Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

MARINE INVESTIGATION REPORT

M00L0114

GROUNDING

BULK CARRIER *FOSSNES*

OFF CAP MARTIN, ST. LAWRENCE RIVER

18 OCTOBER 2000

Canada

Marine Investigation Report

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Summary

On 18 October 2000, the Norwegian bulk carrier *Fossnes* was steaming up the St. Lawrence River bound for Sarnia, Ontario, in fair weather and under the conduct of a pilot.

Shortly before noon, the helmsman advised the officer of the watch that the helm was not responding. The rudder was immobilized to starboard. Full astern was ordered, and both anchors were dropped. The vessel maintained its headway and ran aground shortly thereafter off Cap Martin.

That evening, the vessel was refloated with the assistance of a tug. The *Fossnes* continued on its voyage and docked in the port of Québec. An inspection of the hull revealed that one of the ballast tanks was holed. The occurrence did not result in pollution.

Ce rapport est également disponible en français.

Other Factual Information

	Fossnes
Official Number	8908868
Port of Registry	Bergen, Norway
Flag	Norway
Type	Bulk carrier
Gross Tons[1]	11542
Length	149.44 m
Draught	Forward: 8.0 m Aft: 8.0 m
Cargo	14 105 tonnes of calcium nitrate
Crew Members	19
Built	Stocznia Szczecinska, Szczecin, Poland
Propulsion	Low-speed diesel engine, B&W, 4S50MC, 5720 kW, with one fixed-pitch propeller
Owners	Aboitiz Jebsen Ship Management, Norway

Description of the Vessel

The *Fossnes* is a bulk carrier designed to carry a variety of cargo. The wheelhouse, the accommodations, and the engine room are aft of the four cargo holds. The holds are served by two gantry cranes that have a capacity of 25 tonnes each. On the stern, the vessel carries a fully enclosed, free-fall–launched lifeboat with a capacity of 27 persons.

The vessel was launched on 25 February 1995 and was classed with Lloyd's Register of Shipping. Its certificates were issued under Norwegian regulations and the international conventions of the International Maritime Organization, including, among others, the *International Convention for the Safety of Life at Sea* (SOLAS). The vessel was operated in accordance with the *International Safety Management Code*.

1 Units of measurement in this report conform to International Maritime Organization standards or, where there is no such standard, are expressed in the International System (SI) of units.

History of the Voyage

On 07 October 2000, the *Fossnes* left Sagunto, Spain, with a load of 14 105 tonnes of fertilizer bound for Sarnia, Ontario.

On October 18, around 0705,[2] off the Les Escoumins pilotage station, a pilot boarded the *Fossnes* to carry out his assignment to Québec . Both steering gear power units were operating, and the helmsman was steering in follow-up (FU) control mode.

While relieving the watch in the engine room around 0800, the chief engineer relieved the first engineer. The master went up to the bridge from time to time to ensure that all was well. Around 1130, he left the wheelhouse for lunch. After a course change off Cap-aux-Oies, the vessel was steaming at an over-the-ground speed of 10 knots on a course of 243° by the gyrocompass (G). Navigating by parallel indexing, the pilot set the electronic bearing line at six cables to round Cap Martin.

At 1138, a steering gear alarm went off on the bridge. The officer of the watch (OOW) saw that one of the red warning lights for the No. 1 power unit was lit. He cancelled the audible alarm and switched off the No. 1 pump.

The OOW then telephoned the chief engineer in the engine control room to advise him of the breakdown. The chief engineer called him back and told him to restart the No. 1 pump. Thereafter, the chief engineer went to the steering gear compartment. The OOW tried to start the pump twice but was unable to do so, and the alarm went off both times. Meanwhile, the chief engineer requested the assistance of the electrician. The electrician joined him a few minutes later and was advised of the breakdown. The chief engineer asked the OOW to restart the No. 1 pump. When it started, the electrician noted that the motor ammeter indicated very high current. Around 1146, the electrician told the chief engineer to immediately shut down the pump locally. While trying to turn the rotor manually, he noted that the electric motor turned freely. He then examined the No. 1 starter panel. When he pressed the contactor for the electric motor, he noticed that it offered a high mechanical resistance.

Around 1154, the pilot gave the helmsman the order to steer 250°G. The helmsman turned the wheel to the right and initiated stabilization manoeuvres to steer steady. At about the same time the electrician, who was still in the steering gear compartment, attempted to manually start the No. 1 pump by operating the contactor. After a few attempts, sparks began to fly out of the contactor.

While the helm was set at approximately 7° to starboard, the helmsman realized that it was no longer responding. An alarm on the steering control stand sounded, and a blue warning light came on, indicating a loss of electrical power in the FU control circuit.

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2 All times are eastern daylight time (Coordinated Universal Time minus four hours).

The pilot ordered the OOW to carry out an emergency stop. The second officer, who had just arrived on the bridge to stand his watch, set the engine telegraph to stop, then full astern. The third officer then rushed to the forecastle. The master heard the speed change from his cabin, and he hurried to the wheelhouse. After assessing the situation, the master set the engine telegraph to stop, then he gradually increased speed from dead slow astern to full astern at 1158.[3]

After hearing the engine speed reduction, the chief engineer hurried to the control room, where he noticed that the main engine was set at full astern. He immediately called the wheelhouse and was told that the rudder was not responding and that the vessel was headed for land.

Although both anchors were let go, the vessel continued its swing to starboard. At 1201, the vessel grounded in position latitude 47°27'48" North and longitude 070°17'54" West, about two cables southwest of Cap Martin.

The ebb current was estimated at 3.5 knots, setting at 070° true. A light wind was blowing from the east.

The pilot advised Marine Communications and Traffic Services in Québec that the vessel was aground, and the master requested that a tug assist the vessel as soon as possible.

With the assistance of the tug *Ocean Delta*, the *Fossnes* was refloated around 2025 at high tide. It was then escorted by the tug to berth No. 27 in the port of Québec.

Additional Information

The pilot remembers hearing alarms, but he does not remember if he tried to find out the nature of these cautions. The pilot was reportedly advised by the OOW that one of the power units had failed and that the steering gear was operating on one pump. However, the pilot reports having understood that the alarms were not important.

No alarms related to power unit No. 2 were recorded by the alarm data logger. Except for the main breaker on the No. 1 power unit in the emergency switchboard, no circuit breaker was found in the tripped position.

Between approximately 1146 and 1156, the chief engineer and the electrician who were in the steering gear compartment noticed no failure of the No. 2 power unit, and the rudder appeared to respond normally to the helm.

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3 See Appendix B for additional information on the main engine data logger.

After the grounding, a simulation carried out in the presence of Transport Canada inspectors revealed that the steering gear continued to function after the transfer from FU control mode to non-follow-up (NFU) control mode.

Damage to the Vessel

An underwater inspection revealed that the port bilge strake was buckled and holed in way of frames nos. 121 to 125. Also, the port bottom strake adjacent to the bilge strake was indented in way of frames nos. 123 to 125. The starboard bilge strake was buckled and fractured in way of frame No. 110. The damage was repaired in dry dock.

Engine Telegraph

The main engine is a reversible low-speed diesel engine manufactured by Burmeister & Wain, model 4S50MC, developing 5720 kW at 123 rpm. It drives a fixed-pitch propeller and is equipped with an AutoChief 4, model AC-4, control system manufactured by NorControl. The main engine can be controlled from the bridge or the engine control room.

The propeller's AC-4 controller system has an emergency stop feature. Emergency stop is activated when the engine telegraph lever on the bridge is moved directly from an ahead speed greater than 26 rpm to the full astern position without momentarily selecting the "stop" position. A warning light on the console in way of the engine telegraph lights up when the system is activated and goes out when the main engine has started to turn astern. From full ahead, tests have demonstrated that this manoeuvre is carried out in 135 s.

Sea trials demonstrated that, in an emergency stop, the vessel's headway could be stopped in 4 min 49 s. This information was posted on a bulkhead in the wheelhouse.

Steering Gear

The steering gear is an electric-hydraulic system with two cylinders and was manufactured in Poland by Hydroster. It has two identical power units and develops 320 kNm of torque.

Power units nos. 1 and 2 were supplied from the emergency and main switchboards, respectively. Each supply line was connected to the switchboard via a dual-protection three-phase circuit breaker made by Klockner Moeller, model NZMS4-63.

The settings for overcurrent protection (long delay) and short-circuit protection (short delay) on the No. 1 power unit breaker were 55 A and 550 A, respectively.

During a steering gear test before departure about two months before the grounding, the No. 1 power unit had sustained a breakdown. An inspection of the circuit had revealed that the main breaker on the supply line of that power unit was in the tripped position.

No. 1 Power Unit Motor Contactor

The starter panels for the two power units that were installed in the steering gear compartment were identical. A rotary selector mounted on the panels' cover was used to select the start-up from the bridge or the steering gear compartment.

The starter for the No. 1 power unit motor has a three-phase contactor, model SLA 85, manufactured by Elester. The starter consisted of a moulded plastic casing containing one fixed contact and one moveable contact. In the centre of the casing was an electrical coil with a series of contacts at either end. When the circuit was de-energized, four compression springs held the moveable contact away from the fixed contact. When the coil was energized, the moveable contact touched the fixed contact to complete the circuit between the supply and the electric motor.

After the grounding, it was observed that the contact surfaces of all phases were damaged by arcing burns, but damage was not uniform. Also, the moveable contact slid with difficulty over the fixed contact, preventing a positive contact.

An inspection of the main circuit breaker, the electric motor, and the power circuit wiring revealed no malfunction. A resistivity test with a megohmmeter on the supply line to the power unit and on the electric motor revealed resistance of at least 1000 MΩ.[4]

Pieces of yellowish polymer from one of the spring guides were found scattered around the inside of the contactor casing, and one of the guides was dislodged (Photo 1). Polymer can deteriorate after prolonged exposure to chemicals, heat, cold, stress, sunlight, oxygen, moisture, or pollutants in the atmosphere. Any of these factors, either individually or collectively, will alter the chemical composition of the material. Symptoms such as surface fragility, yellowing, cracking, or loss of elasticity and resilience are all signs of chemical deterioration.

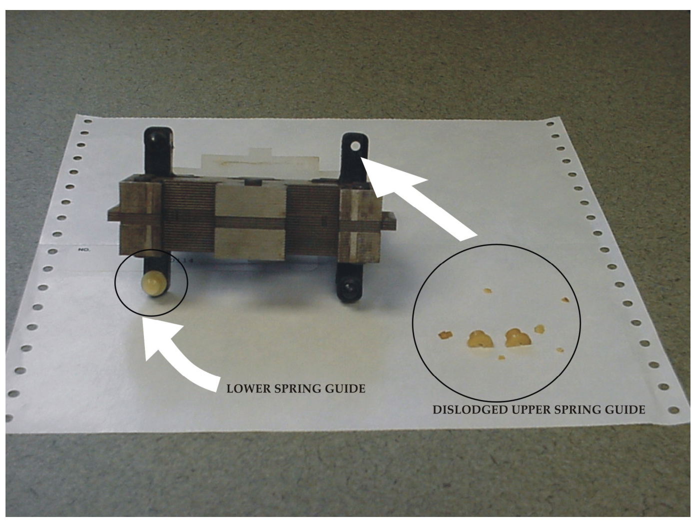

Photo 1. Moveable contact of Elester SLA 85 contactor.

An inspection of the No. 2 power unit contactor revealed that one of the spring guides was also broken and showed signs of chemical deterioration. The working life of the two contactors was approximately the same.

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4 According to a specialist firm's service report.

The contactor for the No. 2 greaser pump for the main engine also had a dislocated spring guide.

Steering Gear Control

The rudder is activated by a steering wheel on the steering control stand (Photo 2). Below the steering wheel, there is a selector switch used for selecting FU or NFU control mode. The electrical circuit for the FU control mode was energized from the No. 1 starter panel power unit; the NFU control mode was from the No. 2 .

Photo 2. Arrangement of steering control console.

The OOW and the helmsman reported that they tried NFU control mode immediately after the breakdown. However, since they observed no rudder movement from the rudder indicator, they again selected FU control mode.

Steering Gear Alarm Panels

The steering gear has two alarm panels, one on a bridge console and the other in the steering gear compartment. Mounted on each of these panels are warning lights and switches for the two power units. On the bridge panel there are starter switches and a warning light intensity switch. One white and one green warning light indicate the energizing of the power circuit and the power unit, respectively. They are also equipped with a vibration alarm.

Central Processing Unit

Each power unit has its own central processing unit (CPU), which is connected to the alarm system on the bridge, in the engine room, and in the steering gear compartment. When the circuits supplying the CPUs were de-energized, the warning lights on the alarm panels in the steering gear compartment and on the bridge went out. However, de-energizing of the CPUs did not affect the operation of the steering gear power units.

The Steering Gear Electric Diagram, B570-DZ/614-1-1, dated 14 September 1994, indicates that the No. 1 CPU was supplied from the emergency switchboard via the 220 V - 2EL distribution box; the No. 2 CPU was supplied from the main switchboard via the 220 V - 2L distribution box. Contrary to that diagram, the CPUs were energized only through the emergency switchboard.

Rudder Indicators

Five rudder indicators were on board: four were found on the bridge and one in the steering gear compartment. All five rudder indicators were connected to the same electrical circuit, which was supplied by two different sources. A selector switch was used to select the source of power from either the main or the emergency switchboard. A third position was used for drawing power from the main switchboard; in the event of a power failure, a relay automatically switched the power to the emergency switchboard. At the time of the breakdown, the selector switch was in the third position.

Regulations Pertaining to Steering Gear

"Machinery Installations", Chapter II-1, Regulation 29, paragraph 8 of the SOLAS Convention (1992 consolidation edition) reads in part as follows:

> Any main and auxiliary steering gear control system operable from the navigation bridge shall comply with the following:
>
> [8.1] if electric, it shall be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment, or directly from switchboard busbars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit.
>
> [8.5] short circuit protection only shall be provided for steering gear control supply circuits.

"Machinery Installations", Chapter II-1, Regulation 30, paragraph 3 of the SOLAS Convention reads in part as follows:

> Short circuit protection and an overload alarm shall be provided for such circuits and motors. Protection against excess current, including starting current, if provided, shall be for not less than twice the full load current of the motor or circuit so protected, and shall be arranged to permit the passage of the appropriate starting currents.

Analysis

Communication on the Bridge

The OOW represents the master and is essentially responsible at all times for the safety of the ship. S/he should ensure that an effective visual and auditory watch is maintained at all times. The alarm for the No. 1 steering gear power unit went off four times. Although alarms may go off frequently on the bridge, each and every one must be investigated to determine the cause of the failure.

The OOW reportedly advised the pilot as soon as the first alarm sounded on the bridge, but, according to the pilot, he was not advised. It is the responsibility of the crew to ensure that the pilot has understood all information pertaining to the conduct of the vessel. This allows the bridge team to analyze the situation and make decisions that are necessary for the proper conduct of the ship. Any unexpected change that could alter the way the navigation is planned and executed can then be discussed by all bridge team members.

Bridge resource management essentially consists of efficiently utilizing all available resources in order to promote safe transportation.

Emergency Stop Control System

A computerized system in the emergency stop control system maximizes the effectiveness of speed changes in an emergency situation and prevents overloading of main-engine and auxiliary components.

In the seconds following the steering gear failure, the engine telegraph was set to the "stop" position, then to full astern. The main engine took 155 s to stop and then engaged in reverse mode. Had the telegraph been operated so as to make use of the emergency stop feature, the main engine would have stopped in about 135 s, that is, approximately 20 s sooner.

The main-engine response time for emergency crash stops was posted on the bridge, but the crew did not know how to operate the AutoChief 4 system. That information could be found in the operations manual. In this occurrence, reducing the stopping time by 20 s would not have prevented the occurrence. Nonetheless, good working knowledge of a vessel's components enhances a crew's confidence and promotes optimal operations.

Transfer of Steering Gear Control Mode

The crew seemed to be familiar with navigation equipment, including the steering gear control system and emergency procedures. In the event of a rudder failure on the *Fossnes*, the crew was required to switch from one control mode to the other (that is, from FU control mode to NFU control mode).

The NFU control mode was tried in the moments following the rudder failure, but this mode transfer did not produce the desired effect. The investigation showed that the No. 2 power unit was operating during the occurrence. Moreover, the No. 2 power unit did not trigger any alarms or trip the No. 2 circuit breaker. When the chief engineer and the electrician arrived, the No. 2 power unit was operating normally. Hence, NFU control mode should have been operationally ready throughout the occurrence.

Since the vessel was a short distance from shore, the crew was under pressure to correct the situation quickly. It is possible that the steering gear control mode switch was carried out but that the crew did not leave it in the NFU mode long enough. A certain period of time is required for the system to activate and for the vessel to respond to the change in rudder angle. The rudder remained to starboard and, despite all efforts, the vessel went aground.

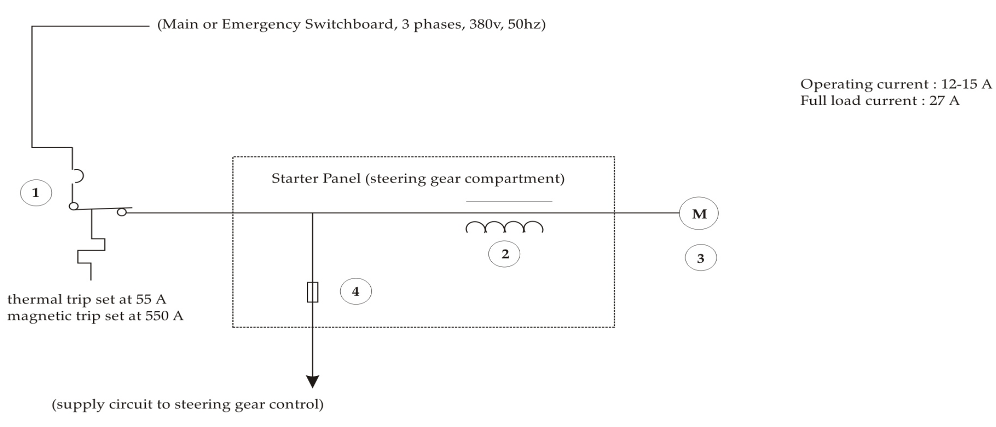
Had the power failure affected the rudder indicator system, the transfer to the other power source would have been automatic, given that the selector switch was in position No. 3. The steering gear control system does not have this type of protection, nor is it required under SOLAS.

Steering Gear Electrical System

When the breaker trips, it will cut power to all circuits connected to it because the steering gear control circuit is connected to the main breaker output of the power unit's power circuit.

The supply circuit of the ship's steering gear control was in compliance with SOLAS requirements. However, although it was in compliance, the point from which power is taken and the location where the overload device is installed could allow an unanticipated breakdown of the control system in FU mode and NFU mode. A test determined that the sudden tripping of the main breaker results in the de-energizing of the supply line to the No. 1 power unit and, consequently, a failure of the FU control mode (Figure 1).

Electrical Arrangement of Steering Gear Power Unit and Control Circuits



1 Main breaker (with overload and short circuit protection devices) Solas Consolidated Edition, 1992, Chap. II-I Reg 30/3
2 Three-phase contactor for electric motor (Elester SLA 85)
3 Electric motor
4 Fuses (short circuit protection) Solas Consolidated Edition, 1992, Chap. II-I Reg 29/8.5

Figure 1. Electrical arrangement of steering gear power unit and control circuits.

To protect the supply line, the main breaker of power unit No. 1 has two protection devices: one for short circuits and one for overcurrents. These two types of protection are acceptable pursuant to the SOLAS Convention. After the grounding, the test with a megohmmeter on the electrical components of power unit No. 1 revealed no evidence that a short circuit had occurred. All indicates that the malfunction of the closure mechanism of the power unit motor contactor, combined with the high starting current following several starts, contributed to an overcurrent exceeding the setting for long-delay protection. Hence, this excessive overcurrent tripped the main breaker.

The contactor malfunctioned because small pieces of polymer affected the mechanical movement of the contactor. The deterioration of the polymer used to manufacture the spring guide shows the importance of carefully monitoring the condition of parts and the environment in which the parts are intended to be used.[5] The degradation of this polymer contributed to the reduction of the theoretical service life of the contactor and created an overcurrent in the supply circuit. Since the three contactors examined had the same defect, the choice of contactors used on board can be questioned.

Central Processing Unit

The investigation revealed that the wiring of the CPUs, although not a contributing factor in the incident, was contrary to that shown on the drawings. The design drawings show that an individual electrical feeder circuit is to be provided for each CPU, making each system an independent system. The vessel has been wired with a single source of electrical power to both CPUs. Therefore, when that single source was compromised, the redundancy of the system was also compromised.

Findings as to Causes and Contributing Factors

1. The tripping of the main circuit breaker cut power to the supply line of the No. 1 power unit and, consequently, resulted in the failure of the FU control mode.

2. At the time of the failure, the rudder was turned to starboard. The crew was unable to restore steering gear control.

Findings as to Risk

1. The point from which power is supplied and the point where the overload protection device is installed can allow unexpected failure of the control system.

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5 G.O. Watson (ed.), *Marine Electrical Practice*, 6th ed., revised by BP Shipping.

2. Deterioration of the polymer used to manufacture the spring guide contributed to the malfunction of the contactor.

3. Broader knowledge of the main-engine emergency stop control system would have enabled the crew to instigate astern propulsion sooner.

Other Findings

1. A loss of power at the emergency switchboard deactivates all steering gear alarms.

Safety Action

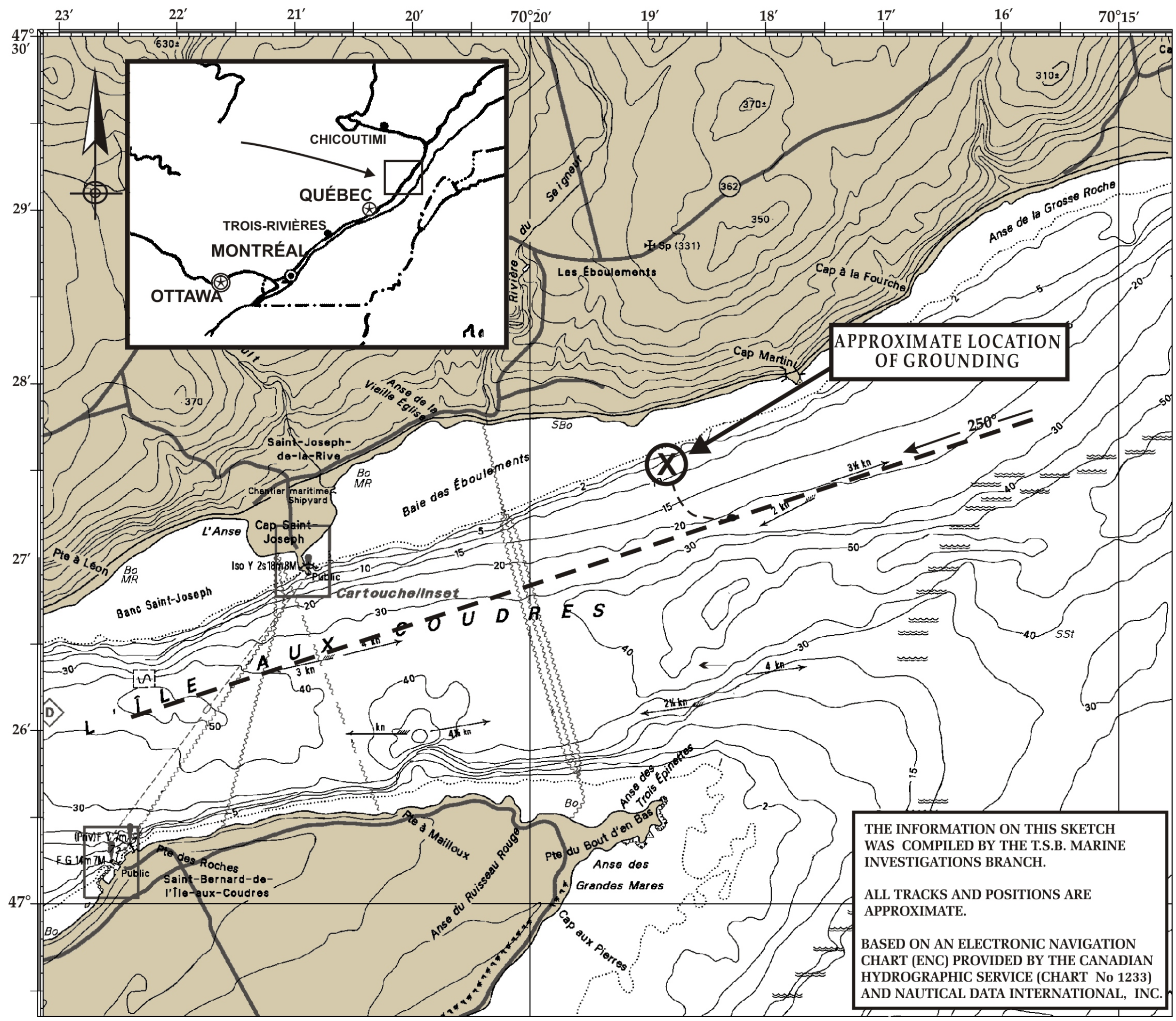
The TSB sent Marine Safety Information Letter (MSI) 01/01, concerning the contactor defect, to the owner, with copies to the manufacturer, the Administration of the Registry, the shipyard, and the International Association of Classification Societies. The manufacturer, Hydroster, had decided to use other types of contactors as a result of testing new products in 1997.

The TSB sent MSI 08/01, concerning the inadequacy of SOLAS regulations on steering gear electrical systems, to Transport Canada. If Transport Canada deems necessary, a submission can be made to the International Maritime Organization.

The TSB sent MSI 09/01, concerning the CPU connections that are not in accordance with the approved drawing, to the owner, with copies to the Port State and the classification society.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 01 May 2002.

Appendix A—Sketch of the Occurrence Area



Appendix B—Main Engine Data Logger Information

Time[6]	Speed[7]	rpm[8]
0721:32	full ahead	120
1155:49	stop	85
1156:00	full astern	56
1156:44	stop	55
1156:48	dead slow astern	49
1157:02	slow astern	42
1157:34	half astern	37
1157:46	dead slow astern	34
1158:46	slow astern	-52
1158:52	half astern	-63
1158:56	full astern	-71
1200:28	half astern	-97
1200:36	slow astern	-87
1201:00	stop	-53

6 The times in the above table are expressed in local terms.

7 Partial data from Les Escoumins pilot station to the grounding.

8 Engine rpm and times are simultaneous with the changes in the position of the engine room telegraph lever.

Appendix C—Glossary

A	amperes
MSI	marine safety information (letter)
FU	follow-up
G	gyrocompass
kNm	kilonewton metres
kW	kilowatt
MΩ	megohm
m	metre
min	minutes
No.	number
NFU	non-follow-up
OOW	officer of the watch
rpm	revolutions per minute
s	seconds
SI	International System of Units
SOLAS	*International Convention for the Safety of Life at Sea*
V	volts
°	degrees