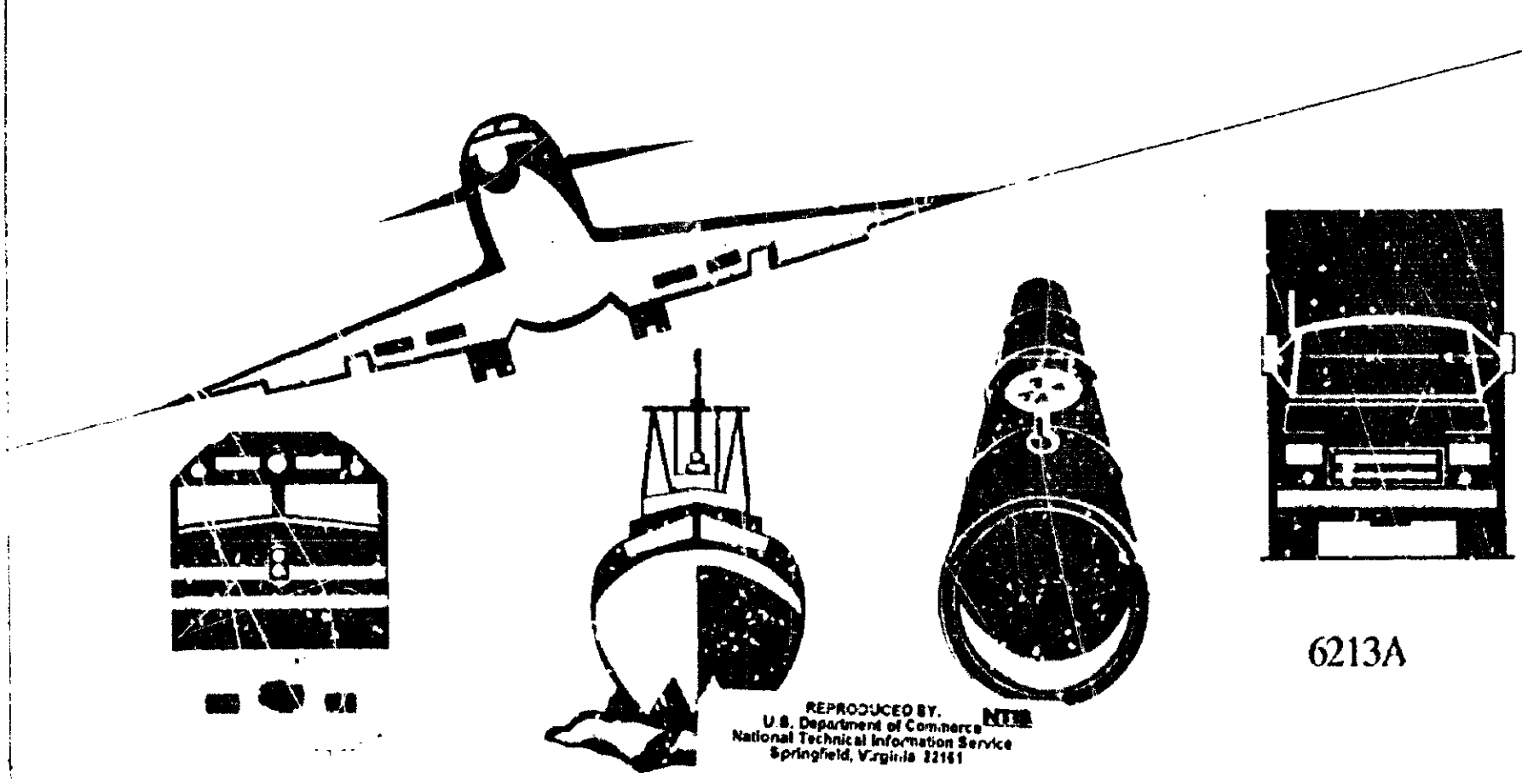
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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

EXPLOSION AND FIRE ON BOARD
THE U.S. TANKSHIP OMI CHARGER
AT GALVESTON, TEXAS
OCTOBER 9, 1993



6213A

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Abstract: On October 9, 1993, an explosion occurred on board the 660-foot-long U.S. tankship OMI CHARGER, which was anchored in Bolivar Roads near Galveston, Texas. At the time of the explosion, a welder, who was making repairs to stop a small leak in the bulkhead, burned through the bulkhead, initiating an explosion in the No. 5 port cargo tank. The welder, the firewatch, and the vessel's pumpman were killed by the explosion. The vessel, valued at $12 million, was declared a constructive total loss.

The safety issues discussed in this report include preparation of tanks for welding on board the OMI CHARGER; management oversight of tank vessel gas-freeing procedures; fire and disaster preparedness in the Galveston area; and timeliness of toxicological testing.

As a result of its investigation of this accident, the Safety Board makes recommendations to the U.S. Coast Guard, OMI Corporation and OMI Bulk Management, the National Fire Protection Association, and the Texas Department of Public Safety.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable cause of accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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EXPLOSION AND FIRE ON BOARD THE U.S. TANKSHIP OMI CHARGER AT GALVESTON, TEXAS OCTOBER 9, 1993

MARINE ACCIDENT REPORT

Adopted: December 20, 1994
Notation 6213A

NATIONAL
TRANSPORTATION
SAFETY BOARD

Washington, D.C. 20594

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EXPLOSION AND FIRE ON BOARD THE U.S. TANKSHIP OMI CHARGER AT GALVESTON, TEXAS, ON OCTOBER 9, 1993

EXECUTIVE SUMMARY

About 2000 on October 9, 1993, an explosion occurred on board the 660-foot-long U.S. tankship OMI CHARGER, which was anchored in Bolivar Roads near Galveston, Texas. At the time of the explosion, a welder was making repairs to stop a small leak in the bulkhead between the port ballast and No. 5 port cargo tanks, about 14 feet below the main deck. The welder burned through the bulkhead, initiating an explosion in the No. 5 port cargo tank, which the ship's crew had not properly gas-freed. The welder and the firewatch, both of whom were inside the ballast tank, and the vessel's pumpman, who was working on deck near the No. 5 port cargo tank, were killed by the explosion. The vessel, valued at $12 million, was declared a constructive total loss.

The National Transportation Safety Board determines that the probable causes of the explosions and fire on the U.S. tankship OMI CHARGER were (1) the failure of the master and chief mate to follow prescribed company and industry guidance to ensure that the No. 5 port cargo tank was safe before permitting welding on the tank and (2) inadequate oversight by OMI Corporation and OMI Bulk Management Company, which allowed unsafe practices to develop over an extended period of time.

The safety issues discussed in this report include preparation of tanks for welding on board the OMI CHARGER; management oversight of tank vessel gas-freeing procedures; fire and disaster preparedness in the Galveston area; and timeliness of toxicological testing.

As a result of its investigation of this accident, the Safety Board makes recommendations to the U.S. Coast Guard, OMI Corporation and OMI Bulk Management, the National Fire Protection Association, and the Texas Department of Public Safety.

INVESTIGATION

The Accident

On October 9, 1993, the 660-foot-long U.S. tankship OMI CHARGER was en route from Tampa, Florida, to the AMOCO refinery at Texas City, Texas, to load a cargo of gasoline. The vessel was empty of cargo and in a ballasted condition. In addition to its crew of 27, the vessel carried 4 welders and 4 painters, who were on board to complete piping repairs in the engineroom and to paint the ballast (saddle) tanks.[1] (See figure 1.)

Two small leaks had been discovered in the after bulkhead of the No. 5 center cargo tank that allowed gasoline cargo to leak into the pumproom, and a third leak in the No. 5 port cargo tank allowed gasoline to leak into the port saddle tank. (Throughout the remainder of the report, the three leaks will be referred to as leaks 1, 2. and 3, respectively.) Consequently, painting in the port saddle tank had been postponed, and the lead welder was tasked to repair the leaks. Leak 1, the largest of the three, initially amounted to about 1 gallon every 5 minutes; application of a temporary epoxy patch had reduced it to a slow drip. Leak 2 was a weep through a small fracture, and leak 3 was indicated by a damp vertical area on the unpainted bulkhead that eventually extended about 5 feet.

Before welding could begin, the cargo tanks and adjacent spaces had to be rendered safe, that is, the tanks where personnel were to perform welding had to be made gas-free.[2] Adjacent tanks were to be made gas-free, or inerted,[3] or filled with water. Leaks 1 and 2 from the No. 5 center cargo tank into the pumproom were repaired on October 8. The crew planned to make the repair to stop leak 3 (in the No. 5 port cargo tank) before the vessel arrived at its berth in Texas City on October 9.

Preparations to ready the tanks for welding leak 3 began early on October 9. Between 0600 and 1100, the chief mate and the pumpman pumped water out of the No. 5 port and starboard tanks to lower the water level from completely full to a 36-foot ullage,[4] leaving about 14 feet of water in the bottom of the 50-foot deep tank. (Both the No. 5 port and starboard tanks had been filled with water and overflowed the day before to prepare for welding repairs to the No. 5 center tank.)

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[1] The port and starboard ballast tanks, also called saddle tanks, surrounded the pumproom on the top, port, and starboard sides. They will be referred to as the port and starboard saddle tanks in the remainder of the report.

[2] As defined at 46 Code of Federal Regulations 30.10-29, "gas-free" means that no dangerous concentrations of flammable or toxic gases are present. Other sources define the term as meaning that the atmosphere contains about 21 percent oxygen and that any combustible or flammable vapors are well below the level required to support combustion.

[3] Filled with an inert gas to reduce the oxygen level to 8 percent or less so that combustion cannot take place.

[4] Ullage is the distance from the top of a cargo tank to the level of the liquid in the tank.

The chief mate and master stated that they believed all gasoline had been flushed out of the No. 5 port and starboard tanks when they were overflowed on the previous day; they did not consider conventional tank washing necessary. Washing the No. 5 tanks using conventional methods would have required transferring the ballast water in them to other tanks, a process the chief mate estimated could take as long as 12 hours. According to the boatswain, about 1 1/2 hours would have been needed to wash the No. 5 port tank and about 8 hours to ventilate it thereafter to ensure that it was gas-free.

The chief mate estimated that the No. 5 port cargo tank could be inerted in less than 1 hour but did not consider inerting because the port engineer wanted to hose test[5] the tank following the repairs; the chief mate estimated a ventilation time of 2 hours to remove the inert gas. The master stated that overflowing was effective for removing clean product from a tank that was well-coated and clean. He said he was aware that due to the ship's trim (about 13 feet by the stern), overflowing would result in a small, wedge-shaped void in the top of the tank forward of the hatch trunk; he believed that running two cargo pumps simultaneously would flush any gasoline from such a wedge. (See figure 2.)

During the pumping to lower the water level on October 9, the hatch trunk covers on the No. 5 port and starboard cargo tanks were open, allowing air to flow into the tank. About 1100, the chief mate stopped pumping seawater out of the No. 5 port and starboard tanks and closed the tank hatch trunk covers. The water level in the tank at this time was about 20 feet below the leak and, according to the chief mate and master, met the lead welder's and port engineer's[6] requirement that the water level be below the welding site to ensure a good weld.

Meanwhile, about 0800, the crew began ventilating the port saddle tank. About 1000, the chief mate entered the port saddle tank to test the atmosphere. He testified that the meter reading indicated 10 percent of the lower explosive limit (LEL)[7] near the bottom of the tank. At this time, the chief mate discovered about 50 gallons of water in the bottom of the tank and some gasoline on top. Because gasoline was present, the chief mate washed the tank with cold water using a fire hose and then ordered the water pumped out. He also had an additional blower, with an air duct leading to the bottom of the tank, placed in operation to prevent gas vapors, which are heavier than air, from settling to the tank bottom.

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[5] Applying water under pressure to a bulkhead while personnel on the other side watch for leaks.

[6] The port engineer visited the vessel in Tampa on October 7 to inspect areas where leaks had occurred and to issue instructions for the repairs.

[7] The lower explosive limit, also called the lower flammable limit (LFL), is the lowest concentration of hydrocarbon gas in air that will support combustion; it is about 1.3 percent for gasoline. The upper explosive limit (UEL), also referred to as upper flammable limit (UFL), is the highest concentration of hydrocarbon vapor in air that will support combustion; it is about 7.6 percent for gasoline. The LEL-to-UEL range of hydrocarbon vapor concentrations in air is the explosive range for a product.

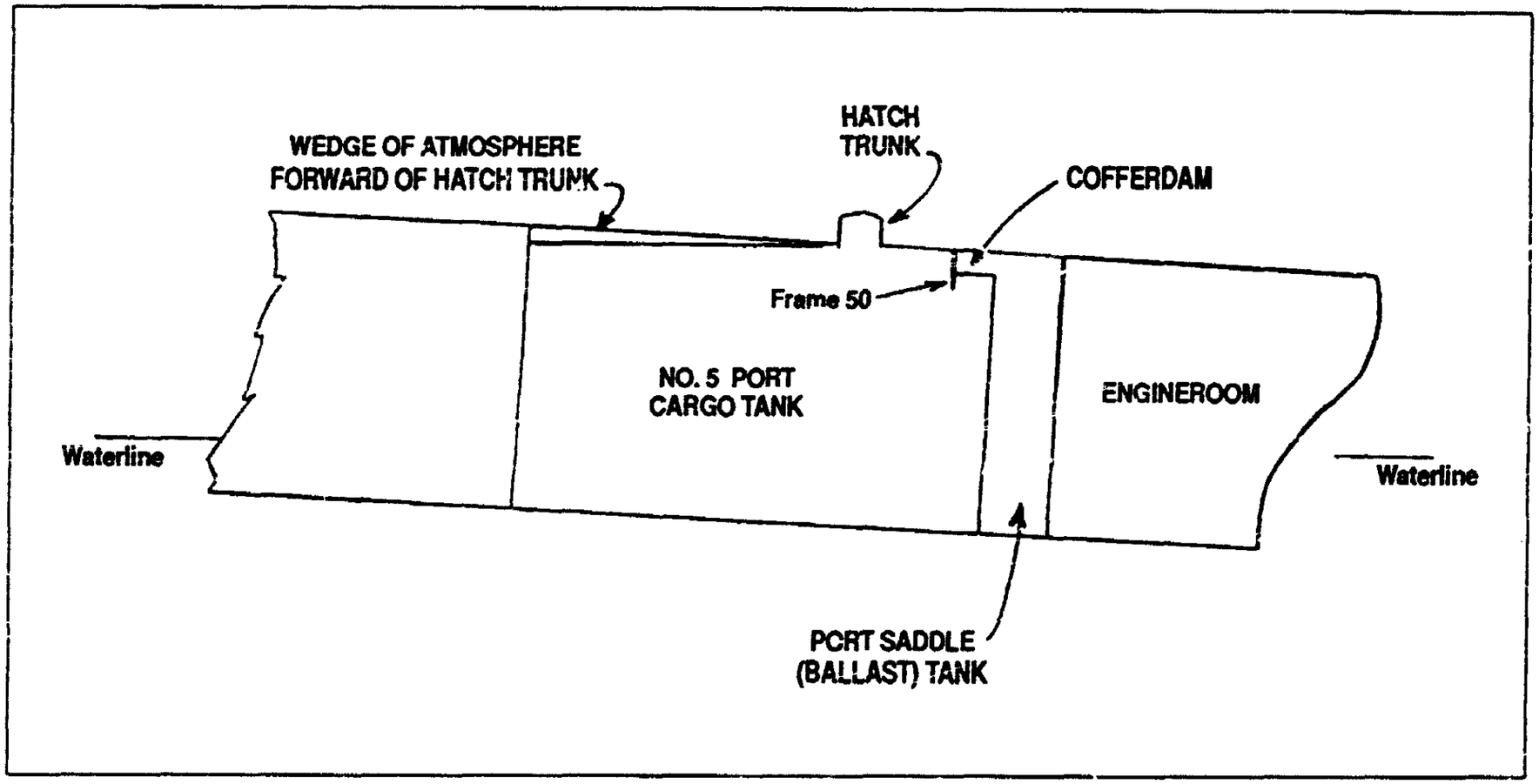


Figure 2.–Wedge-shaped void in No. 5 port cargo tank.

After the water was pumped overboard, the chief mate found scale and dirt at the bottom of the port saddle tank and instructed the crew to remove it. They removed some 30 buckets of material, and about 1300, the chief mate again inspected the tank, which he found clean and dry. His meter still indicated the presence of hydrocarbon gas, although well below the previous 10-percent LEL. Ventilation of the tank, using the two portable blowers, continued.

At 1436 on October 9, the OMI CHARGER anchored in Bolivar Roads, Inner Anchorage A, near Galveston, Texas, because its berth at Texas City was not available. (See figure 3.) Because the vessel was in a U.S. port, Federal regulations required that a marine chemist examine it before welding began.[8] The master stated that he did not consider calling a marine chemist because he regarded the chief mate as competent to conduct the testing. At this time, the master did not know when the vessel's berth would become available. He testified that he could take as much time as was necessary to complete the repairs but said that if the vessel's berth became available before repairs began, he had planned to use epoxy resin to make a temporary patch while proceeding to the terminal and would have made permanent repairs later.

The chief mate testified that he opened the hatch trunk cover to the No. 5 port cargo tank about 1505 and entered the tank alone to test the atmosphere for oxygen and explosive vapors. He acknowledged that entering a tank alone violated company instructions, which require that someone stand by outside the tank whenever it is entered. According to the chief mate, he detected no smell of gasoline and ran his meter continuously without a hose attached[9] as he descended the ladder into the tank. He stated that he found 21 percent oxygen and 0 percent LEL. Because water was in the tank, he did all testing from the ladder.

The chief mate also stated that he checked the water surface using a flashlight and saw no sheen. He said he left the tank and closed the hatch trunk cover about 1515. The period from 1500 to 1520 was the daily afternoon coffee time, and most crewmembers were in the crew mess; no one was on deck and no one could be found who saw the chief mate enter or leave the tank. The chief mate testified that he tested the tank at this time to "get ahead" of the work, but he acknowledged that the welding repairs were not expected to start until later in the afternoon.

The chief mate stated that at 1520 he again tested the port saddle tank; his meter indicated 21 percent oxygen and 0 percent LEL. He said he then decided to start the repair work after the evening meal. When he retested the pumproom at 1600, he found 21 percent oxygen and 0 percent LEL.

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[8] When a tank vessel is in port, a marine chemist, certified by the National Fire Protection Association (NFPA), normally inspects and tests the tanks and issues the hot work permit authorizing welding, riveting, and other work. When a tank vessel is at sea, the master is responsible for inspecting and testing to ensure that NFPA standards for hot work are met. Most companies require the person doing the testing, normally the chief mate, to fill out a company hot work permit. The chief mate testified that the hot work permit he had prepared for welding in the No. 5 center cargo tank on October 8 and the permit for welding in the No. 5 port saddle tank were posted on a clipboard in the port saddle tank. Investigators were unable to find the clipboard or permits after the accident.

[9] A small-diameter hose is normally attached to the sampling port on the side of the meter. The operator can lower the hose to the tank bottom or insert it into difficult-to-reach areas to collect a sample of the atmosphere for testing.

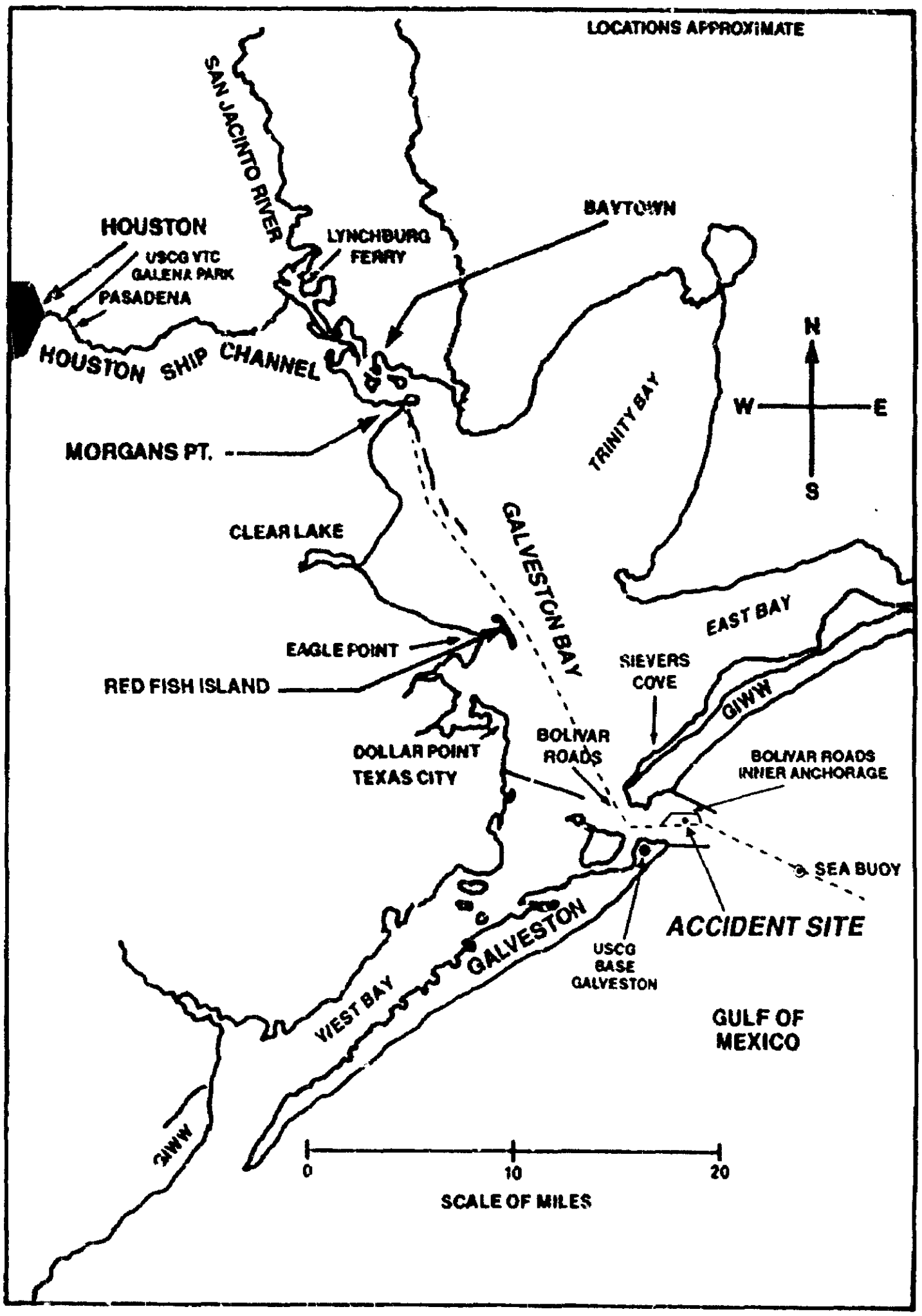


Figure 3.--Bolivar Roads, Inner Anchorage A.

Workmen began setting up equipment in the port saddle tank at 1750 in preparation for welding the bulkhead leak between that tank and the No. 5 port cargo tank. At 1800 the chief mate issued the hot work permit required by OMI Bulk Management Company (OMI)[10] before welding is permitted in or adjacent to cargo tanks. (See appendix C.) Shortly thereafter, the lead welder began welding around the landing plate.[11] (See figure 4.) The chief mate, acting as the firewatch, was in the tank, and his test meter was operating continuously to test for combustible vapors. Another welder stood by outside the tank. The hatch cover to the No. 5 port tank remained closed, and the tank was not being ventilated.[12] The chief mate later stated that he did not believe ventilating the No. 5 port cargo tank was necessary because his test at 1500 had indicated the tank was gas-free.

According to the chief mate, when the welder ran out of welding rod at 1915, he and the chief mate left the tank to get more. The lead welder told the chief mate that he had one more side of the landing plate to weld, which he estimated would take about 30 minutes, and that he would have one of the painters act as firewatch. The welder suggested that the chief mate need not return to the tank, and the latter then went to his office.

About 1950, the lead welder, accompanied by a painter, returned to the port saddle tank to resume welding, and about 1955, an assistant welder entered the tank to offer his assistance. The tank was dark, and the assistant welder called to the lead welder to find out where he was working. The latter said he would begin welding, which would illuminate the tank and indicate his location. (Subsequent examination of the weld by the Safety Board's laboratory indicated that the welder had welded for about 5 minutes before his welding rod burned through the bulkhead into the No. 5 port cargo tank, where the explosion occurred.)

The assistant welder, standing on a ladder just inside the entrance to the tank, said that soon after the lead welder resumed welding, he heard a rumbling noise and held tightly onto the ladder. An explosion ensued, and fire filled the tank. The assistant welder, who sustained burns on his head and face, was able to climb out of the tank.

The explosion lifted the deck over the No. 4 and 5 port tanks and peeled it forward over the port main deck, causing the port side shell of the No. 4 and 5 tanks to tear lose and fold over to port, exposing both tanks to the sea. (See figure 5.) The No. 4 center tank was also opened to the sea, as were the port saddle tank and the engineroom, causing the vessel to begin sinking by the stern. The force of the explosion fatally injured the lead welder, the painter acting as the firewatch, and the pumpman on deck near the No. 5 port tank. Ten people, including the assistant welder, were injured and transported to local hospitals.

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[10] OMI Bulk Management Company, a division of OMI Corporation, is responsible for operating and chartering vessels.

[11] The 8" x 12" landing plate had been installed during the shipyard period ending on September 28, 1993, when the forward 5 feet of the No. 5 longitudinal were renewed.

[12] Portable, water-powered fans, installed at open deck cleaning ports, provide ventilation. They are typically fitted with flexible ducts to convey air to the bottom of the tank.

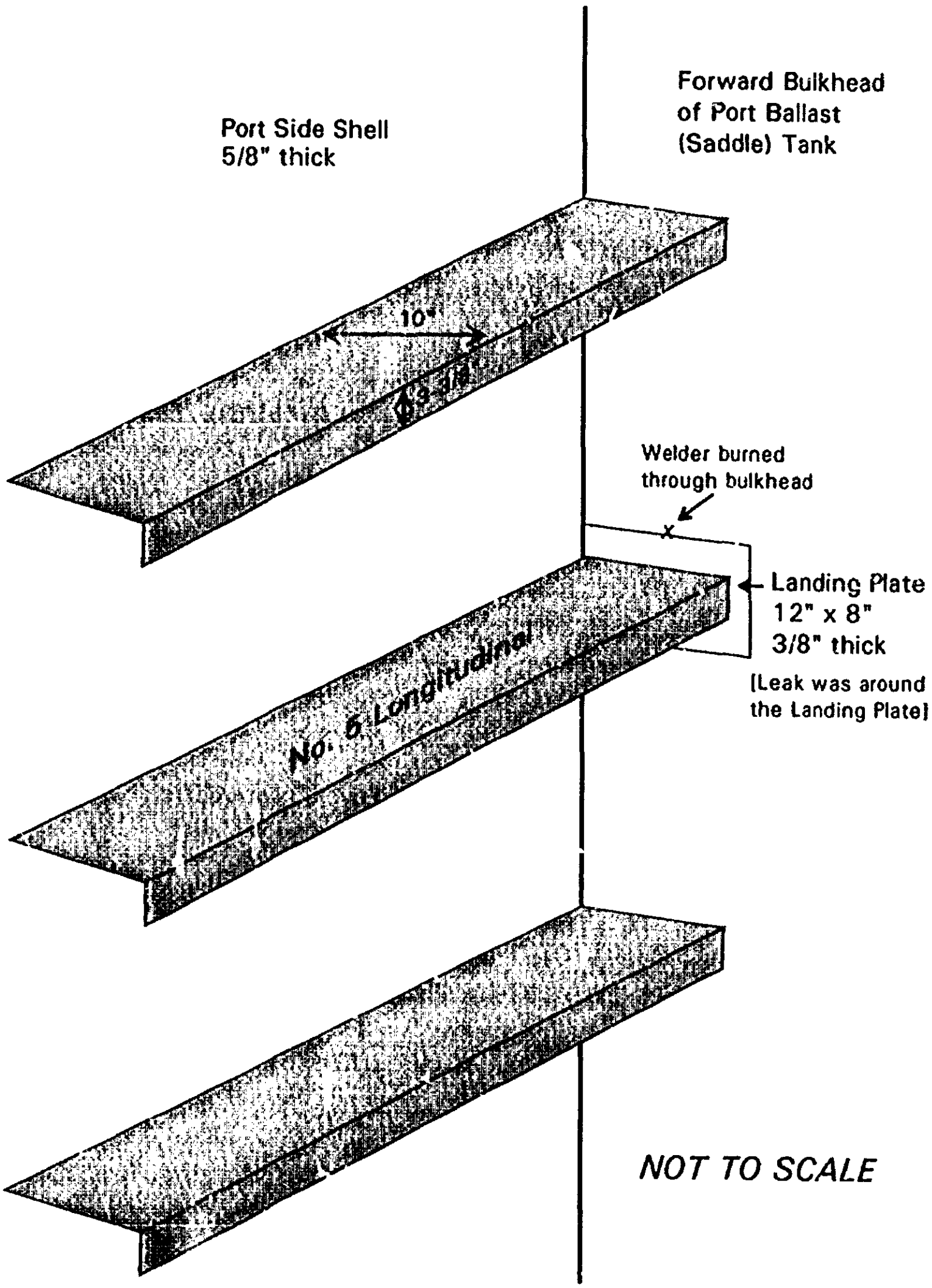


Figure 4.--Side view of tank longitudinals.

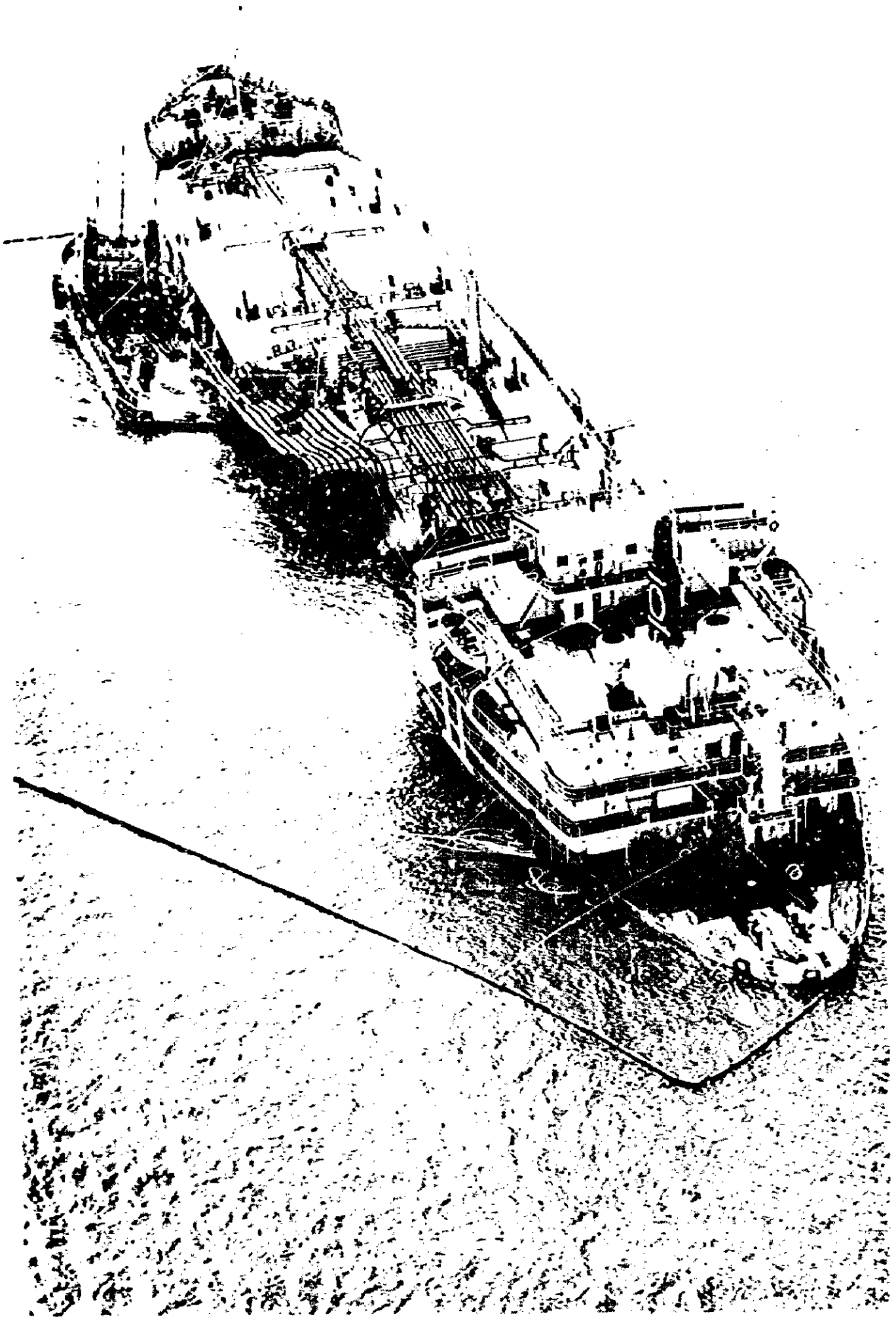


Figure 5.--OMI CHARGER after the explosion and fire.
***(Photograph courtesy of the* Houston Chronicle.)**

Postexplosion Events

The master, who was in his cabin at the time of the explosion, was uninjured and immediately reported to the bridge, where he observed "orange flames on the port side sweep aft past the wheelhouse." According to the master, the No. 4 and 5 port tanks were "completely gone, open to the sea." The crews of vessels responding to the fire said that initially the fire was "midships, mostly portside".

Immediately after the explosion, the third mate on watch sounded the general alarm from the bridge; at 2004 he began broadcasting a distress message ("Mayday"), which the Coast Guard Group Galveston Operations Center received, on VHF/FM radio channel 16. The third mate advised that the vessel was involved in a major fire in the Galveston Inner Anchorage adjacent to the Houston Ship Channel near channel markers 9 and 10, that the vessel was in ballast without cargo, and that 35 people were on board.

The chief engineer and first assistant engineer proceeded at once to the engineroom. They met the third assistant engineer, who had started the fire pump. The first assistant engineer noticed that the fires in the steaming boiler were out and he relighted the boiler. According to the chief engineer, a wall of water entered the engineroom and soon submerged the fire pump, rendering it inoperative. Seawater entered the engineroom on the port side through the ruptured transverse bulkhead at frame 46, which separated the port saddle tank from the engineroom. The rapid flooding soon forced the engineering crew to evacuate the engineroom.

Because flames were sweeping past the deckhouse and the lifeboat stations, the crew withdrew to the vessel's stern. The master decided that attacking the fire with the foam monitor(s)[13] was not feasible since the engineroom flooding had disabled the vessel's fire pump and foam fire fighting system.

After the distress message broadcast, more than 12 vessels in the area near the mouth of the Houston Ship Channel came to the aid of the OMI CHARGER; the Coast Guard Galveston Operations Center initiated a search and rescue (SAR) operation; and the ocean tug TALLAHASSEE BAY[14] deployed from the AMOCO refinery at Texas City, Texas.

Shortly after the explosion, Group Galveston was designated the SAR mission coordinator, and Marine Safety Office (MSO) Galveston focused on vessel salvage operations and

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[13] Large water-foam canons with fixed nozzles capable of being aimed to spray foam onto the forward deck to combat a fire.

[14] The TALLAHASSEE BAY and the barge FLORIDA BAY, owned by Coastwise Trading Company, were built primarily for use as an articulated tug-barge unit to carry petroleum products. By 2000 on October 9, the barge FLORIDA BAY was completing the loading of 170,000 barrels of naphtha at the AMOCO loading facility in Texas City, Texas. By 2010 the TALLAHASSEE BAY had disconnected from its barge and was responding to the OMI CHARGER's Mayday. The TALLAHASSEE BAY was equipped with fire monitors, 1,000-gallon fire fighting foam storage tanks, fire fighting protective clothing, and emergency medical kits. The master was trained in marine fire fighting procedures for naphtha and other petroleum products and was familiar with tank vessels.

on coordinating actions to control any spill or pollution. MSO Galveston also notified and requested technical assistance from the Coast Guard Gulf Strike Team in Mobile, Alabama.

At 2010, after receiving the distress call, Coast Guard utility boat (UTB) CG41445 got under way from Coast Guard Station Galveston, arriving on scene at 2015. UTB CG41445 was the first Coast Guard unit on scene, and its coxswain therefore became the on-scene commander. During the next 15 minutes, an additional Coast Guard UTB, two helicopters from Coast Guard Air Station Houston, two other small boats, and two cutters (the POINT SPENCER and later the KNIGHT ISLAND) were dispatched to patrol the safety and security zone established by the Coast Guard near the vessel and to participate in the SAR operation for any missing crewmen.

Between 2010 and 2017, various small vessels began arriving to offer assistance. As directed by the master, 27 crewmembers and shoreside workers were evacuated to the offshore crewboat TIM MCCALL. The master, chief mate, second mate, deck cadet, chief engineer, and first assistant engineer remained on board to try to save the ship.

While the TIM MCCALL was en route to Galveston with the evacuated personnel, the Coast Guard Galveston Operations Center directed the vessel to pier 9, adjacent to the John Sealy Hospital (University of Texas Medical Branch) in Galveston. By 2130, 10 patients had been transported to two local hospitals.

Meanwhile, by 2019, the captain of the port (COTP) had notified the Coast Guard vessel traffic service (VTS)[15] to stop traffic on the Houston Ship Channel between buoys 8 and 18. Shortly afterward, aircraft were restricted from the airspace within a 5-mile radius of the accident site. The master, unable to fight the fire, decided to abandon the vessel, and he and the other five crewmembers were evacuated by the pilot vessel GALTEX before 2100.

At 2110, a second large explosion occurred on the OMI CHARGER. A Coast Guard UTB crew, monitoring the fire on the port side of the tanker, made the following report about this explosion, which occurred in the No. 5 starboard cargo tank:

> A large fireball shot about 150 feet out from the port side, about 80 feet wide, and just looked like a big red mushroom of fire. It sounded like a jet going right over us. The heat and smoke just shot straight across our boat.

Following his arrival at the anchorage about 2110, the pilot of Coast Guard helicopter CG6553 reported to the group operations center that the fire involved much of the vessel forward of the deckhouse, that the fire had crossed the beam of the vessel, and that not much

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[15] The Houston-Galveston VTS, operated by the U.S. Coast Guard, is a vessel movement system established under the authority of the Ports and Waterways Safety Act. From a continuously manned vessel traffic center in Houston, operators monitor the entire Houston Ship Channel from the Galveston sea buoy to the Houston turning basin and disseminate marine traffic information to participating vessel operators via VHF-FM radio. The VTS is a traffic advisory network, not a traffic control system.

waterline remained exposed on the port side. He further reported that the stern of the vessel was swinging near the ship channel.

About 2110, shortly after the second explosion, the ocean tug TALLAHASSEE BAY arrived alongside, and the master of that vessel took charge of the fire fighting effort. He stated that he observed several vessels spraying water toward the burning tankship when he arrived but that much of the water was not hitting the OMI CHARGER. Using his vessel, with assistance from other vessels, the tug master turned the tankship so that the wind blew forward to protect the deckhouse from wind-driven flames.

The tug master then directed application of water and foam onto the tankship from his and the other vessels to fight the fire and cool the vessel to prevent further explosions. The fire, which involved 6 of the 15 cargo tanks, burned for more than 5 hours, but no further explosions occurred. The chief mate later stated that he believed hydraulic oil from broken pipelines to deepwell pumps in the No. 2 and 4 port and starboard cargo tanks had contributed to the fire.

By 2300, OMI had contracted Smit America Salvage, Inc., to coordinate fire fighting efforts and act as salvage master. OMI also contracted Garner Environmental Service to surround the vessel with 1,900 feet of 36-inch oil containment boom and oil skimming platforms in case of a spill of the 8,700 barrels of product remaining in the vessel's fuel tanks.

The master of the TALLAHASSEE BAY declared the fire out by 0120 on October 10, although fire monitors continued to be used to cool the vessel until 0700. The last fire to be extinguished was around the cargo manifold. On October 11, salvors opened the manifold valves and removed a few gallons of gasoline from the manifold.

About 1443 on October 10, one-way traffic was allowed past the anchorage, and the channel was fully opened at 1200 on November 17.

Events Preceding the Accident

On September 28, 1993, the OMI CHARGER departed the shipyard after a 3-week repair period at Atlantic Marine, Inc., shipyard in Mobile, Alabama. On October 1, the third mate, making routine inspections as the vessel loaded gasoline at its AMOCO berth in Texas City, discovered a small amount of gasoline leaking into the pumproom near the upper starboard side (leak 1). She immediately reported the leak to the chief mate, who inspected it and determined that the gasoline was coming from the No. 5 center tank.

The chief mate reported the leak to the master, who approved application of a temporary patch using epoxy resin. About 1400, the third mate, making a routine check of the pumproom, discovered a second leak into the pumproom from the No. 5 center cargo tank (leak 2). According to the chief mate, the leak was a small weep, and the master concurred with the chief mate's recommendation not to make repairs but to monitor the leak closely. When the vessel got under way about 2100, the chief mate received a report that the painters smelled gasoline in the No. 5 port saddle tank.

About 0830 on October 2, the chief mate found a damp area on the forward bulkhead in the port saddle tank, indicating a leak from the No. 5 port cargo tank (leak 3). This damp area initially extended 3 to 4 inches outward from a landing plate installed during the recent shipyard period; it eventually reached about 3 feet below and 2 feet above the landing plate.

The vessel continued its voyage from Texas City to Port Everglades and then Tampa, Florida, to discharge its cargo. The port engineer,[16] who had directed the shipyard overhaul, visited the vessel while it was in Tampa on October 7, to inspect the leaks and to issue instructions on how repairs were to be made. He directed that all three leaks were to be repaired by welding that would be done by the lead welder, who was in charge of a welding gang already on board to make engineroom repairs and whom the port engineer described as very competent.

Before welding could be performed in any tank, the tank had to be gas-free. Adjacent spaces needed to be gas-free, or inerted, or flooded with seawater. The master, in consultation with the chief mate and port engineer, decided that the No. 5 center tank would be water-washed using conventional, portable washing machines[17] and ventilated. The pumproom was also to be washed using a portable washing machine, hose-washed, and ventilated. After leaving port, the No. 5 port and starboard tanks were to be filled with seawater and overflowed to flush out remnants of the gasoline cargo, and then left full. The port engineer later stated that he preferred washing and ventilating to overflowing but that the method used was the master's decision.

The crew washed the No. 5 center cargo tank and the pumproom while the vessel was in port on October 7, and both spaces were ventilated overnight. While the OMI CHARGER was en route to Texas City on October 8, the chief mate and chief pumpman, as previously directed by the master, overflowed the No. 3 port, center, and starboard cargo tanks and the No. 5 port and starboard cargo tanks. They used two cargo pumps to produce a high flow of seawater out of the hatch trunk. The chief mate reported no sheen or evidence of gasoline flowing out of the open hatch trunk of either tank after the first 2 to 10 minutes of overflowing. He also stated that he tested the water with his hand and felt no gasoline in the water. He said that the tank cleaning covers[18] on both tanks were secured during the overflowing; afterwards, water was left pressed up into the hatch trunks of the No. 5 port and starboard tanks.

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[16] The individual referred to as the port engineer in this report was listed in OMI's telephone and information booklets as a special projects superintendent. As a subcontractor to OMI, he functioned as a port engineer during shipyard vessel repairs and conversions. He was not a full-time OMI employee. When working for the company, he reported directly to the vessel's operations manager. Depending on the nature of vessel repairs required, he also reported to OMI's structural manager and to the permanent port engineer assigned to the vessel. The ship's officers, OMI's shoreside management, and the port engineer himself considered him an OMI employee, subject to the direction of OMI management.

[17] A rotating nozzle device that is attached to the end of a hose and lowered into a tank through deck openings. Pressurized water rotates the nozzles as they spray water to clean the tank.

[18] Small hatches, frequently called Butterworth openings, that are opened to lower portable washing machines into the cargo tanks.

The chief mate testified that he had flushed the cargo lines on deck with seawater, except for the cargo manifold, and had consulted closely with the master about the hot work preparations. According to the master's testimony, the cargo lines were "packed," that is, filled with seawater, so that any gasoline remaining in the cargo pipelines ould not flow into the tanks.

The chief mate later testified that he had overflowed the No. 3 port, center, and starboard tanks and the No. 5 port and starboard cargo tanks before going to the shipyard on September 7, 1993. He also testified that he overflowed the tanks because the master instructed him to do so. According to the chief mate, he had never overflowed tanks before; after experimenting with the process while the tank cleaning openings were both open and closed, he concluded that the gasoline cargo cleared the tanks better with the openings secured because flow through the hatch trunk was greater.

The master said he had used the overflowing method when he was a chief mate and found it effective for flushing a clean product like gasoline, provided the tanks were well-coated and free of sediment. He stated that the small amount of gasoline removed during flushing quickly evaporated, leaving no sheen in the vessel's wake, and thus caused no water pollution. He added that the preparations for the September 1993 shipyard repairs were the first time he had employed overflowing since becoming master in 1983.

The master and chief mate both testified that a marine chemist had tested the cargo tanks after the vessel arrived in the shipyard and found them gas-free. The marine chemist who conducted the testing stated that he first lowered a hose through the ullage opening of each tank to within a fraction of an inch of the tank bottom or liquid level and determined that all tanks were 10 percent or less LEL, the safe level for ventilating with electric fans. The chemist stated that to facilitate testing for benzine, all tanks were ventilated overnight to reduce the LEL to zero. He tested for benzine the following day and, finding all tanks free of the distillate, entered each one for the first time to inspect for residue (rust or scales) that could emit gas. Very little residue was present, and the chemist certified the tanks gas-free and safe for personnel and hot work. One stipulation of the certificate was that the tanks be continuously ventilated.

About 0830 on October 8, the chief mate began testing the pumproom and the No. 5 center cargo tank and found that the atmosphere in both contained 21 percent oxygen and no evidence of hydrocarbon vapors. Atmospheric testing of the No. 5 center cargo tank, according to the chief mate, involved sampling the tank at different elevations, several locations throughout the port and starboard bottom over the length of the tank, and several locations in the area where the welding would be conducted. After the testing, ventilation of both spaces resumed and continued uninterrupted during the hot work.

The chief mate stated that he completed the hot work permit and authorized the welding to begin about 1030. According to the chief mate, the welder was unable to weld the foot-long fracture (leak 1) that caused the leak into the starboard side of the pumproom because the bulkhead was too thin from wastage, and a doubler plate had to be welded over the fracture to stop that leak. By 1900, the welder had completed the repair of leaks 1 and 2 in the No. 5 center cargo tank.

Injuries

Injuries	Crew	Maintenance Crew	Total
Fatal	1	2	3
Serious	0	1	1
Minor	7	2	9
None	19	3	22
Total	27	8	35

Vessel Damage

The explosions on the OMI CHARGER resulted in extensive structural and flooding damage to the 24-year-old tankship. Five cargo tanks, one ballast tank, the pumproom, and the engineroom were opened to the sea and flooded. The forward section remained afloat, the stern settled to the seabed, and the ship assumed a list to port of about 10°. The vessel, valued at $12 million, was declared a constructive total loss.

The Coast Guard incurred $183,000 in costs for facilities and personnel responding to the accident, and local (nongovernment) responders in the Houston Ship Channel and Galveston Bay area incurred undetermined expenses. Shipping industry losses totaled $8 to 10 million due to marine traffic stoppage and delays in the channel, resulting in subsequent losses to local commercial and industrial organizations. OMI's costs for salvage and removal of the vessel amounted to $1 million; the company's revenue losses and liability costs have yet to be determined.

Crew Information

The OMI CHARGER had a crew of 27, including the master. All were properly licensed and certificated under U.S. law. (See appendix B for additional personnel information.)

Master.--A 1970 graduate of Maine Maritime Academy, the master had served on tankships for more than 20 years. At the academy, he received formal instruction in tank vessel operations and safety, including tank cleaning and testing procedures. He had been a ship's master about 10 years.

The master reported that he generally works a 12-hour day, beginning at 0800 and ending when he closes the door to his cabin at 2000 hours. He also said he is usually on the bridge between 0630 and 0700 for coffee. The master did not recall his exact schedule for the 3 days before the explosion but thought it broadly corresponded to the hours just described. His bedtime on the night before could not be determined. At the time of the explosion, about 2000, he was in his bedroom watching a movie.

Chief Mate.--A 1981 graduate of the U.S. Merchant Marine Academy, the chief mate had served on tankships for more than 8 years. He had been a chief mate for 3 years. He also held a master's license but had not sailed in that capacity. His marine transportation (deck) course at the academy included formal instruction in tank vessel operations and safety, including tank cleaning and testing procedures. The chief mate had completed a 1-week course in inert gas and crude oil washing systems and operation. Company performance appraisals of the chief mate gave him very high marks for job performance. The master stated that he was very pleased with the chief mate's performance and had recommended him for promotion to master.

The chief mate told investigators that he usually went to bed between 2200 and 2300 and arose each morning about 0630. If pumping operations were under way, he said he altered that schedule, as necessary.

For the 3 days prior to the explosion, the chief mate reported the following schedule. On October 6, he arose at 0630. The ship moored in Tampa that night at 2400. The chief mate said he remained awake until about one-half hour after beginning to discharge cargo at 0218. On October 7, he arose about 0630 or 0700 and went to bed at 2200. He got up at 0410 on October 8 and worked through the day until going to bed at 2230. He said he slept 8 hours before getting up at 0630 on October 9.

In addition to the crew, the OMI CHARGER was carrying eight shoreside maintenance personnel--a four-man welding gang and a four-man painting gang.

Vessel Information

General Vessel Description.--The OMI CHARGER, official number 522864, was a single-hull (no double bottom or double sides), U.S.-flag tankship. It was 660 feet long, 90 feet wide, and 48.9 feet deep and measured 20,877 gross tons. The OMI CHARGER was one of four sister tankships constructed by Bethlehem Steel Shipbuilding in its Sparrows Point shipyard at Baltimore, Maryland. The tankship was built from plans approved by the Coast Guard, which had certified the vessel for the carriage of crude oil products, grade B[19] and lower, under Title 46, Code of Federal Regulations (CFR), Subchapter D, Parts 30 to 35 and 39 and Subchapter O, Parts 151, 153, 154, and 157.

Delivered to its owners, Rio Grand Transport, Inc., in December 1969, the tankship was designated a product carrier, designed and built to meet the structural requirements of the American Bureau of Shipping (ABS) *Rules for Building and Classing Steel Vessels*. ABS had retained the vessel in class from its construction to the date of the accident.

Constructed of all-welded steel, the OMI CHARGER had a single, continuous main deck,

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[19] Coast Guard regulations at 46 CFR 30.10-22 define grade B flammable liquids as any liquids that give off flammable vapors at or below a temperature of 80°F and that have a Reid vapor pressure between 8.5 and 14 psi. The gasoline cargo was a grade B product.

straight raked stem, and bulbous bow. The deckhouse on the main deck at the stern had accommodations and navigation spaces situated above the main deck and machinery spaces and engineering control stations below the main deck.

Vessel Arrangements.--The OMI CHARGER's total cargo capacity was 334,799 barrels. Its forward-to-aft tank layout comprised the forepeak clean ballast tank, the forward fuel oil tank, 15 cargo tanks, and after port and starboard saddle (ballast) tanks overlapping the pumproom. (See figure 1.)

The 15 tanks in the cargo tank block were divided into 5 transverse tank sections, numbered 1 to 5, from forward aft. Each transverse tank section was subdivided longitudinally into three tanks: port, center, and starboard cargo tanks.

The saddle tanks and the pumproom formed the structural barrier between the machinery spaces and the cargo tank block. The engineroom forward transverse bulkhead at frame 46 was also the after transverse bulkhead of the port and starboard saddle tanks.

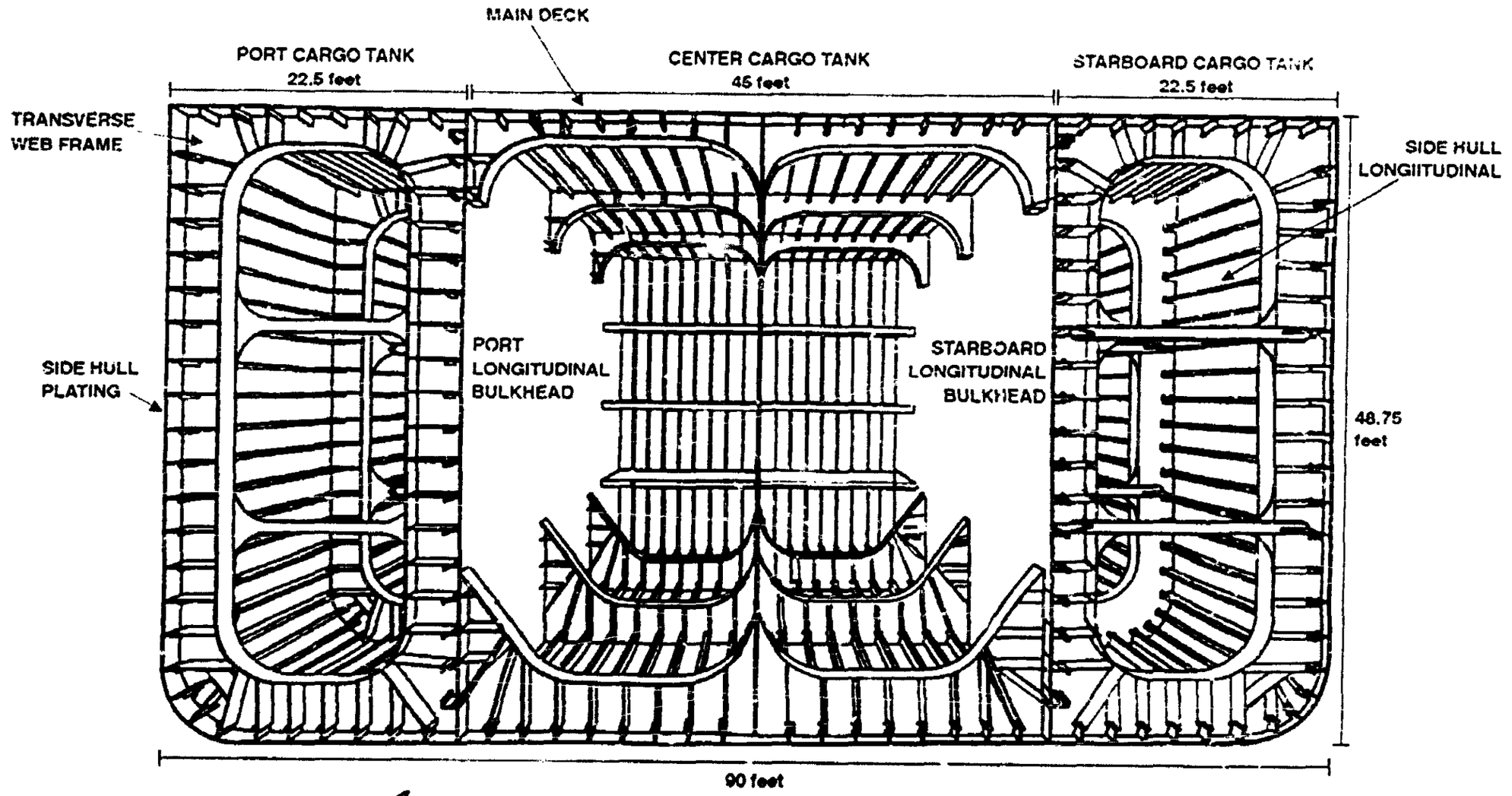
No. 5 Port and Starboard Cargo Tank Construction.--National and international tankship construction regulations require a void space between a deckhouse and a cargo tank, and the OMI CHARGER complied with those requirements. The bottom of the deckhouse extended over the top of the saddle tanks, the pumproom, and the after end of the No. 5 cargo tanks. As required by U.S. standards, a void space, (3 feet deep, 22.5 feet wide, and 11.25 feet long) was located below the deckhouse main deck in the overhead of the No. 5 port and No. 5 starboard cargo tanks, between frames 49 and 50. (See figures 1 and 2.)

The top portion of the transverse web at frame 50, in both the No. 5 port and starboard cargo tanks, was constructed without underdeck longitudinal cutout openings, which allow fluids and vapor to migrate between transverse web frame sections at the top of the tank. This construction feature was found only in the port and starboard transverse web frames at frame 50, extending below the forward end of each void space. (See figure 6.)

The port and starboard saddle tanks were located between the No. 5 port and starboard after transverse bulkhead at frame 49 and the engineroom forward bulkhead at frame 46. The pumproom was partly under the central portion of the saddle tanks and partly in the after bottom of the No. 5 center cargo tank. The after end of the pumproom was common with the engineroom.

Cargo Pumping System.--The OMI CHARGER's pumping, ballast, and tank washing equipment was typical of that found on modern tankships. The vessel was capable of carrying three grades of fully segregated cargoes.

The OMI CHARGER's four main cargo pumps and two smaller cargo stripping pumps were located at the bottom of the pumproom. The stripping pump had a capacity of 1,142 barrels per hour (bph) and served all cargo tanks except the No. 2 and 4 port and starboard tanks. The main cargo pumps each had a discharge capacity of 6,850 bph and could be connected via piping



S.S. OMI CHARGER
MIDSHIP SECTION - LOOKING FORWARD

Figure 6.–Cutaway of OMI CHARGER tank.

and valves to one of the three segregated tank groups of cargo. The port engineer stated that after stripping cargo from the No. 5 port tank, the amount of cargo residue remaining in the tank was typically between 3 and 10 barrels. In addition to pumping cargo and ballast ashore, the main cargo pumps could distribute seawater ballast from the pumproom sea chest throughout the OMI CHARGER's cargo tank piping system.

The No. 2 and 4 port and starboard tanks had been modified to serve as segregated ballast tanks but were converted back to cargo tanks for the vessel's current charter operation. The tanks were fitted with hydraulic-operated deepwell pumps that were independent of the main and stripping pumps and pipelines. The deepwell pumps were used for pumping both cargo and ballast. Motive power for the pumps was a large hydraulic pumping system and hydraulic reservoir tank located in the forward part of the deckhouse; it was connected to the deepwell pump motors by pipelines on deck.

Inert Gas System.--Some of the flue gas from the exhaust stack of the OMI CHARGER's boilers was collected, cooled, cleaned, and blown by fan through the inert gas pipelines to the 15 cargo tanks. As inert gas entered the cargo tank or tanks, the tank gases were vented to the atmosphere through manually opened purge valves installed at the top of the purge pipe riser, which was attached to the hatch trunk near the aft end of each tank. Oxygen levels in each tank were usually maintained at 4 percent. Inert gas was routinely supplied to the tanks during cargo or ballast discharge or when purging a hydrocarbon atmosphere in an empty tank with inert gas. Individual tank isolation valves controlled the inert gas pipelines to each cargo tank.

Shipyard Repairs.--The steel renewals required to rehabilitate the port and starboard saddle tanks were a major repair item on the OMI CHARGER during the September 1993 shipyard repair period. They were the subject of both a 1991 Coast Guard "Inspection Deficiency" (CG-835)[20] and an ABS "Outstanding Recommendation."[21] Both the Coast Guard and ABS were concerned that the deteriorated condition of the after bulkhead between the engineroom and the ballast tanks could result in structural failure and flooding of the engineroom.

Both the CG-835 and the ABS Outstanding Recommendation had remained unresolved from 1991 through 1993, and repairs were to have been completed by the next drydocking in September 1993. During that 2-year period, the tankship was not allowed to carry any liquids in the saddle tanks. Part of the steel renewals involved the continuous portside hull longitudinals,

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[20] Coast Guard inspectors complete a form CG-835, "Inspection Deficiency," when they find either a failure to meet minimum requirements of the vessel inspection laws and regulations or a condition that may reasonably be expected to result in a failure to meet those statutes before the next inspection for certification and renewal of the vessel's certificate of inspection. Such discrepancies must be corrected within a specified period of time, such as before departing port, loading the next cargo, or issuing the next certificate of inspection.

[21] The ABS issues an "Outstanding Recommendation" for any damage to a vessel's hull, machinery, or equipment that affects or may affect class and that is not repaired at the time of the survey but must be dealt with to the satisfaction of an ABS surveyor in a specified time period.

which passed through the common forward transverse bulkhead between the port saddle tank and the No. 5 port cargo tank.

Wreckage

Safety Board investigators examined the OMI CHARGER soon after the accident, both while the vessel was partially submerged and after it had been raised.

The atmospheres of those cargo tanks not open to the sea were checked with an oxygen meter after the fire was extinguished. The No. 1 and 2 port, center, and starboard tanks and the No. 3 center and starboard tanks maintained oxygen levels between 4 and 13 percent. The isolation valves to the No. 5 port, starboard, and center tanks; the No. 4 port tank; and the No. 4 center tank were found in the closed position. All these valves were in good condition and made an effective seal in the closed position. The cargo pipeline valves to the No. 5 port and starboard cargo tanks were found closed.

Uncontrolled Flooding.--Examination of the wreckage revealed that the No. 4 and 5 port tanks were open to the sea at the side hull plating, allowing uncontrolled flooding of these tanks. The No. 4 center was found open to the sea vertically over its full height at the aft port corner. The No. 5 center and starboard tanks were found open to the sea through their port and starboard longitudinal bulkheads. The No. 5 port tank's aft transverse bulkhead, at frame 49, was breached, allowing seawater to flood the saddle tank. The port saddle tank after bulkhead at frame 46, between the engineroom and saddle tank, was open to the sea, permitting flooding of the engineroom. The longitudinal bulkhead between the port saddle tank and the pumproom was also breached, flooding the pumproom.

Main Deck and Port Hull Damage.--. 113-foot long section of the portside main deck (the full 90-foot length above the No. 5 port tank plus 23 feet above the No. 4 port tank), nearly the width of the port cargo tanks, was found lying inverted on the forward main deck. The displaced portion of the main deck landed on the No. 3 port tank access trunk and other deck appliances, puncturing the main deck and opening that tank to the atmosphere.

A 90-foot length of the portside hull plating, extending the full length of the No. 5 port cargo tank, was found torn 30 feet vertically at each end. The after tear was at the side hull intersection with the No. 5 port cargo tank after transverse bulkhead (frame 49), and the forward tear was at the side hull intersection of the No. 5 port cargo tank forward transverse bulkhead. The side hull section was found folded overboard in the sea, still attached longitudinally to the vessel at the fold more than 30 feet below the main deck.

When the hanging side hull plating was removed and transported to shore, a section of the transverse bulkhead at frame 49, where the welding was done, was found still attached to the side hull plating. This section was removed and shipped to the Safety Board's metallurgical laboratory in Washington, D.C., for further examination.

Cargo Tanks.--The No.5 port cargo tank forward transverse bulkhead, at frame 57, was found severely bent toward the bow, resting about 30 feet forward of its installed position. The bulkhead was found torn horizontally at the overhead main deck welds and along the vertical welds with the inboard longitudinal bulkhead and the outboard port side hull plating.

The after transverse bulkhead at frame 49, between the No. 5 port cargo and port saddle tanks, was found severely bent toward the stern and torn horizontally from the overhead and vertically along the welds inboard from the longitudinal bulkhead and outboard from the port side hull plating. It was displaced about 20 feet aft into the saddle tank. The No. 4 center cargo tank was found open to the sea for almost its full height along the after port corner.

The Second Explosion.--Examination of damage in the area of the No. 5 center and No. 5 starboard cargo tanks and the main deck above them revealed the following.

The main deck above the No. 5 starboard and No. 5 center tanks was found distorted upward about 3 feet at its highest point. The distortion extended smoothly from the starboard side hull plating through the center tank to the port longitudinal bulkhead of the No. 5 center cargo tank and forward to aft over the full length of the No. 5 starboard and center tanks.

Inside the No. 5 center tank, the forward two-thirds of the starboard longitudinal bulkhead (60 feet) was found resting nearly level in a transverse position against the No. 5 center cargo tank forward bulkhead. The after one-third of the longitudinal bulkhead (30 feet) was found in a similar position in the after end of the No. 5 center tank adjacent to the port side of the pumproom access trunk.

The 90-foot-long centerline longitudinal web frame inside the No. 5 center cargo tank was found torn horizontally along its full length; the upper and lower portions were heavily bent toward the port side. The portside longitudinal bulkhead between the No. 5 center and No. 5 port cargo tanks was found bent outboard toward the port side and into the No. 5 port tank.

Waterway Information

Bolivar Roads Anchorage Area A is inside the breakwaters that form the entrance to Galveston Bay. The anchorage, which is approximately 3,100 feet long and 1,000 feet wide, lies on the north side of the dredged channel used by all seagoing vessels proceeding to and from Galveston, Houston, and other Texas ports, such as Texas City. The Coast Guard controls use of the anchorage.

Although within Galveston County, Bolivar Roads Anchorage Area A is outside the limits of the City of Galveston (the closest municipality) and is not within the fire jurisdiction of any municipality. Moreover, even if the area were within the City of Galveston's jurisdiction, the city lacks resources, such as a dedicated fireboat, to provide fire protection to the area.

No organization or municipality in the area had an emergency plan in place to deal with

a major ship fire in the anchorage, and no drills for vessel fires in the anchorage had been conducted or planned.

Operations Information

Rio Grand Transport, Inc., owned the OMI CHARGER. and OMI Bulk Management Company operated it and 28 other bulk carriers and tankships, including 6 vessels in foreign registry. Coast Guard records showed that three major accidents had occurred on OMI vessels in 25 years (OGDEN WILLAMETTE, OMI YUKON, and OMI CHARGER)[22] and that OMI vessels were involved in oil spills in 1981, 1988, and 1991.

The OMI CHARGER was in the fourth year of a 5-year charter to carry AMOCO gasoline from that company's oil refinery in Texas City to discharge ports in Florida. Under the arrangement, OMI was responsible for maintaining and operating the vessel, including furnishing the crew, provisions, and fuel. The charter specified minimum speed the vessel was to make between ports, standards for cargo loading and discharge rates, and penalties to be levied on OMI when the vessel failed to meet the times specified. The master testified that the OMI CHARGER met its charter requirements without difficulty.

The tankship's certificate of inspection limited the vessel to trading between U.S. ports and permitted it to load only at the AMOCO facility in Texas City, Texas. Tank washings, cargo residue, and all ballast were to be retained on board and discharged at either the AMOCO facility or an alternate facility approved by the Coast Guard Officer in Charge of Marine Inspection. Only in an emergency could such washings, residue, or ballast be discharged overboard.

Meteorological Information

The weather at the time of the accident was cloudy but slowly clearing, and visibility was good. About 2000 on October 9, local weather stations reported a 15-to-20 mph northwesterly wind, a temperature of 78°F, no precipitation, unlimited visibility, and about a 1-foot wave height with an incoming tide at the mouth of the Houston Ship Channel. Following the accident, the wind shifted to a northerly direction. A front moved through the area during the evening of October 10, and a high pressure area moved slowly to the east of Galveston, Texas.

Medical and Pathological Information

Survivors' Injuries.--Twenty-seven of the 35 vessel personnel evacuated onto another

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[22] See Marine Accident Report--*Engineroom Flooding and Near Foundering of the U.S. Tankship OGDEN WILLAMETTE, Caribbean Sea, June 16, 1982* (NTSB/MAR-83/06) and Marine Accident Report--*Explosions and Fires Aboard the U.S. Tankship OMI YUKON in the Pacific Ocean about 1,000 Miles West of Honolulu, Hawaii, October 28, 1986* (NTSB/MAR-87/06).

vessel within 15 minutes of the first explosion (by 2015); 6 crewmembers, including the master, remained on board; and 2 riding gang members were missing. The crewmembers who remained on board were evacuated at 2053.

Six of the 10 injured persons transported to local hospitals by 2130 were treated for minor injuries such as muscle spasms and for contusions and abrasions and released. Four patients were admitted to St. Mary's or John Sealy Hospital in the Galveston area:

- One member of the maintenance crew was admitted for small metallic bodies in his cornea and second-degree (less than 10 percent of body area) burns.
- Two crewmembers who complained of smoke inhalation were admitted for observation.
- One crewmember who complained of back pain was admitted for observation.

Fatal Injuries.--The lead welder, 31, who was welding in the port saddle tank, received multiple fractures and lacerations to the head and lower extremities. On October 10, 1993, divers recovered his body from the port saddle tank.

The painter, 20, who was in the port saddle tank acting as the firewatch at the time of the explosion, sustained blunt force trauma injuries, including a traumatically amputated femur, chest and head fractures, and chest hemorrhage. On October 11, 1993, divers recovered his body submerged in the port saddle tank.

The chief pumpman, 46, who had been working on deck above the port saddle tank at the time of the explosion, received multiple lacerations and fractures. He died at 2100 en route to the John Sealy Hospital emergency room.

Postaccident Toxicological Sampling.--Within minutes of the explosion, an OMI marine superintendent in Houston was notified and dispatched to the scene as the company's representative. He reported that his primary responsibilities were to stabilize the situation and ensure the crew's safety. He said that he was familiar with the marine employer's responsibility to conduct postaccident toxicological testing but that fulfilling that responsibility was a lower priority.

After receiving notification, the marine superintendent drove to Galveston. While en route, he notified a local law firm of his need for their assistance. OMI had previously arranged with the law firm for the services of a team of attorneys in the event of an accident.

The marine superintendent arrived in Galveston about an hour after the explosion, just after the crew had been brought ashore and taken to a nearby hotel. He said that those crewmembers who lived in the area wanted to go home and that some left even though he asked them to stay. The superintendent's interpretation of the regulation was that since those crewmembers were not involved in causing the accident, toxicological testing of them was not necessary. He also said he advised the crew not to go to the hotel bar. Nonetheless, five crewmembers,

including the chief mate, did so and drank alcoholic beverages after the accident. They later reported to the sample collector that they had not been warned about drinking after the accident.

The marine superintendent reported that within 2 or 3 hours after the accident he mentioned to a company attorney that postaccident testing needed to be done, but neither he nor the attorney initiated the process. During the same period, MSO investigators had responded and interviewed the crew. The MSO investigator then returned to his local office at 2400 to report on events. A lieutenant there reminded him that toxicological testing needed to be done.

The MSO investigator then called one of the attorneys at the hotel and reminded him--4 hours after the accident--of the toxicological testing requirement. The attorney replied that the investigator could bring his kit and do the testing. Informed that sampling is the company's responsibility, not the Coast Guard's, the attorney said, "Ok, how do I go about it?"

The MSO investigator then read a list of sample collection services in the area to the attorney, who chose one and called the service within 5 minutes (0005 on October 10). The attorney suggested to the collection service that sampling could be done the following morning, but the service said it needed to be done expeditiously and dispatched a collector immediately. The collector sampled the entire crew, taking the first samples at 0100, 5 hours after the accident, and the last sample at 1435, 18.5 hours after the accident. The long delay in obtaining the last samples was due to difficulties in locating the crewmembers who had gone home.

Results of the drug and alcohol tests were negative for most of the crew, including the chief mate, who told the collector he had consumed one beer after the accident. The other four crewmembers who drank in the hotel bar tested positive for alcohol; none of them had been involved in the hot work activities aboard the ship.

The memorandum containing the list of local sampling services also cited Federal regulations concerning toxicological testing and included a note reminding investigators to notify companies of their responsibility to test. The lieutenant at MSO Galveston had prepared the memorandum for local use after an accident on December 21, 1992, in the Houston Ship Channel. In that incident, confusion concerning requirements and responsibilities for toxicological testing resulted in samples being obtained 14 to 18 hours after the accident. The Safety Board has discussed the deficiencies of the sampling process in five recent accident investigation reports.[23] It has recommended that the Coast Guard provide guidelines to investigators about informing marine employers of their responsibility to conduct toxicological testing as soon as

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[23] See Marine Accident Report--*Grounding of the United Kingdom Passenger Vessel RMS Queen Elizabeth 2 near Cuttyhunk Island, Vineyard Sound, Massachusetts, August 7, 1992* (NTSB/MAR-93/01); Marine Accident Report--*Collision of the U.S. Towboat FREMONT and Tow with the St. Vincent and the Grenadines-Registered Containership JURAJ DALMATINAC, Houston Ship Channel, December 21, 1992* (NTSB/MAR-93/02); Highway-Marine Accident Report--*U.S. Towboat CHRIS Collision with the Judge William Seeber Bridge, New Orleans, Louisiana, May 28, 1993* (NTSB/HAR-94/03); Marine Accident Report--*Grounding of U.S. Passenger Vessel M/V YORKTOWN CLIPPER in Glacier Bay, Alaska, August 18, 1993* (NTSB/MAR-94/02); and Railroad-Marine Accident Report--*Derailment of Amtrak Train No. 2 on the CSXT Big Bayou Canot Bridge near Mobile, Alabama, September 22, 1993* (NTSB/RAR-94/01).

practicable following a serious marine incident and providing assistance when necessary.[24] The lieutenant stated that the memorandum was his attempt to improve the sampling process.

Emergency Response

The Coast Guard's Galveston Bay Area Contingency Plan (ACP) was the main mechanism for coordinating the overall emergency response. As provided in the ACP, the COTP, as the Federal on-scene coordinator, managed Federal, State and local emergency response under a unified command that involved more than 10 public and private agencies.

Except for the MSO Galveston *Command Duty Officer's Manual*, which contains notification procedures for vessel fires, the MSO Galveston does not have a port contingency plan for vessel fires. The ACP is in place to address pollution response. The COTPs of Galveston and Houston approved it on May 28, 1993, as meeting all Federal and State emergency planning requirements under the Oil Pollution Act of 1990 (OPA 90). Prior to this accident, MSO Galveston had last conducted an emergency preparedness exercise on September 23, 1993. It was a tabletop drill involving a simulated oil spill following the collision of two barges carrying oil product in the Houston Ship Channel.

The Houston-Galveston area is one of the largest petrochemical complexes in the world, and its port ranks as the third busiest in the United States. From the Gulf of Mexico, deep-draft vessels enter Galveston Bay through the pass at Bolivar Roads and by ship channel to Houston, Galveston, Texas City, and Port Bolivar.[25] In 1987, more than 10,206 tankers and 32,843 tank-barge tows in hazardous commodity service transited the Houston-Galveston area, including the Houston Ship Channel, the Galveston Channel, Texas City Channel, and the Gulf Intercostal Waterway.[26]

The Galveston Bay Contingency Plan lists five major spills in the Galveston area since 1990, most involving more than 900 barrels of oil contaminant. The largest spill resulted from the fire on board the loaded tanker M/V MEGA BORG[27] on January 8, 1990, at the offshore lightering area. In 1990 and 1992, respectively, the Safety Board investigated two accidents

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[24] Safety Recommendation M-94-11 was issued to the Coast Guard on June 7, 1994.

[25] The Port of Houston, Texas, U.S. Army Corps of Engineers, Port Series No. 24, Revised 1989, NDC 89-p-1.

[26] D. Maio, R. Ricci, M. Rossetti, J. Schwenk, and T. Liu, *Port Needs Study (Vessel Traffic Services Benefits) Volume I: Study Report*, U.S. Department of Transportation, Research and Special Programs Administration, John A. Volpe National Transportation Systems Center, Cambridge, MA, August 1991.

[27] The MEGA BORG explosion and fire occurred in the Gulf of Mexico at an offshore loading facility beyond Safety Board jurisdiction to investigate.

involving spills.[28] The last major pollution response involving the ACP prior to the OMI CHARGER accident took place on June 17, 1992, following the release of 2,350 barrels of crude oil at Texas City, Texas. The ACP was again fully activated following the October 19, 1994, release of more than 1 million gallons of petroleum product in the San Jacinto River near Houston, Texas.[29]

Tests and Research

Test Meter.--On October 15, 1993, a marine chemist examined the combustible gas and oxygen alarm meter (model 261) used by the chief mate; he found it to be properly calibrated and operating satisfactorily.

Metallurgical Tests.--The Safety Board metallurgical laboratory conducted tests on a section of transverse bulkhead at frame 49, where welding was taking place at the time of the explosion. The results indicated that:

- the weld at the landing plate and forward transverse bulkhead at frame 49 was deformed by the explosive force while in the molten state;
- the weld at the landing plate and forward transverse bulkhead at frame 49 penetrated through the port saddle tank bulkhead into the No. 5 port cargo tank at the time of the explosion; and
- the transverse bulkhead section exhibited an average 49 percent reduction (wastage) in thickness (25 percent is the maximum wastage allowed under ABS Rules).

Chemical Testing and Explosion Calculations.--Safety Board testing of cargo samples from the OMI CHARGER verified that the substance was gasoline. According to Safety Board calculations, 21 to 121 gallons, or about 0.5 to 3.0 barrels (LEL to UEL, respectively), of liquid gasoline cargo and air were needed in the No. 5 port cargo tank to create an explosive atmosphere.

Other Information

Guidance for Hot Work.--OMI and Coast Guard regulations set forth in National Fire

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[28] See Marine Accident Report--*Collision Between the Greek Tankship SHINOUSSA and the U.S. Towboat CHANDY N and Tow near Red Fish Island, Galveston Bay, Texas, July 28, 1990* (NTSB/MAR-91/03) and Marine Accident Report--*Collision of the U.S. Towboat FREMONT and Tow with the St. Vincent and the Grenadines-Registered Containership JURAJ DALMATINAC, Houston Ship Channel, December 21, 1992* (NTSB/MAR-93/02).

[29] The Safety Board investigation of that pipeline accident is under way.

Protection Association (NFPA) Publication 306,[30] as well as guidelines in the *International Safety Guide for Oil Tankers and Terminals* (ISGOTT), prescribe similar standards that must be met before hot work is allowed to take place on tank vessels. Specifically, tanks must meet one of the following criteria:

(a) be gas-free, that is, the atmosphere must contain adequate oxygen for personnel (about 21 percent), and any combustible gas present must be well below the LEL, which NFPA 306 specifies as less than 10 percent LEL and ISGOTT not more than 1 percent LEL;

(b) inerted so that the oxygen level is 8 percent or less and combustion cannot occur; or

(c) filled with water.

Tank Washing.--Coast Guard regulations that invoke NFPA 306 and ISGOTT refer to washing as the means to clean cargo tanks in preparation for gas-freeing; they give few details about how the washing is to be conducted. Tank cleaning using portable and fixed washing machines is common, accepted practice, well understood by tankship personnel, and comprehensive instructions for tank cleaning are found in some deck officer handbooks.[31] Neither these handbooks nor OMI guidance mentioned overflowing a tank with water as a procedure for cleaning or gas-freeing. NFPA 306 contains no specific guidance about testing procedures to follow; it states that testing is at the marine chemist's discretion.

One former tankship master stated that he had served on vessels on which tanks had been overflowed to flush out gasoline cargo remaining in them after discharging. He stressed that overflowing did not remove all of the gasoline and that ventilating the tanks was necessary to make them gas-free. According to one tankship chief mate, overflowing is a method formerly used on some tankers but no longer practiced because uncontrolled discharge of petroleum into the sea is illegal.[32] An expert witness called by OMI testified that he had overflowed tanks while he was chief mate to expel the gaseous atmosphere from the tanks following washing.

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[30] Title 46 CFR 35.01 mandates that the *Standards for Control of Gas Hazards on Vessels to be Repaired* (NFPA Publication 306) be used as a guide in conducting the inspections and issuing the certificates required when making alterations, repairs, or other operations involving welding, burning, or similar fire-producing actions (hot work).

[31] See, for example, G. A. B. King, *Tanker Practice: The Construction, Operation and Maintenance of Tankers*, Stanford Maritime Ltd., London, 1976; G. S. Marton, *Tanker Operations: A Handbook for the Ship's Officer*, Second Edition, 1978, Cornell Maritime Press, Centerville, Maryland; William B. Hayler, ed., *Merchant Marine Officers Handbook*, Fifth Edition, 1989, Cornell Maritime Press, Centerville, Maryland.

[32] Federal regulations at 33 CFR 157.37 prescribe the amount of cargo residue that a tankship may discharge while en route, provided the vessel is more than 50 miles from land. An approved cargo monitor and control system must be used to ensure that the oil content in the cargo residue does not exceed the prescribed discharge rate and total amount.

OMI Management Oversight.--As stated in OMI's *Manual of Fleet Standing Orders*, "The Company safety policy has, as its foundation, the requirement to operate the bulk chemical tankers, oil tankers, OBO's, bulk carriers and other vessels in the fleet that are safe for the personnel working on board, safe for the environment, and in full compliance with recognized international and national standards for safety and construction."

The OMI CHARGER was part of a 12-vessel fleet that OMI's Vice President of Operations (VP Ops) was responsible for managing. He said his corporate oversight responsibilities include a vessel's day-to-day commercial, financial, operational, and personnel functions.

The VP Ops stated that OMI used various means to conduct safety oversight of each vessel from headquarters. He cited vessel inspection reports; safety checklists; monthly safety meetings, the minutes of which are sent to OMI's company office; copies of classification records sent to the company office; Coast Guard inspection reports, with any deficiencies noted, sent to the company office; port captains' and port engineers' periodic reports on their ship attendance; charterers' inspection reports provided at least annually; and independent training and safety auditors who ride each vessel biannually to teach safety and ensure that the vessel complies with company safety policy and procedures.

The various reports to OMI management concern a vessel's material status, such as its ability to load, contain, and discharge cargo in a timely manner, and the structural, mechanical, and electrical condition of its systems. OMI accomplished shoreside operational safety oversight of vessels through safety checklists, safety meetings, and an independent safety auditor riding on each vessel once every 2 years. Two masters, two chief engineers, and two chief mates (one member of each pair working while the other is on vacation) operate each vessel in OMI's 12-ship fleet. They are directly responsible for safe vessel operations; according to the VP Ops, OMI's safety auditor does not meet with all of them each year.

The VP Ops also stated that OMI does not provide formal training, that is, classroom study, to deck and engineering officers. These officers, who are required to be fully qualified and Coast Guard-licensed, receive training throughout the licensing process and by participating in tanker safety courses offered at the maritime academies, according to the VP Ops. In addition, as the chief mate testified, on-the-job training, while not a formal program, is provided aboard the vessels.

Three times a year OMI offers a company-specific, 2-week, simulator-based course entitled "Vessel Resources/Incident Response Management" in Dania, Florida, at the simulation training and research center of the American Maritime Officers Union. This course, which takes place under the direction of the company's vice president for safety quality and risk management, provides safety training to senior vessel personnel, including masters, chief engineers, chief mates, and first assistant engineers. These personnel have the opportunity to interface with OMI's shore-based management, who also participate in the seminars.

OMI's *Manual of Fleet Standing Orders* states, "The proper management of the vessel is the sole responsibility of the master," who is to ensure compliance with corporate safety and

operational policies and procedures on board each vessel. In accordance with OMI policy, the master is to appoint an "experienced and conscientious" officer on each vessel as safety officer. That individual chairs the ship's four-member safety committee, which includes one deck or engineering officer and one person from each department on the vessel. Safety committees discuss any safety problems identified, training needs, emergency drill procedures, and related matters. The master appointed the chief mate as safety officer on board the OMI CHARGER.

For operations such as hot work, OMI requires the preparation, filing (on board), and distribution (to the company) of vessel-initiated company hot work permits. (See appendix C.) No such permits for the OMI CHARGER could be found in the company's records for the 3 years preceding the accident, even though hot work had been performed many times on the vessel. Investigators also determined that routine shipboard operations, such as entering a tank, use of tank atmosphere testing devices, tank cleaning, and purging, were not always conducted in compliance with recognized company or industry procedures. For example, the chief mate stated that, contrary to well-established safety standards, he entered the No. 5 port cargo tank for testing without someone standing by at the access trunk.

OMI's International Safety Management (ISM) program is in the process of being certified by the Norwegian classification society, Det Norske Veritas (DnV), which began the process in March 1991. Thus far (March 1994), DnV has certified OMI's office management and administration. After DnV issues full certification, it will annually audit OMI to confirm continuing compliance of both office and shipboard systems.

Recent OMI Developments.--Under DnV rules, a company is eligible for full certification only after successfully completing shipboard implementation audits, and OMI did so (for four vessels) on October 29, 1994. DnV certified OMI on December 1, 1994, at which time the four shipboard management certificates were issued to the respective vessels. According to OMI, all its vessels will eventually undergo similar certification audits.

This independent certification process provides various means to reduce the risk of accidents on OMI vessels. It includes an oversight component that comprises an internal and, through DnV's independent reviews, an external auditing mechanism for review and correction of shipboard procedures. If nonconformities are detected, DnV requires that the company take corrective action and make process improvements to retain its certification.

According to OMI, since the accident on board the OMI CHARGER, it has provided more formalized safety procedures to the fleet and officers of all its vessels. The company reports that as part of the International Safety Management Code administered and certified by DnV, it has implemented a Safety, Quality, and Risk Management (SQRM) program at corporate offices and on board OMI vessels. OMI has stated that the program, together with DnV's independent audits, provides various means to reduce the risk of accidents. As described by the company, SQRM includes an oversight mechanism for review and correction of shipboard procedures. In addition, according to the company, it has provided written instructions in the form of a *Guide for Masters--Implementation of the Shipboard Safety and Quality Management System* to clarify DnV rules and OMI's procedures for complying with those rules.

ANALYSIS

Exclusions

The Safety Board eliminated several factors, including the weather, crew qualifications, sleep loss, and drug or alcohol use as causal to this accident.

Visibility was good on the day of the accident. The wind blowing over the vessel prevented an accumulation of combustible vapor about the decks. Sea conditions in the anchorage were slight, making the ship a stable platform for welding repairs.

Both the master and chief mate were qualified, experienced, and properly licensed under Coast Guard regulations. Their sleep-wake histories indicated that sleep loss did not influence their behavior. There was no evidence that drugs or alcohol were a factor in this accident.

The Explosions

Two explosions took place on board the OMI CHARGER, the first in the No. 5 port cargo tank about 2000 and the second in the No. 5 starboard cargo tank about 1 hour later. Both tanks had been overflowed in an attempt to flush any remaining gasoline out of them. The source of ignition for the first explosion was the welding on the port saddle tank to stop a leak in the bulkhead separating that tank and the No. 5 port cargo tank. The key question is how an explosive atmosphere was allowed to develop in the No. 5 port cargo tank.

The sections of the bulkhead where the welding was being done were recovered and examined in the Safety Board's metallurgical laboratory. The examination revealed that the welder had burned through a thin area in the bulkhead and that the immediate area of the welding was in a molten state at the time of the explosion. The molten state, about 2500°F, was well above the 495°F auto-ignition temperature of the gasoline cargo, and the Safety Board concludes that a spark or piece of molten metal probably dropped down into the cargo tank to ignite the explosive vapors in it when the welding rod burned through the bulkhead.

Gasoline necessary to create an explosive atmosphere in the No. 5 port and starboard cargo tanks was probably a remnant from the last gasoline cargo, either gasoline remaining in the tank or gasoline flushed from the cargo lines when the tank was ballasted, or both. Alternately, the gasoline could have entered the tank after testing by way of the cargo piping, the inert gas system piping, or a fracture in the bulkhead between the No. 4 and 5 cargo tanks.

The master and chief mate testified that the cargo pi[illegible] except for the cargo manifold, had been flushed with seawater and that the pipes to the No. 5 cargo tanks had been left full of water to prevent any residual cargo in the deck pipes from gravitating into the No. 5 tanks. This procedure was apparently effective, since the No. 5 center tank had remained free of any explosive vapors during October 8 and 9. Moreover, the 14-foot head of water in the No. 5 port and starboard tanks would have inhibited any gasoline from gravitating into the tanks. Thus,

gasoline to fuel the explosion is unlikely to have entered the No. 5 port or starboard cargo tanks by way of the cargo pipelines.

The inert gas piping system was common to all cargo tanks, some of which had been inerted but still contained gasoline vapors. That system could have been a conduit for introducing gasoline vapors into the No. 5 port and starboard tanks. However, the stop valves to both tanks were found closed following the accident. What's more, examination of the stop valve to the No. 5 port tank revealed that the valve, like those to the No. 3 center, No. 5 center, and No. 4 port and center tanks, was in sound condition and was making an effective seal in the closed position. Since the inert gas piping system on the OMI CHARGER seems to have been operating properly at the time of the accident, it is unlikely to have introduced flammable vapors into either the No. 5 port or starboard cargo tank. The investigation did not reveal any evidence of a failure of the bulkheads between the No. 4 and 5 cargo tanks.

Thus, the Safety Board was unable to identify any means by which gasoline or gasoline vapor could have been introduced into the No. 5 port and starboard cargo tanks after the chief mate stated he had tested it.

Because the evidence did not indicate that gasoline or gasoline vapor entered the No. 5 port tank after 1520, when the chief mate said he completed testing, the Safety Board reviewed the tank preparation procedures used to make it safe for hot work.

When the No. 5 port and starboard cargo tanks were overflowed, the vessel was trimmed down at the stern about 13 feet, creating a wedge-shaped void over the width (22.5 feet) of the approximately 60 feet of tank that extended forward of the hatch trunk. Because the four main deck tank cleaning openings were closed, gasoline in the wedge would have been trapped in the top of the tank. Gasoline, which is lighter than and therefore floats on top of water, would also have been trapped in the 11.25-foot-long tank space aft of the hatch trunk between transverse web frames 49 and 50. Unlike the majority of transverse web frames, which were open at the overhead, transverse web frame 50 (located aft of the hatch trunk in the No. 5 port and starboard cargo tanks) was solid. Thus, the frame would have formed an isolated pocket of atmosphere above the ballast water that would have trapped gasoline on top in the No. 5 port and starboard tanks.

Operation of the two cargo pumps would have resulted in a substantial volume of water entering the tank and flowing out of the hatch trunk. However, the pipe discharge into the bottom of the tank would not have sufficiently agitated the entire water surface to flush gasoline from the wedge or from the isolated pocket aft of frame 50. Once the tank was full and water was flowing out of the trunk, the flow within the tank would have stabilized. The Safety Board concludes that overflowing failed to flush all gasoline from the tank and that enough gasoline remained in the No. 5 port cargo tank to produce sufficient vapors to fuel the initial explosion.

The No. 5 starboard cargo tank, like the No. 5 port cargo tank, had been overflowed in an attempt to flush out the remnants of gasoline in it, pumped down to a 36-foot ullage, and closed. Enough gasoline could have remained in the No. 5 starboard cargo tank after the

overflowing operation to produce sufficient vapors to fuel the second explosion. Like the first explosion, the second shows that overflowing is an ineffective means to clean a tank. The Safety Board was unable to identify the exact means by which the combustible atmosphere in the No. 5 starboard tank was ignited. The likelihood is that an opening developed in this tank as a result of the initial explosion or subsequent fire. Such an opening would have provided a path for flames to enter the tank and ignite the second explosion.

Analysis of damage in the area of the No. 5 starboard and center cargo tanks indicates that the second explosion was at least equal in magnitude to the first. Examination of vessel damage revealed that the second explosion ignited in and burst from the No. 5 starboard cargo tank into the No. 5 center tank as the tank ruptured and displaced the starboard longitudinal bulkhead. Burning cargo vapors from the No. 5 starboard cargo tank continued to expand inside both tanks. Overpressurization of the tanks by burning and expanding gases caused the main deck above the No. 5 starboard and center cargo tanks to bulge upward evenly across the two tanks. Then, explosive forces erupted from the No. 5 center tank into the atmosphere through the port longitudinal bulkhead, bending it outboard toward the port side and into the No. 5 port cargo tank and causing the fireball observed by vessels in the area.

Tank Preparation Procedures

Because proper tank preparation procedures were necessary to make the No. 5 port tank safe for hot work, the Safety Board examined the qualifications of the personnel involved. Both the master and chief mate had received formal training that included instruction in proper tank cleaning procedures, and both were experienced in cleaning and gas-freeing tanks, which is not a complex procedure. Moreover, they were familiar with the abundant guidance, which is clear and easy to understand, that prescribes gas-freeing standards for tank entry and for hot work. They were also aware that releasing petroleum into the sea was prohibited by Federal regulations and contrary to OMI instructions for avoiding pollution.

To weld safely in the port saddle tank, the No. 5 port cargo tank first had to be made either gas-free by means of washing and ventilating or nonexplosive by using the inert gas system on the vessel or by filling the tank with water and leaving it full. Nonetheless, the master and chief mate overflowed the No. 5 port cargo tank with seawater in an attempt to flush the remnants of the gasoline cargo from the tank rather than wash it using acceptable conventional methods. The chief mate, apparently confident in the effectiveness of overflowing to flush the tank, neglected to ventilate or inert the tank and to test the tank's atmosphere effectively before authorizing welding operations adjacent to the tank. The chief mate's critical omissions allowed an explosive atmosphere to exist and go undetected in the No. 5 port cargo tank. By instructing the chief mate to use an unauthorized tank cleaning procedure, the master failed to properly discharge his responsibility for safe operation of his ship.

Preparation of Tanks for the Shipyard

In early September 1993, the master and port engineer met in Tampa to discuss preparations for the vessel's September 7 entry into the Mobile shipyard. One topic of discussion was gas-freeing the ship for entry into the shipyard. They had several factors to consider: the amount, location, and nature of the ballast (clean or dirty) aboard the ship; the shipyard's ability to accept dirty ballast and washing slops; the need to gas-free the vessel; and the time and equipment available to do so. The master, with the concurrence of the port engineer, addressed some of these concerns by instructing the chief mate to overflow certain tanks. Overflowing was a method the master had used earlier in his career.

However, overflowing did not comply with the ship's certificate of inspection, which required that all tank washings, cargo residue, and ballast be pumped ashore for processing. In addition, the 1973/78 MARPOL international pollution prevention agreement prohibited discharging petroleum into the sea.

Despite the prohibitions, the chief mate did as the master instructed; before arriving at the shipyard, he overflowed the No. 3 and 5 port and starboard cargo tanks. The chief mate stated that since he had not overflowed tanks before, he experimented with the best way to do it, first overflowing the No. 3 tanks with the access trunk closed and the four tank cleaning hatches open and then overflowing the No. 5 tanks with the four tank cleaning hatches closed and the access trunk open. He said the latter method yielded a better flow rate. The chief mate stated that he did not ventilate the tanks following overflowing.

The chief mate testified that he did not know what to expect concerning the effectiveness of overflowing. Since he had never used the method before entering the shipyard, he was unaware of its limitations and derived his knowledge of it from this single experience. Upon arrival at the shipyard a few days later, a marine chemist tested all cargo tanks aboard the ship for combustible gases and oxygen levels and found them to be within permissible limits. After determining that the tanks were safe for use of an electric fan to ventilate, the marine chemist ordered overnight ventilation and conducted further testing the next day.

Overflowing had been directed by the chief mate's supervisor, concurred in by the port engineer, and in effect pronounced successful by an independent expert, the marine chemist employed by the shipyard. The Safety Board concludes that in combination with the instruction from the master, the one-time achievement of positive results using the method served as an endorsement of it to the chief mate, giving him confidence that overflowing was an effective, time-saving method for cleaning and gas-freeing tanks. That confidence undoubtedly influenced the chief mate's actions 1 month later when he prepared for hot work repairs in the port saddle tank.

Preparation of Tanks for Welding

The three methods for preparing spaces for hot work discussed in ISGOTT and OMI company guidelines are: wash and ventilate, flood with water, or inert. Washing and ventilating,

the most time-consuming of the three, was the method the chief mate used to prepare both the No. 5 center cargo tank and the pumproom; his choice of a safe and appropriate method in that instance was dictated by circumstances. The fact that human beings would be in those tanks (welders in the No. 5 center tank and the firewatch in the pumproom) made that option the only viable one available to the chief mate. He chose to flood the adjacent No. 5 port and starboard cargo tanks, in which no one would be present.

The chief mate tested and monitored the atmosphere in the No. 5 center tank and the pumproom, using a properly calibrated meter to test both spaces before hot work began. Thereafter, he remained in the No. 5 center tank, with the meter on during hot work, to continue monitoring the atmosphere. The chief mate also provided continuous blower-forced ventilation in the No. 5 center tank and the pumproom until the repairs were completed and everyone had left the tanks. The No. 5 port and starboard cargo tanks were full of water while hot work was being conducted in the No. 5 center tank. To this point, the chief mate's efforts to make conditions safe for hot work in the No. 5 center tank and adjacent tanks had closely adhered to the ISGOTT and OMI guidelines, except in the case of the port saddle tank, which was not gas-free.

The same guidelines applied to the hot work to be done on the bulkhead between the No. 5 port cargo and port saddle tanks. The work space had to be gas-free and the adjacent tanks had to be made safe. Since the hot work was to take place from within the saddle tank, that tank was appropriately washed and ventilated to permit human entry. The adjacent pumproom had already been washed and ventilated the day before. Still, the chief mate retested the pumproom on October 9 to be sure it remained gas-free. This action complied with the guidelines and was appropriate for safety.

The master and chief mate testified that both the port engineer and the welder had asked that the water level in the No. 5 port cargo tank be lowered below the weld site to facilitate an effective weld in the port saddle tank. To accommodate that request, a method other than filling with water had to be used to make the No. 5 port tank safe for hot work. The other two approved methods were inerting or washing and ventilating.

Washing and ventilating the No. 5 port cargo tank was an unattractive option for the chief mate because it would have required changing the ship's ballast configuration. He estimated that this process may have taken 12 hours.

Inerting the tank was also an unattractive option. The master and port engineer, according to the chief mate, had directed that after the welding was completed, a hose test was to be conducted on the bulkhead to ensure the leak had been stopped. If the No. 5 port cargo tank was inerted, no one could enter it to observe or to do the hose test until the inert gas had been removed, about a 2-hour process. The chief mate said he never considered inerting the No. 5 port cargo tank.

In sum, the master and chief mate used none of the three approved methods for making the No. 5 port cargo tank safe for hot work. Instead, they chose the expedient method, overflowing the tanks, that had been used successfully before entering the shipyard a month earlier.

The chief mate's actions on the day of the accident suggest he was confident that overflowing had left the No. 5 port and starboard cargo tanks gas-free. He elected to pump down the tanks, a process that draws in air to replace the fluid removed. Because changing the atmosphere could produce a volatile atmosphere, the tanks needed to be tested to determine whether the atmosphere had become volatile.

Testing would logically begin as soon as possible after the pumping down process to allow maximum time for additional gas-freeing measures if testing revealed they were necessary. (The hot work did not begin until some 7 hours after the pumping down process was completed.) The chief mate probably did not test early because he believed the No. 5 port tank was gas-free, thereby making testing unnecessary.

The ISGOTT guidelines state that testing should be conducted just before hot work begins (in this case, at 1800) and during the hot work. The chief mate testified that he conducted a test in the No. 5 port cargo tank between 1505 and 1515, about 3 hours before the hot work began, or about 5 hours before the explosion.

Because of the possibility of being overcome by noxious fumes, being injured, or drowning in the tank, acceptable safety procedures dictate that a second person stand by at the top of the tank to be available in the event of an emergency. The chief mate entered the tank alone, when no one else was around or likely to be around because the 1505-to-1515 period occurs during the ship's 20-minute "coffee time," a contractually planned break for crewmembers each day. Most crewmembers are in the crew mess at that time. Conducting tests before or after coffee time would have assured the availability of a crewmember to assist, thereby avoiding a safety risk that was unnecessary, given the short duration of the break and the lack of urgency to begin the welding repairs.

The chief mate's previous successful experience with overflowing and his apparent confidence that overflowing the No. 5 port cargo tank had succeeded in ridding it of the gasoline cargo argued against testing the No. 5 port cargo tank at all. That is, if no gasoline was present, why test? Considering his attitude, the inopportune testing time, the lack of witnesses to the test, the fact that the testing meter was functioning properly, and the likelihood that the gasoline that caused the explosion was always in the tank, the Safety Board concludes that the testing, if done at all, was inadequate to ensure that the No. 5 port cargo tank was safe for hot work.

The OMI CHARGER master testified:

> I've sailed with [the chief mate] for a long time. We know what we are carrying. This is an explosive. You cannot do hot work without testing. He just would not ever. No one in their right mind would weld on a bulkhead without testing the adjacent space.

The Safety Board agrees that testing of the tank was imperative before permitting hot work in an adjacent tank. Confidence in the effectiveness of overflowing as a means of tank cleaning may have prompted the chief mate to take a testing shortcut that failed to detect the residual

gasoline that fueled the explosion. The master's confidence in the chief mate apparently led the master to disregard his responsibility to provide effective management oversight, that is, to ensure that all testing had been accomplished properly and that the intended hot work could be conducted safely.

The master testified that the OMI CHARGER had sufficient time to comply with the schedule set forth under the vessel's charter agreement. He acknowledged, for example, that he was free to take as much time as was necessary to complete any repairs needed in the No. 5 port saddle tank. Preparations for repairs to the No. 5 cargo tank, including transfer of ballast, could have begun about 1900 the day before the accident. Even on the day of the accident, the chief mate delayed the repairs from about 1600 to 1800 to accommodate the evening meal. Therefore, the Safety Board concludes that the vessel's charter imposed no urgency or scheduling constraints that pressured the master and chief mate to compromise safety.

Sleep-Wake Cycles

Chief Mate.--According to the chief mate, he usually received 7.5 to 8.5 hours of sleep per night, although he altered his schedule as the demands of pumping cargo or ballast dictated. In the 3 days before the accident, he slept 3.5 to 4.5 hours, 6 hours 10 minutes, and 8 hours, respectively. The first night's sleep was severely limited, the second was more reasonable, and the third was the norm. Still, the chief mate is unlikely to have been fully rested. Sleep loss can accumulate and lead to impaired performance and diminished alertness. The Safety Board cannot determine whether one full night of sleep was sufficient for the chief mate to recuperate fully from his accumulated sleep loss of the previous 2 days. However, since the chief mate received directions from the master (with the concurrence of the port engineer) on how to prepare the various tanks, sleep loss probably did not influence the chief mate's actions.

Master.--Although the master did not recall his exact schedule, it generally allowed sufficient rest. During the 3 days before the accident, the ship's log revealed no unusual activities that would have prevented the master from adhering to his regular schedule. Thus, the master's directives concerning overflowing apparently were not a result of diminished mental alertness because of sleep loss.

Tank Testing Guidance

NFPA 306 provides guidance for marine chemists and is cited in Coast Guard regulations as the source of standards to be followed for hot work on tank vessels. Although it is a basic reference tool with which tank vessel personnel are familiar, NFPA 306 does not prescribe testing procedures to be followed in preparing for hot work. The Safety Board believes that considering the availability and prominence of NFPA 306, modification of it to include guidance on testing specifically designed for vessel personnel would enhance safety.

Safety Oversight

This investigation revealed that while written corporate, national, and international procedures concerning hot work, tank entry, tank cleaning and testing, and related topics were carried on board the OMI CHARGER and were known to the master and chief mate, they did not always comply with them.

Safe vessel operations require that shore-based management verify adherence to regulatory, national, and international operational safety procedures. Management ashore must obtain and evaluate safety and operational data that accurately reflect crew compliance with corporate safety policy and procedures. Companies are responsible for developing and implementing oversight procedures that yield measurable, verifiable feedback that can be used to evaluate compliance with safety policy and procedures on board vessels.

The Safety Board reviewed OMI's safety management system to determine the adequacy of the company's safety management and oversight as it applied to this accident. OMI had written procedures for tank entry, cleaning, purging, atmosphere testing, gas-freeing, and hot work that were up-to-date. The procedures, as set forth in the company's *Fleet Standing Orders* manual on board the tankship, contain adequate, clear, and understandable direction. If these procedures had been properly implemented on board the OMI CHARGER, they could have prevented this accident.

The actions of the master, who was the company's on-board management representative, in suggesting, supporting, and directing unsafe procedures for tank cleaning and hot work preparation were causal to the accident. Another causal factor was the lack of a corporate oversight program, which allowed conditions to develop that were dangerous and ultimately catastrophic to the vessel and its crew. The master can usually be expected to ensure that company directives and policies are adhered to aboard a vessel; however, exigencies do occur that lead a master to employ procedures not endorsed by management. Hence, corporate oversight is essential to prevent unsafe or illegal methods from becoming accepted practice. In this case, management oversight was insufficient to detect that the OMI CHARGER's master had adopted an unauthorized, ineffective procedure for cleaning cargo tanks.

Management responsibilities in marine transportation have historically been divided between corporate offices ashore and masters on board company ships. Time and distance between the two resulted in two distinct management operations. Although OMI's *Fleet Standing Orders* state that "the proper management of the vessel is the sole responsibility of the Master," the Safety Board maintains that corporate management cannot entirely assign away its responsibilities to a vessel's master. Management's responsibility resides at various levels throughout an organization, both on shore and at sea and regardless of geographic location.

The Safety Board found that while the OMI CHARGER crew had conducted numerous welding repairs in the past 3 years, not one hot work permit, which the vessel was required to submit, was on file in the company's offices. Such omissions should have led management to review its oversight procedures and take action. Whether its tanker officers were following

proper tank cleaning and testing procedures should have been areas of concern to OMI management. Yet the Safety Board found no evidence that OMI management had made any effort to monitor these operations on the vessel. Even OMI's shoreside management representative, the port engineer, who was aware that the master planned to overflow the No. 5 port and starboard cargo tanks to flush residue from them, made no effort to prevent the master from doing so. The port engineer in effect granted management's tacit approval for use of the ineffective overflowing procedure to clean the tanks.

Numerous reports were on file with the company from the vessel's officers, charterers, classification societies, the Coast Guard, and others. They all related to the OMI CHARGER's material condition, not to operational safety and practices. Nor were these reports directed to a corporate entity specifically responsible for vessel safety. The Safety Board believes that effective management oversight should extend to operational safety practices.

Therefore, the Safety Board concludes that OMI's oversight of the on-board operations of the master and chief mate was inadequate and ineffective. Furnishing its vessels with the company's *Fleet Standing Orders* manual, requiring the filing of forms with the main office, and a biannual visit from an independent safety auditor did not constitute adequate oversight. The company had no method in place to ensure that the *Fleet Standing Orders* were complied with, and OMI management did not verify that forms were submitted as required.

Effective management oversight of vessel operations should have prevented conditions conducive to an accident from developing on board the OMI CHARGER. Given the current state of communications technology, a telephone call or telefacsimile from a vessel to the home office would suffice to relay even the most minute details concerning a hot work repair or tank gas-freeing plan. No matter how many thousands of miles separate them, the company and its ships can readily communicate via the vessels' radiophone, satellite telephone, and telefacsimile machine.

A company's oversight program can emphasize safe tankship operations by using shore-based personnel to audit each vessel's operations regularly. Essential to the success of such a program is the systematic examination of each vessel's operational system, processes, procedures, certificates, and documentation, as well as an evaluation of crewmembers' training and experience. Once the organization's processes and procedures are documented, understood, and evaluated, an auditing program that includes frequent visits to the vessel can be developed and implemented.

The Safety Board believes that OMI should implement operational safety policies and procedures, managed and evaluated by company officials, that include an auditing program with verifiable feedback. Implementation of a uniform, companywide safety management system to identify, mitigate, control, or eliminate operational safety risks would significantly improve OMI's management of each vessel's safety.

Emergency Response Coordination

Numerous vessels responded quickly to evacuate the crew and fight the fire. During these operations, fire fighters faced the danger of additional explosions, since the vessel's cargo tanks were not gas-free and the ballast water was contaminated with residual gasoline. The prompt fire fighting effort prevented further structural deterioration and possible breakup of the vessel. By focusing on moving and cooling the burning ship and extinguishing the fire, fire fighters may have prevented channel blockage and release of 8,700 barrels of fuel oil into Galveston Bay during an incoming tide. The Safety Board concludes that the rapid response by many vessels resulted in timely evacuation of the crew and facilitated an effective fire fighting effort.

Fortunately, the OMI CHARGER was in ballast (empty). Had it been on its outbound run from Texas City, Texas, carrying more than 300,000 barrels of refined product, local fire fighting resources would have been overwhelmed; and officials would have been required to mount a rapid, multijurisdictional response, coordinated under one command, to extinguish the fire during extensive pollution mitigation activities. No such multijurisdictional organization exists in the Galveston Bay area of the Houston Ship Channel, nor has anyone been designated to assume command of such an effort. Moreover, even though the Port of Houston has fire boats, they are not authorized to proceed below Morgan's Point in the upper Galveston Bay, and the OMI CHARGER was not within their jurisdiction.

OPA 90 required the operator or owner of tank vessels carrying oil in bulk to submit to the Coast Guard a Vessel Response Plan (VRP) by February 18, 1993. As specified under 33 CFR Part 155, that plan must include placement of a "qualified individual" at the site to work with the Federal on-scene coordinator and implement oil spill mitigation procedures. This accident was one of the first major incidents investigated by the Safety Board for which a VRP was in place.

The response was timely and effective largely because the TALLAHASSEE BAY, commanded by a well-trained and experienced master, was available at AMOCO's Texas City facility to deploy immediately and direct the fire fighting effort. In addition, under OMI's VRP, shoreside support personnel, salvors, and qualified individuals had been delegated to deal with such emergencies and to communicate with the Federal on-scene coordinator. During the initial stages of the emergency, OMI asked AMOCO to coordinate fire fighting and pollution mitigation operations and contracted Smit America to coordinate salvage operations. Because the responsible party or individuals were immediately available, the VRP was effective in mitigating the consequences of the vessel fire.

The Galveston Bay ACP identifies numerous marine fire fighting resources, and their effective deployment requires planning and preparation. For example, within the first 30 minutes of the incident, more than six local towing and offshore supply vessels responded voluntarily to fight the fire. The master of the TALLAHASSEE BAY stated that when he arrived around 2100, about 1 hour after the first explosion, he observed that hose streams from the fire monitors of the vessels were not being directly applied to the fire or deck on the OMI CHARGER and "everyone was standing back." Shortly afterwards an explosion took place.

The Safety Board has long maintained that responsibility for control of vessel fires occurring outside a local county or municipal fire jurisdiction rests with the Coast Guard. Among the COTP's responsibilities are contingency planning for port emergencies, such as fires, spills, and other maritime casualties. Each COTP zone must develop port contingency plans that contain guidelines for effective coordination of Federal and local resources in the event of emergencies. The Coast Guard's *Marine Safety Manual*, Volume 6, Chapter 8, Section B states:

> Paramount in preparing for vessel or waterfront fires is the need to integrate Coast Guard planning and training efforts with those of other responsible agencies, particularly local fire department and port authorities. COTPs shall work closely with the municipal fire department, vessel and facility owners and operators, mutual aid groups, and other interested organizations. The COTP shall develop a firefighting contingency plan which addresses firefighting in each port in the COTP zone.

However, the Galveston MSO does not have a port contingency plan for vessel fires beyond the notification procedures set forth in its *Command Duty Officer's Manual*. What's more, the Galveston Bay ACP, developed in response to OPA 90, is limited solely to pollution response. Lacking is a comprehensive contingency plan that incorporates fire fighting contingency plans for the entire Galveston Bay area. The Safety Board believes that the current Galveston Bay ACP could provide a framework and format for fire fighting contingency plans for the area.

Following a review of this accident, the COTP and the Houston-Galveston Navigation Safety Advisory Committee identified several deficiencies in the Houston-Galveston-Texas City Ship Channel contingency plans. "Although we have identified local private and commercial firefighting resources," the COTP stated, "the single largest problem with local plans is the lack of a marine firefighting coordinator for Galveston Bay." Subsequently, the COTP appointed a project officer to approach representatives of the local maritime community, local emergency planning committees, and local fire fighting agencies.

The project officer found that the maritime industry is cautious about establishing a marine fire fighting capability; its primary concern is liability. He noted that local authorities are concerned but keep their distance from this issue because they have neither the responsibility for marine fire fighting nor the resources to support such an effort. Galveston Bay includes several jurisdictions, and as the COTP noted, "It appears everyone has an interest, but no one has the ball." The Safety Board's position is that these deficiencies must be addressed for the Galveston Bay area and the Houston Ship Channel, particularly in light of the massive size of the Houston-Galveston petrochemical complex and incidents such as the June 1990 MEGA BORG accident, which involved considerable fire fighting resource coordination over a 2-week period.

Adding to the urgency of the situation is the increase in vessel traffic and congestion in the Houston Ship Channel over the past several years. Interruption of marine traffic on the Houston Ship Channel to the Ports of Houston, Texas City, and Galveston would have enormous economic impact. Beyond the vessel loss in this accident, the Coast Guard incurred $183,000 in costs for facilities and personnel responding to the accident, and local (nongovernment)

responders in the Houston Ship Channel and Galveston Bay area incurred undetermined expenses. Shipping industry losses totaled $8 to 10 million due to marine traffic stoppage and delays in the channel, resulting in subsequent losses to local commercial and industrial organizations. OMI's costs for salvage and removal of the vessel amounted to $1 million; the company's revenue losses and liability costs have yet to be determined.

Salvage and vessel fire fighting are professions requiring a high degree of expertise; inexperienced responders might inadvertently allow a channel blockage to occur that could be prevented. The Safety Board concludes that the absence of readily available fire fighting resources such as a port fireboat and marine fire fighting coordinator seriously undermines the effectiveness of a response to a major marine accident in the Houston-Galveston area. A marine fire fighting coordinator, available 24 hours a day, is needed to ensure that marine fires can be quickly brought under control and prevented from spreading in the large petrochemical complex.

The Safety Board believes that the Coast Guard, together with the Texas Department of Public Safety (Division of Emergency Management), which is mandated to "adopt standards and requirements for local and interjurisdictional emergency management plans," should develop a fire fighting contingency plan for the Galveston Bay area that ensures rapid response with adequate fire fighting resources to a major shipboard fire. This plan should clearly delineate lines of authority and responsibility for fighting a shipboard fire and mandate that a written agreement be formulated among fire fighting authorities within the COTP zone.

The Safety Board believes that the COTP should facilitate agreements between vessel owners and marine salvage firms for contracting fire fighting services. Because private salvors are in the business of saving shipboard property, they should be called as soon as extinguishing a fire is no longer within the municipality's capability. The Coast Guard and the local authorities can then assume fire fighting support roles, which they are generally able to fulfill effectively.

Galveston is but one of many ports without a marine fire fighting contingency plan, and the circumstances of the OMI CHARGER accident raise questions about other ports that do not have fireboats or marine fire fighting plans. Based on a 1994 Safety Board survey and contacts with Coast Guard MSOs, fire fighting contingency plans for the ports of New York, Louisville, Port Arthur, Memphis, Portland, Baltimore, and others are being revised or do not exist. (See appendix D.) The Safety Board believes that policy and guidelines to assist COTPs in other ports that lack fireboats or marine fire fighting coordination personnel are clearly needed.

As a result of its investigation of previous accidents, the Safety Board has addressed issues concerning jurisdictional responsibility and the adequacy of fire fighting resources. On February 14, 1982, a fire erupted in the engineroom of the Cypriot bulk carrier PROTECTOR ALPHA while it was moored to the dock in the Columbus River near Kalama, Washington. Three crewmen were injured and damage was estimated at $15 million. The Safety Board found that failure to provide rapid response capability contributed to the propagation and spread of the fire aboard the ship. The Safety Board advised that while the Ports and Waterway Safety Act of 1972 definitely establishes a Coast Guard role in protecting life and property in, on, and along the navigable waters of the United States, the degree to which the Coast Guard should actively

participate in the attempt to save property from fire is not clearly defined. Therefore, the Safety Board recommended that the Coast Guard:

M-83-7

Establish and execute a policy whereby private fire fighting and marine salvage firms are summoned to take control of fire fighting activities if the immediate extinguishment of a shipboard fire is beyond the capabilities of the local fire department, or if the fire occurs while the ship is located outside a municipal fire jurisdiction. (Class II, Priority Action)

In its June 21, 1983, and March 23, 1994, responses to this recommendation, the Coast Guard pointed out that it does not have the authority to contract private firms for service without the owners' permission and that it can only alert private firms and put them in contact with owners and operators of burning ships. The Safety Board contends that the Coast Guard already has sufficient authority under the Ports and Waterways Safety Act and OPA 90 to require the recommended fire fighting policy. Because the Coast Guard plans no further action, Safety Recommendation M-83-7 was classified "Closed--Unacceptable Action" on November 28, 1994.

The Safety Board cannot understand why the Coast Guard, in the 12 years since the PROTECTOR ALPHA accident, has not fully developed fire fighting contingency plans for all U.S. ports. To ensure a prompt, well-coordinated response to major port fires, the Safety Board urges the Coast Guard to review existing fire contingency plans for all U.S. ports and, as required by its own *Marine Safety Manual*, Volume 6, Section 8D, Contingency Planning for Firefighting Activities," to complete and update these plans by January 1996. At a minimum, the plans should include initial notification procedures and identification of resources to be provided and actions to be taken by vessel operators and the community. But first and foremost, they should identify jurisdictional authority and responsibility for fighting a ship fire at different locations and, to the extent possible, should prescribe the chain of command.

Timeliness of Toxicological Sampling

OMI's Houston-based marine superintendent had experience with postaccident testing. His responsibility for stabilizing the situation and ensuring the crew's safety encompassed various tasks that arise following such an event. Action to ensure timely collection of toxicological samples is only one of those tasks, albeit an important one.

Although OMI recognized that many tasks must be performed after an accident, including postaccident toxicological sampling, that task was not given sufficiently high priority. Many hours passed before the MSO investigator's reminder prompted initiation of the sampling process. The Safety Board concludes that postaccident toxicological sampling did not occur in a timely manner.

To determine whether drugs and alcohol caused or contributed to an accident, toxicological sampling must take place soon afterwards. Because alcohol and, to a lesser degree, drugs are

quickly eliminated from the body (generally at a rate of 0.015 to 0.018 percent of alcohol per hour), delays in obtaining samples hinder assessment of the effect of alcohol or drugs on an individual's performance. The Safety Board believes OMI should speed the collection of samples by predesignating a company representative whose primary responsibility in the event of an accident is to initiate and ensure completion of postaccident toxicological specimen collection as soon as possible.

The memorandum that the MSO investigator read to OMI's attorney was effective and showed foresight and initiative on the part of the Coast Guard lieutenant. As a result of its investigation of the 1992 grounding of the QUEEN ELIZABETH 2,[33] the Safety Board recommended that the Coast Guard provide guidelines to boarding officers about informing marine employers of their responsibility to conduct toxicological testing as soon as practicable and about providing assistance when necessary. The Safety Board has subsequently discussed the need for such guidelines after investigating other accidents.[34]

The Coast Guard concurred with the need for guidelines and issued an "All Districts" message (ALDIST 179/94) on November 15, 1994, directing that after an accident investigators "immediately alert the involved marine employers to their responsibilities." The message further states that with respect to drug testing procedures, "Coast Guard personnel shall not provide urine collection materials or perform as the collection site person. Coast Guard personnel may suggest local sources for those materials and services." To facilitate alcohol testing, according to the message, "Appropriately qualified Coast Guard or other local law enforcement personnel may perform breath tests, if such testing would be more timely than the testing arranged by the marine employer or if there is any concern that testing would not otherwise be accomplished." The Coast Guard also plans to incorporate provisions of ALDIST 179/94 in future changes to the *Marine Safety Manual*. The Safety Board therefore classifies Safety Recommendation M-94-11 "Closed--Acceptable Action."

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[33] That safety recommendation (M-93-24) was superseded by Safety Recommendation M-94-11, issued as a result of the Safety Board's investigation of the collision of the U.S. towboat CHRIS with the Judge Seeber Bridge in New Orleans, Louisiana, on May 28, 1993 (NTSB/HAR-94/03).

[34] See, for example, Marine Accident Report--*Collision of the U.S. Towboat FREMONT and Tow with the St. Vincent and Grenadines-Registered Containership JURAJ DALMATINAC, Houston Ship Channel, December 21, 1992* (NTSB/MAR-93/02); Highway-Marine Accident Report--*U.S. Towboat CHRIS Collision with the Judge William Seeber Bridge, New Orleans, Louisiana, May 28, 1993* (NTSB/HAR-94/03); and Railroad-Marine Accident Report--*Derailment of Amtrak Train No. 2 on the CSXT Big Bayou Canot Bridge near Mobile, Alabama, September 22, 1993* (NTSB/RAR-94/01).

CONCLUSIONS

Findings

1. Weather, sea conditions, crew qualifications, sleep loss, and use of drugs or alcohol were not causal factors in this accident.

2. Overflowing was not effective in flushing gasoline from the No. 5 port cargo tank, and consequently enough gasoline remained in it to fuel the initial explosion.

3. The source of ignition for the explosion in the No. 5 port cargo tank was the welding process in the port saddle tank.

4. The chief mate's one-time achievement of positive results using the overflowing method, in combination with the master's instruction to use the method, gave the chief mate confidence that overflowing was an effective, time-saving method for cleaning and gas-freeing tanks.

5. Despite the chief mate's testimony to the contrary, available evidence indicates that the No. 5 port cargo tank was not adequately tested, if tested at all, to determine whether the tank was safe for hot work.

6. The OMI CHARGER's charter imposed no urgency or scheduling constraints that pressured the master and chief mate to compromise safety.

7. OMI Corporation's and OMI Bulk Management's oversight of the on-board operations of the master and chief mate was inadequate and ineffective, allowing conditions to develop that led to this accident.

8. The voluntary, rapid response by many vessels in the Houston-Galveston area resulted in timely evacuation of the crew and facilitated an effective fire fighting effort.

9. The absence of readily available fire fighting resources such as a port fireboat and marine fire fighting coordinator seriously undermines the effectiveness of a response to a major marine accident in the Houston-Galveston area.

10. Postaccident toxicological sampling did not occur in a timely manner.

Probable Cause

The National Transportation Safety Board determines that the probable causes of the explosions and fire on the U.S. tankship OMI CHARGER were (1) the failure of the master and chief mate to follow prescribed company and industry guidance to ensure that the No. 5 port cargo tank was safe before permitting welding on the tank and (2) inadequate oversight by OMI Corporation and OMI Bulk Management Company, which allowed unsafe practices to develop over an extended period of time.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board makes the following recommendations:

--to the U.S. Coast Guard:

Develop, in coordination with the Texas Department of Public Safety, a fire fighting contingency plan for the Galveston Bay area that ensures a rapid response with adequate fire fighting resources to a major shipboard fire. (Class II, Priority Action) (M-94-46)

Review existing fire contingency plans for all U.S. ports to ensure that these plans are complete and up-to-date by January 1996 and that they include, at a minimum, initial notification procedures, jurisdictional authorities, and identification of resources to be provided and actions to be taken by the Coast Guard, vessel operators, and the community. (Class II, Priority Action) (M-94-47)

Develop policy and guidelines to be used by the Captains of the Port in facilitating agreements between vessel owners and marine salvage firms for contracting fire fighting services. (Class II, Priority Action) (M-94-48)

--to OMI Corporation and OMI Bulk Management Company:

Implement an auditing program to ensure that corporate policy and guidance related to critical safety functions, including tank cleaning, tank testing, and tank entry, are followed aboard company vessels. (Class II, Priority Action) (M-94-49)

Develop a postaccident toxicological testing policy and procedures that include prearrangements designed to enhance collection of samples as soon as practicable following the occurrence of a serious marine incident. (Class II, Priority Action) (M-94-50)

--to the National Fire Protection Association:

Amend your publication NFPA 306 to include specific guidance about gas testing that is readily comprehensible by tank vessel operating personnel. (Class II, Priority Action) (M-94-51)

--to the Texas Department of Public Safety, Division of Emergency Management:

Develop, in coordination with the U.S. Coast Guard, a fire fighting contingency plan for the Galveston Bay area that ensures a rapid response with adequate fire fighting resources to a major shipboard fire. (Class II, Priority Action) (M-94-52)

APPENDIX A

Investigation

The National Transportation Safety Board was notified about this accident at 0100, October 10, 1993, and immediately dispatched four accident investigators from Washington, D.C., headquarters to Houston, Texas, to begin the investigation.

The Safety Board and the Coast Guard jointly investigated the accident under the authority of section 304(a)(E) of the Independent Safety Board Act of 1974 and in accordance with 49 CFR 850 (Coast Guard-NTSB Marine Casualty Investigations).

This report is based on the factual information developed as a result of the investigation and on Safety Board analysis. The Safety Board has considered all facts in the investigative record relevant to its statutory responsibility to determine probable cause of the accident and to make recommendations. The Safety Board has made its analyses and recommendations independently of the Coast Guard.

The following parties participated in the investigation: OMI Bulk Management Company, the master of the OMI CHARGER, the chief mate of the OMI CHARGER, and the estate of the chief pumpman, who was one of three people fatally injured in the accident.

The Safety Board did not conduct a public hearing during the investigation; the joint NTSB-Coast Guard Board of Investigation took sworn testimony at Galveston, Texas, on October 12-15, 1993, and at Houston, Texas, on January 5-6, 1994.

APPENDIX B

Crew Information

Master.--Captain Wayne Edward Nason graduated from Maine Maritime Academy in 1970. He earned a bachelor of science degree in nautical science and a third mate's license. He began sailing in 1970 and has served on board tankers almost all his career, having served on only one freighter.

Captain Nason first held the position of chief mate in 1981 for Coastal States Gas. He obtained his master's license in 1983 and was first employed as a master in 1984 by Marine Transport Lines. From 1985 to 1987, he worked for Ocean Shipholding, Inc., as both a master and a chief mate.

Nason has worked for OMI (and its predecessor, Rio Grande Transport, Inc.,) since 1987, primarily on board the OMI CHARGER, both as chief mate and master. He has served exclusively as a master since 1988. OMI's VP (Ops) stated that if and when the OMI CHARGER is returned to service, he "felt comfortable in turning it back over to Captain Nason."

Captain Nason's license is, "master of ocean steam or motor vessels of any gross tons; also, radar observer - unlimited (expires December 1997)."

Chief Mate.--Chief Mate Robert Lawrence Wren graduated from the U.S. Merchant Marine Academy at Kings Point, New York, in 1981. He earned a bachelor of science degree in nautical science-marine transportation and received his third mate's license. The curriculum at Kings Point included a course in tank ship operations and safety, including tank cleaning methods. The chief mate also completed a 1-week "Inert Gas Systems and Crude Oil Washing" school at the Maine Maritime Academy's Center for Advanced Maritime Studies in August 1986.

The chief mate began working in the tankship industry in 1982. Between 1982 and 1985, he was employed by Union Oil Company of California (Union Oil) as second and third officer aboard two chemical tankers. His duties included maintenance of cargo systems and control of segregated ballast. He was laid off by Union Oil when his assigned vessel suffered a casualty. He was not aboard the vessel at the time.

From 1985 to 1988 and again from 1988 to 1989, he worked for Keystone Shipping Company as a chief mate aboard a chemical carrier, a products carrier, and a crude oil carrier. His duties included supervision of cargo operations and tank cleaning procedures. He also served as a second mate aboard a coal carrier and another products carrier. As second mate, he was responsible for cargo system maintenance and ballast control, as well as other duties.

For 10 months in 1988, Wren worked for Martech Unlimited, Inc., as a marine surveyor-marine consultant. He administered cargo loss control and tanker expediting programs.

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APPENDIX C

OMI Hot Work Permit

OMI CORP. 280 PARK AVENUE, NEW YORK, N.Y. 10017 (212) 949-4500

HOT WORK PERMIT

Vessel Name	Date/Time of Inspection	Location of Vessel
Master's Name	Name and rank of Officer conducting Gas Free inspection	Name and rank of Senior Officer supervising work

Name and rating of designated Fire Watch

Brief description of prevailing weather conditions

Purpose of hot work _____

Location of site and general description of its condition _____

Is site an enclosed space? Yes / No

Method of testing for flammable and/or toxic gases and results of test _____

Type and condition of flammable gas testing and oxygen analyzing equipment _____

Date above equipment tested for proper calibration and operation _____

Methods of ventilation and/or means for maintaining gas free or inerted status of job site and adjacent areas

Listing of areas adjacent to site of hot work and description of their condition _____

APPENDIX C

Is fire main to be pressurized and hoses lead out? Yes / No

Are suitable portable fire extinguishers available at the site and adjacent areas? Yes / No

List of types and specific location _____

_____

List brief description of specific responsibilities of designated fire watch _____

_____

_____

This form is intended to insure a high degree of control and supervision when hot work is carried out. Before this permit is issued authorizing hot work the following conditions must be met. Initial next to each signifying compliance.

1. The area and any equipment to be worked on is free of flammable material and in a non-flammable atmosphere as well as being isolated from sources of hydrocarbons by means of disconnecting, blanking or inserting blinds. _____
2. The work area is clear of any combustible material such as oil soaked rags, wood, sediments, etc. _____
3. Welding or other equipment being used is properly earthed. _____
4. The degree of risk and potential sites of accidental release of hydrocarbons in the area have been fully assessed. _____
5. Fire fighting equipment is ready for immediate use. _____
6. The frequency of atmospheric testing has been established, and the use of portable continuous gas tester selected if appropriate. _____
7. An effective means of containing and extinguishing welding sparks and molten slag has been developed and implemented. _____
8. Personnel involved have been briefed and/or trained as appropriate. _____

This is to certify that I have personally determined that all spaces in the foregoing list are in accordance with NFPA 306 Control of Gas Hazards on Vessels and have found the condition of each to be in accordance with its assigned designation.

This Certificate is based on conditions existing at the time the inspection herein set forth was completed and is issued subject to compliance with all qualifications and instructions.

_____ _____

Name of person issuing permit Signature

ISSUED IN TRIPLICATE: ORIGINAL TO JOB SITE
COPY TO VESSEL FILES
COPY TO NEW YORK OFFICE

APPENDIX D

Status of U.S. Port Fire Fighting Plans

In October and November 1994, the Safety Board contacted more than 25 Coast Guard Marine Safety Offices (MSOs) and area commands to obtain their marine fire fighting contingency plans. Except where noted, fire fighting contingency plans were either not up-to-date or not available.

MSO-COTP AREA	COMMENTS
Huntington, WV	Yes (Revised 3/91)
Juneau, AK	Yes
Anchorage, AK	Yes (Revised 9/87)
Wilmington, NC	Reportedly has a plan that is being revised
Louisville, KY	No
New York/New Jersey*	No - Memo of Understanding Only
Baltimore, MD*	Reportedly has a plan that is being revised
Galveston, TX	No - Duty Officer Operations Manual (Notification Procedures Only)
Portland (Maine/Hew Hampshire)	No
Buffalo, NY	No - probably will be completed in July 1995
Port Arthur, TX	No - Duty Officer Operations Manual (Notification Procedures Only)
St. Louis, MO	Yes (Revised 8/90)
Hampton Roads, VA	Yes (Revised 1/92)
Miami, FL	Yes

MSO/AREA COMMAND	COMMENTS
Memphis, TN	No
New Orleans, LA*	Yes
Corpus Christi, TX	Yes (Revised 9/89)
Mobile, AL*	Yes (Revised 9/92)
Charleston, SC	Yes (Revised 12/91)
San Juan, Puerto Rico	No
Cleveland, OH*	Yes (in final stages of review)
Grand Haven (Southeast Michigan)	No

*Has a port fire boat

END

FILMED

DATE:

3-16-95

NTIS