The Salvage of MV *Essi Silje* and Lloyd's Arbitration Hearing[1]

by Edwin S. Chan

In 1982 the chemical tanker MV Essi Silje *caught fire and was abandoned in the North Atlantic. The Canadian naval supply ship, HMCS* Protecteur, *undertook the salvage operation before the arrival of the salvage tugs. The vessel was eventually salvaged. For the subsequent Lloyd's Arbitration Hearing in London, the author was tasked by the Department of Justice of Canada to provide evidence for presentation at the hearing. This paper presents a brief account of the incident, the technical investigation, the technical disputes, and provides recommendations for future salvage operations.*

The incident

On 8 June 1982 the chemical tanker MV *Essi Silje* (registered in Norway) sailed from Ellesmere Port, U.K., for Curacao with a load of 9234 tonnes(t) [9088.2 long tons (LT)] of tetraethyl lead antiknock compounds, 2175.6t (2141.2 long tons) of caustic soda, and 354.96t (349.4 long tons) of potash. At about 2055 hours, on 11 June, at an approximate position 44°40'N and 20°40'W in the North Atlantic, fire erupted in way of the port main engine. The fire spread quickly into the accommodation space and, within half an hour, the crew lowered the lifeboats and abandoned the vessel after the "Mayday" call was sent out.

The Canadian naval supply ship HMCS *Protecteur*, carrying two Sea King type helicopters, on passage from Plymouth, U.K. to Halifax, Canada, upon receiving the distress signal, directed the helicopters to the scene to provide assistance. At the same time *Protecteur* was approaching the burning vessel at high speed, from a distance of 41.7km (25 miles). *Protecteur* arrived alongside the lifeboats at about 0030 on the 12th and the crew of the vessel was picked up, including the master of the *Essi Silje*, after a brief visit to the burning vessel.

At early dawn of the 12th, the fire in the engine room appeared to be out but the fire in the superstructure appeared to intensify, with flames on various parts of the bridge and funnel area. Periodic explosions were observed. In the afternoon the paint on the ship sides peeled off and burned. By evening the fire appeared to have peaked — after the fire

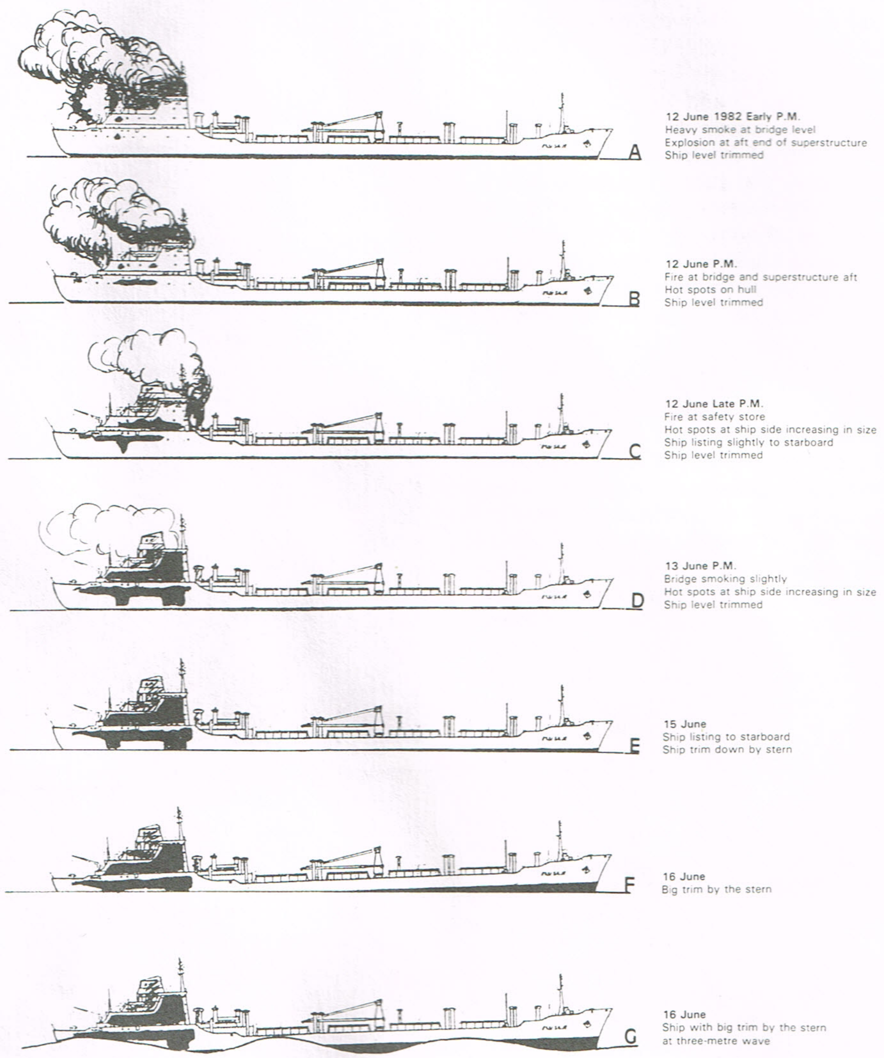


Figure 1. Observations based on photographs taken by crew of HMCS *Protecteur*.

---

[1]*Presented at the April 10, 1986 meeting of the Eastern Canadian Section of the Society of Naval Architects and Marine Engineers, and published in the January 1987 issue of Marine Technology.*

on the bridge was out. Figure 1 shows the condition of the vessel at different time periods, based on the photographic record of the crew of *Protecteur*. Figure 2 shows actual photographs of the burning superstructure.

Throughout the 13th, the vessel continued to burn, especially around the fuel tanks in the engine room. *Protecteur* patrolled around the burning vessel at a radius of one nautical mile. By midday on the 14th the fire seemed to have burned itself out, but the vessel was observed to start trimming down by the stern (Fig. 3). After 1300, the boarding party discovered that the engine room was flooding rapidly. Coventry Climax portable fire pumps were transferred from *Protecteur* and were set up in the engine room above the main diesel engine by the crew of *Protecteur*, who worked under great difficulties and hazards due to flooding water and heavy smoke. The pumps could not operate effectively because of the lack of oxygen in the space. With the rising of floodwater in the engine room, the master considered it unsafe for anyone to remain on board. Therefore the vessel was abandoned once again.

With the rescue tugs chartered by the owner of the vessel still a long distance away, and in consideration of the ecological damage to the sea had the vessel sunk, the commanding officer of *Protecteur* undertook the salvage responsibility after signing of a Lloyd's Open Form during the morning of the 15th. *Protecteur*'s crew undertook measures to stop the flooding of the vessel and to dewater the flooded compartments. Navy divers were sent to plug up sea inlets at the bottom of the vessel. Due to the rolling of the vessel the underwater work was extremely dangerous, but three leaking inlets were plugged with plastic cloths, canvas and wooden damage-control plugs. At the same time, personnel, pumps and other necessary equipment were transferred by helicopter from *Protecteur* to the vessel. Pumps were set up to pump water from the space forward of the engine room, which was now starting to flood. The portlights at the starboard poop close to the trim waterline were plugged to prevent water from entering.

During the evening, it was decided that the vessel should be towed toward the rescue tugs, which were still a long distance away. A helicopter was used to transfer wire pendant and shackle. With some difficulties, the towline was finally connected at about 2155, and towing by *Protecteur* commenced. All together, the vessel was towed by *Protecteur* a distance of 297km (178 miles) during a period of 43 hr.

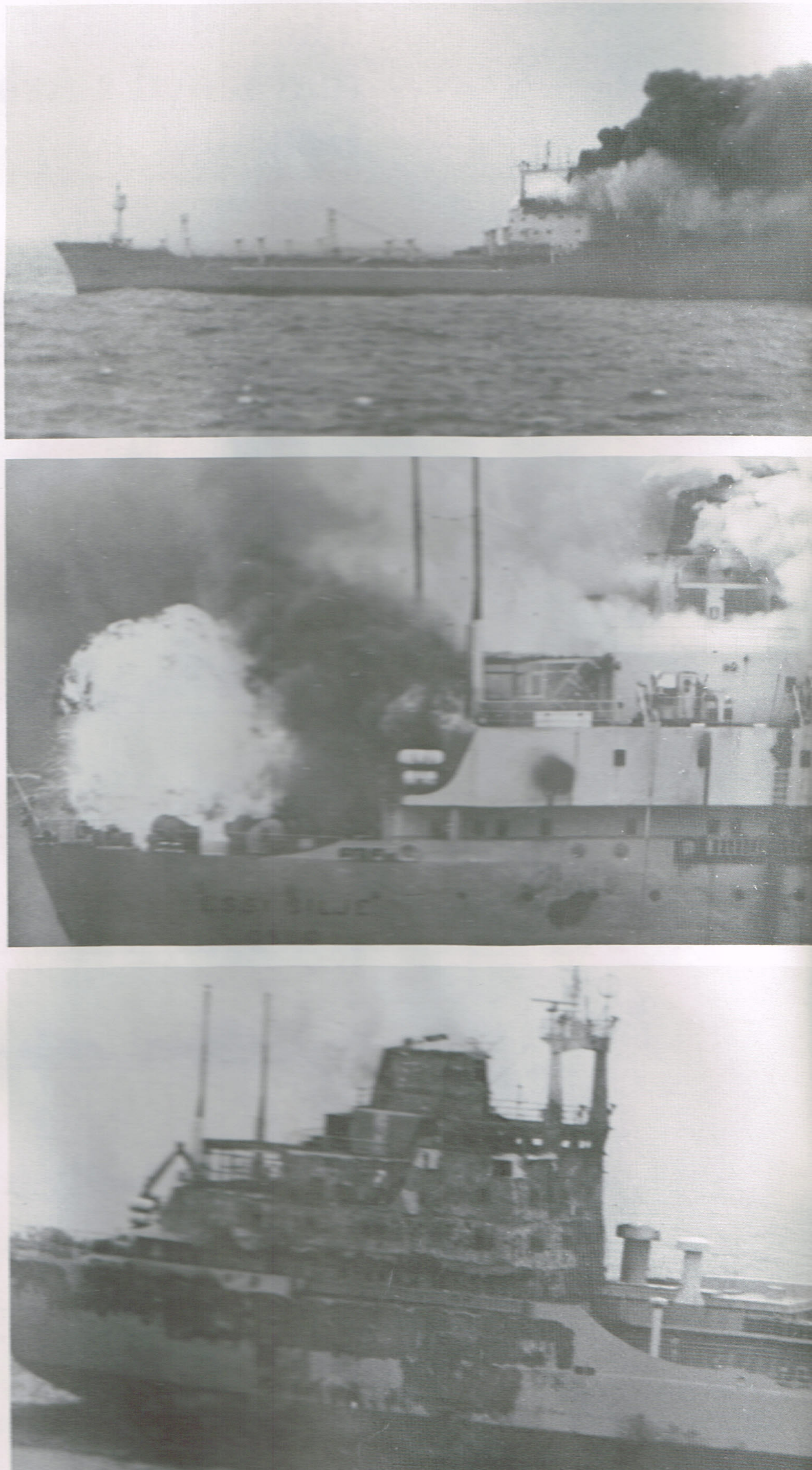


Figure 2. Bridge area of MV *Essi Silje* on fire. Note hot spots (dark patches) appearing on hull.

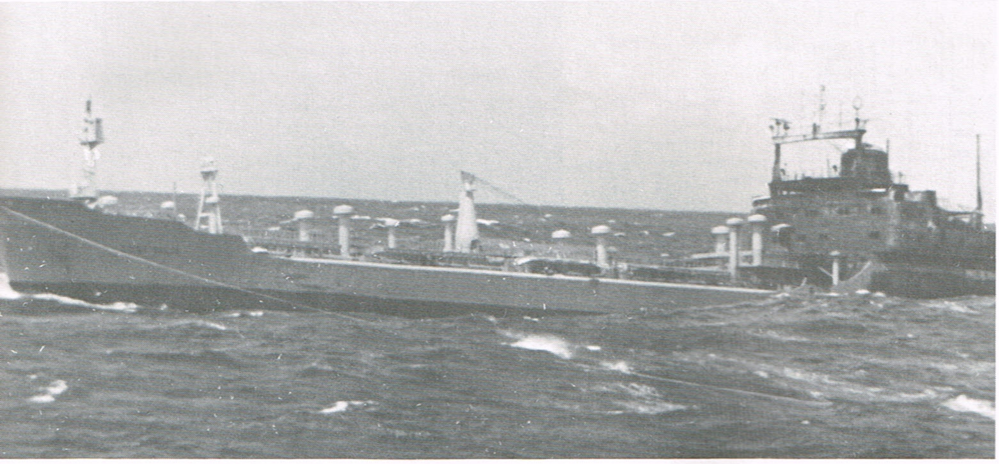


Figure 3. MV *Essi Silje* down by the stern.

On the 16th, due to the ineffectiveness of the Coventry Climax pumps, the helicopters were sent to locate the approaching rescue tugs and bring back pumps. In the afternoon the approaching tugs *Seefalke* and *Sypestyns* were located and pumps with operators were airlifted to the vessel. When the new pumps were set up, the flooding seemed to be checked. However, the new pumps turned out to be unreliable and continued to break down. The diesel unit from *Sypestyns* was the only one that provided continuous pumping service. With the few pumps running intermittently, they were unable to dewater the spaces.

On the 17th, the rescue tugs arrived, and *Protecteur* continued to provide support by sending the helicopters to airlift equipment, and by repairing the broken-down pumps. The towline was slipped at about 1614, and the tug *Seefalke* had the vessel in tow by 1910. The *Protecteur* stood by overnight and departed for Halifax at about 0828 on the 18th.

It was a long tow for the salvage tugs to their destination in England. The problems with the pumps continued. On 22 June, the tug *Sypestyns* was tied up to the stern of the vessel and four electric pumps were set up to clear the water from all flooded spaces. Leaks through the condenser and evaporator oil cooler were discovered and repaired. On the 24th, the tow was transferred to the tug *Baltic*, which towed the vessel to Barry, arriving 1 July.

The hearing

An arbitration hearing took place in London, England on 14 March 1984. An arbitrator was appointed by the Committee of Lloyd's. There were three parties involved: the Government of Canada, including the commanding officer and crew of HMCS *Protecteur*, Messrs. Bureau Wijsmuller, the salvage tug company, and the Respondent Ship and Cargo Interests, the owner of the ship and cargo.

The normal practice in a Lloyd's Form Hearing is that the parties first open their cases with short summaries of the points at issue and then the arbitrator is invited to read the bundles of evidence in private. Once the arbitrator indicates that he has completed his reading, the parties return and make their final submissions. This procedure is time efficient and usually is applied to cases where the parties generally agree to the circumstances of the service and the value of the vessel and cargo.

When there may be disputes in both the circumstances of the service and the value of the vessel, each counsel presents his case by reading the entire evidence bundles in front of the arbitrator. Before the final evidence bundles are agreed upon by all parties, questions are asked, rebutting arguments are presented and new evidence can be substituted. During the hearing it is not unusual for expert witness to present oral evidence and to be cross-examined.

It was perceived that the amount awarded to the salvors was based on the degree of risk of the vessel and her cargo becoming a total loss, the danger of the operation, and the merit and contribution of the salvors to the recovery of the vessel. Because of that, the main dispute of this case was centered around the issue of whether the vessel was in any danger of becoming a total loss, especially without the salvage operations undertaken by the crew of *Protecteur*. The author was tasked by the Department of Justice firstly to provide a technical opinion of the situation in the form of an expert's report to be presented as evidence. He was also present at the hearing to provide technical advice to the Government's legal counsel and to prepare rebutting arguments.

In order to provide a clear picture of the arrangement of the vessel, especially the key locations of the doors and hatches, a rough model of the stern of the vessel was also constructed of transparencies made from the general arrangement drawings and structural plans. This model became an important piece of evidence.

Ship characteristics

The *Essi Silje* was a chemical tanker with engine room located aft. The hull was a typical bulk carrier hull with a bulbous bow. Her principal dimensions were as follows:

Length (OA)	154.500m	(506.9 ft)
Length (BP)	142.240m	(466.7 ft)
Breadth (mld)	20.600m	(67.6 ft)
Depth	12.700m	(41.7 ft)
Design draft	9.785m	(32.1 ft)
Displacement at design draft	23,231 t	(22,864.2 LT)

At full displacement, the vessel was capable of carrying from 8961 to 9894 t (8819.5 to 9737.8 LT) of antiknock compound and at the same time 6233 to 7166t (6134.6 to 7052.8 LT) of caustic soda, depending on the loading situation.

A general arrangement of the vessel is shown in Figure 4. Longitudinally the vessel was divided into ten watertight compartments by nine watertight bulkheads. All watertight bulkheads except the one at frame 37 were tight all the way to the main deck. There were two doors on bulkhead frame 37 at the level between the main deck and the second deck. It is unknown whether the doors were watertight.

In the aft end of the ship abaft frame 37, with the exception of minor tanks in the double bottom and the fuel oil tanks in the engine room, there were very few compartments that would cause asymmetric flooding. The pump and gas space was located between frames 37 and 47; this space was divided into three transverse compartments by two longitudinal bulkheads. The space at the starboard wing was larger than that at the port wing, and the flooding of one or both wing spaces would cause asymmetric flooding, or listing of the vessel.

In the cargo tank area, frames 47 to 177, there were two longitudinal bulkheads running the whole length on each side of the centerline. The tetraethyllead cargo tanks were located in between the two longitudinal bulkheads. Those tanks were separated from the ship's structure by spaces known as cofferdams. Outboard of the longitudinal bulkheads were wing tanks including the caustic soda tanks.

The crew accommodation was all located aft and in the superstructure above the engine space from the main deck up. The navigation bridge was located at the top of the superstructure.

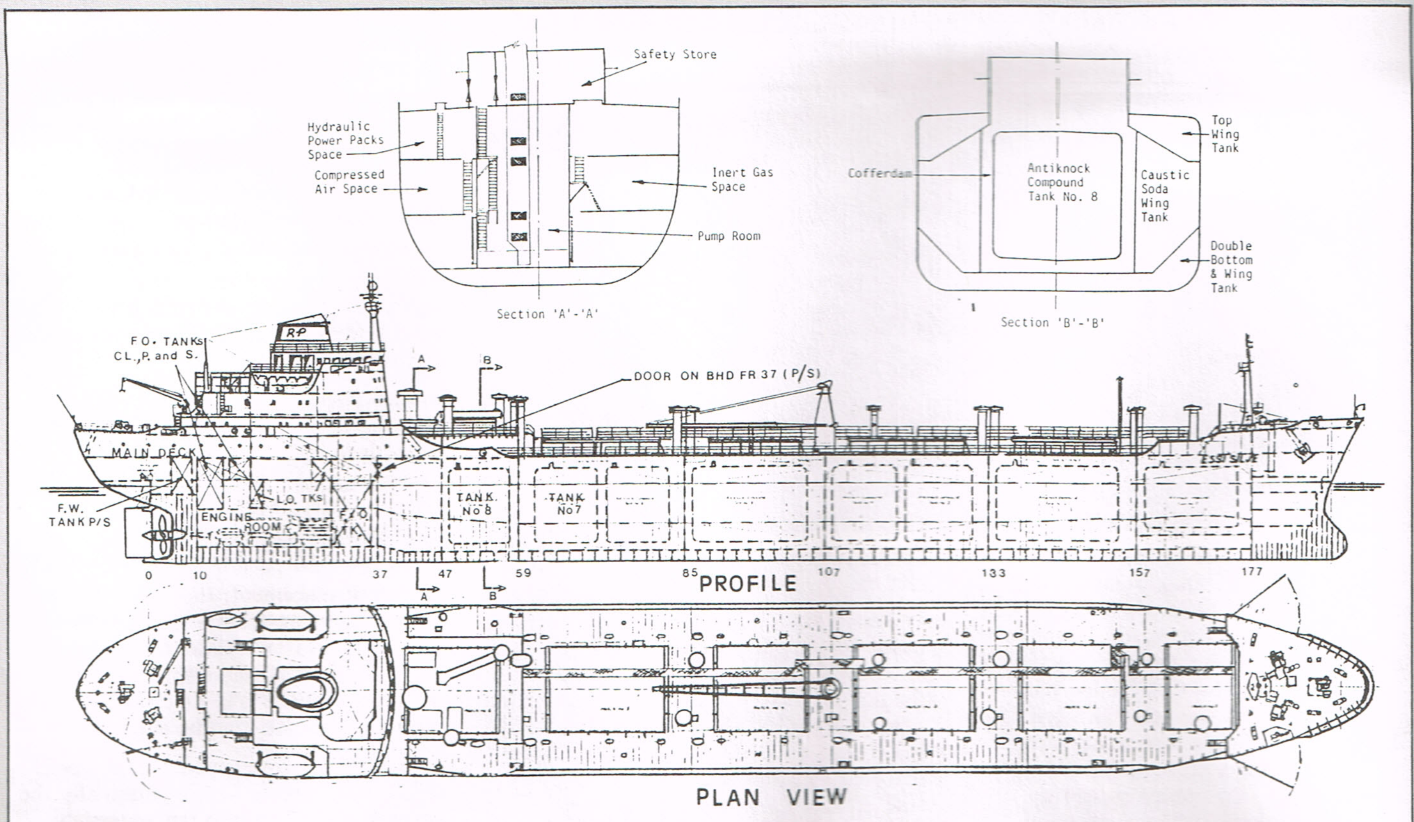


Figure 4. General arrangement

The engine room was located below the accommodation between frames 10 and 37. Fuel tanks were located in the engine room.

Technical investigation

As a result of the fire and the subsequent flooding of the vessel, there are three possible ways that the vessel might have become a total loss:

a. Vessel could have broken in two due to structural failure as a result of the intense heat and stress built up by the excessive weight at the stern due to the flooding of the spaces.
b. Vessel could have been destroyed by explosions as a result of chemical cargo reaction to the fire and sea water.
c. Vessel could have been sunk by stern due to excessive trim by stern as a result of progressive flooding.

As it was necessary to show that the vessel was in danger of one or more of the above possibilities, solid evidence in the form of expert testimonies or reports, photographs, test results or calculations was required. Throughout the hearing, there had been marked reluctance of the ship and cargo interests to supply technical data regarding the design and construction of the vessel, especially in areas surrounding the cargo storage space. Data related to the transportation and safety of the antiknock compound were not released unless absolutely deemed necessary to their benefit, and usually at the last possible moment.

The vessel was originally built as a bulk cargo carrier, the MV *Sabinia*, but was later converted into a special carrier to transport antiknock compounds. The pump room space was added or converted at a much later date. As a result, there were few drawings available, except for an outdated general arrangement plan, some machinery arrangement drawings, piping line diagrams and the pump room arrangement. There was a copy of the stability booklet for typical loading conditions, but no hydrostatics or lines plan was available.

At Barry, U.K., the damaged vessel was inspected by surveyors who were mainly interested in the cause of the fire and the cost to repair the vessel. Their reports did not clearly address which compartments were flooded, level reached by the floodwater, condition of the piping and glands, and the integrity of the steel watertight bulkheads.

Soon after, the vessel was taken to a shipyard and the damaged stern, considered to be a total loss, was cut off and replaced by the stern from another retired bulk carrier. The damaged stern was scrapped before the author had the opportunity to make arrangements for inspection. In order to proceed with the technical investigation, the major source of data therefore came from the few drawings mentioned above, the reports and photographs from the crew of *Protecteur*, the surveyors, the salvors and the crew of the casualty.

Hull structural failure

Due to the intense heat of the fire at the stern, it was perceived that the hull structure was weakened, and with the increase of bending stress as a result of flooding, the stern of the vessel might have been broken off somewhere behind frame 37. The bulkhead at frame 37 would then be subjected to wave action. If this bulkhead failed, the bulkhead at frame 47 would be the last line of defence before the cargo tanks were subjected to damage resulting in the spilling of the toxic chemical.

It was not possible to either prove or disprove this hypothesis because of the lack of information regarding the actual loading of the cargo tanks, the weight distribution, the midship section or structural details, and the longitudinal strength data of the vessel.

Two officers on board *Protecteur* thought that they had spotted cracks on both sides of the shell along the welds in way of the forward end of the engine room. This may have indicated a weakening of the ship's hull structure, but this was not confirmed by the surveyors' inspection at Barry. Without any photographs to back up the officers' observations, their observations were not considered accurate, and the evidence of structural failure could not be pursued. The conclusion at the hearing was that structural failure was unlikely to occur.

The chemical cargo

The chemistry experts in the Department of National Defence were tasked to investigate the hazards of the chemical cargoes. Their report indicated that the caustic soda was unlikely to have any reaction that would threaten the ship when mixed with sea water. A caustic soda solution is not flammable and also will not deteriorate under elevated temperatures. In high concentration caustic soda is toxic and extremely caustic and causes irritation and damage to tissue contacted. It is toxic to human and aquatic life, and therefore the chemical was a threat to the salvors if spilled.

The tetraethyllead, the antiknock compound, is highly toxic both in liquid and vapor form. It is fatal to human and marine life if ingested, inhaled or physically contacted. It is not soluble in water, and since its density is higher than water, it will sink and break up into globules under turbulent conditions and eventually affect a large area.

Tetraethyllead is combustible with a flashpoint of approximately 85°C (185°F). The vapor will ignite once this temperature has been reached. Bulk tetraethyllead cannot burn without sufficient oxygen, and therefore it probably would not burn unless spilled out of tanks. On burning, toxic fumes of lead oxides will be produced, and can decompose and eventually explode at temperatures above 110°C (230°F). It is possible that a fire involving the chemical could cause the destruction of the vessel. The main fire burned itself out in the engine space and the aft superstructure. Therefore, except for the close call of the burning of the kerosene tanks in the safety store abaft the cargo tank cofferdam (see Fig. 1.c), the fire never penetrated the forward compartment bulkhead and the chemical cargo was at no time in the way of the spreading fire.

The conclusion is that the vessel would not have been destroyed by the cargo she was carrying, but the spilling of either one or both of the chemical cargoes would have constituted an ecological disaster.

Damaged stability investigation

The next issue to be considered was whether the vessel would sink as the result of progressive flooding. Due to the small amount of technical data available, as indicated before, the vessel's lines were constructed based on the outlines shown in the general arrangement, the deck structural plan, and the machinery and piping diagrams. Some guesswork was required for the forward end of the vessel to match the hydrostatic properties indicated by the stability booklet. Offsets were lifted from the body plan, which was produced from the lines. The offsets were used to prepare the hydrostatic properties and compartment description with the aid of the CASDOP computer program of the Department of National Defence of Canada. Later the same program was used to perform damaged stability calculations.

More than 30 cases of flooding were investigated and the key conditions are summarized in Figure 5. Case B of Figure 5 demonstrates that once the engine room is completely flooded, the water level will be above the doors at bulkhead frame 37. If the doors are non-tight, the water will flood into the forward spaces. Case G demonstrates that if all the spaces abaft frame 47 and together with the cofferdam around the cargo tank No. 8 are flooded, the vessel would sink by the stern. The investigations also showed that the vessel had maintained enough margin of stability under all stern flooding conditions that there would be no danger of capsizing.

The worst trimming condition of the vessel observed by the crew of *Protecteur* was somewhat similar to Cases D and E of Figure 5. The actual trim of the vessel was unknown because no freeboard or draft readings were taken during the salvage. Also, the time when the photographs showing the various trimming situations were taken was not recorded. The result was that it was not possible to deduce the rate of flooding and sinking of the vessel.

With the knowledge of the mechanism required to sink the vessel, it had to be

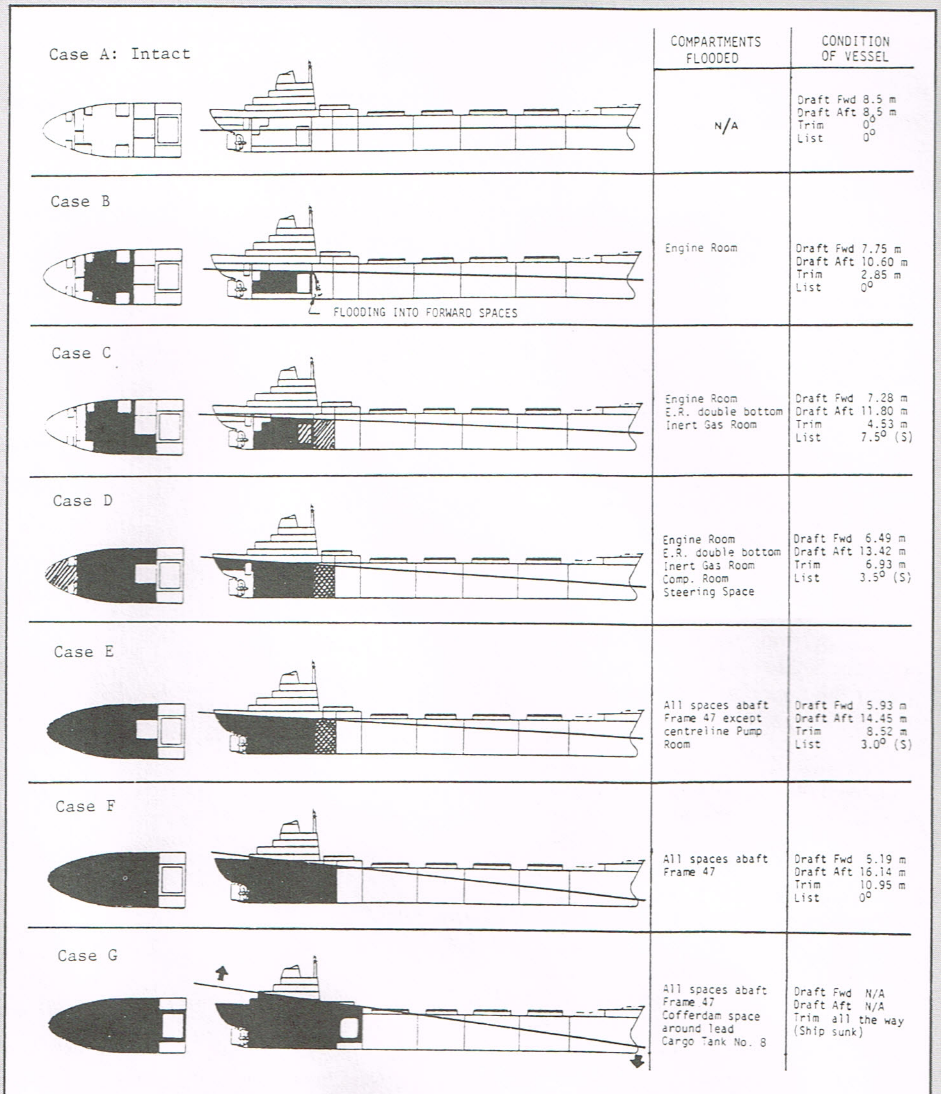


Figure 5. Summary of technical investigation

convincingly demonstrated to the arbitrator how the flooding from Case B to Case G was possible.

Progressive flooding abaft frame 47

The flooding of the vessel was the direct result of the fire. The fire was concentrated in the after section of the vessel, abaft frame 47. Figure 2 shows hot spots at the side of the ship in way of the main deck. The peeling off of the paint indicated that a hot fire was burning inside the hull, most likely in way of the diesel fuel oil and lube oil tanks in the engine room. Because of the intense heat it is highly possible that most of the fuel tanks with their fuel lines, vents and sounding pipes were damaged and no longer watertight. Similar damage could be expected in way of the glands and stuffing boxes for the pipes or cables penetrating the watertight bulkheads, decks and side shell. In fact the flooding of the vessel was due mainly to the failure of the seawater inlet to the evaporator and the condenser, where the non-metallic parts were destroyed by the fire.

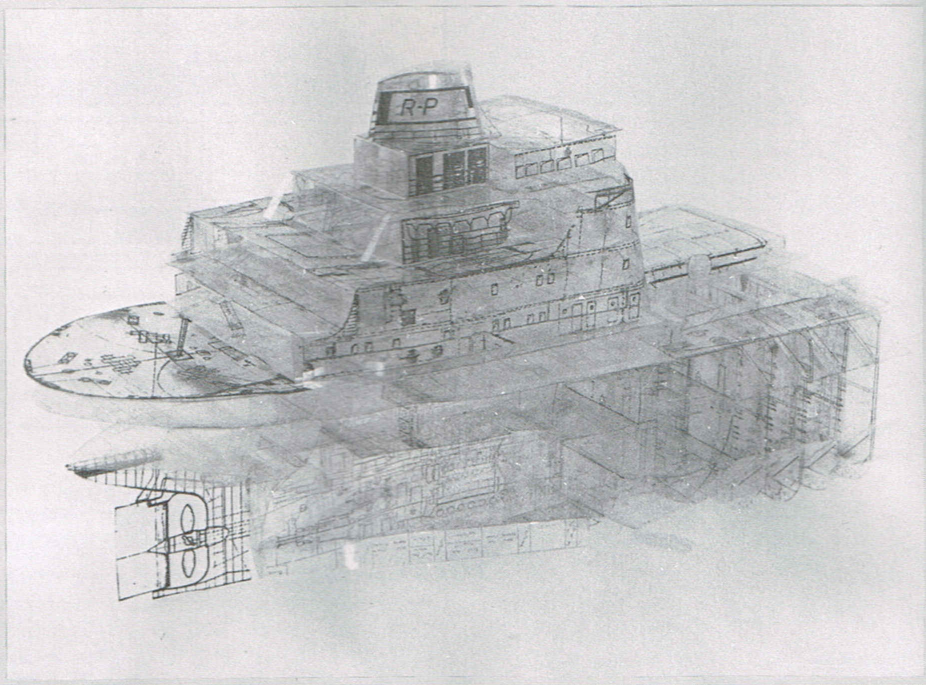
There were conflicting reports regarding the conditions of the tanks in and around the engine room. The contents and sounding of those tanks were not systematically checked and recorded after the fire. When the vessel was safely in port a mixture of oil and water was found in the double bottom tanks, and the sight windows of their sounding pipes in the engine room were discovered to be melted. There was no concrete proof that the tanks were damaged, but there was evidence that water could enter and fill these tanks when the engine room was flooded.

Once the engine room was completely flooded, as indicated in Case B of Figure 5, the water could flood into the forward spaces through the two doors on bulkhead frame 47 on the main deck. It is unknown whether they were watertight doors, but the photographs show that both the doors and their frames were greatly distorted by the fire. It was suspected that the wing spaces forward of frame 47 were flooded before the doors were under water, possibly as a result of leaking pipe glands on the watertight bulkhead damaged by the fire. It might also be possible that the watertight integrity of the bulkhead was destroyed. There was no report on the condition of the bulkhead or its penetrations, and no photograph of the area was taken. Therefore, the method by which the wing spaces such as the hydraulic power pack room, the compressed air space and the inert gas space were flooded could not be determined, and the floodwater was assumed to have passed through the doors. It is possible that the starboard wing space was flooded first, because the observed eight-to-ten-degree list to starboard at one time may be similar to Case C of Figure 5.

Water was observed in the steering space. With the large trim of the vessel by the stern, under wave action, water came in through the damaged portlights. It was also reported that water came up through an air pipe, location unknown, from the engine room. It is believed that with the vents and sounding pipes damaged, the floodwater at the steering flat would eventually fill up the tanks below. Therefore it is highly possible that, without assistance, all spaces abaft frame 47 other than the centerline pump room would have been flooded.

The pump room

The next stage was to consider the flooding of the pump room. It was recognized that there were three possible



This rough, three-dimensional model of the after section of Essi Silje *became an important piece of evidence during the 1984 arbitration hearing. Constructed by the author from transparencies of the ship's general arrangement drawings and structural plans, the model clearly showed key locations and arrangements on the vessel. (DND Photo by Cpl Paul Howe)*

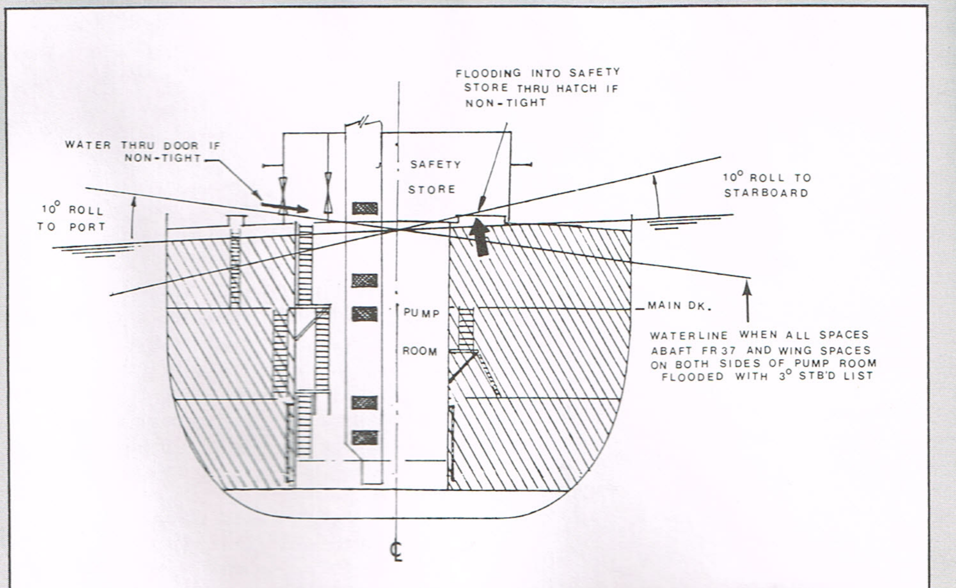


Figure 6. Flooding of pump room

routes through which the water might enter the space:

a. via the port-side door of the safety store and the hatch on the port side of the pump room,
b. via the hatch from the inert gas space on the starboard side of the safety store and across to an opening in the pump room ventilation trunk in the safety store, and
c. via the ventilators if they were damaged.

In the reports of witnesses, on many occasions the pump room was mixed up with the compressed air space, the inert gas space or the hydraulic power pack room, and the actual condition of the space was unknown. Photographs of the space showing pieces of ash on top of all horizontal surfaces indicated that the space must have been on fire at one time. It might be due to the extreme high temperature on bulkhead frame 47, with a fire burning on the other side in the engine room, that the paint was ignited. With no report of the space having been flooded, the space was considered by the arbitrator to be intact.

The main entrance to the pump room was through a door on the port side of the safety store, and then down a hatch along the port side of the pump room. This door was left open when the crew abandoned the vessel. It had been observed that during the worst trimming condition, the waves were breaking at the front face of the poop. When all space abaft frame 47 had been flooded (Case E, Fig. 5), in high sea states water would get into the pump room through the door. The master of the vessel closed the door upon his first return to the vessel and the danger of downflooding through the door was minimized. There were doubts whether he would have been able to return to close the door if he had been picked up by another passing cargo vessel which, with a tight schedule to meet, would not have stayed around for a long period of time like *Protecteur*.

Later on there was a raging fire in the safety store due to the burning of the kerosene tank. Photographs showing the door and its frame all charred indicated that the gasket and sealing might have been destroyed, and water would once again be able to pass through the closed door. However, with the vessel listing to starboard, the rate of water getting into the space would be much slower compared with the case of the door wide open.

The next alternate route for the water to enter the space was to go through the hatch on top of the inert gas space. The closing appliance of the hatch was unknown. Again, with a raging fire on both sides of the hatch, the watertightness of

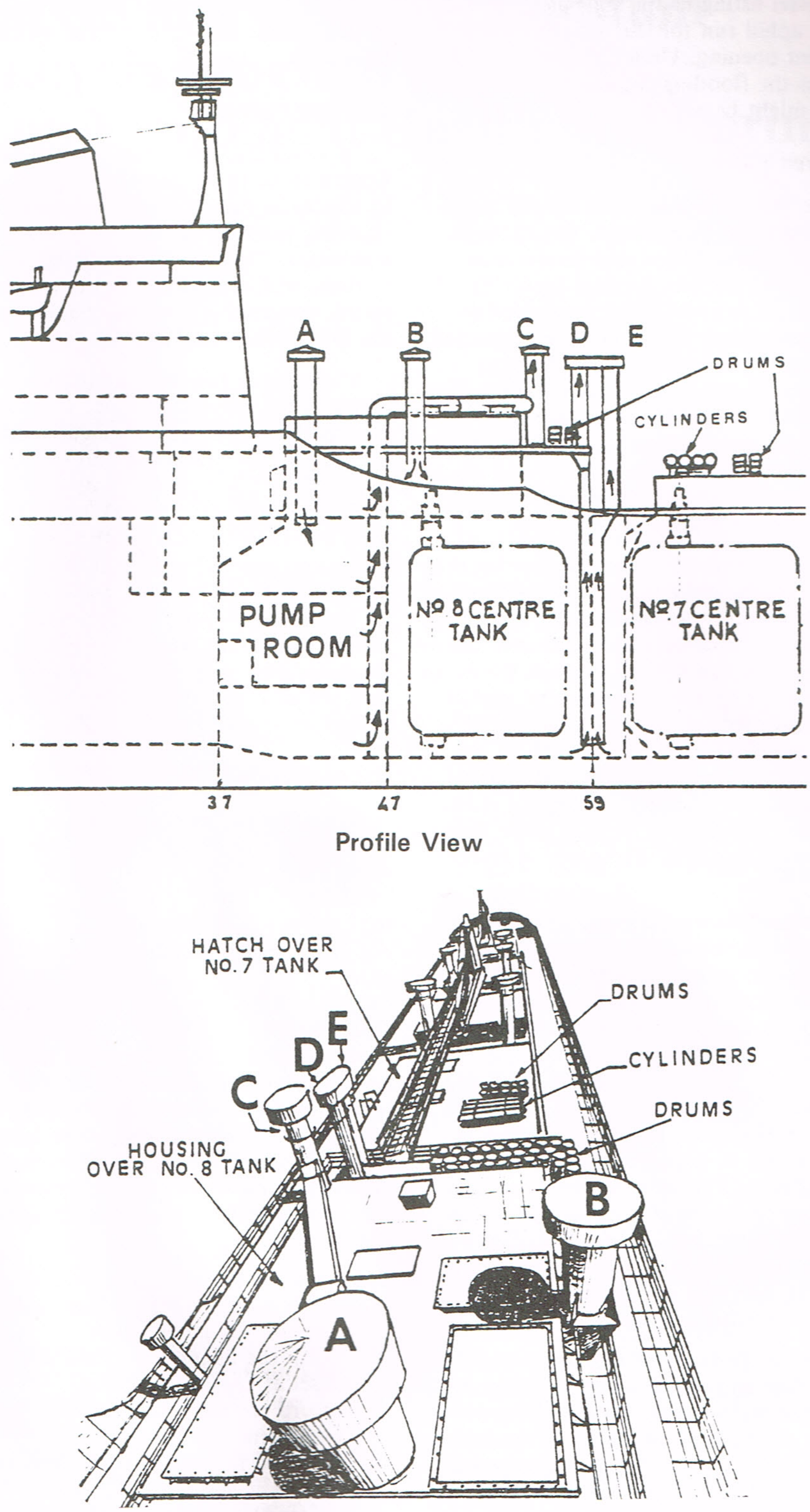


Figure 7. Arrangement of ventilators from top of bridge

the cover, if any, would have been destroyed. A vent trunk joining one of the ventilators passed through the safety store to the pump room below with a vent opening a few inches above the deck of the safety store. The water coming into the space through the hatch would rush to the port side when the vessel rolled to port, and drained into the pump room below. Figure 6 demonstrates such a possibility for a three-degree listing to starboard and under a ten-degree roll. On the other hand, there was a chance that the hatch might still be watertight. Without taking the rolling of the vessel into consideration even if water was able to enter the space through the hatch, the amount might have been small, and with the vessel listing to the starboard it would be an uphill run for the water to reach the vent opening. Under such circumstances the flooding scenario of the pump room might be remote.

The ventilators

The third possible route for the water to get into the pump room was through the ventilators. There were five ventilators around the No. 8 cargo tank (Fig. 7). Ventilators A and C were connected to the pump room, B and D were connected to the cofferdam around No. 8 cargo tank, and E ran into the cofferdam around No. 7 and No. 6 cargo tanks. Therefore, the risk of the vessel becoming a total loss depends on whether any of those five ventilators might be damaged and allow the ingress of sea water.

The existence of drawings showing the arrangements and detail construction of the ventilators was not disclosed by the cargo and shipowners until well into the hearing, and it was too late to perform any analysis on the magnitude of impact wave force that those ventilators could withstand. The experts on behalf of the cargo owner cited examples that ventilators on similar chemical tankers in laden condition received no damage when the decks were partially submerged in heavy seas.

The ventilators were constructed from 10-mm-thick (3/8 in.) steel plates. Because ventilators A and C were situated on top of the hatch housing, and their bases were above the reach of 12-ft (3.5m) waves (the worst sea state during the salvage), even with the trimming and listing of the vessel taken into consideration, the chance of flooding into the pump room through the ventilators was insignificant. The base of ventilator B was located on the starboard side of the hatch coaming, but its base structure was heavily constructed and well supported by brackets, and was considered to be strong enough to withstand wave impacts.

Ventilators D and E were tied together at the fore end of the hatch housing. At the trimming condition, the main deck area at the base of ventilator E would be awash under a 12-ft (3.5m) wave, and the wave most likely would break at the front of the hatch housing. Directly on the starboard side of the base of ventilator D were drums of unknown material and, on top of the hatch above cargo tanks 6 and 7 were long torpedo-shaped steel cylinders (Fig. 7). If some of these drums and cylinders had been torn loose under constant wave impact, the ventilators, especially E, not only might have been subjected to wave impacts but also there could have been damaging collisions of the drums and cylinders. If sea water had been allowed to flood into the large cofferdam around cargo tanks 6 and 7 through ventilator E, the vessel would have sunk.

The assessment

In summary, the vessel was not considered to be in danger of sinking due to structural failure, loss of stability or chemical reaction of the cargo with fire and water. There was a possibility that in time, with changing weather and sea states, progressive flooding would lead to the loss of the vessel and its cargo.

Considering the toxic nature of her cargo, if the vessel had sunk, it would have been a major environmental disaster. The prompt response and service rendered by the crew of *Protecteur* was highly meritorious. The risk taken by the crew of *Protecteur* during the salvage operation, especially those involved in the dangerous diving mission, those working on board the burning vessel amidst the smoke and fumes, and those involved in the helicopter operations carried out over long distance in unfavorable weather should be specially recognized.

Recommendations

From the earlier discussions it can be seen that many of the disputes were the direct result of the lack of information on the actual condition of the vessel. If the evidence is indisputable, and all parties can come to a consensus of opinion much sooner, the time required for the hearing can be shortened considerably. Good information must come from the observations of the salvors, the inspectors and the surveyors. From the salvors' reports and the experience of the author during the technical investigation and the hearing, the following is a list of recommendations for future salvors, surveyors and inspectors who are involved in salvage operations:

For the salvors:

1. Check the draft or freeboard of the vessel at regular intervals.
2. Check the listing and trimming of the vessel at regular intervals.
3. Record the compartments that have been burned or flooded.
4. Note and record the conditions of the watertight doors and hatches.
5. If possible, sound all tanks and determine the contents.
6. Take ample photographs and record the time.
7. Gasoline fire pumps or other pumps whose operation requires a large amount of oxygen should not be used for dewatering. Carry the appropriate equipment.
8. A helicopter is highly valuable in salvage operations.
9. A diving team definitely has its place in salvage operations.
10. Determine the cargo carried, the quantity and location of stowage.

For the inspectors and surveyors:

1. Note the drafts of vessel at time of inspection.
2. Check and record the amount of cargo left on board the vessel, with its location.
3. Sound all tanks and determine their contents.
4. Note which bulkheads have been subjected to intense heat, and degree of damage.
5. Note which compartments have been flooded, and measure the highest point reached by the floodwater at each of the bulkheads.
6. Check and record the condition of the pipes, pipe glands, stuffing boxes and bulkhead penetrations.
7. Take ample photographs of bulkheads, decks, doors and hatches which have been damaged by fire or flooding.
8. Appropriate sketches and part prints of general arrangement drawings should be included in the report, showing the area under consideration.

Edwin Chan is a graduate of the University of Michigan (M.S.E. Naval Architecture, 1970). His considerable experience in commercial ship design and DND ship-system engineering led to his being selected to conduct the technical investigation of the Essi Silje *incident on behalf of the Government of Canada. His thorough investigation and expert testimony at the Lloyd's Arbitration Hearing were largely responsible for the captain and crew of HMCS* Protecteur *being awarded compensation for their salvage efforts. In recognition of his contribution, Mr. Chan was awarded the ADM(Mat) Certificate of Merit in October 1986. Edwin Chan is currently the DMEM 2 project manager of the Naval Reserve Modernization Project.*