MARINE OCCURRENCE REPORT

M97N0099

EXPLOSION AND FIRE ABOARD

THE PETROLEUM TANKER "PETROLAB"
AND THE SUBSEQUENT DESTRUCTION OF
THE GOVERNMENT WHARF AT
ST. BARBE, NEWFOUNDLAND
19 JULY 1997

Transportation Safety Board
of Canada

Bureau de la scurit des transports

du Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Report Number M97N0099

Synopsis

On the evening of 19 July 1997 an explosion and fire occurred on board the tanker "PETROLAB" while the crew was washing cargo oil tanks in preparation for loading cargo. The ship's owner was killed and three members of the crew, one of whom later died in hospital, were injured by the explosion. The ensuing on-board fire subsequently spread to the government wharf. The combined efforts of two Canadian Coast Guard vessels and several shore-based fire departments were required to bring the fire under control. As a precaution, the town of St. Barbe was partially evacuated. Both the ship and the government wharf were destroyed before the fire was fully extinguished some 63 hours later. No pollution was reported as a result of the fire.

The Board determined that the explosion occurred due to an accumulation of gasoline vapour in the after cofferdam, 'tween-deck space, and engine-room. The source of ignition was not determined. Factors contributing to the explosion were: the owner's and crew's ignorance of tanker safe working practices; the improvised and unsafe working practices devised to replace a tank-stripping system that had been inoperable for at least 10 years; the fact that there was no safety management system in place; the use of the cofferdam, which was open both to the 'tween-deck and the engine-room, as a slop tank; the use of pumping equipment uncertified for use in a hazardous environment; the fact that the mechanical ventilation for the cofferdam and 'tween-deck area was not used and no atmospheric monitoring was carried out; and the presence of substandard electrical equipment and fittings in the engine-room.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 Particulars of the Vessel

	"PETROLAB"
Official Number	802334
Port of Registry	St. John's, Newfoundland
Flag	Canada
Type	Petroleum tanker (refined product)
Gross Tons[1]	472
Length[2]	41 m
Draught	Forward: 2.4 m Aft: 3.0 m
Built	1962 (lengthened 1968)
Propulsion	One General Motors V16 marine diesel engine of 746 kW, driving a single fixed-pitch propeller
Cargo	Ballast (last cargo: gasoline)
Crew	8
Owner	William Normore Ltd., L'Anse-au-Loup, Labrador

1.1.1 Description of the Vessel

The motor tanker "PETROLAB" was a steel-hulled product tanker built in 1962 in Norway, with accommodation and machinery spaces aft and six pairs of cargo oil tanks (COTs) numbered 1 through 6 (port and starboard) from forward. The main deck was enclosed by a 'tween-deck space, which housed the cargo-pumping equipment and pipelines. The 'tween-deck was also used to store cargo hoses, equipment, and lube oil products, which were sold at various ports. An after cofferdam was positioned at frames 18 to 21 between the engine-room and No. 6 COTs. There were dedicated slop tanks (7.97 m^3) between frames 19 and 21, at the bottom of the cofferdam. An engine room escape door was located in the forward port engine room bulkhead giving access to the cofferdam and ladders to the main deck.

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

2 See Glossary at Appendix E for all abbreviations and acronyms.

1.2 History of the Voyage

1.2.1 Before the Explosion

In May 1997 the "PETROLAB" was chartered by Ultramar Canada Inc. to tranship refined petroleum products from its St. Barbe terminal to ports on the Lower North Shore of Quebec. The vessel underwent an annual inspection by Transport Canada (TC) Marine Safety and a pre-charter survey by Ultramar during May, before beginning operations for the 1997 season. Gasoline and diesel oil were normally carried on each trip, and the vessel was equipped with cargo pumps dedicated to pumping each. From time to time, due to the unavailability of product at St. Barbe or the requirements of the discharge terminals, homogeneous cargoes would be carried.

On 16 July 1997, at 1355, the "PETROLAB" departed St. Barbe with a full load of gasoline bound for Saint-Augustin, Quebec.[3] After discharging her full cargo and ballasting Nos. 3 and 4 COTs, the vessel departed Saint-Augustin at 0700 on July 18 and arrived back in St. Barbe at 1400 the same day. Because another tanker was discharging, the "PETROLAB" was secured on the opposite side of the wharf, at the berth normally used by the Quebec North Shore ferry "NORTHERN PRINCESS".

During a previous trip in 1997, a cargo of diesel oil had been loaded after carrying a full load of gasoline. No flushing oil had been used or tank washing carried out and, as a result, the flash point of the diesel oil was reportedly below specifications when discharged. It was learned on July 18 that a full cargo of stove oil was to be loaded. To avoid a re-occurrence of the low flash point problem, the owner and first mate decided to wash Nos. 1, 2, 5, and 6 COTs with seawater.

The accepted tank washing procedure on the "PETROLAB" was for a mate to enter the tank wearing a Scott air pack and trailing a fire hose. After the tank was hosed down, the remaining un-pumpable residue would be scooped into buckets and dumped into the cofferdam (referred to by the crew as the "slop tank"). Tank washing began after noon on July 19, but trouble was encountered maintaining suction while stripping tanks with the main cargo pumps. The vessel's fixed tank-stripping system had been out of service for at least 10 years and was not available. As a result, tank stripping was attempted using a rented diesel-driven pump situated on the dock. When this failed to pick up suction, a Honda portable gasoline-driven pump was rigged on deck, with the suction hose in the tank being washed and the discharge hose running aft through the 'tween-deck escape hatch (See figure 1, page 9). It was reported that the hose extended approximately one metre into the hatch, and was not grounded. The cargo slops, a mixture of gasoline and water, fell through the 'tween-deck into the cofferdam, a distance of 4.5 metres. During this time, no atmospheric monitoring was conducted in the COTs, 'tween-deck, cofferdam, or deck work areas.

Nos. 1 and 2 COTs were cleaned in this manner without incident and, in the early evening, attention was turned to No. 5 COTs. At approximately 2000, the first mate had just placed the suction hose into the slops in No. 5

[3] All times are Newfoundland daylight saving time (coordinated universal time (UTC) minus 2½ hours) unless otherwise stated.

COT when his Scott air pack low air pressure alarm sounded. He left No. 5 port COT and was standing next to the ‘tween-deck escape hatch with the owner and a deck-hand. A rumbling sound was heard from the ‘tween-deck area, followed by an explosion. The owner, who was looking into the ‘tween-deck escape hatch, was thrown over the port railing into the harbour by the force of the explosion. The first mate and deck-hand, standing one metre away, were thrown to the deck and were burned by the explosion.

Earlier in the afternoon, the chief engineer and second engineer had been employed changing a cargo system valve within the ‘tween-deck, in the vicinity of No. 2 COTs. Work on the valve was completed by 1930, after which the engineers had their evening meal. The second engineer then went to his cabin for a shower.

The second engineer heard the chief engineer enter the engine-room by the entrance on the port side of the accommodation. Shortly afterward, an explosion occurred, immediately followed by the sound of the halon release alarm in the engine-room.

The Board of Steamship Inspection (BSI) had granted the vessel an exemption from the requirement to have an engine-room oily water separator on board. It was reported that it was not uncommon for the engine-room bilges to be pumped into the cofferdam for disposal ashore along with the COT slops. During the post-occurrence examination of the engine-room, a portable direct current (DC) electric bilge pump was found in the bilge, forward of the main engine. A plastic discharge hose led from this pump toward the engine-room escape door. The door was found in the open position after the fire.

1.2.2 After the Explosion

Following the explosion, the injured first mate and deck-hand of the watch made their way to the wharf. The second engineer left his cabin and exited the accommodation to the deck outside on the starboard side. There he met the injured chief engineer and assisted him from the vessel to the wharf. The master, who had been on the bridge at the time of the explosion, made his way to the main deck where he shut down the portable pump before disembarking to the wharf and asking the Ultramar agent to call the fire department and an ambulance. The second mate, who had been on the dock at the time of the explosion, boarded the vessel and put out several small fires on deck with a portable fire extinguisher.

In an attempt to rescue the owner from the water, the second engineer, master and second mate reboarded the vessel. Assisted by the master and second mate, the second engineer climbed down the ship’s side with a life ring. The rescue attempt was unsuccessful but the second engineer managed to secure the owner’s body with a rope attached to the ship’s railing.

The ensuing fire was limited to ship’s stores burning in the ‘tween-deck until, some two to three hours after the explosion, the paint on the outer hull began to burn and spread fire to the creosote-impregnated dock pilings. Out of concern that the fire might spread to the adjacent tank farm, the pipelines to the dock were flushed with seawater and part of the town of St. Barbe was evacuated. On July 20, at 0100, the CCGS “HOOD” arrived and began firefighting on the dock. The mooring lines of the “PETROLAB” burned through and, at 0500, the vessel drifted across the harbour and grounded 0.15 mile from the wharf, where local firefighters applied foam. The

CCGS "SIR WILFRED GRENFELL" arrived at 0930 and fought the dock fire using water cannon and foam until the fire on the wharf was declared out at about 1100 on July 22.

1.3 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	-	1	2
Missing	-	-	-	-
Serious	2	-	-	2
Minor/None	5	-	-	5
Total	8	-	1	9

None of the crew was wearing protective flame-retardant clothing at the time of the explosion.

The owner, who was in the path of the explosion and flame front as it exited the 'tween-deck escape hatch, was thrown over the port railing into the water. His body was recovered from the water early the next morning. He suffered third-degree burns over 50 percent of his body.

The first mate and deck-hand, who were standing on deck next to the owner, suffered first- and second-degree burns to the hands and face. As well, the deck-hand suffered a dislocated shoulder when he fell while climbing onto the dock.

The chief engineer, who was in the engine-room at the time of the explosion, suffered third-degree burns to 50 percent of his body. He died in hospital two weeks later.

1.4 Damage

1.4.1 Damage to the Vessel

As a result of the explosion, the deck house structure was distorted and its port holes shattered. The vessel was damaged extensively by the fire. The accommodation was completely gutted and the aluminium superstructure extensively deformed. All combustible materials in the 'tween-deck were destroyed and the structure of the 'tween-deck was extensively damaged. There is no indication of fire in the engine-room although heat and smoke damage from the fire above was present on the upper portions, particularly the deckhead. The COTs were not breached during the explosion and fire. Since the fire, the "PETROLAB" has been declared a constructive total loss and has been sold.

1.4.2 *Damage to the Government Wharf*

As a result of the fire, the government wharf, pipelines, and ferry ramp were completely destroyed.

1.4.3 *Damage to the Environment*

There was no damage to the environment.

1.5 *Certification*

1.5.1 *Vessel*

The "PETROLAB" was certified by TC in accordance with the requirements for a vessel of her type in the trade in which she was engaged. She was exempted from carrying an engine-room oily water separator. The vessel had been built to Det Norske Veritas standards, but was not classed with a classification society at the time of the explosion.

1.5.2 *Personnel*

The master and officers held valid Canadian certificates for the nature of the voyages undertaken.[4] Only the first mate and chief engineer held petroleum tanker endorsements.

[4] Issued under the Marine Certification Regulations

1.6 Personnel History

1.6.1 Crew Certification and Experience

The master of the "PETROLAB" had no previous experience on board oil tankers and had been in command of the "PETROLAB" since September 1996. His previous experience with transporting petroleum products consisted of four seasons as master of a tug towing oil barges in James Bay. At the time of the occurrence, he held a Canadian Master Home Trade certificate of competency but he did not have a petroleum tanker endorsement. He had been employed in various capacities as a ship's officer since the mid-1960s.

The first mate held an Ocean Navigator Level II (ON II) certificate of competency. He had been employed on board the "PETROLAB" for 10 years, starting as a deck-hand and working his way up to mate. He held a petroleum tanker endorsement (Level I) but had not taken a tanker safety course. The endorsement was issued based on tanker time served. All of his qualifying tanker sea service had been aboard the "PETROLAB".

The chief engineer held a Canadian Third Class Engineer (motor) certificate of competency and had been employed on board the "PETROLAB" since 1992. He held a petroleum tanker endorsement (level II) but had not taken a tanker safety course, the endorsement having been issued based on tanker time served. Like the first mate, the chief engineer's entire qualifying tanker sea service had been aboard the "PETROLAB".

The vessel's owner held no certificate of competency and had no formal training in marine emergency duties (MED) or petroleum tanker safety. He had been employed many years ago on coastal passenger vessels as an uncertificated crew member.

All of the certificated crew (officers) had been trained in shipboard firefighting, as required by the Canadian Marine Certification Regulations.

1.6.2 Crew Training

None of the crew had taken a petroleum tanker safety course and only two crew members, the first mate and the chief engineer, held petroleum tanker endorsements, which they had obtained on the basis of their length of service on board. There was no formal orientation/training policy or procedure for new employees. New crew members would be shown their duties by "old hands" who were familiar with the vessel.

At the time of the explosion on the "PETROLAB", it was not mandatory under Canadian regulations for any of the officers or crew to have taken a petroleum tanker safety course. New Canadian regulations complying with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) came into force 30 July 1997 at which time only Masters and Chief Mates were required to have taken a tanker safety course. Chief and second engineers were granted a two-year transition period until 30 July 1999 before they are required to have taken a course. Other officers and crew will continue to be granted tanker endorsements (level I)—without a formal course or TC examinations—by serving 3 months on board tankers.

There is no record of boat or fire drills being conducted on the "PETROLAB" during the 1997 season.

1.6.3 Crew Work Practices

Some non-standard work practices and procedures had developed over time, and came to be accepted on board the "PETROLAB", including the following:

- Entering a cargo tank with a Scott air pack to wash tanks.
- Entering a cargo tank without proper atmospheric monitoring of the tank.
- Using an ungrounded fire hose to wash cargo tanks containing flammable vapours.
- Using a pump not designed for use in a hazardous location to transfer slops.
- Use of the open aft cofferdam as a slop tank.
- Allowing slops to free-fall through the 'tween deck into the cofferdam.
- Not using the 'tween deck /cofferdam exhaust fans during the slop transfer.
- No atmospheric monitoring was conducted during the slop transfer.
- None of the crew had formal training in confined space entry.
- The crew were not familiar with the Workplace Hazardous Material Information System (WHMIS) and its associated hazardous material data sheets describing the health dangers from the cumulative carcinogenic effects of benzene in petroleum products.
- The engine-room escape door was not kept closed at all times.
- The use of an uncertified submersible bilge pump in the engine-room for pumping engine-room bilge slops to the cofferdam.

1.6.4 Management Oversight and Chain of Command

The owner had operated the "PETROLAB" since 1991 and had been using the vessel to supply his own petroleum tank farms on the Labrador Coast. He did not have a formal safety management system in place for the vessel, but relied on the crew (in particular the first mate) to operate the vessel in a safe manner.

Problems existed with the chain of command on board the "PETROLAB". Because the first mate had been on board for many years, the owner often communicated shipboard business directly with the mate. As a result, on the “PETROLAB” decisions were often made without the master’s knowledge or participation. This situation led to friction between the master and first mate. The master had expressed his displeasure to the owner concerning this situation and, two weeks before the explosion, the first mate had left the vessel. He had returned to his duties on board three days before the explosion.

1.7 Weather

The weather on July 19 had been rainy; thunder and lightning during the morning and early afternoon was followed by a clearing spell. At the time of the explosion winds were calm from the northeast and the sky had become overcast again. The air temperature was approximately 14 degrees Celsius. The master reported that just before the explosion he had seen lightning to the south, but this was not observed by the other people interviewed.

1.8 Activities and Conditions Creating a Danger of Explosion

The majority of the crew members had acquired their experience of tanker operations solely aboard the “PETROLAB”. There was no formal training scheme on board and the work practices and procedures in place had been developed through “on-the-job” training. Some of these procedures created unsafe conditions.

These unsafe work practices had been passed on to new crew members who, lacking formal petroleum tanker training, did not recognize the inherent dangers of conducting tanker operations in the manner in which they were conducted. None of the “PETROLAB” crew had taken a petroleum tanker safety course. Only the first mate and the chief engineer held petroleum tanker endorsements and these had been issued solely on the basis of the time they had served aboard the “PETROLAB”.

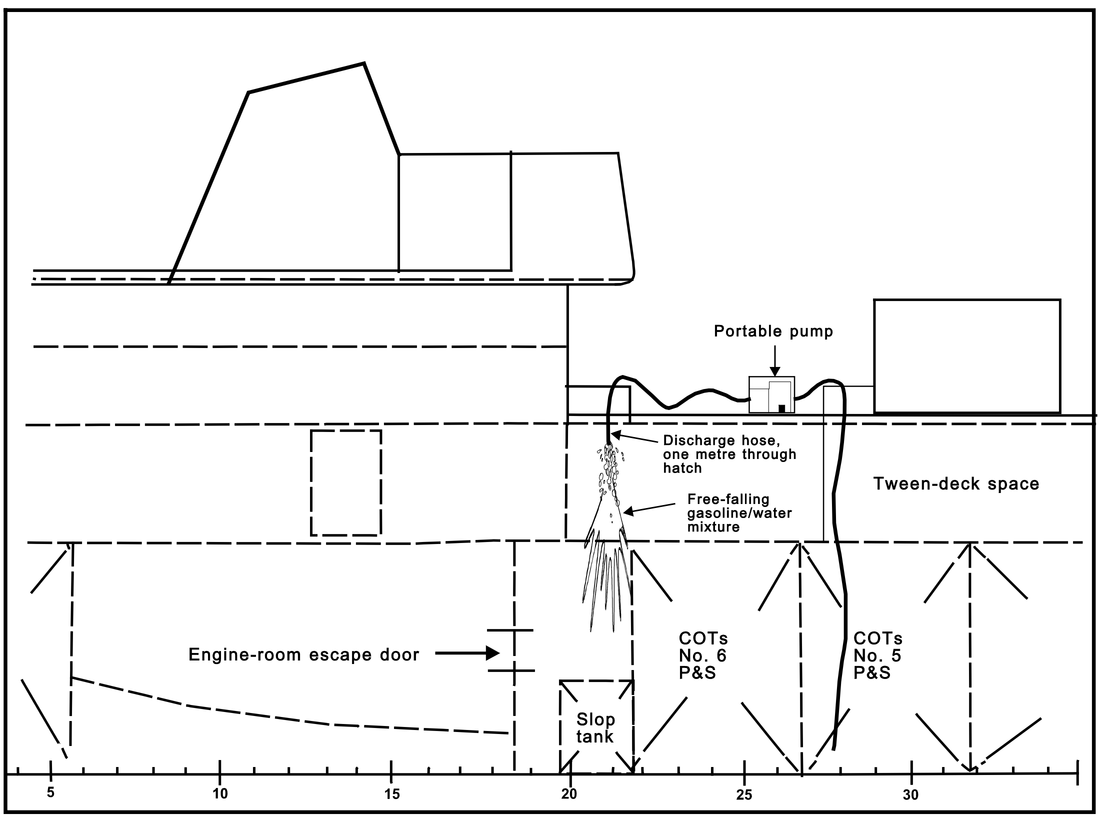
The activities and conditions creating a danger of explosion were:

- COTs were washed down by members of the crew wearing breathing apparatus and using a fire hose that was not grounded.

- The resulting cargo slops were transferred to the cofferdam by a portable pump that was not designed for use in this type of operation.

- The slops were discharged into the cofferdam immediately forward of the engine-room instead of into the dedicated slop tanks.

- The slops were allowed to free-fall into the cofferdam from an uncertified and ungrounded rubber hose, creating vapour concentrations in excess of the lower explosive limit (LEL) and a static electricity hazard.



- The exhaust fans for the cofferdam and 'tween-deck space were not in use.

- The engine-room escape door was unsecured during the slop transfer.

1.9 Sources of Ignition

Several potential sources of ignition were present in the explosive environment that resulted from the vessel's non-standard cargo tank washing procedures.

1.9.1 Build-up of Static Electricity

The static electrical charge that builds up during the handling of gasoline on board tankers presents a potential source of ignition. Certain operations can give rise to accumulations of an electric charge that may be released suddenly in electrostatic discharges—with sufficient energy to ignite flammable gasoline/air mixtures.

The operations that can cause static charges to accumulate, and the characteristics of static charge accumulation on petroleum cargoes, are well understood by the tanker industry. When gasoline is mixed with water, a static charge is generated between the two. Both speed and turbulence of flow of the gasoline and water mixture will affect the charge that accumulates. The damage to the Honda pump impeller (TSB Engineering Lab report No. LP 115/97)[5] would have contributed considerable turbulence to the flow of the gasoline and water tank washing slops as it passed through the pump. The discharge hose of the pump, which was of smaller diameter than intended, would have increased the speed of the gasoline and water mixture through the hose.

As gasoline is pumped through the steel pipelines that are part of the ship's installations, static charges accumulate between the gasoline and the pipe. The charge left on the pipe will quickly pass to the structure of the ship and dissipate into the sea and thereby to ground.

When rubber hoses are used to pump gasoline, the accumulated charge in the hose does not dissipate to ground. Bonding wires (usually built into the hose) are used to connect the steel flanges of the hose to one another and to the ship's structure, allowing static charges to dissipate to ground. The discharge hose leading into the 'tween-deck space on the "PETROLAB" was not grounded and would have presented another source of static electricity.

When cargo transfer hoses are tested, a continuity test is normally conducted to ensure that the internal bonding wire is intact and that there is electrical continuity between both ends of the hose. No hose test certificate was available for the portable pump discharge hose in use at the time of the explosion, nor was there any record of continuity tests being conducted on any other hoses (including cargo discharge hoses) on the "PETROLAB".

Oil splashing or spraying also results in an accumulation of static charge. Oil droplets striking solid surfaces such as bulkheads result in a charge accumulation between the oil and the bulkhead. Oil that is loaded through flexible hoses inserted into tanks will produce a considerable amount of splashing and spraying as the liquid falls to the bottom of the tank, resulting in a statically charged mist in the tank. On the "PETROLAB", the Honda pump discharge hose extended only one metre into the 'tween-deck escape hatch; from there, the

[5] This report is available upon request from the Transportation Safety Board of Canada.

gasoline and water mixture sprayed down into the cofferdam, striking bulkheads, gratings, and pipework as it fell.

1.9.2 The Portable Centrifugal Pump

The portable centrifugal pump being used to transfer tank washing slops was a Honda model WB30X. The operating manual for this pump gives several specific warnings:

> [in the Introduction] WARNING This Honda pump is designed to give safe and dependable service if operated according to instructions. Read and understand the Owners Manual before operating the pump. Failure to do so could result in personal injury or equipment damage.
>
> [under Safety Instruction] WARNING For safety, never pump flammable or corrosive liquids such as gasoline or acid. Also to avoid pump corrosion, never pump sea water, chemical solutions, or caustic liquids such as used oil, wine, or milk.
>
> [under Safety Instruction] WARNING Gasoline is extremely flammable and is explosive under certain conditions. Do not smoke or allow flames or sparks in the refuelling area or where gasoline is stored. Do not overfill the tank. After refuelling, make sure the tank cap is closed and properly secured.

At the time of the explosion, the pump was being used to pump a mixture of gasoline and seawater; substances specifically warned against by the pump manufacturer. The fuel cap on the pump's tank was not in place and the fuel tank was nearly full, indicating that it had been filled recently. The TSB Engineering Laboratory inspection found that the cap was not blown off by an explosion.

Internal inspection of the pump revealed a damaged impeller that caused an imbalance and vibration when the pump was running. Earlier in the day, the pump had been mounted on rubber tires to prevent it from "walking" around the deck while it was running, but at the time of the explosion the pump was sitting directly on deck. The Safe Working Practices Regulations state:

> In any working area where flammable gas vapours or dust is present in the atmosphere, no person shall use any equipment or materials that are spark producing.[6]

The pump was not equipped with an exhaust spark arrester and was operating in the presence of gasoline fumes.

1.9.3 Engine-room Electrical Equipment

[6] Sect 33 (1) (b)

Much of the electrical equipment in the engine-room was not intrinsically safe or certified for use in a hazardous area, and several possible sources of sparks or open flame were present in the engine-room at the time of the explosion.[7]

- Post-occurrence examination of the engine-room found that covers were missing from several light fixtures and lights were jury-rigged with substandard wiring.
- A portable DC bilge pump was used to transfer oily waste from the engine-room bilges to the cofferdam through a non-grounded plastic discharge hose. The pump wiring was jury-rigged to the port generator starter motor.
- There was an oil-fired domestic hot water boiler in the engine-room.
- The port ship's service generator, located adjacent to the escape door, was running and supplying power to the vessel at the time of the explosion.

1.10 Firefighting

1.10.1 Emergency Preparedness

The wharf at St. Barbe served both oil tankers and passenger vessels on a regular basis, but none of the local volunteer fire departments responding to the fire had training in shipboard firefighting.

The harbour facilities in St. Barbe had been turned over to the Province of Newfoundland on 1 April 1997 as part of TC's port divestiture program. When transferring a port to new owners, TC does not ensure that the owners have contingency plans in place to deal with emergencies.

The terminal operator, Ultramar, did have a contingency plan in place for an oil spill at the dock or a fire at the tank farm; however, the terminal supervisor had not been given formal training in firefighting. As a result, Ultramar was relying on the local fire department, which did not have the equipment (foam) to fight petroleum fires or the experience and training to fight shipboard fires and contain them at an early stage.

1.10.2 Shipboard Firefighting Capability

The vessel's firefighting equipment and its installation met regulatory requirements. On board equipment included:

- a main electrically driven fire pump in the engine-room,

[7] ISGOTT Definitions pg. XIX

- a mechanical foam system in the 'tween-deck,
- a CO_2 system for the COTs, and
- a halon system for the engine-room.

The "PETROLAB", as a vessel under 45.7 m long, was not required by regulation to be equipped with an emergency fire pump or emergency generator.

At the time of the explosion, the ship's service generator failed. As the vessel was not equipped with an emergency generator, neither the fire pump nor the 'tween-deck foam system could be operated.

The actuating handle for the engine-room halon system was located in the deck-house where the force of the explosion distorted the bulkhead and the mechanical actuating system, causing the release of the halon into the engine-room. The halon helped to suppress the ensuing fire and to protect the engine-room and cofferdam from further damage.

Immediately after the explosion, the second mate put out several small fires on deck with a fire extinguisher, then joined the remaining crew who had gathered on the wharf. No attempt was made to re-enter the engine-room to restart the ship's service generator and put the fire pump on line. The vessel was not fitted with an international shore connection, and the vessel's fire main could not be charged from a source on shore. The ship's Scott air pack bottles were empty, having been used during the tank washing operations. The vessel's firefighting system was disabled. The Royal Canadian Mounted Police (RCMP) sent the crew away from the scene to a local hotel.

Fire wires, to which a towing vessel could quickly make fast and so tow her away from the government wharf, had not been rigged at the bow and stern of the vessel.

1.10.3 *Shore-based Firefighting Capability*

In all, six local volunteer fire departments responded to the fire, arriving between 2015 and 2130 on July 19. At this time, the fire was still confined to the 'tween-deck area where stored lube oil and other consumable stores had caught fire. The master informed the fire chief of the local fire department of the previous cargo, the state of the vessel's tanks and the location of the fire.

The fire departments were unfamiliar with fighting shipboard fires, especially oil tanker fires, and were reluctant to fight the fire in its early stages using water as they believed that water should not be applied to oil (tanker) fires. The Port au Choix fire department arrived with medium expansion foam at 2050 (about one hour after the explosion), but the foam was not applied to the fire which, at that point, was still limited to the area inside the vessel's 'tween-deck. No coordinated firefighting was conducted until the regional fire commissioner arrived in the early morning of July 20. After the ship's mooring lines burned through and she drifted across the harbour and grounded, the fire department applied foam and brought the fire under control from a position on shore.

For two to three hours after the explosion, no effort was made by the ship's crew or the shore-based firefighters to fight the fire which, at that point, was limited to the 'tween-deck area.

1.10.4 *Canadian Coast Guard Firefighting Capability*

The CCGS "HOOD" arrived on the scene early in the morning of 20 July and began fighting the dock fire. No fire wires had been rigged on the "PETROLAB", which made it hazardous for the "HOOD" to attempt towing of the burning tanker from the dock. After the mooring lines burned through and the "PETROLAB" began drifting across the harbour, a small boat from the "HOOD" managed to get a line aboard the tanker and secure it to shore.

At 0930 on 20 July, the CCGS "SIR WILFRED GRENFELL" arrived on the scene and began alternately fighting the dock fire with water cannon and trying to dismantle the dock to give better access to the seat of the fire. The CCG's firefighting efforts were coordinated with the shore-based units through the district fire commissioner.

1.11 *Condition of the Vessel's Cargo-handling Equipment*

The condition of cargo pumps and piping systems is important for the safe operation of all oil tankers. Besides being used to discharge cargo, a tanker's pumping system may be used in damage and stability control situations resulting from flooding, and in cargo transfer operations to mitigate pollution resulting from accidents. As such, cargo-pumping systems on oil tankers are analogous to bilge-pumping systems on other vessels.

Cargo-pumping systems on oil tankers vary considerably, but one consistent feature found on each is a stripping system with the ability to remove all possible cargo from the tanks. The "PETROLAB" was originally equipped with a vacuum stripping system to maintain suction on the cargo pumps, but at the time of the explosion the system had been inoperable for at least 10 years. As originally built, the “PETROLAB” was capable of stripping tanks using the main cargo pumps, with the tank washing slops being pumped directly through a fixed piping system to the dedicated slop tanks located between frames 19 and 21 at the bottom of the after cofferdam. Use of a portable pump was neither necessary nor desirable. Several years before the occurrence, the owner and the first mate had investigated the possibility of returning the stripping system to service, but inspection had revealed that it was extensively deteriorated; the system was blanked off permanently.

It is unknown when the cofferdam started to be used as a slop tank, but the first mate indicated that it had been used to store slops before he first served aboard 10 years earlier. Post-occurrence inspection of the cargo piping system showed that a drain valve had been added to the main cargo line with a hose leading into the cofferdam. Such an arrangement by-passed the dedicated slop tanks, allowing the use of the cofferdam as storage for cargo slops. The cofferdam was open on top to the ‘tween-deck and connected to the engine-room by an emergency escape door on the port side. With such an arrangement, vapour from the slops in the cofferdam could easily enter the ‘tween-deck area, or if the engine-room escape door was opened, into the engine-room. Post-occurrence sounding of the cofferdam revealed that it contained 975 mm of liquid, 640 mm of which was water and 335 mm a mixture of hydrocarbons (see TSB Engineering Lab report No. LP 115/97).

1.12 Oily Water Separator

Oily water separators are used on vessels to remove oil from bilge water before it is discharged overboard. They allow a vessel relative freedom to pump the bilges without fear of polluting surrounding waters. Under the Oil Pollution Prevention Regulations, all Canadian tankers of 150 gross tons and over are required to have a Canadian Oil Pollution Prevention (COPP) certificate, which requires, in part, that the vessel be equipped with an oily water separator for handling engine-room bilge slops. In 1993 the owner of the “PETROLAB” made application to the BSI for an exemption from the requirement to equip his vessel with an engine-room oily water separator. In his letter of application, he made a proposal to store engine-room bilge slops in the dedicated slop tanks located between frames 19 and 21. The BSI granted the exemption on 30 August 1993. One of the conditions attached to the exemption was that the engine-room bilge slops would be stored in the slop tanks and be pumped ashore as necessary. There is no record to indicate if, subsequent to that time, the dedicated slop tanks were used to store engine-room slops. Post-occurrence sounding of the dedicated slop tanks indicated that they were empty.

It is known that the engine-room bilges were routinely pumped overboard when the vessel was at sea or into the cofferdam during extended stays in port. It is also known that, before and after this exemption was granted, the cofferdam was routinely being used as a slop tank. Normally, such transfers were handled by the first mate or the chief engineer.

1.13 Engine-room Escape Door

On board oil tankers, special precautions are taken to ensure that no petroleum or petroleum vapour can enter the engine-room. Many tankers have pump rooms just forward of the engine-room, and special arrangements are used to seal piping, electrical and machinery penetrations through the bulkhead between the two spaces. On board the “PETROLAB”, an escape door was fitted in the forward engine-room bulkhead leading into the cofferdam, which was being used as a “slop tank” at the time of the explosion. Examination of the soot patterns on the door dogs indicates that it was unsecured at the time of the explosion.

This escape door had been added to satisfy the regulatory requirement for a second means of escape from the engine-room when the vessel came under Canadian registry in 1983. TC Marine Safety approved the design, location and installation of the door.

1.14 ‘Tween-deck Arrangement

The ‘tween-deck arrangement on the “PETROLAB” was not a feature commonly found on oil tankers. The ‘tween-deck contained the cargo pumps and piping equipment and performed the function of the pump room found on more conventional tankers. The International Convention for the Safety of Life at Sea (SOLAS) requires that pump rooms be equipped with mechanical ventilation.[8] Because the vessel was under 500 tons it did not have to comply with SOLAS regulations. The ‘tween-deck on the “PETROLAB” was equipped with exhaust fans but, because petroleum vapours could be smelled on the bridge deck when they were running, the fans were not used.

The fourth edition of the *International Safety Guide for Oil Tankers and Terminals* (ISGOTT) is the standard reference text used by tanker and terminal operators. It states that the “pumproom should be kept continuously ventilated during cargo operations,” and that “ventilation should be continuous until access is no longer required or cargo operations have been completed.”[9]

There was no copy of the ISGOTT manual on board the “PETROLAB”, and the officers and crew were unfamiliar with the publication.

1.15 Inspection of the Vessel by Transport Canada

When the “PETROLAB” came under Canadian flag in 1983, drawings of the cargo-pumping system were submitted to and approved by TC.

Under current Canadian regulations, there is no requirement for the inspection of cargo pumps and pumping systems of oil tankers.

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8 SOLAS, Ch. II-2, Reg. 59.3.

9 ISGOTT, 4th Ed., Sect. 2.17.3.

In May 1997 the vessel underwent an annual inspection by TC in St. John's, Newfoundland. At the time of inspection, several lights in the engine-room were found to have covers missing and to have jury-rigged (non-standard) wiring. This situation was not treated as a deficiency.

The cargo-pumping system was not inspected, nor was it required to be. The engine-room bilge-pumping system was only inspected every five years. The after cofferdam was not listed as a survey item, and had not been formally examined by TC as part of the continuous hull survey regime since the vessel was brought under Canadian registry in 1983. TC did not conduct a boat and fire drill as required at annual inspections, nor were the crew's certificates examined.

The inspector had no tanker experience or training, did not possess a petroleum tanker endorsement, nor had he taken a tanker safety course.

Ultramar also inspected the vessel in May 1997 to determine if she was suitable for charter. The cargo-pumping system was inspected at the time using the Oil Companies International Marine Forum survey form. However, the type of cargo pump priming/stripping system, or defects to the system, were not noted. The crew's certificates were not sighted. The vessel was accepted for charter by Ultramar.

1.16 Use of the Government Wharf by Passenger Ferries and Tankers

On at least 20 occasions a year, the "PETROLAB" was present at the dock while the Quebec North Shore ferry "NORTHERN PRINCESS" embarked and disembarked passengers. The ferry's published schedule shows that she departs St. Barbe at 0800, 1230, and 1700, and would have been alongside the dock for 30 to 45 minutes before each departure on the day of the explosion. Besides a barricade and a fire extinguisher at the end of the government wharf, no special precautions were taken when the passenger vessel docked.

1.17 Fire Safety in Canadian Ports and Harbours

In December 1994, during the unloading of a cargo of rock phosphate in the port of Belledune, N.B., a fire broke out in the conveyor belt system of the bulk carrier "AMBASSADOR" (TSB Report No. M94M0057). The combined efforts of the ship's crew and several shore-based fire departments were required to bring the fire under control before it was fully extinguished, some 28 hours later. The port of Belledune is a divisional port administered by Canada Ports Corporation. In Canadian ports and harbours, the responsibility for risk assessment and emergency plans generally rests with the local harbour master or port official whilst the firefighting is provided by the local fire department. In Canada, none of the ports have a dedicated or trained marine fire brigade. Concerned that many municipal fire departments may not have properly trained personnel to fight shipboard fires, the Board made three recommendations:

> The Department of Transport [should] conduct a special audit of firefighting facilities at Canadian ports and harbours under its jurisdiction to ensure that an adequate year-round capability exists to contain shipboard fires.
>
> (M96-06, issued October 1996)

> The Department of Transport [should], in collaboration with ports and harbour authorities, take measures to ensure that shore-based fire brigades expected to support on-board firefighting receive appropriate training.
>
> (M96-07, issued October 1996)

> The Department of Transport [should] take appropriate measures to ensure that on-board firefighting capabilities of vessels in Canadian ports and harbours are functional and readily available during cold weather operations.
>
> (M96-08, issued October 1996)

In its response, TC indicated that the Canadian Association of Fire Chiefs (CAFC) is responsible for the standards and training of shore-based fire brigades.[10] The majority of public harbours have only a local volunteer force to fight small fires and their training generally does not include entering and fighting fires in restricted places. TC also indicated that at present there are no legislated requirements for public harbours and ports to enter into firefighting activities aboard vessels. Subsequently, in May 1997, the CAFC forwarded a questionnaire to selected municipalities to determine their firefighting capabilities and the type and extent of assistance that could be called upon by operators of marine terminals in the event of a fire on board a vessel in port.

Since the “AMBASSADOR” occurrence, there have been three occurrences in which municipal fire departments were involved in fighting shipboard fires (TSB Report Nos. M97W0035, M97W0044, and M97W0194).

[10] The CAFC has no jurisdiction over fire departments outside its membership.

1.18 Safety and Emergency Preparedness in Canadian Ports

Pursuant to the *Public Harbour and Port Facilities Act,* TC, Harbours and Ports (H&P) is responsible for the administration and safety of approximately 549 small ports and harbours in Canada. Under the *Canada Ports Corporation Act,* Ports Canada oversees 14 of the largest and more important commercial ports, such as those at Vancouver and Montreal. There are also nine harbour commissions with their own enabling legislation. The Department of Fisheries and Oceans is responsible for 2,000 small recreational and fishing harbours.

In December 1995 the Minister of Transport announced the new National Marine Policy, and early in 1996 introduced the Canada Marine Act in the House of Commons. One of the objectives of the National Marine Policy is the commercialization of the 572 public ports and harbours. While the larger, more-profitable ports will become the responsibility of Canada Port Authorities (CPA), a second category of smaller regional and local ports will be divested to the provinces and municipalities.

The *Emergency Preparedness Act,* which became effective 1 October 1988, bestows a government-wide mandate on all federal departments and agencies to develop and coordinate programs to deal with unforeseen and potentially disastrous events, including emergencies such as fire, explosions, chemical spills, etc., in Canadian ports and harbours. Emergency preparedness involves three elements: assessing the risks associated with the operation, emergency planning to deal with the risk identified, and training and practice to effectively execute the plan. There has not been any evaluation of risks at regional or local ports across Canada to prepare emergency plans.

Today, only the larger CPA have the physical and human resources to prepare for emergencies. Small local ports administered by TC and DFO—or those divested to the provinces or municipalities—do not have adequate resources to ensure emergency preparedness. As for the divested ports, it appears that the onus is on the new owner/operator to ensure that they have what they need to operate safely and remain an ongoing viable entity. TC does not maintain physical or regulatory supervision over divested sites/facilities to ensure compliance by the new entity with the safety provisions of acts and regulations administered under its authority. As such, there are no provisions for enforcement of safety measures nor for safety audits of divested facilities.

1.19 Guidelines on Risk Assessment and Emergency Plans for Ports

Internationally, the United Nations Environment Programme (UNEP) has developed a process for responding to technological accidents, called *Awareness and Preparedness for Emergencies at Local Level* (APELL). Two basic approaches are used: first, to increase knowledge in the community about possible risks and hazards in the area and, second, to develop a coordinated emergency response plan.
In 1994–95 the International Maritime Organization (IMO) and the UNEP developed a joint publication for port users and operators on how to apply APELL in ports. The publication addresses port facilities' unique hazardous situations and activities that pose risks to persons, property and the environment.

In February 1995 a group of international experts gathered in London to develop and review the joint UNEP/IMO document *Guidance on Application of APELL in Ports*. Documents like this, and other publications prepared by the Emergency Preparedness College, provide adequate guidance to port management for conducting risk assessment and for the development of emergency plans in local ports and harbours.

2.0 Analysis

2.1 Crew Training

Petroleum tankers are specialized vessels and special technical skills and knowledge are required to operate them safely. The competence of tanker crews is a critical factor for safe and efficient operations. Traditionally, tanker crews acquired the necessary skills and competence during years spent at sea, preferably on a variety of vessels, but the quality of such experience can vary considerably between ships and from one company to another.

The majority of the crew members on the "PETROLAB" had gained tanker experience solely on board the "PETROLAB", which resulted in unsafe tank washing/slop transfer practices and procedures being developed on board and passed on to new crew members. The officers and crew had not received formal petroleum tanker training and none of them recognized the dangers inherent in the ship's accepted tanker work practices and procedures.

Tanker safety courses enhance awareness of safe operational practices. The value of such training is recognized by IMO, and is contained in the STCW, which states in part:

> 1 Officers and ratings assigned specific duties and responsibilities related to cargo or cargo equipment on tankers shall have completed an approved shore-based fire-fighting course . . . and shall have completed:
>
> > (.1) at least three months of approved seagoing service on tankers in order to acquire adequate knowledge of safe operational practices; or
> >
> > (.2) an approved tanker familiarization course . . . .
>
> 2 Masters, chief engineer officers, chief mates, second engineer officers and any person with immediate responsibility for loading, discharging and care in transit or handling of cargo shall, in addition to meeting the requirements of sub-paragraphs 1.1 or 1.2 , have:
>
> > (.1) experience appropriate to their duties on the type of tanker on which they serve; and

> (.2) completed an approved specialized training programme which at least covers the subjects set out in section A-V/1 of the STCW Code that are appropriate to their duties on the oil tanker, chemical tanker or liquefied gas tanker on which they serve.[11]

Had the owner, officers, or crew taken a petroleum tanker safety course, they may have recognized the dangers inherent in their tank washing procedures.

Only the officers on board the “PETROLAB” had taken MED courses and received instruction on fighting shipboard fires. No regular emergency drills were held on the “PETROLAB”; therefore, the uncertificated crew members had only a limited possibility of acquiring the confidence and skills required to successfully fight a fire on board the ship.

During the vessel’s annual inspection, TC Marine Safety did not assess or determine the crew’s ability to deal with emergencies on board ship as no boat and fire drill was carried out.

2.2 Management Oversight

The key to good safety management is commitment from the top. Although the master is in overall command, management has the ultimate responsibility for setting policies, procedures, and operating instructions for the safe operation of a vessel. The owner of the “PETROLAB” had not established formal policies or procedures, particularly in the areas of cargo handling and tank washing. As a result, the crew did not have the guidance required for them to perform their duties safely.

The owner often sailed with the vessel and was assisting with tank washing operations at the time of the explosion, but he lacked experience (on other tankers) and had no formal petroleum tanker safety training. Therefore, he could not, and did not, provide effective oversight to ensure the vessel’s safe operation.

2.3 Chain of Command

Although the owner did not interfere with navigational decisions made by the master, his presence aboard—and his reliance on the first mate—disrupted the chain of command on the vessel. The weak relationship (and conflict) between the master and first mate resulted in a lack of communication. In an economic climate where seagoing jobs are scarce, the master was reluctant to implement changes to the work responsibilities and unsafe procedures which had become accepted as normal by the owner and crew.

There had been no resolution of this conflict at the time of the explosion. The first mate was working with the owner who was not qualified to conduct or direct petroleum tanker cargo operations.

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[11] STCW Convention, 1995, Reg. V/1.

2.4 *Explosive Environment and Sources of Ignition*

When a flammable cloud of petroleum vapour is ignited, flames spread quickly through the mixture and a rapid expansion of gas occurs, resulting in a local pressure rise. In an open space, the expanding gases can disperse easily; however, in an enclosed space such as the 'tween-deck of the "PETROLAB", the expanding gases were contained. The pressure continued to build up until it was released through openings and by the partial structural failure of the vessel. The explosion on the "PETROLAB" had enough force to severely distort the deck house structure, throw the owner over the side, knock down the mate and deckhand, and jam the engine-room escape door in the open position against the adjacent bulkhead. The fact that the flames exiting the 'tween-deck escape hatch were a deep red indicates that the vapour concentration in the 'tween-deck was rich (between 5 and 8 percent of vapour in the air).

For a petroleum explosion to occur, three elements must be present: vapour, oxygen, and a source of ignition. For petroleum vapour to ignite, the amount of vapour in the air must be between strictly defined limits known as the lower explosive limit (LEL) and the upper explosive limit (UEL). The LEL and UEL range for gasoline is between 1 and 8 percent of vapour in the air. Below the LEL, the mixture is too lean and above the UEL it is too rich to ignite (see Appendix C).

When gasoline and water mixtures being pumped from the COTs were allowed to free-fall through the 'tween-deck into the cofferdam during tank washing operations, vapour concentrations in excess of the LEL were created. Since the exhaust fans for the cofferdam and 'tween-deck space were not in use, gasoline vapours filled the cofferdam and 'tween-deck area, and the unsecured escape door (on the port side of the forward engine-room bulkhead leading into the cofferdam) would have allowed gasoline vapours to enter the engine-room.

Although the exact source of ignition was not determined, several possible sources were present at the time of the explosion:

- *Static electrical accumulation and discharge in the cofferdam or 'tween-deck.* The conditions for static accumulation and discharge were present in the cofferdam and 'tween-deck. The spray of gasoline into the 'tween-deck and cofferdam provided both the vapour concentration and potential static electrical ignition source necessary for an explosion to occur.

- *A spark from the Honda pump being used to transfer slops from the COTs to the cofferdam.* Although no flames were reported around the pump at the time of the explosion, the pump was not equipped with an exhaust spark arrester and was operating in an area where gasoline fumes were emanating from the pump house door, 'tween-deck escape hatch and COTs.

- *The non-intrinsically safe equipment in the engine-room.* Much of the electrical equipment in the engine-room was not intrinsically safe and several possible sources of sparks or open flame, such as the boiler and running port generator were present in the engine-room.

It is unknown why the chief engineer entered the engine-room when he did. He may have intended to pump the engine-room bilges into the cofferdam (for later disposal ashore) by means of the small non-standard submersible bilge pump. To do this, he may have opened the escape door to the cofferdam. Because the explosion occurred shortly after he entered the engine-room, such a transfer may have been made earlier (laboratory analysis of slop samples from both the cofferdam and the engine-room bilges show similar properties). The discharge hose from this pump was found leading toward the escape door after the explosion, but it is unknown when it was so deployed.

The oil-fired domestic hot water boiler raised the temperature of the engine-room and accommodation. Therefore, it was often shut down and used only when hot water was required. It is known that the second engineer had intended to take a shower, and the boiler's main power switch was in the closed (energized) position; however, there is no clear indication as to whether the boiler was running at the time of the explosion or if the chief engineer had started or intended to start it.

In summary, the conditions existed for a static discharge in the accumulated gasoline vapours in the cofferdam and 'tween-deck area, but as the chief engineer's activities in the engine-room are unknown, an ignition source from within the engine-room cannot be ruled out.

2.5 Local Firefighting

Immediately after the explosion the second mate put out several small deck fires with a portable fire extinguisher; however, in the ensuing two to three hours after the explosion no effort was made by the ship's crew or the shore-based firefighters to fight the fire which, at that point, was limited to the 'tween-deck area. Although the "PETROLAB" was equipped with firefighting appliances as required by TC Marine Safety, there is no requirement for an emergency fire pump or emergency generator for a vessel under 45.7 metres, even if the vessel is engaged in carrying hazardous petroleum cargoes. The ship's Scott air pack bottles were empty, having been used during tank-washing operations and, with no ship's power, no emergency fire pump, and little training or leadership, the vessel's crew was left with no firefighting options.

The first shore-based volunteer firefighters arrived shortly after the explosion. The master requested assistance in fighting the fire; however, the local firefighters were reluctant to fight the fire without foam, as they were under the mistaken impression that water could not be applied to an oil tanker fire. Although the wharf at St. Barbe served both oil tankers and passenger vessels on a regular basis, none of the local fire departments responding to the fire had training in shipboard firefighting. Medium expansion foam arrived with the Port au

Choix fire department approximately one hour after the explosion, but was not applied to the fire which, at that point, was still limited to the area inside the vessel's 'tween-deck.

The terminal operator, Ultramar, had a contingency plan in place for a fire at the tank farm; however, the terminal supervisor had not been given formal training in firefighting. The contingency plan relied on the local fire department which was not equipped with foam to fight petroleum fires, and did not refer to shipboard fires. By flushing the pipelines on the dock with water, the Ultramar employees helped prevent the spread of the fire to the tank farm and prevented pollution.

The fire on board the vessel was left to burn out of control, and it eventually spread to the creosote-impregnated pilings under the dock. Once the piles caught fire, the concrete deck hampered the efforts of the firefighters and of the CCG vessels to reach the seat of the fire under the dock. The "SIR WILFRED GRENFELL" attempted to use her winches to dismantle the dock, with little success.

Early intervention by the ship's crew and local fire departments using water and, when it arrived, foam, would probably have brought the fire under control before it had a chance to spread to the wharf.

2.6 Condition of the Vessel's Cargo-handling Equipment

The condition of cargo pumps and piping systems is important for the safe operation of all oil tankers. Besides being used to discharge cargo, a tanker's pumping system may be used in damage and stability control situations resulting from flooding, and in cargo transfer operations to mitigate pollution resulting from accidents. As such, cargo-pumping systems on oil tankers are analogous to bilge-pumping systems on other vessels.

The vessel's original vacuum tank-stripping equipment had been inoperable for at least 10 years and was considered too deteriorated to repair and return to service. It had therefore been blanked off. The alternative means of stripping tanks used by the first mate and condoned by the current owner was intrinsically unsafe—particularly the pumping of tank-washing slops into the cofferdam by means of a pump that the manufacturer's operating manual specifically warned was unsuitable for the task.

2.7 Oily Water Separator Exemption

An oily water separator enables treated water from the bilges to be pumped directly overboard. As the BSI had granted an exemption to the vessel, the “PETROLAB” was not required to have an oily water separator.

One effect of this exemption was that an alternative, unsafe system to pump out the engine-room bilges had developed aboard the vessel. A non-intrinsically safe, 12-volt, small yacht-type submersible bilge pump was used to transfer engine-room bilge slops to the cofferdam. Its discharge hose was passed through the open engine-room escape door.

2.8 Engine-room Escape Door

On board the “PETROLAB”, the after cofferdam was contiguous with the ‘tween-deck (pump room) above, being covered only by open mesh deck gratings. It was unorthodox to have installed a door, which, among other uses, could have been used to escape from an engine-room fire, particularly as the door accessed a space which often contained petroleum vapours. To prevent the movement of vapours between the two spaces, the engine-room escape door leading to the cofferdam should have been kept closed and secured at all times.

Post-occurrence inspection of the door indicated that it was not secured at the time of the explosion. Therefore, the open door would have allowed the passage of gasoline vapours from the cofferdam into the engine-room. Additionally, if the source of the explosion was within the cofferdam and ’tween-deck area, the open door would have provided a path for the explosion flame front to enter the engine-room.

Given the relatively small size of the engine-room and the location of the door, the door’s benefit as an escape route was minimal. On the day of the explosion, not only did it not provide an escape route, it enabled the passage of gasoline vapours (or of a flame front) from the cofferdam into the engine-room, which caused the chief engineer’s fatal injuries.

2.9 Use of the Government Wharf by Passenger Ferries

The “PETROLAB” and the passenger ferry “NORTHERN PRINCESS” were both alongside the dock at St. Barbe for a total of about 90 to 135 minutes on the day of the explosion. Passengers were embarked and disembarked from the ferry while the “PETROLAB” was conducting cargo and other hazardous operations.

The precautions taken to physically separate the ferry passengers from the tanker’s inherently hazardous cargo operations were minimal, and the travelling public was unnecessarily put at risk.

2.10 Transport Canada Inspections

"Seaworthiness is the sufficiency of a vessel in materials, construction, equipment and crew for the trade or service in which it is employed."[12] Shipowners must therefore ensure that all of these conditions are satisfied. The vessel must also comply with TC construction, equipment, and crewing standards.

2.10.1 Construction

The vessel's arrangement of an enclosed 'tween-deck and contiguous after cofferdam was unorthodox. While this did not necessarily mean that the vessel was unsafe, a level of safety equivalent to that of conventional petroleum tankers would have to be present for acceptance into Canadian registry. Canadian regulations required a second engine-room escape route. In 1983 the vessel's previous owner submitted plans to TC showing an escape door through the forward engine-room bulkhead. These plans showed the engine-room contiguous with the 'tween-deck space, which was effectively a pump room. TC approved the plans as submitted.

2.10.2 Bilge-pumping Arrangements

In 1993 the owner applied for a COPP certificate. In his application for an exemption from the requirement to equip the vessel with an engine-room oily water separator, the owner indicated that the vessel would store all bilge slops on board in the dedicated slop tanks. This exemption was granted by the BSI, but no follow-up inspection was undertaken to verify the bilge-pumping arrangements. TC did not know that an unsafe engine-room bilge-pumping system, which required that the engine-room escape door be left open, had been jury-rigged.

The after cofferdam was not on the list of hull spaces to be inspected, and had not been formally inspected since the vessel came under Canadian flag in 1983.

2.10.3 Cargo-pumping Arrangements

As Canadian regulations do not require that the vessel's cargo-pumping system be inspected and as the vessel was out of class, the unserviceable condition of the vessel's vacuum tank-stripping system was not determined by either TC or a classification society.

The vessel had been inspected by TC under Canadian regulations and issued the appropriate certificates, but the unnoticed poor condition of the cargo-pumping system compromised her seaworthiness. The condition of the pumping equipment had not been assessed since the vessel came under Canadian registry in 1983.

2.10.4 Emergency Equipment

Under Canadian regulations, a vessel the size of the "PETROLAB" is not required to be equipped with an emergency generator or an emergency fire pump, irrespective of her use as a petroleum tanker. Therefore, no

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12 International Maritime Dictionary, 2nd Ed.

shipboard resource (particularly the 'tween-deck foam system) was available to fight the fire after the ship's service generator stopped as a result of the explosion.

2.10.5 Assessment of the Crew's Competence

The TC inspector who carried out the vessel's annual inspection in May 1997 was not trained in petroleum tanker safety and did not hold a petroleum tanker endorsement. He did not require the crew to perform a boat and fire drill nor did he inspect the crew's certificates. Therefore, the crew's ability to safely operate the vessel and to respond to emergency situations (such as a shipboard fire) was not adequately assessed.

3.0 Conclusions

3.1 Findings

1. The vessel was inspected by TC Marine Safety in May 1997, but no inspection of the cargo-pumping or engine-room bilge-pumping systems was carried out.

2. Under current Canadian regulations, there is no requirement for oil tanker cargo pumps and pumping systems to be inspected by TC.

3. The vessel's tank-stripping system had been inoperable for at least 10 years, and the cargo piping system had been modified to discharge directly into the cofferdam instead of the dedicated slop tanks.

4. The after cofferdam was not on the list of hull spaces to be formally inspected by TC as part of the continuous hull survey regime.

5. The Board of Steamship Inspection (BSI) had granted the vessel an exemption from the requirement to have an engine-room oily water separator, based on the understanding that all bilges would be pumped to the dedicated slop tanks and then ashore.

6. The vessel was not equipped with an emergency generator or an emergency fire pump nor was such equipment required under Canadian regulations.

7. No regular boat and fire drill was carried out by the crew on the "PETROLAB" and no such drill was witnessed by the TC inspector at the annual inspection in May 1997.

8. The TC inspector who inspected the vessel in May 1997 did not hold a petroleum tanker endorsement nor had he taken a petroleum tanker safety course.

9. The vessel was inspected by the charterer, Ultramar Canada Inc., prior to hire in May 1997, but no inspection of the cargo-pumping equipment was carried out.

10. The owner did not have a formal safety management system in place.

11. There was no formal orientation/training policy for new employees.

12. For at least 10 years , non-standard and unsafe work practices and procedures for tank washing and cargo slop storage had developed and come to be accepted.

13. Only the first mate and chief engineer held petroleum tanker endorsements, which had been issued solely on the basis of the experience they had gained exclusively aboard the "PETROLAB".

14. The owner and first mate often left the master out of the decision-making process concerning ship's business and cargo handling.

15. The owner and first mate made the decision to wash down cargo oil tanks (COTs), which had contained gasoline, with seawater delivered through a fire hose that was not grounded.

16. The gasoline and water mixture (slops) was transferred using a portable pump that was not designed for this type of operation.

17. The slops were being discharged into the cofferdam instead of into the dedicated slop tanks.

18. The slops were allowed to free-fall into the cofferdam from an uncertified and ungrounded rubber hose, creating vapour concentrations in excess of the lower explosive limit (LEL) and a static electricity hazard.

19. The exhaust fans for the cofferdam and 'tween-deck space were not running to ventilate these spaces.

20. No atmospheric monitoring was conducted in the 'tween-deck, cofferdam, engine-room or COTs during the tank washing and slop transfer operations.

21. The emergency escape door between the engine-room and the cofferdam was open during the transfer of slops.

22. A small, non-standard submersible electric bilge pump was found in the forward engine-room bilge with its discharge hose leading toward the engine-room escape door.

23. Engine-room bilge slops were present in the cofferdam.

24. Much of the electrical equipment in the engine-room was not certified for use in a hazardous area and some wiring and fixtures were non-standard.

25. While the precise source of ignition of the gasoline vapours created during the transfer of slops is unknown, the open engine-room escape door allowed the passage of either gasoline vapours or an explosion flame front from the cofferdam into the engine-room.

26. None of the crew was wearing personal protective equipment such as fire-retardant clothing at the time of the explosion.

27. The crew was unaware of the dangers associated with the cumulative carcinogenic effects of benzene in petroleum products.

28. After the explosion, the ship's service generator stopped and there was no power to the vessel's fire pump. The vessel was not fitted with an international shore connection to charge her fire main from shore, and the ship's Scott air pack bottles were empty, after being used in the tank washing operations.

29. After the explosion, the crew put out several small fires on deck with a portable fire extinguisher but the crew made no attempt to enter the engine-room to restart the generator to provide power to the fire pump before leaving the vessel.

30. Fire wires were not rigged at the bow and stern of the vessel to enable the vessel to be towed clear of the wharf.

31. Ultramar had no contingency plans in place for a major fire at the tanker loading berth; however, the action taken to flush the dock pipelines with seawater did prevent the spread of the fire to the tank farm, and possible pollution.

32. Before the fire, Ultramar had not assessed the capability of the local fire department to fight shipboard—in particular, oil tanker—fires.

33. The local fire department was not equipped with foam and had no training in fighting shipboard—in particular, oil tanker—fires.

34. The fire departments did not bring the shipboard fire under control in its early stages, and burning paint on the vessel's outer hull spread the fire to the creosote-impregnated piles of the government wharf.

35. The concrete deck on the government wharf limited the fire departments' access to the seat of the fire underneath, and the wharf was destroyed.

36. The government wharf in St. Barbe was often used simultaneously by petroleum tankers conducting cargo operations and by the Quebec North Shore passenger ferry "NORTHERN PRINCESS".

37. The minimal precautions taken to separate ferry passengers from oil tanker hazardous cargo operations unnecessarily put the travelling public at risk.

38. There has not been any evaluation of risks at regional and local ports handling petroleum products across Canada to prepare emergency plans.

39. TC does not maintain physical or regulatory supervision over divested ports to ensure their compliance with existing safety provisions of acts and regulations.

40. The UNEP/IMO has published guidelines to assist port officials in the preparation and application of emergency preparedness in port areas.

3.2 Causes

The explosion occurred due to an accumulation of gasoline vapour in the after cofferdam, 'tween-deck space, and engine-room. The source of ignition was not determined. Factors contributing to the explosion were: the owner's and crew's ignorance of tanker safe working practices; the improvised and unsafe working practices devised to replace a tank-stripping system that had been inoperable for at least 10 years; the fact that there was no safety management system in place; the use of the cofferdam, which was open to both the 'tween-deck and engine-room, as a slop tank; the use of pumping equipment uncertified for use in a hazardous environment; the fact that the mechanical ventilation for the cofferdam and 'tween-deck area was not used and no atmospheric monitoring was carried out; and the presence of substandard electrical equipment and fittings in the engine-room.

4.0 Safety Action

4.1 Action Taken

Following this occurrence, Transport Canada (TC) was apprised of several safety problems regarding the cargo-pumping system on the “PETROLAB” (TSB Marine Safety Advisories (MSA) Nos. 01/98, 02/98, 03/98 and 04/98).

4.1.1 Cargo-pumping Systems

MSA No. 01/98 stressed the importance for tanker owners to maintain the operational integrity and the safe working condition of all sub-elements of a tanker cargo-pumping equipment and stripping system. The current regulations and present annual survey requirements do not cover the inspection of such items. TC Marine Safety indicated its intention to issue a Ship Safety Bulletin to remind tanker owners of the hazards associated with improper practices. With regard to a more comprehensive inspection program to verify the operational integrity of cargo-pumping systems on oil tankers, TC indicated that amendments to the inspection regulations would require consultation with vessel operators and other interested parties to ensure consistent application.

4.1.2 Petroleum Tanker Endorsements

MSA No. 02/98 apprised TC of several unsafe work practices—such as tank washing with improper equipment and slop transfer into inadequate spaces—employed for many years on board the “PETROLAB”. Such practices were the result of crew members’ insufficient awareness of the hazards inherent in tanker operations. Not all crew members held a petroleum tanker endorsement, and those who did had never taken a petroleum tanker safety course. Consequently, unsafe work practices were perpetuated and reinforced. The MSA indicated the need for TC to reassess its requirements for the issuance and renewal of petroleum tanker endorsements.

Subsequently, TC indicated that as part of the Continued Proficiency Endorsement process a regulatory change is to be implemented requiring that all certificate holders re-validate their Tanker Certificates every five years.

4.1.3 Firefighting in Canadian Ports

Following the fire on board the bulk carrier “AMBASSADOR” in the port of Belledune, N.B. (TSB Report No. M94M0057), the Board recommended that the Department of Transport conduct a special audit of firefighting facilities at Canadian ports and harbours under its jurisdiction to ensure that there is adequate year-round capability to contain shipboard fires.

Subsequently, the Canadian Association of Fire Chiefs (CAFC), with the aid of TC circulated a short questionnaire to assess the firefighting capabilities of municipal fire departments responsible for fighting fires in Canadian ports.

In February 1998, in light of preliminary information coming from the "PETROLAB" investigation, TC Marine Safety and the CAFC were requested (via TSB MSA No. 03/98) to expedite their safety audit and review of risks and contingency measures in Canadian ports and harbours that contain oil terminals and where the installations are more susceptible to catastrophic damage should a fire break out onboard a vessel at the dock.

In July 1998 the CAFC received a limited response to the survey questionnaire and found the answers poor and relatively insignificant. Most of the municipal fire departments surveyed are not members of the CAFC and did not feel compelled to respond. However, the CAFC found that the survey provided enough information to raise concerns that the firefighting services available in municipalities with public ports may not be adequate to provide firefighting services in the event of a fire on board a vessel. The CAFC indicated that they are interested in working with TC to pursue research in this area.

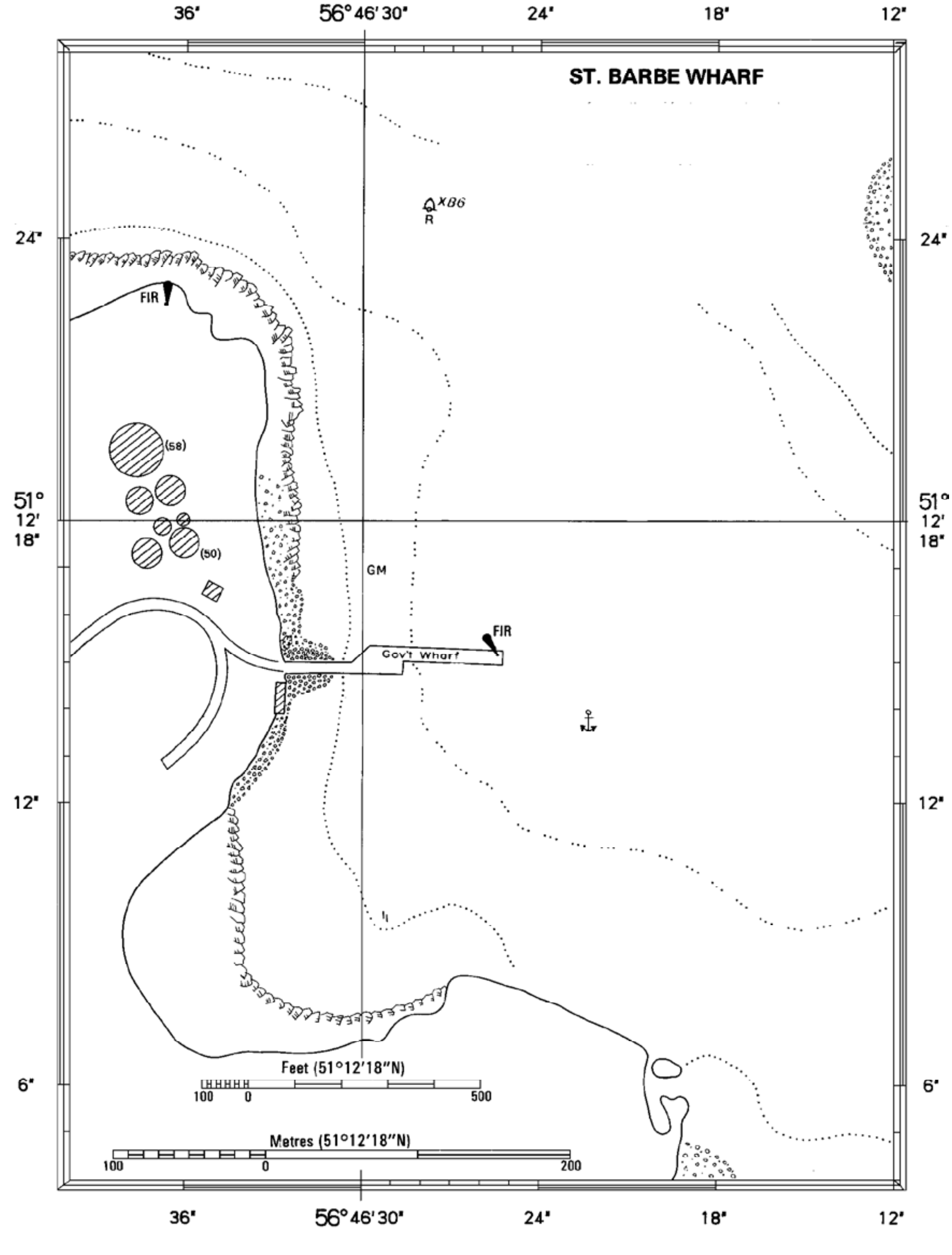
4.1.4 Public Safety

MSA No. 04/98 apprised TC of the potential risk to the public due to the simultaneous oil tanker and passenger vessel operations in small public harbours. TC recognized the risk and indicated that several precautionary measures are already in place, including the posting of "no smoking" signs, and the requirements to have an individual stand by the manifold and have fire extinguishers near the manifold during tanker cargo loading and unloading operations. In addition, TC indicated that harbour masters and wharfingers have sufficient authority to direct vessels and manage the site.

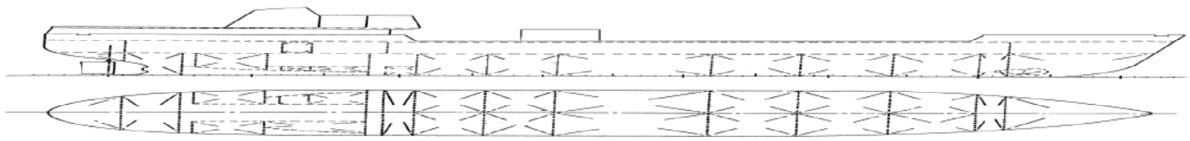
4.1.5 Transport Canada Inquiry

Pursuant to section 504 of the *Canada Shipping Act*, the Minister of Transport has appointed a commissioner to conduct a regulatory inquiry into this accident. The inquiry has been temporarily adjourned.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 9 April 1999.

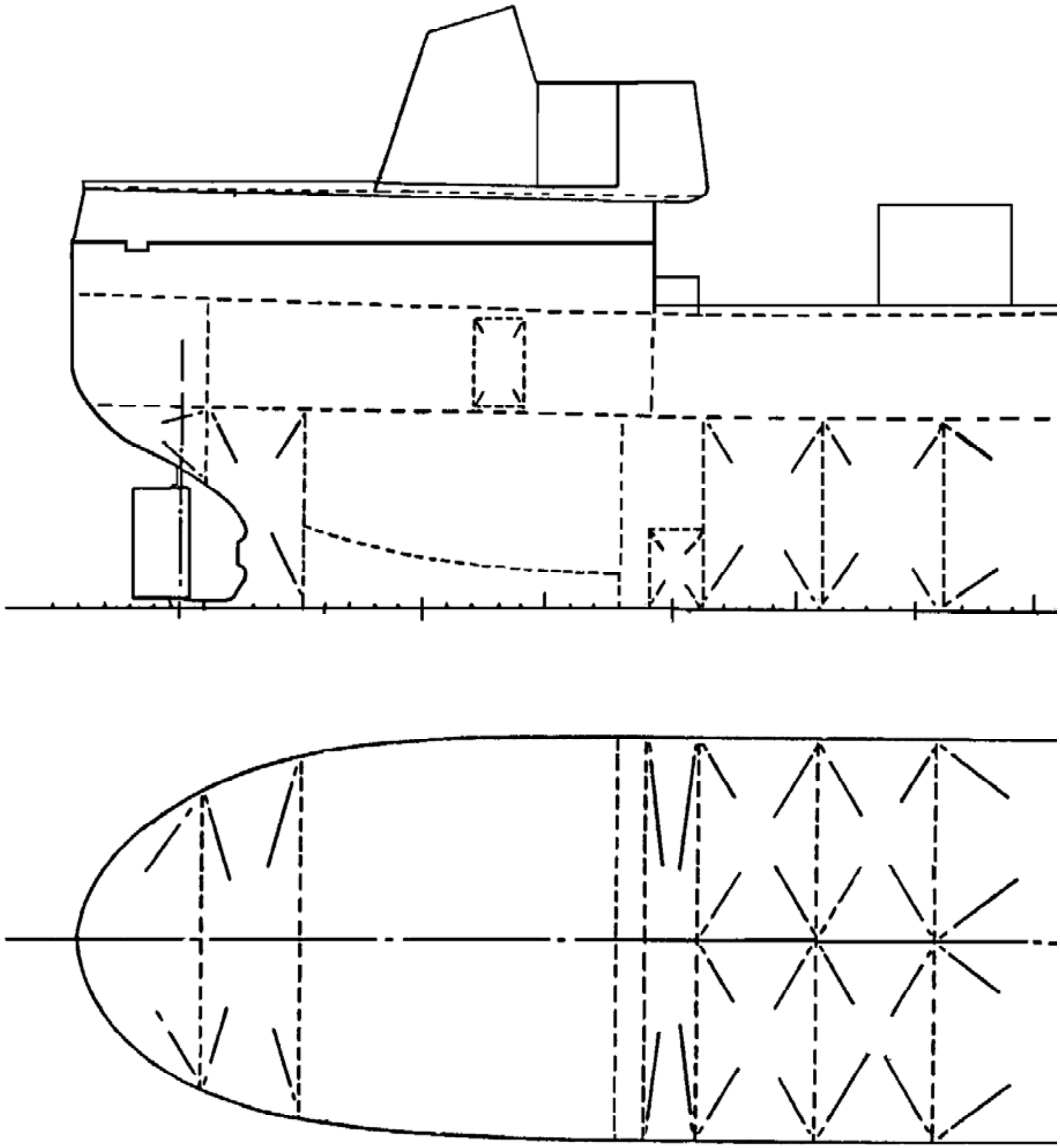


Appendix A - Sketch of the Occurrence Area



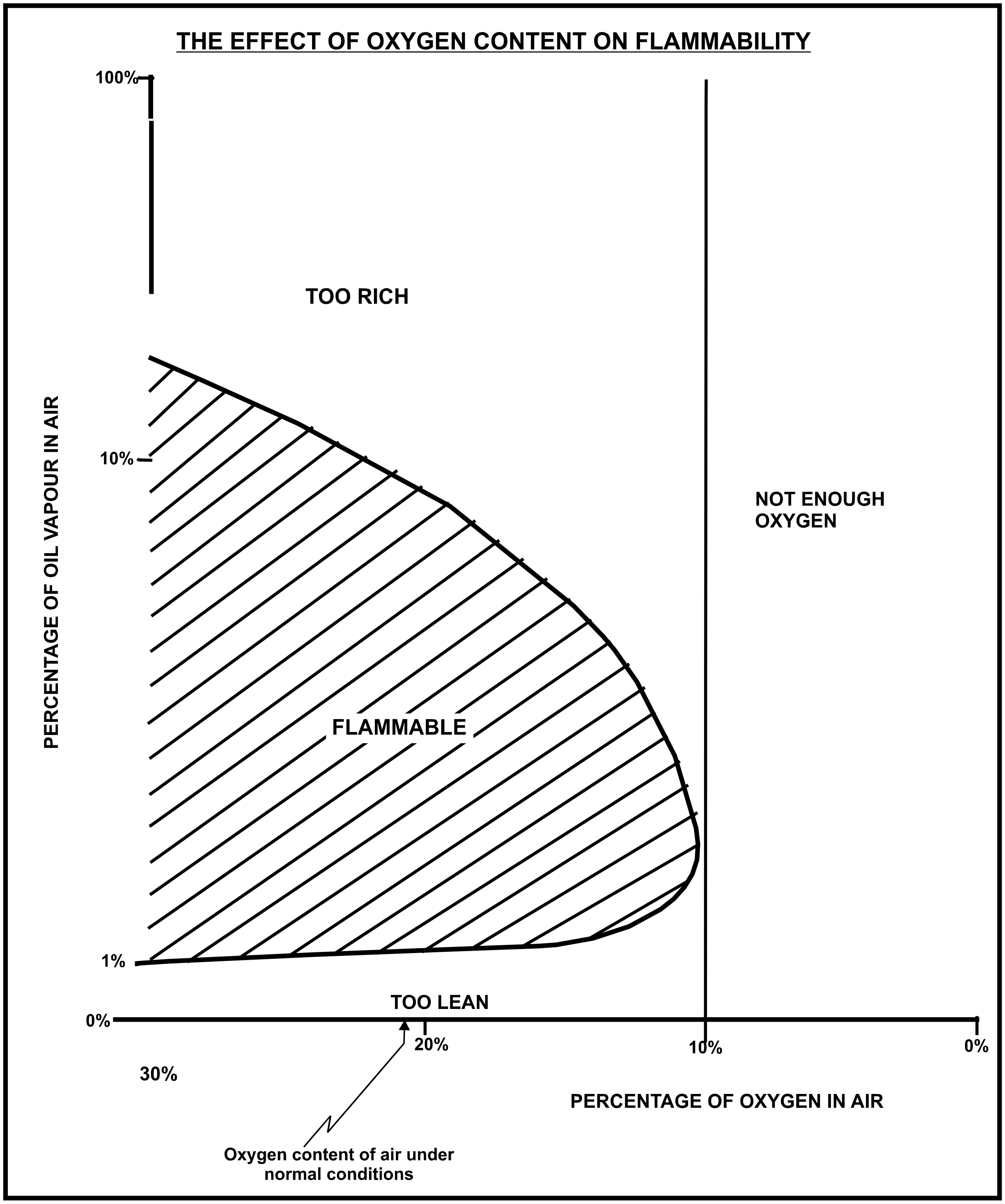
Appendix B - Drawings

General Tank Layout of the "PETROLAB"



Arrangement of the After Cofferdam, Slop Tank, 'Tween-deck Space and Engine-room

Appendix C - Graph of Oxygen/Oil Vapour Flammability


THE EFFECT OF OXYGEN CONTENT ON FLAMMABILITY
100%
10%
1%
0%
PERCENTAGE OF OIL VAPOUR IN AIR
TOO RICH
FLAMMABLE
NOT ENOUGH OXYGEN
TOO LEAN
20%
10%
0%
30%
PERCENTAGE OF OXYGEN IN AIR
Oxygen content of air under normal conditions

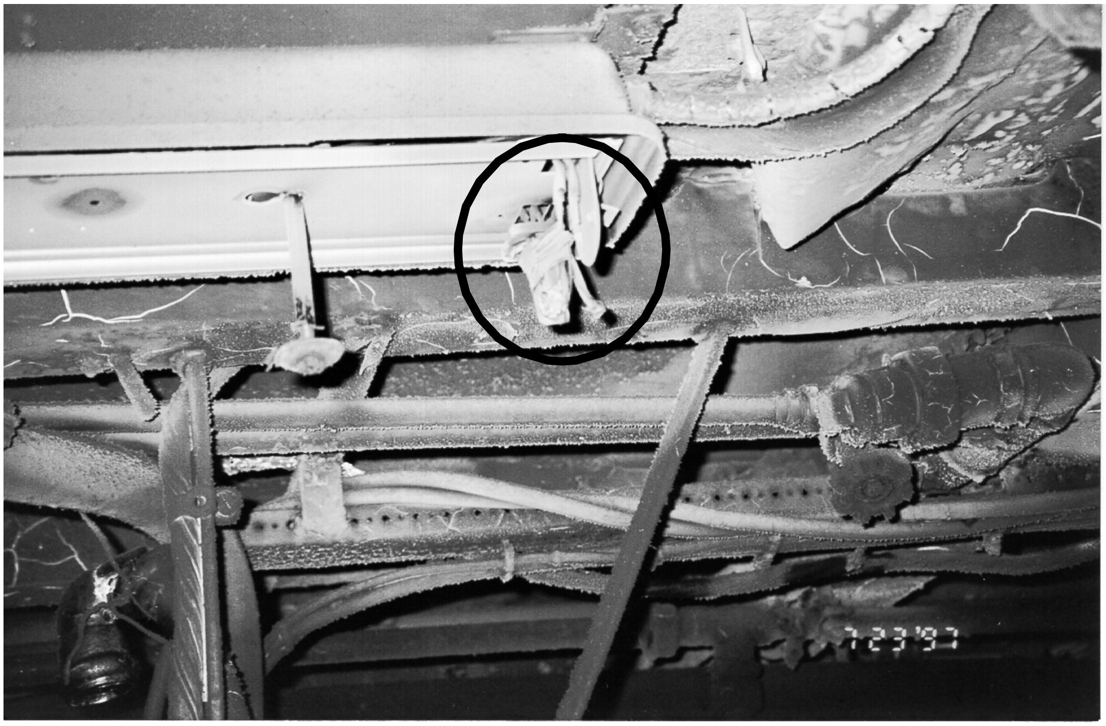
Appendix D - Photographs

The "PETROLAB" before the explosion and fire

The "PETROLAB" after the explosion and fire

'Tween-deck escape hatch leading to the after cofferdam,
through which slops were being pumped.

Portable Honda pump in way of the open hatch to No. 5 port COT



Sub-standard wiring in engine-room

Open engine-room escape door in forward engine-room bulkhead;
cofferdam beyond.

The CCGS “SIR WILFRED GRENFELL” fighting the fire

Government wharf burning

Appendix E - Glossary

A.P.	after peak
APELL	Awareness and Preparedness for Emergencies at Local Level
BHP	brake horse power
BSI	Board of Steamship Inspection
CAFC	Canadian Association of Fire Chiefs
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
cofferdam	an empty space separating adjacent compartments
COPP	Canadian Oil Pollution Prevention (Certificate)
COT	cargo oil tank
DC	direct current
F.O. tk	fuel oil tank
F.W. tk	fresh water tank
halon	bromo-trifluoro-methane (a gaseous fire-suppressant chemical)
IMO	International Maritime Organization
ISGOTT	International Safety Guide for Oil Tankers and Terminals
kW	kilowatt
LEL	lower explosive limit
L.O. tk	lube oil tank
m	metre
m^3	cubic metre
MED	marine emergency duties
mm	millimetre
MSA	Marine Safety Advisory
ON II	Foreign-going, Second Mate (Certificate)
Scott air pack	a self-contained breathing apparatus
SI	International System (of units)
slop tank	a tank used to store waste oil
SOLAS	International Convention for the Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995
stripping	removing residual liquid from a tank
TC	Transport Canada
TSB	Transportation Safety Board of Canada
‘tween-deck	the space between the weather deck and the deck below
UEL	upper explosive limit
UNEP	United Nations Environment Programme
WHMIS	Workplace Hazardous Material Information System