Contents

Summary

On 22 July 1991, the Netherlands flag livestock vessel Zebu Express was lying at anchor in Darwin Harbour. The Master and Second Mate had left the ship, the Chief Officer being the Officer in Charge.

In the morning the Chief Engineer and Second Engineer began working in the bow thruster compartment, cleaning the electrical motor of the bow thruster.

Early in the afternoon the Chief Engineer observed the Second Engineer to be in physical difficulty in the lower part of the compartment and raised the alarm. He then made several attempts to assist the Second Engineer, entering the compartment without using a breathing apparatus.

Both the Chief Engineer and Second Engineer collapsed in the lower part of the bow thruster compartment. Attempts to rescue the two men were made by the Assistant Engineer, wearing a self-contained compressed-air breathing apparatus, but he was unable to effect a rescue.

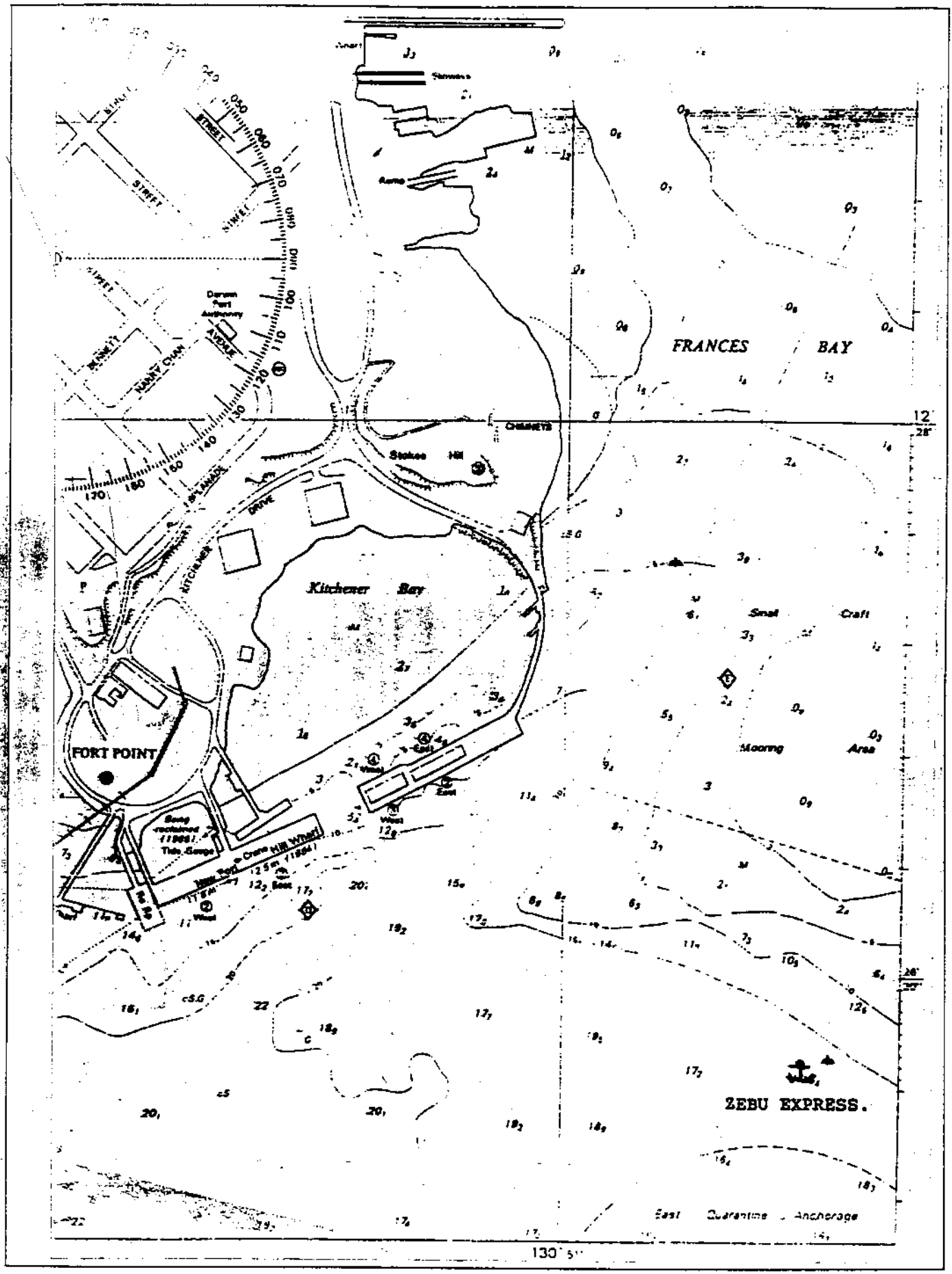
The bodies of the Chief Engineer and Second Engineer were eventually recovered from the bow thruster compartment by members of the Darwin Fire Service.

A surveyor of the Australian Maritime Safety Authority conducted an investigation into the incident under the provisions of the Navigation Act.

Sources of information

The Inspector's report is based on the surveyor's report, which included details of interviews with:

Zebu Express - Chief Officer, Assistant Engineer;
Northern Territory Work Health Authority Officer;
The Senior Station Officer, Darwin Fire Station;
Burns Philp Agencies Representative, Darwin.



Location of Zebu Express in Darwin
Chart AUS28

SEQUENCE OF EVENTS

The Netherlands flag livestock carrier Zebu Express is a relatively small vessel, 81.72m in length, with the bridge well forward, overlooking the forecastle. At the time of the incident the ship was in class with Lloyds Register.

The ship arrived off Darwin, in ballast, on 16 July 1991 and proceeded to the anchorage, to await the next cargo. On 18 July both the Master and the Second Officer were repatriated, the Dutch Chief Officer becoming the "Officer in Charge" of the ship and the sole deck officer remaining on board. Other crew on board included the Chief Engineer and Second Engineer, both of whom were Dutch nationals, and eight Indonesians.

A small crack had been discovered in the bulkhead between the fore-peak ballast tank and the bow thruster compartment, through which seawater sprayed on to the bow thruster's electrical motor. The fore-peak tank was pumped out and the crack repaired.

On the morning of 22 July, the Chief and Second Engineers started to clean the bow thruster's electrical motor. Equipment taken into the bow thruster compartment included a bucket containing some "Drew Electric" electrical cleaning fluid, two paint brushes, a small compressed-air spray gun with an integral, one-litre canister, and a small portable fan.

The ventilation fan for the bow thruster compartment was powered from the main shaft generator, operated only when the main engine was running. There was, therefore, no fresh air ventilation in the compartment while the men were working on the motor.

The two engineers removed the steel cover of the electric motor and proceeded to dry and clean the motor, breaking for lunch at about 1200.

At about 1400, the Chief Officer, who was working in the wheelhouse, heard the Chief Engineer calling for help, saying that the Second Engineer was in difficulty in the bow thruster compartment. He alerted the crew, detailing some of them to collect the breathing apparatus (from the fireman's outfit), and then proceeded to the forecastle space.

The Assistant Engineer, who was working on deck, was alerted by the Chief Officer. He went to the forecastle space, where he noticed a strong smell of electrical cleaner. He saw the Chief Engineer climbing out from the bow thruster compartment hatch, suffering from the effects of the fumes. He assisted the Chief Engineer to the area beneath the forecastle space hatch, where he took a few deep breaths of "fresh" air.

Apparently revived, the Chief Engineer then pushed aside the Assistant Engineer and climbed back down into the thruster compartment. The Assistant Engineer followed, descending to the middle platform level.

The Second Engineer was seen sitting on the bow thruster tunnel, obviously suffering from the effects of the fumes. The Chief and Assistant Engineers

were unable to reach him because of the fumes and had to climb back up into the forecastle space. The Chief Engineer had become very distressed, gasping for breath, but after taking a few gulps of air beneath the forecastle space hatch, he again descended into the bow thruster compartment, this time getting into difficulty himself.

The Assistant Engineer, assisted by the Chief Officer, donned the self contained breathing apparatus brought by a seaman, and some of the crew collected a length of rope to assist the rescue. The Chief Officer returned to the wheelhouse to call for assistance from ashore, while the Assistant Engineer climbed down the ladder into the bow thruster compartment. However, the fumes were getting into the mask of the breathing apparatus and he had to climb out again. After adjusting the straps on the mask, he made a number of attempts to go to the assistance of the two men, but each time felt he was being affected by the fumes and had retreated.

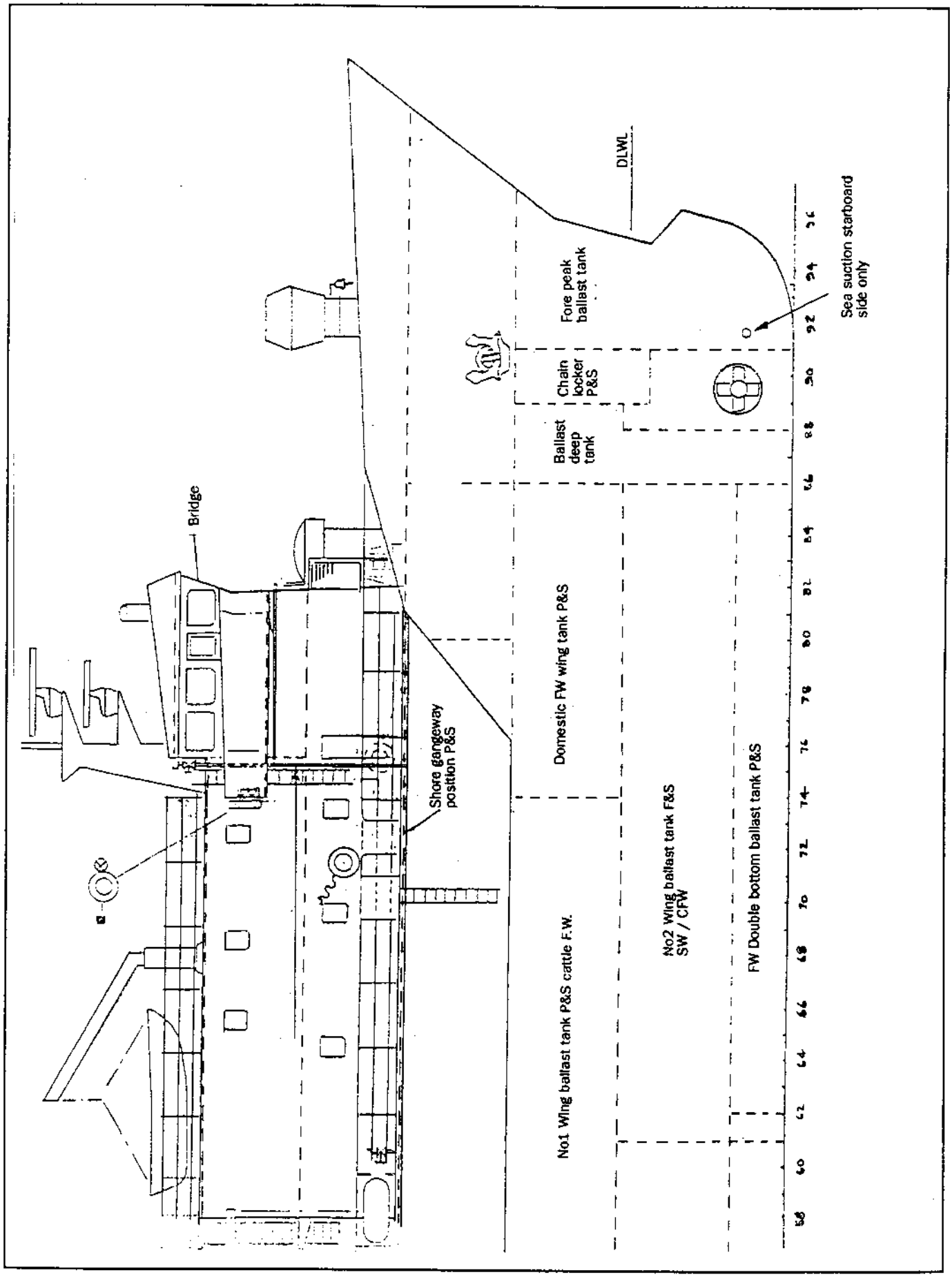
On one of his attempts to reach the two men, the Assistant Engineer saw the Second Engineer topple from his sitting position on the tunnel and fall into the water in the bilge. He also saw the Chief Engineer fall while trying to climb the ladder to the forecastle space.

A number of the crew donned respirator masks, normally used when fumigating the livestock pens with Pestigas, but found these to be ineffective. Some of the crew members began vomiting as a result of exposure to the fumes.

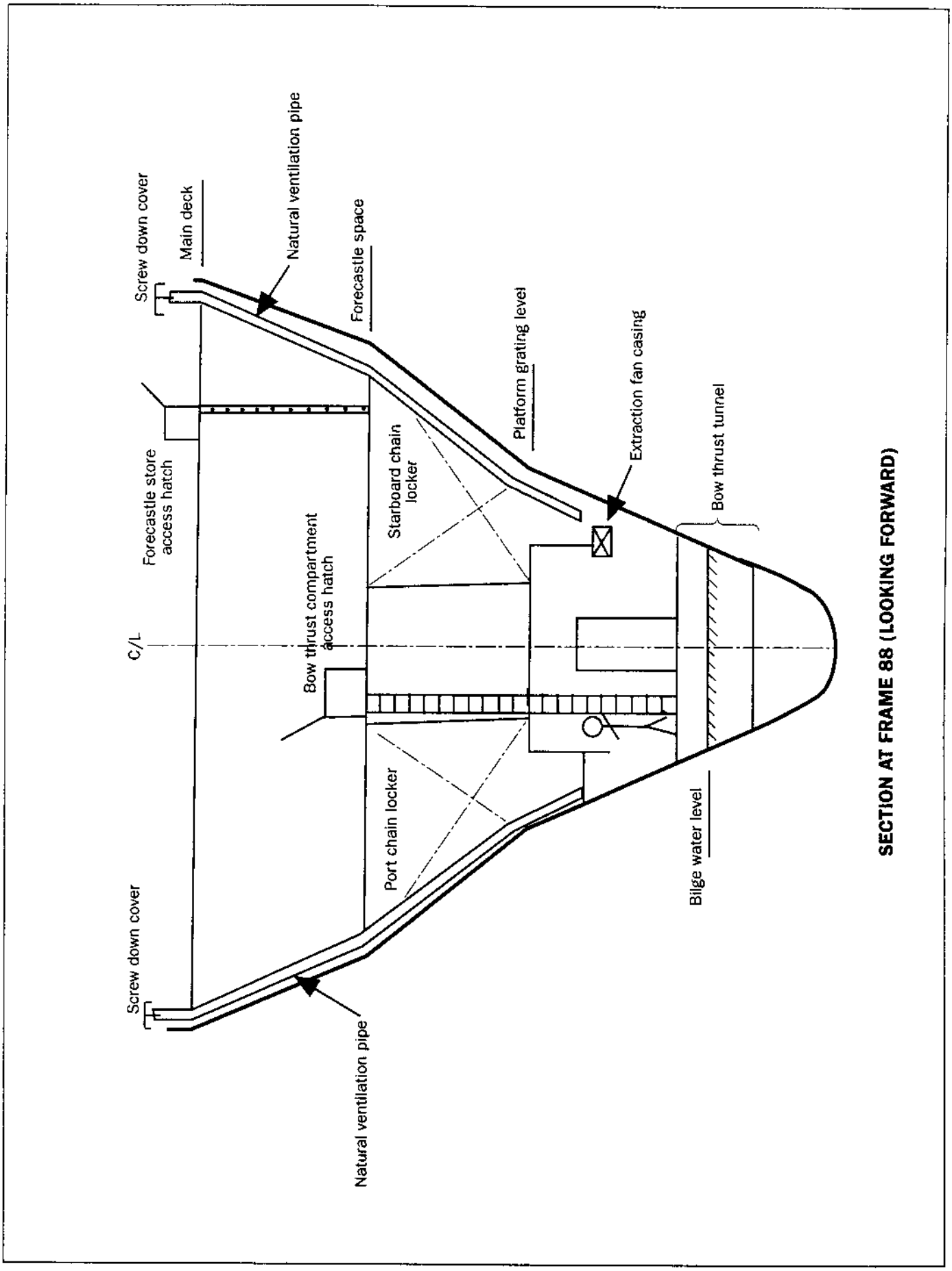
The Chief Officer made a general call on VHF channel 10, (the local calling channel) at about 1415, advising that there was an unconscious person in the bow thruster space and that assistance was needed. This call was heard at the Burns Philp Agencies' office in Darwin and relayed to the St John Ambulance Service. About 10 minutes later, having been advised of the Chief Engineer's fall, the Chief Officer made another broadcast over the VHF, advising that there were now two unconscious people in the bow thruster compartment. This information was also passed to the St John Ambulance Service, from where it was relayed to the Darwin Fire Station, where the time of the notification was logged as 1432.

Fire and ambulance service personnel proceeded to the vessel aboard the pilot boat, but found their breathing apparatus too bulky to effect an entry into the bow thruster compartment. At 1445 a request was made to the fire station to send the air line breathing equipment, consisting of a wheeled battery of compressed air bottles, a filter system and an air hose on a reel.

Firemen, using the air line equipment, entered the bow thruster compartment at 1552, the body of one of the engineers being removed from the compartment at 1623, the body of the other at 1649.



General Arrangement - Forward Section



Diagrammatic Arrangement of Bow Thruster Compartment

COMMENT

Bow thruster compartment

The forward bow thruster compartment is an enclosed space located between the fore peak tank and deep tank, beneath the chain lockers and accessed by a trunking located between the two chain lockers. Access to the trunking is through a hatch located within the forecastle space, itself an enclosed space accessed through a hatchway on the main deck.

Two air ventilation pipes, fitted with screw-down mushroom covers and located one on either side of the ship, lead down from the main-deck into the compartment. An electrical fan is located within the compartment itself, fixed to the framing beneath the starboard chain locker. The fan is not provided with any trunking, but is fixed so as to direct the airflow towards the after starboard corner, to the bottom of the starboard air pipe leading to the main-deck. When operating, the fan generates a cooling air flow, down the port air ventilation pipe, across the bow thruster motor and up the starboard air ventilation pipe.

The electrical supply cables for the fan are directly coupled to the main contactor starting circuits of the main bow thruster motor, located in the forecastle space. The fan does not have a separate start/stop arrangement. Under normal operating conditions, the fan automatically starts or stops with the supply of power to the bow thruster motor.

The bow thruster motor is fed from a selector switch on the main switchboard and the only electrical supply to that selector switch is from the main engine driven shaft alternator. With the main engine and, therefore, the main shaft alternator stopped, there is no power supply to the bow thruster motor contactor box and, therefore, the fan is inoperative.

The ventilation system of the bow thruster compartment was designed to comply with Classification Society requirements and was adequate for the purpose of cooling the bow thruster unit. However, it was not available at times when maintenance work was being carried out on the unit, when chemical solvents and cleaners might normally be expected to be used.

It is considered that some form of mechanical, fresh-air ventilation should be available for use during maintenance work in such spaces.

Drew Electric cleaner

On board the Zebu Express was a 20-litre drum of Drew Electric, purchased in Singapore. Drew Electric, a product marketed by Drew Ameroid Marine Division, New Jersey, United States, and manufactured under licence in Singapore, is a commonly used electrical-component cleaner, consisting mainly of 1.1.1-trichloroethane.

No detailed information on the chemical was provided with the drum, but a label on the drum provides

Drew Electric Label

DREW ELECTRIC

Motor and Parts Cleaner

HAZARD:

HARMFUL IF INHALED.
IRRITANT, EYE AND SKIN.

WARNING!

EXCESSIVE INHALATION MAY BE TOXIC
CAUSES IRRITATION

Do not breathe vapor or mist.
Avoid contact with eyes, skin or clothing.
Wear protective gloves and goggles while handling.
Use with adequate ventilation.
Wash thoroughly after handling.
Vapors are heavier than air and will collect in low areas.
This material or its vapors, when in contact with flames, hot glowing surfaces or electric arcs, can decompose to form hydrogen chloride gas and traces of phosgene.

In case of spill, evacuate area. Provide maximum ventilation. Only personnel with proper respiratory equipment should be permitted in the area. Absorb spill on sawdust or vermiculite and place in closed container for disposal. Maintain ventilation until vapors are eliminated. Flush area with water.

FIRST

In case of inhalation overexposure: Remove to fresh air. If breathing is difficult, give oxygen, obtain medical aid.

In case of contact: for eyes, immediately flush with plenty of water for at least 15 minutes, for skin, immediately wash with plenty of soap and water. If irritation occurs, obtain medical aid.

If swallowed and patient is *conscious*, give a quart of water. Then induce vomiting by placing a finger far back in the throat. Obtain medical aid. If patient is *unconscious* or in convulsions, obtain immediate medical aid. Do not induce vomiting or give anything by mouth.

USE INSTRUCTIONS:

DREW ELECTRIC is a safe (non-flammable) cold cleaning chlorinated organic solvent used for degreasing and removing soil on electrical equipment.

DREW ELECTRIC is applied undiluted as a soaking or dipping solution in a tank or bucket, by brushing, by wiping with a clean lint free cloth or by spraying with a hand spray gun.

It is used to clean electric motors, generators, contact points, switches, commutators, armatures, brushes, bearings, solenoids, gauges and other electrical parts and assemblies.

For more detailed instructions refer to product literature MC PD-2.

NET CONTENTS SHOWN ELSEWHERE ON CONTAINER.

Drew Ameroid® Marine Division
ASHLAND CHEMICAL COMPANY DIVISION
One Drew Plaza Boonton, New Jersey 07005
Phone: (201) 263-7600 Telex: 136444

Manufactured in Singapore
ES-475-R-1/81-GL

(Important Notice:
Seller warrants that the product conforms to its chemical description and is reasonably fit for the purposes stated on the label under normal conditions and use. THE FOREGOING WARRANTIES ARE EXCLUSIVE AND ARE IN LIEU OF ALL OTHER WARRANTIES WHETHER WRITTEN, ORAL OR IMPLIED. THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE IN OTHER RESPECTS THAN EXPRESSLY SET FORTH HEREIN, ARE EXPRESSLY EXCLUDED AND DISCLAIM

instructions on use and First Aid, and carries a hazard warning. The instructions describe Drew Electric as a:

"... safe (non-flammable) cold cleaning chlorinated organic solvent, to be applied undiluted as a soaking or dipping solution, by brushing, wiping with a clean cloth, or by spraying with a hand spray gun."

The hazard warning advises that Drew Electric is harmful if inhaled; excessive inhalation may be toxic. Users should:

"... not breathe vapor or mist - use with adequate ventilation - in case of spill, evacuate area, provide maximum ventilation and only personnel with proper respiratory equipment should be permitted in the area."

Information on 1.1.1-trichloroethane is available in the ICS Chemical Guide. Although the threshold limit value (TLV) is detailed as being only 350 parts per million (ppm), the effect of the vapour when inhaled is described as being :

"... moderate irritation of air passages plus moderate narcotic effect with dizziness, headache, nausea and drowsiness",

and the chemical is stated to have:

"No significant hazard".

However, under "Emergency Procedures", for where vapour is inhaled, the instructions are to:

"... remove victim to the fresh air. If breathing has stopped or is weak or irregular, give mouth to mouth or mouth to nose resuscitation."

More detailed information is contained in literature of the Canadian Centre for Occupational Health and Safety. Under "Inhalation" the advice is:

"High levels (above 900 ppm) of 1.1.1-trichloroethane can depress the nervous system and cause headache, dizziness and fatigue. Impaired performance of behavioural tests was also reported at these concentrations. The results of the tests came back to normal within a few minutes following cessation of exposure. At very high levels (greater than 5000 ppm), 1.1.1-trichloroethane can cause unconsciousness, respiratory depression and death. Several deaths resulting from exposure to high levels of 1.1.1-trichloroethane in confined spaces have been reported."

Calculations (see Attachment 3) indicate that one litre of Drew Electric would be sufficient to cause a vapour concentration in the bow thruster compartment sufficient to cause death.

It is considered that the hazard-warning label on the Drew Electric drum did not fully reflect the dangers inherent in the chemical. The word "safe" was misleading, referring only to its non-flammable properties. 1.1.1-trichloroethane is extremely unsafe in confined spaces where ventilation is inadequate. While this hazard was noted, the general impression of the wording did not

fully impart the danger of asphyxiation.

It is further considered that the owners of the Zebu Express should have ensured that the ship was provided with all available safety data on the chemicals placed on board for domestic use. In this context, it is considered the data on 1.1.1-trichloroethane contained in the ICS Chemical Guide is inadequate as it does not indicate under the headings "The Main Hazard" and "Effect of Vapour" that vapour may cause asphyxiation.

Actions

Whether the Drew Electric was used during the morning is not known, but it was evident that the spray gun was used at some time to spray the cleaner on to the electric motor. Use of the spray gun would have caused the cleaner to evaporate much more rapidly than if applied by brush and with no, or inadequate, ventilation, a toxic atmosphere would have been generated quite rapidly.

From the described actions of the Second Engineer, it is evident that he was affected by the vapour, to the extent that he was unable to climb out of the compartment and eventually became unconscious, toppling into the water in the bilge.

It is considered that the Second Engineer died as a result of becoming asphyxiated by accumulated vapour produced by the Drew Electric being used in a confined, enclosed space without adequate ventilation.

Although raising the alarm, the Chief Engineer, realising that the Second Engineer was in trouble, entered the compartment without waiting for assistance and without donning a breathing apparatus. Even after having to retreat because of the toxic atmosphere, and despite being affected by the vapour himself, he again entered the compartment, still without a breathing apparatus. In his re-entering the space, it is possible that the Chief Engineer's judgement might have been impaired because of the fumes he had inhaled.

It is considered that the Chief Engineer also died as a result of being asphyxiated by the accumulated toxic Drew Electric vapour when he went to the assistance of the Second Engineer without donning breathing apparatus.

Although the Chief Engineer made it known to the Chief Officer that he and Second Engineer would be working in the bow thruster compartment, the procedures for entry into, and working in enclosed spaces were not followed. A small portable electric fan was taken into the compartment, but it was inadequate to provide proper ventilation for the bow thruster space.

There was no check-list procedure in place on board, no communication system was set up, no crew member was detailed to assist and maintain a safety watch on the two men working in the compartment, and no rescue apparatus was placed near to hand, ready for use. This resulted in the Second Engineer being unmonitored in the bow thruster compartment for some considerable time after lunch, in which time he became affected by the toxic vapour.

There are safety procedures for the safe entry into, and rescue from, enclosed

spaces, which are well publicised throughout the maritime industry. The deaths of the two engineers resulted from their failure to follow these procedures.

The Assistant Engineer, realising that the atmosphere in the compartment was toxic, donned the self contained breathing apparatus, but despite several attempts to reach the two collapsed men, was defeated due to the vapour getting inside the face mask.

From the evidence of the Assistant Engineer, he had received very little training on board in the use of self contained breathing apparatus, not having worn one since he was on his previous ship.

The Chief Officer, as the Officer in Charge and the sole deck officer, correctly passed information to the shore, advising of the emergency. Initially, he was aware that the Chief Engineer was organising the rescue, but was apparently not aware that the Chief Engineer had entered the compartment without the breathing apparatus.

In fact, he was not aware of the situation until he returned to the forecastle space and received a report from the Assistant Engineer. He then realised the need to pass the updated information to the shore authorities, so had to leave the rescue attempt to the Assistant Engineer, supported by the crew. As the Assistant Engineer was the one trying to effect the rescue, there was no officer in charge to fully organise and direct the rescue attempt.

It is considered that the on-board operational procedures were deficient in that:

- The crew had not been properly trained in the use of emergency equipment, specifically the breathing apparatus, and in emergency procedures.

- The officers failed to implement standard safety procedures for when working in an enclosed space.

It is further considered that the absence of the Master and the Second Officer significantly reduced the capability of the crew to deal with the emergency situation that arose.

CONCLUSIONS

The deaths of the two engineers resulted from their failure to follow the well publicised safety procedures for safe entry into, and rescue from, enclosed spaces.

It is considered that:

1 The Second Engineer died as a result of becoming asphyxiated by accumulated vapour produced by the Drew Electric electrical cleaner being used in a confined, enclosed space without adequate ventilation.

2 The Chief Engineer also died as a result of being asphyxiated by the accumulated toxic Drew Electric vapour when he went to the assistance of the Second Engineer without donning breathing apparatus.

3 The on-board operational procedures were deficient in that:

- the crew had not been properly trained in the use of emergency equipment, specifically the breathing apparatus, and in emergency procedures;

- the officers failed to implement standard safety procedures for when working in an enclosed space.

4 The absence of the Master and the Second Officer reduced the capability of the crew to deal with the emergency situation that arose.

5 Some form of mechanical, fresh-air ventilation should be available for use in bow thruster compartments, to provide for periods of maintenance work involving chemical solvents and cleaners.

6 The hazard-warning label on the Drew Electric drum did not accurately reflect the dangers inherent in the chemical. The word "safe" was misleading, referring only to its non-flammable properties. Drew electric is extremely hazardous in confined spaces where the ventilation is inadequate. While this hazard was noted, the general impression of the wording did not fully impart the danger of asphyxiation.

7 The Owners should have ensured that the ship was provided with all available safety data on the chemicals placed on board for domestic use.

8 The data on 1.1.1-trichloroethane contained in the ICS Chemical Guide is inadequate in that it does not indicate, under the headings "The Main Hazard" and "Effect of Vapour" that vapour may cause asphyxiation.

ATTACHMENT 1

Particulars of ship

Name of Vessel:	Zebu Express
Flag:	Netherlands
Port of Registry:	Breskens.
Official No:	17038 Z Rotterdam 1984
Call Sign:	PIWD
GRT:	1011.07
Length OA:	81.72m
Keel Laid:	1982
Shipbuilder:	J. W. Cook and Co Wivenhoe, England
Type of Vessel:	Motor Livestock Carrier
Classification:	Lloyds Register +100A1 +LMC UMS
Managing Agents:	VROON BV PO Box 28, Breskens, The Netherlands
Crew:	5 Dutch 8 Indonesian

ATTACHMENT 2

Particulars of safety equipment

Cargo Ship Safety Equipment Certificate

The Cargo Ship Safety Equipment Certificate was issued at Brisbane, on 26 February 1990 by the Australian Maritime Safety Authority (then the Department of Transport and Communications) at the request of the Government of the Netherlands.

The statutory Annual Survey of the Vessel for the endorsement of the Certificate was completed in Singapore on 14 February 1991.

Date of Expiry of the Certificate was 25th February 1992.

Fireman's outfits

Two fireman's outfits are provided on the vessel, and are normally located, one each in the forward and after crane deckhouse.

Each fireman's outfit has a breathing apparatus of an approved type in compliance with Regulation 14, Chapter 11-2, SOLAS 1974.

One breathing apparatus comprises of a compressed-air self-contained breathing apparatus.

The other consists of a smoke helmet, provided with an air pump and a length of air hose sufficient to reach from the open deck to any part of the holds or machinery spaces.

ATTACHMENT 3

Bow thruster compartment volumetric/ concentration calculations

The following simplified calculations are made to illustrate the possible concentration levels which might have evolved in the bow thruster compartment, given that the actual amount of Drew Electric used is not known.

The conversion factor for 1.1.1 - trichloroethane is taken from the information supplied by the Canadian Centre for Occupational Health and Safety :

1 PPM = 5.45mg/m^3
1mg/m^3 = 0.184ppm @ 25°C

The Drew Ameroid Safety Data Sheet gives the composition of Drew Electric as min. 95% 1.1.1 Trichloroethane by weight.

Volume of lower compartment
(3.0x2.1x1.8) + 2(1.5x1.8x0.5)m^3
= 14.04m^3
Less volume of bow thruster motor
= (1.5x3.142x(0.6)2/4)

Volume of lower compartment
14.04 - 0.42 = 13.62m3
Volume of access trunk
(2.5x2.0x1.0) = 5.0m3

Total Volume of space
13.62 + 5.0 = **18.62m^3**

Possible concentration levels

Assuming 1 litre Drew Electric

Lower compartment concentration
$\frac{1x10^6 \text{ x } 0.184 \text{ x } 95\%}{13.62}$
= 12,825ppm

Total compartment concentration
$\frac{1x10^6 \text{ x } 0.184 \text{ x } 95\%}{18.62}$
= 9386ppm

Assuming 0.5 litre Drew Electric

Lower compartment concentration
$\frac{0.5x10^6 \text{ x } 0.184 \text{ x } 95\%}{13.62}$
= 6412ppm

Total compartment concentration
$\frac{0.5x10^6 \text{ x } 0.184 \text{ x } 95\%}{18.62}$
= 4693ppm

Exposure levels in excess of 5000ppm can cause unconsciousness, respiratory depression and death.

The vapour is heavier than air and, therefore, the higher concentration levels would be concentrated in the lower compartment.

M.R. Balsdon 8/9

ATTACHMENT 4a

No. 210

1, 1, 1-TRICHLOROETHANE

"chlorothene" (a trade name for the inhibited product)

methyl chloroform
α - trichloroethane
"genklene"
methyl chloroform

APPEARANCE	Clear, colourless liquid.
ODOUR	Sweet.

THE MAIN HAZARD

No significant hazard.

EMERGENCY PROCEDURE

IF THIS HAPPENS	DO THIS
FIRE	Keep tanks cool with water. Provide fire fighters with breathing apparatus as protection against toxic decomposition fumes.
LIQUID IN EYE	Flood eye gently with clean sea or clean fresh water. Continue washing for at least 15 mins.
LIQUID ON SKIN	Remove contaminated clothing and wash affected areas with plenty of water.
VAPOUR INHALED	Remove victim to fresh air. If breathing has stopped or is weak or irregular, give mouth to mouth or mouth to nose resuscitation.
SPILLAGE	Wash away with water. Inform port authorities if a major spillage occurs.

For abridgment excluding solubility see note page of Volume 1 of the Code. 9/71.

ATTACHMENT 4b

No. 210

1, 1, 1-TRICHLOROETHANE

FIRE AND EXPLOSION DATA

for 95% ^{W}/w concentration.

FLASH POINT	None; see note (i) on page 4.
AUTO-IGNITION TEMPERATURE	500^{o}C
FLAMMABLE LIMITS	6% – 15%
EXPLOSION HAZARD	Moderate; see also note (i) on page 4.

CHEMICAL DATA

for 95% ^{W}/w concentration.

FORMULA	CH_3CCl_3
CHEMICAL FAMILY	Halocarbon (sat. aliphatic)
	Is not hygroscopic. A stable compound under all normal conditions, but it will degrade slowly when heated above 500^{o}C producing toxic fumes of chlorides.

REACTIVITY WITH

OXIDISING AGENTS	No dangerous reaction.
ACIDS	No dangerous reaction.
ALKALIS	No dangerous reaction.
SALT OR FRESH WATER	Some reaction, but insignificant at ambient temperatures, although cargo may become slightly acidic. Cargo may contain an inhibitor to minimise this reaction.
AIR	No reaction.
OTHER CHEMICALS	A dangerous reaction with organometallic compounds, otherwise in general, no dangerous reactions, but for confirmatory information consult the data sheet for the 'other' cargo in question.

For conditions excluding liability see white pages of Volume 1 of this Guide.
BVT).

ATTACHMENT 4c

No. 210

1, 1, 1-TRICHLOROETHANE

HEALTH DATA

For 95% $^{w}/_{w}$ concentration.

TLV	350 ppm.
ODOUR THRESHOLD	75 ppm.

EFFECT OF LIQUID

ON EYES	Irritation; no permanent damage.
ON SKIN	Defats the skin on prolonged contact.
BY SKIN ABSORPTION	No significant hazard.
BY INGESTION	Not toxic in small doses. Large quantities could be toxic.

EFFECT OF VAPOUR

ON EYES	Irritation at high concentrations.
ON SKIN	Nil.
WHEN INHALED (acute-effect)	Moderate irritation of air passages plus moderate narcotic effect with dizziness, headache, nausea and drowsiness.
WHEN INHALED (chronic-effect)	Nil.

For completeness, including reference see title page at Volume 1 of the Guide. 9/71.

No. 210

1, 1, 1-TRICHLOROETHANE

PHYSICAL DATA

For 95% $^{w}/_{w}$ concentration.

SPECIFIC GRAVITY	1.314 @ 20°C
BOILING POINT	74°C
FREEZING POINT	−35°C
VAPOUR PRESSURE	@ 20°C = 104 mmHg
COEFFICIENT OF CUBIC EXPANSION	0.00129 per °C @ 20°C
VAPOUR DENSITY	4.6
SOLUBILITY IN WATER	Nil
VISCOSITY	0.65cS @ 20°C
ELECTROSTATIC GENERATION	Possible

HANDLING AND STORAGE RECOMMENDATIONS

NORMAL CARRIAGE TEMPERATURE	Ambient.
NORMAL CARRIAGE PRESSURE	Atmospheric.
FILLING RATIO	See 1: 6.4.

HANDLING AND STORAGE MATERIALS

UNSUITABLE	SUITABLE
Aluminium and its alloys	Mild steel Galvanised steel Stainless steel (NB. Cargo may become acidic when wet)

NOTES: (i) 1,1,1-trichloroethane vapour does not burn readily, and can only be ignited by high energy sources. The flame speed is low. Nevertheless, a dangerous "flash" can occur in an enclosed space if the vapour concentration and ignition energy are correct.