sea.**
- **Calculation of the dynamic behaviour of the ship under the sea conditions met. These calculations were made for increasing stages of flooding. Thus we get the statistical value of heaving, rolling and pitching for the centre of gravity of the vessel.**

- **The probability of the air vents being submerged: for those equipping ballast tanks numbers 2 to 5 and the forepeak tank (port and starboard), the height fluctuations from the surface of the swell are calculated. This swell is defined statistically from the sea conditions met. The probability of submersion of each air vent is deduced, indicated in height and length of time submerged. This height value expressed as a time function makes it possible to calculate the probable mean flow of water entering the tank for the different loaded scenarios previously selected. For this calculation, the air vent is assumed to be totally destroyed, or the *"automatic closing"* device (balls) is assumed to be inoperative, which has the same result. The diameter in both cases is that of the pipe fixed to the deck.**

7.3.1 HYDROSTATIC CALCULATIONS OF THE SHIP IN A CALM SEA*

Calculation details are given in appendix F. The following tables are the synthesis of the results.

Load conditions investigated:

- **Case A: when the ship left Fawley.**
- **Case B: Case A + flooding of the forecastle store + chain lockers + bow thruster room + companionway to this room.**

NOTE: The choice of these spaces is the result of what the crew observed.

- **Case C: Case B + 1 m of water on the forecastle deck (66m3).**
- **Case D: Case C + 0.8 m of water covering 13 m of the forward part of the main deck aft of the forecastle (90m3); the results of the dynamic behaviour study justify taking into account that quantity of water remaining on the forecastle deck and the forward part of the main deck.**
- **Case E: Case D + flooding of the forepeak tank.**
- **Case F: Case D + flooding of ballast tank N° 2.**

Both cases E and F were studied, but, as the purpose was to assess the consequences of ingress of water through the air vents, it stands to reason that we have to focus on case F, the air vents of ballast tank N° 2 being closer to the water-line than that of the forepeak tank, located on the forecastle deck.

- **Case G: Case D + flooding of ballast tank N° 2 and forepeak tank.**
- **Case H: Case G + flooding of ballast tank N° 3.**
- **Case I: Case H + flooding of ballast tank N° 4.**
- **Case J: Case I + flooding of ballast tank N° 5.**

The results concerning the risks of submersion of the air vents are summed up in the following table:

Air vent designation	Leaving FAWLEY (m)	Case D (m)	Case F (m)	Case H (m)	Case I (m)	Case J (m)
Forepeak tank	6.14	5.27	4.39	3.30	2.41	1.50
Ballast tank 2 Std	3.60	2.89	2.16	1.25	0.51	- 0.27
Ballast tank 2 Port	3.60	2.89	2.16	1.25	0.51	- 0.27
Ballast tank 3 Std	3.53	2.90	2.25	1.44	0.77	0.06
Ballast tank 3 Port	3.53	2.90	2.25	1.44	0.77	0.06
Ballast tank 4 Std	3.44	2.91	2.35	1.67	1.08	0.45
Ballast tank 4 Port	3.44	2.91	2.35	1.67	1.08	0.45
Ballast tank 5 Std	3.33	2.93	2.49	1.96	1.49	0.98
Ballast tank 5 Port	3.33	2.93	2.49	1.96	1.49	0.98

It should be noted that, from a statical point of view, we must wait for the last flooding scenario (J) (ballast tank N° 5 flooded) for the lowest air vents (ballast tank N° 2) to be under the water line. The study of the dynamic behaviour is therefore essential to explain ingress of water. Statical and dynamical stability parameters of the various flooding scenarios are the subject of the following table.

We observe that from scenario G (ballast tank N° 2 and forepeak tank flooded) on, the reserve of stability decreases significantly. In scenarios I and J, this reserve becomes too small for the ship to right herself. Finally, in scenario J, the ship becomes statically and dynamically unstable.

Loaded cases	Forward submersion (m)	Aft submersion (m)	Trim (deg)	Stability criteria	Deck immersion in a calm sea
Leaving Fawley	5.29	6.41	- 0.59	6/6	NO
Case B	5.74	6.16	- 0.22	5/6	NO
Case C	5.92	6.06	- 0.07	5/6	NO
Case D	6.13	5.97	0.08	5/6	NO
Case E	6.52	5.76	0.40	4/6	NO
Case F	6.95	5.60	0.72	4/6	NO
Case G	7.34	5.38	1.04	1/6	NO
Case H	8.01	5.11	1.53	1/6	NO
Case I	8.85	4.87	2.10	1/6	YES
Case J	9.73	4.65	2.68	0/6	YES

7.3.2 DYNAMICAL BEHAVIOUR OF THE SHIP IN SWELL*

The calculations were made with the same sea conditions as in the initial stage of the flooding process.

- **course 232° and average speed 5.7 knots;**
- **swell from 250°, Hs = 7m and Tp = 9s. Wind settled at 35 knots. The angle of the swell is therefore 18° on the starboard bow.**

6 flooding scenarios corresponding to the progress of the flooding were investigated:

Cases A, D, F, H, I, J.

For each of these cases, heaving, rolling and pitching mean and maximum values at the centre of gravity of the ship were assessed.

Heaving and pitching increase until ballast tank N° 3 is flooded. They then decrease, the submersion of the forward part of the deck dampening these movements.

The rolling period increases as tanks are progressively flooded.

The results evidence the high probability of water being retained on the forecastle deck and the forward part of the main deck.

Flooding cases	Heaving (m)		Rolling (deg)		Pitching (deg)	
	Mean	Maximum	Mean	Maximum	Mean	Maximum
Case A	0.90	3.71	1.22	5.03	2.47	10.23
Case D	1.06	4.39	1.40	5.73	2.64	10.91
Case F	1.18	4.88	1.53	6.28	2.64	10.89
Case H	1.32	5.44	1.71	7.00	2.77	11.42
Case I	0.79	3.29	1.86	7.60	2.15	8.92
Case J	0.92	3.81	1.98	8.10	1.90	7.83

7.3.3 PROBABILITY OF SUBMERSION OF THE AIR VENTS*

As previously seen with the hydrostatic calculations, the air vent outlets are above the waterline until ballast tank N° 5 is flooded.

If we consider the behaviour of the ship riding a swell, it can be seen that, in relation to the calm sea waterline, each air vent moves vertically.

On the other hand, the free surface of the swell in way of each air vent also changes according to the sea state considered, the ship's speed and the angle of the swell. These two associated movements make it possible to assess the height of the air vent from the surface of the swell and therefore the probability of submersion as a time function.

The calculation method is explained in the appendix and can be summed up as follows:

- **after assessing (cf. above §) the transfer functions of the ship's movements, transfer functions of the vertical movement of each air vent (port and starboard from the forepeak tank to ballast tank N° 5) are calculated for 6 load scenarios corresponding to the flooding process;**
- **then the transfer function of the relative height variation between the air vent and the free surface of the swell is calculated;**

- **the statistical values of the swell considered (Hs = 7m, Tp = 9s) are then given to these functions and thus we obtain the probability of immersion which occurs when the variation of the relative height reaches or exceeds the static height of the air vent above the static waterline level.**

The annexed tables give the statistical values of height variations and the submersion periods for the air vents of every tank from the forepeak tank to ballast tank N° 5.

Thus, if we focus on ballast tank N° 2, the flooding of which played a prominent part in the sinking process,

- **the percentage of submersion time of the air vents was:**
  - ***11% before any flooding;***
  - ***18.5% when the forward spaces were flooded;***
  - ***26% when ballast tank N° 2 was flooded;***
  - ***36% when ballast tank N° 3 was flooded (when the crew noticed it);***
  - ***55% when ballast tank N° 5 was flooded.***

Mean submersion heights of the air vents fluctuate from 1.88m to 2.38m for the flooding conditions investigated.

In addition, assuming that the "flooding diameter" was that of the outlet pipe on deck, namely ND 250 for the forepeak tank and ND 200 for the ballast tanks, the probable instantaneous flow for each condition investigated can be calculated:

$q(t) = S \quad 2gh(t)$

Where h(t) is the submerged height,

S the section of the air vent examined.

The probable flow is then:

$t + \Delta t$

$q(t)dt$

$Q = t$

Δt

Where Δt is the total time of simulation for each condition investigated, corresponding to a representative sample of the sea state and the movements of the ship.

The following table gives the mean values in m^3/h:

Air vent designation		Leaving Fawley(m^3/h)	Case D (m^3/h)	Case F (m^3/h)	Case H (m^3/h)	Case I (m^3/h)	Case J (m^3/h)
Forepeak tank		59.9	103.6	148.5	149.6	204.8	242.3
Ballast tank 2	Std	69.3	115.0	169.9	255.8	255.0	344.9
Ballast tank 2	Port	62.5	112.4	166.9	252.1	255.0	346.2
Ballast tank 3	Std	43.4	83.5	132.5	205.7	203.3	280.8
Ballast tank 3	Port	32.8	77.3	123.6	197.7	198.8	281.5
Ballast tank 4	Std	21.4	48.1	84.5	163.4	140.8	216.4
Ballast tank 4	Port	13.7	41.0	72.5	132.0	128.6	217.8
Ballast tank 5	Std	3.0	18.2	35.4	67.7	62.5	154.6
Ballast tank 5	Port	0.5	13.0	27.9	56.9	54.5	155.3

Thus it can be seen, again for ballast tank N° 2, that when flooding started, with sea water remaining on the forecastle deck and the forward part of the main deck, the probable average flow which could get into the ballast tank through one air vent only was about 115 m3/h, leading to complete filling of the tank within 3 hours.

To conclude, the study shows that:

- **the decrease in trim due to the flooding of forward spaces;**

- **considerable amounts water shipped on the forecastle deck and the forward part of the main deck;**
- **and the resulting trim by the head;**

may have led to the submersion of the ballast tank air vents in the order noted during the sinking process, causing progressive flooding of these tanks due to their lack of watertightness.

7.4* Synthesis - The sinking process

At first sight, the *IEVOLI SUN* left Fawley in good condition except for the proper securing of the forecastle store companionway cover.

As soon as she altered course to SW she encountered bad weather ahead; this bad weather had been forecast and was worsening.

On 29 October at 1230 hours, when the water ingress alarm of the bow thruster room went off, the crew noticed flooding of forward spaces, i.e. the forecastle store and therefore the bow thruster room.

Thus the vessel shipped 130t of seawater right forward, which notably reduced the trim, sank her bow and decreased her freeboard and her protection against the sea.

Nevertheless, the master decided to keep on proceeding, head on to the sea, which was becoming rougher and rougher.

From then on, heaving increased and green seas stayed longer and longer on the forward decks, making the ship, which was now trimmed by the head, heavier.

The upper parts of the air vents, whose watertightness, considering the rate at which ballast tanks 3 and 4 filled, was nearly inexistent, were increasingly submerged by water, which flooded first ballast tank 2 *"the lowest one"* and then the forepeak tank.

At 0130 hours on 30 October, the crew, noticing the decrease in pitching and the sinking of the bow, saw on the remote level display:

- **that the forepeak tank and ballast tanks 2 and 3 were flooded;**
- **then the successive flooding of ballast tanks 4 and 5 with maximum flow.**

Finally, as the submerged electric circuit in the forecastle store had not been disconnected, it proved to be impossible to start the ballast pumps, although it must be remembered that at the stage of flooding noted at 0130 hours on 30 October, there was no hope of draining the ballast tanks completely. At best the trim could have been improved, provided that ballast tank N° 2 was drained first.

The flooding of forward spaces and the fact that the vessel continued to proceed head on to the sea which was becoming rougher and rougher are indeed **the "activating" factors of the casualty.**

As for the bad condition of the air vents, this constitutes a **decisive factor.**

The fact that it was impossible to start the unballasting pumps and that the flooding of ballast tanks 1 and 2 was not noticed immediately constitute the **aggravating factor.**

=**=

8* OTHER FACTORS

8.1* The crew

a) The master

Observing that forward spaces were flooded, he nevertheless decided to return to the initial course.

Even if he had known that the ship had already suffered such damage in 1995 (see appendix E), which does not seem to be the case, worsening weather conditions should have led the master to contemplate the possibility of turning back to seek refuge in Cherbourg, which was within 60 nautical miles of the vessel's position at 1230 hours, or of sheltering under the lee of the eastern coast of Cotentin on a course making her run before the wind.

Moreover, even if the master said he had had possible ballast tank flooding watched, no record of this is found in the ship's log and, while some statements of witnesses indicate a sinking of the bow as early as the evening of 29 October, levels are not checked until 0130 hours, when ballast tanks 1, 2 and 3 are found to be completely filled and ballast tank N° 4 beginning to fill.

Indeed, there was a lack of careful, regular checking of the ballast tanks.

Noticing that ballast tank N° 2 was beginning to fill would have resulted in an earlier detection of the failure of the starting circuit of the ballast pumps, which, at that stage, would have made it possible to keep the water under or even pump it out.

b) *The chief engineer*

After he noticed flooding of the forecastle store, he tested the booster pumps of the hydraulic system and then inspected the cargo control room at 2200 hours. Not until 0130 hours on 30 October did he notice the failure, which he could not repair.

Nevertheless, although he was aware of the equipment and electrical circuits installed in the forecastle store and the thruster room, he does not seem to have analysed the scope and extent of the damage which could affect this equipment and to have taken preventive measures to limit its consequences. He did not take into account the fact that there was, in the forecastle store, a 24V AC box and other electric components which, once submerged, would damage the starting circuit of the FRAMO hydraulic power units, with which the ballast tanks could have been drained.

8.2* Actions of the owner – ISM

As early as the afternoon of 29 October, the technical superintendent on duty was informed by the master of flooding of the forward spaces and in turn he informed the ISM designated person, but as the latter could not assess the weather conditions as well as the master could, he relied on him to make a navigational decision. He had a short conversation with the chief engineer about the electrical equipment which might have been damaged.

When the superintendent was called again, after it had been established in the morning of 30 October that the ballast tanks were flooded and the hydraulic installation damaged, he informed at once the ISM designated person.

He tried to provide technical assistance to the chief engineer in finding and implementing emergency solutions to restart the hydraulic power units.

As for the ISM designated person, he convened the shipowner's crisis management committee.

He dealt with the crisis, informing Corsen MRCC and finding a tug.

He communicated permanently with the ship throughout the event.

8.3* Actions of the coastal State

a) The Regional Operational Centres for Search and Rescue (CROSS) (Jobourg and Corsen MRCCs.)

Jobourg and Corsen MRCCs received the *IEVOLI SUN*'s distress call on 30 October at 0415 hours via VHF / DSC. As *IEVOLI SUN* was in the area managed by Corsen MRCC, they directed the rescue operation.

At 0418 hours Corsen MRCC received a message from *IEVOLI SUN* via INMARSAT C requesting a stern tow, the forward part of the ship being submerged.

At 0717 hours, a *SUPER FRELON* helicopter took off.

All the crew members were winched off between 0822 hours and 0902 hours with the agreement of the master of the vessel.

Moreover, the westerly wind was blowing at more than 40 knots and the risks would have been greater if a second evacuation had been contemplated on an already sinking vessel (see stability calculations § 7.3*). As for the assessment team, they were not landed on board *IEVOLI SUN*, as it was considered that the ship was likely to sink at any time.

b) The Navy Operational Centres (Brest and Cherbourg COMs.)

Corsen MRCC informed Brest COM of *IEVOLI SUN*'s distress call as early as 0420 hours.

It ordered a *SUPER FRELON* helicopter to stand by, summoned the assessment team and ordered the tug *ABEILLE FLANDRES* to leave, which it did at 0500 hours.

At 0800 hours, *IEVOLI SUN* confirmed her request for a tow.

At 0910 hours, the tug *ABEILLE FLANDRES* arrived on scene. Because of the prevailing weather conditions, men from the tug could not be sent on board the abandoned ship to establish the towing line.

At 1210 hours *IEVOLI SUN* was drifting in direction 100° at 2.5 knots, wind westerly speed 40 knots with a swell of height 6 to 7m, making her drift towards the Channel Islands which would have been reached by 1700 hours.

The salvage team was not landed on board until 1420 hours to put across the towing line, which was only established at 1700 hours.

From that moment, the convoy began sailing up towards the Cotentin peninsula, at 5 knots at first, then at 2.5 knots, until *IEVOLI SUN* capsized and sank on 30 October at 0850 hours.

c) Basically, all the operations were managed on behalf of the Maritime Prefect (*Préfet Maritime*):

- **by the COM;**
- **by the MRCC for Search and Rescue.**

9* CONCLUSION

To conclude, the sinking of *IEVOLI SUN* is the result of:

- **flooding of forward spaces, which made her become heavier by about 130 tonnes, sank her bow and brought about the failure of the electric circuit of the hydraulic installation;**
- **continuing to proceed in deteriorating weather conditions, the overload increasing heaving and the shipping of green seas forward;**
- **the bad condition of the closing devices of the ballast tank air vents;**
- **the insufficient monitoring of ballast tank levels;**
- **the failure of the hydraulic system, which was noticed too late and could not be repaired.**

=**=

10* RECOMMENDATIONS

The Commission recommends:

- that manufacturers, builders, classification societies and ship inspection authorities pay particular attention to air vents: design including maintenance, positioning/protection, periodical surveys,…
- that it be possible to operate/monitor from the navigating bridge as well controls and alarms of tank levels which are located in the cargo control room;
- that it be possible to separate **hydraulic systems operating equipment** according to their function: cargo, ballasting, mooring/anchoring;
- that the **ballast system** be treated like a bilge system, safety regulations governing the latter being applied to the former;
- that the **alarms of the hydraulic installation** be duplicated on the alarm network of the vessel;
- that better **segregation of the electric distribution** be ensured (particularly for installations placed forward) and that safety and control functions be separated.

The Commission was able to ascertain that some of these recommendations had already been taken into account by the parties involved, with whom the Commission had had the opportunity to converse throughout the investigation, and that modifications had already been suggested.

= ** =

Paris, 20/12/01

Georges TOURRET **Jean-Louis GUIBERT**

STATEMENTS OF WITNESSES,

OPINIONS

&

COMMENTS

Appendix A

DECISION

TO HOLD AN INVESTIGATION

To identify the reasons which led *IEVOLI SUN* to sink, the Permanent Commission of Investigation into Accidents at Sea (CPEM) was convened as follows:

- **Co-chairmen**
  - Administrator general of Maritime Administration **Georges TOURRET**, *director of BEAmer*
  - Administrator general of Maritime Administration **Jean-Louis GUIBERT**, *secretary general of the French Institute of Navigation.*

- **Experts**
  - Chief engineer **Daniel DREVET**, *engine expert, BEAmer*.
  - Naval architect **Bernard PARIZOT**, *hull expert, BEAmer*

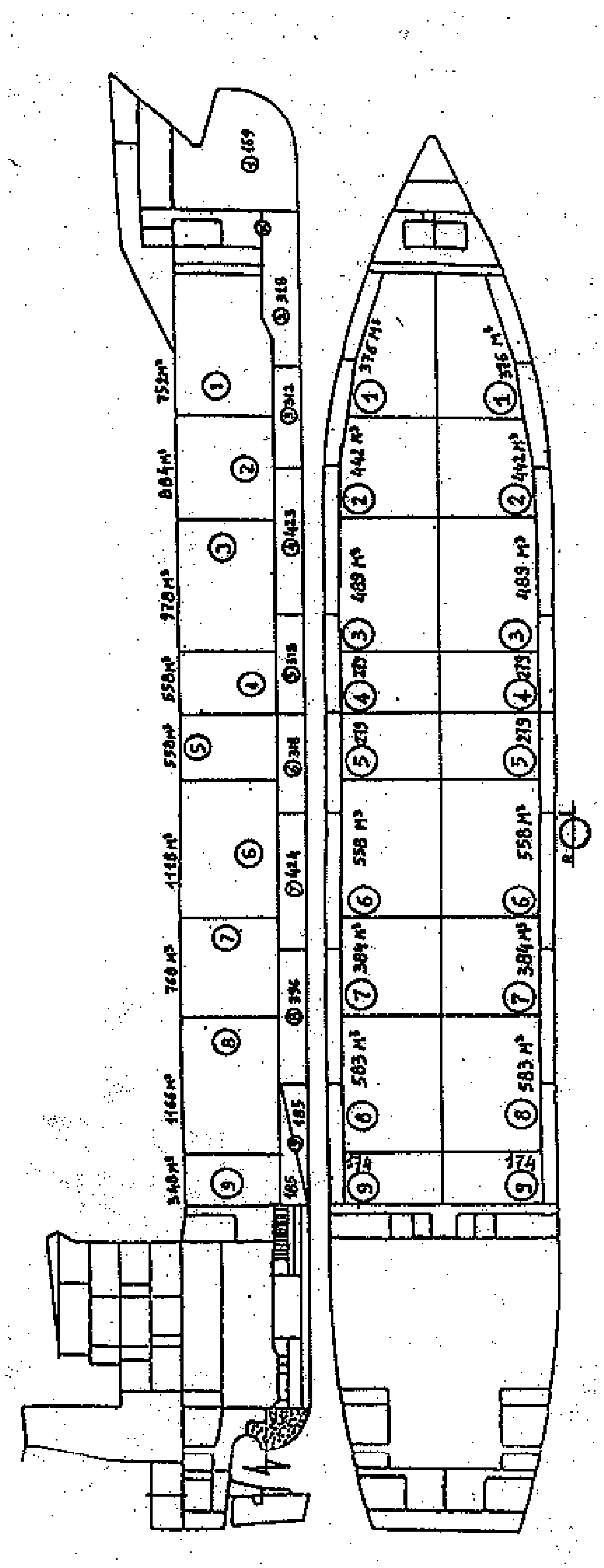
Other specialists (chemical carrier shipmasters, hydrodynamic experts, offshore and underwater surveyors, ISM and vetting inspectors) were consulted.

The work of the Commission is presented by Mr **Bernard LION**, secretary general of the Marine Accident Investigation Board (BEAmer).

Appendix B

SHIP FILE

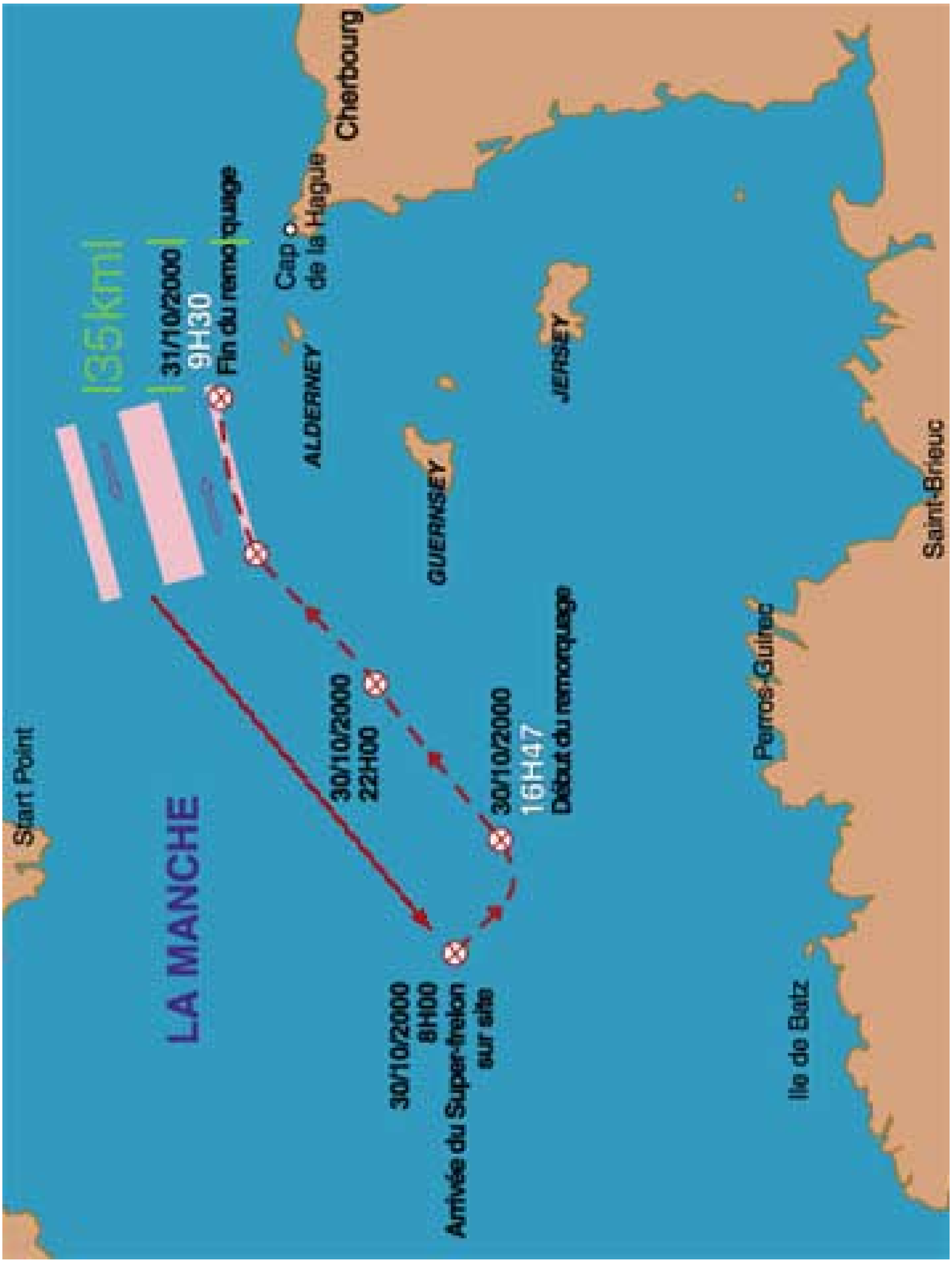
- Plans
- Diagrams
- Photographs



Appendix C

CHARTS

(Copies made with the kind permission of SHOM (Hydrographic Department of the French Navy)


Cherbourg
Cap
de la Hague
35km
31/10/2000
9H30
Fin du remorquage
ALDERNEY
GUERNSEY
JERSEY
Saint-Brieuc
Perros-Guirec
Ile de Batz
Start Point
LA MANCHE
30/10/2000
22H00
30/10/2000
16H47
Début du remorquage
30/10/2000
8H00
Arrivée du Super-frelon
sur site

LA MANCHE	ENGLISH CHANNEL
Arrivée du Super-frelon sur site	Arrival on scene of the Super Frelon helicopter
Début du remorquage	Start of towage
Fin du remorquage	End of towage

Appendix D

AIR VENTS WITH THEIR AUTOMATIC CLOSING DEVICES

Appendix F

CALCULATIONS

Appendix E

FLOODING OF THE FORWARD COMPARTMENTS OF IEVOLI SUN IN JANUARY 1995

(From the master's sea protest)

* On 19 January the *IEVOLI SUN* was sailing in the Eastern part of the English Channel, course 255°, sea from SW force 5, at reduced speed due to the ship's motions and to vibrations.

* On 20 January she was sailing in the Western part of the English Channel, course 231°, sea from south force 9.

* On 21, 22 and 23 January she crossed the Bay of Biscay, course 210°, sea from SW force 9/10/9.

* On 23 January at 0000 hours, as a result of a "water ingress forward" alarm going off, some damage was noticed, including:
    - **cement at the top of the spurling pipes missing;**
    - **the hydraulic system inoperative, thought to be caused by a broken deck pipe.**

* The ship asked to call at Vigo.

* On 23 January at about 1630 hours, weather conditions having improved (sea from SW force 6), a new investigation made it possible to establish that the forward compartments had been flooded. Draining by the Wildel pump was started (it could only operate by day).

* The master, in agreement with the owner, decided to continue to proceed on course 170°.

* On 24 January, as the weather conditions were continuing to get better (sea from SW force 615), the ship increased speed. The chain lockers were dried out completely. The crew began to drain the forecastle store with a second pump.

* On 25 January the ship went through Gibraltar Strait.

* From then on, the ship proceeded on various courses to reach Ravenna (on 31 January), sometimes with adverse gales, but without any new flooding of the forward compartments, drained since 29 January.