MARINE CASUALTY REPORT

STRUCTURAL FAILURE AND SINKING OF THE TEXACO OKLAHOMA OFF CAPE HATTERAS ON 27 MARCH 1971, WITH THE LOSS OF 31 LIVES

U.S. COAST GUARD
MARINE BOARD of INVESTIGATION REPORT
and COMMANDANT'S ACTION

ACTION BY
NATIONAL TRANSPORTATION SAFETY BOARD

DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C. 20591

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ACTION BY THE NATIONAL TRANSPORTATION SAFETY BOARD

This casualty was investigated by a U.S. Coast Guard Marine Board of Investigation convened at New York City, New York, on March 31, 1971. A representative of the National Transportation Safety Board attended the proceedings as an observer. Hearings were also held at Port Arthur, Texas. The National Transportation Safety Board has considered only those facts in the investigative record which are pertinent to the Safety Board's statutory responsibility to determine the cause or probable cause of the casualty and to make recommendations.

SYNOPSIS

At 0330, March 27, 1971, the tankship SS TEXACO-OKLAHOMA, fully loaded with a cargo of black oil, broke in two about 120 miles northeast of Cape Hatteras, North Carolina. The ship was en route from Port Arthur, Texas, to Boston, Massachusetts, and was proceeding at very slow speed in a severe storm when the casualty occurred. The ship split in the vicinity of No. 5 tanks and submerged all of the crew asleep in the forward deckhouse. The forward section then reversed direction and drifted down on the stern section, destroying the starboard lifeboat before the stern section was backed safely away. None of the 13 crewmembers on the forward section survived. The crewmembers on the stern section attempted to attract passing ships by firing flares, blinking white and red lights, and sounding the ship's whistle. One ship responded to the light signals but no distress signals were identified and she departed. The crew also operated the portable lifeboat radio transmitter for at least 12 hours without knowing that distress signals were not being received. The stern section sank at about 0600 Sunday, March 28, which was the time the ship was scheduled to arrive in Boston and 27 hours after the ship broke in two. The crewmembers abandoned the stern, using one 15-person inflatable raft and two rafts improvised from empty oil drums. About 10 hours later, a merchant vessel discovered the raft, rescued 11 survivors, and initiated an extensive rescue effort. Subsequently, two more crewmembers who had been in the water about 32 hours were rescued. Thirty-one of the 44 crewmembers perished in this casualty.

The National Transportation Safety Board determines that the probable cause of the TEXACO-OKLAHOMA hull fracture was the high stresses produced by heavy seas and other forces on the relatively lightly constructed, fully loaded ship. The design, maintenance, and operating standards inherently contained risk levels which were excessive for vessels of this type transiting the seas off Cape Hatteras in winter storms.

The following are considered to be contributing causal factors:

1. The use of a section modulus (a measure used in evaluating longitudinal strength) which results in a relative stress near the upper end of the "acceptable" limit and, therefore, a relatively high risk level.

2. The increase in the load line of the TEXACO-OKLAHOMA in 1967, without change in section modulus, thereby increasing the loaded sagging stresses and the wave-induced loads, with the consequent increase in risk level.

3. The year-round designation of seas off Cape Hatteras as a "summer zone" for load line purposes without knowledge of measured sea conditions in the winter storms that frequent that area.

4. The low probability, with the techniques used during annual drydock and biennial inspections, of detecting all cracks and assuring that steel wastage for all portions of tank interiors has not exceeded permissible limits.

The following contributed to the loss of life subsequent to the splitting of the TEXACO-OKLAHOMA:

1. Failure of the lifeboat radio transmitter to broadcast a distress signal.

2. Lack of sufficient rubber liferafts to accommodate the remaining 31 crewmembers after both lifeboats were lost.

3. Failure of the crew to make an SOS signal by flashing light after they attracted a passing ship.

4. Lack of an effective alerting and appraising procedure for an overdue ship.

SUMMARY OF FACTS

The Vessel:

The TEXACO-OKLAHOMA was one of a class of tankships 632 feet long, 90.4 feet in breadth, and 45.4 feet in depth, built between 1956 and 1959. The ship had a common tank vessel configuration with a deckhouse at the forward one-third point, containing the deck officer's quarters, radio room, and navigating bridge. The stern contained the machinery spaces and living quarters for the remainder of the crew. The propulsion plant consisted of twin boilers driving a 15,000 horsepower steam turbine geared to a single propeller. Two longitudinal and 11 athwartship bulkheads subdivided the main hull to provide 30 individual cargo tanks numbered 1 through 10 with designations to show port, center, or starboard locations. Peak tanks, deep tanks, fuel tanks, feed and portable water tanks were located forward and aft of the cargo tanks.

The TEXACO-OKLAHOMA, official number 275882, was built at Sparrows Point, Maryland in 1958. She was of all welded steel construction except for eight riveted longitudinal shell plating seams and a riveted gunwale plate. Her design and construction had been approved by the U.S. Coast Guard and her hull and machinery were certificated by the American Bureau of Shipping (ABS) at its highest classification. This vessel was operated by Texaco, Inc. on an 18-year bareboat charter from her owner, Wilton Shipping Company, Inc., New York City, N.Y.

The Voyage:

On March 22, 1971, the TEXACO-OKLAHOMA completed loading 220,000 barrels of fuel oil at the Texaco Dock, Port Arthur, Texas. No record exists showing the sequence of tank loading. However, a "Gauge and Inspection" report prepared at that time shows that all cargo tanks were full except No. 3 and No. 5 port and starboard tanks which were empty, No. 9 port and starboard which were about two-thirds full, and No. 9 center tank which was about one-third full. The drafts were reported as 35 feet forward and 36 feet aft. Vessel drafts at this dock are influenced by silting conditions which vary with time and position along the dock and by fluctuations in the salinity and, therefore, the density of the seawater. A true draft reading corrected for salinity and taken away from the dock to remove the silting influence is not available. Computation of the draft in sea water using the tank loading data results in a draft of 35 feet 4.4 inches forward and 35 feet 3.6 inches aft. The ship's radio message to its port of destination gave an arrival draft of 35 feet 6 inches. The maximum summer load line mean draft permitted by the ABS load line certificate was 35 feet 8 inches.

The TEXACO-OKLAHOMA departed Port Arthur, Texas at 1600, March 22, 1971, for Boston, Massachusetts, manned by a crew of 44. The master had been aboard about 2 weeks in relief of the regularly assigned master. He had served with Texaco as a licensed officer for about 20 years and had served as master of seven other Texaco tankers for about 6 years. For 3 days, the voyage was routine as the TEXACO-OKLAHOMA followed a normal coastwise route at full speed of 93 RPM. While heading northerly off the coast of Florida on March 25, the ship began to encounter heavy weather. By Friday, March 26, wind and sea conditions had intensified, and it was necessary to alter the ship's course temporarily whenever a crewmember had to go out on deck. About 1330, on March 26, the ship was slowed to 86 RPM to permit using some of the propulsion steam to heat the cargo in preparation for unloading at Boston. Between 1600 and 2000, the ship was slowed to 75 RPM because of the heavy seas. At about 2015, speed was again reduced, to 65 RPM, and within a few minutes the master ordered reduction to 60 RPM. About 15 minutes later, the third mate on watch ordered reduction to 50 RPM which was the last speed change ordered by the bridge. The ship was then encountering whole gale sea conditions with 30 to 40 foot waves washing over the decks. The wind was blowing generally from the northeast at 60 to 65 knots. The ship was rolling and pitching moderately to heavily.

The Casualty:

During a combined forward pitch and starboard roll at 0330 Saturday, March 27, some of the crewmembers on the stern section heard a loud "crack" followed by a "bumping" sensation a few seconds later. The stern remained pitched, with the forward end lower than the after end. The engine stopped immediately. Although the nature of the emergency was not immediately known, individual crewmembers on the stern passed the alarm to all who were asleep. The TEXACO-OKLAHOMA split aft of the forward deckhouse in the vicinity of No. 5 tanks. The two sections separated. Within about 5 minutes, the bow reversed direction and drifted towards the starboard side of the stern section where the crew was attempting to prepare No. 3 lifeboat for launching. The bow section was tilted at an attitude reported as 45° "bow-up". However, the anchors were reported to have been at the level of No. 3 lifeboat and the master's stateroom was awash, which would indicate an actual angle of about 10 to 15°. The only sign of life on the bow section was an apparent signalling by flashlight by someone in the wheelhouse. The starboard bow began striking and rubbing against the starboard side of the stern section, destroying No. 3 lifeboat and its davits and generating sufficient heat to burn the paint inside the engineroom. To avoid further damage, the stern section was backed away from the bow section which then drifted out of view.

Except for a slight trim by the head, the stern section was little affected by the casualty. All machinery remained operable. The port boiler was secured shortly after 0400, since there were signs of possible salting and since the starboard boiler supplied all needs for steam. Plumb bobs were rigged to keep track of any changes in trim and list to detect any signs of failures in the cargo tanks forward. During the morning, a slight starboard list developed which was corrected by transferring some fuel to the port tank and by pumping accumulated bilge water overboard.

At about 0600, the bow section reappeared and drifted down toward the stern section. No signs of life were evident. The stern was again backed away and visual contact with the bow section was lost. One survivor stated that he last saw the bow section about 1300 Saturday, March 27. The bow section was equipped with two lifeboats, a 10-man liferaft, life preservers, and ring buoys. The liferaft was installed to permit automatic release and inflation upon sinking of the ship. However, this raft was never recovered.

The stern section was equipped with two lifeboats, a 15-man inflatable liferaft, life preservers, and ring buoys. Prior to the casualty, the port lifeboat had been stripped for maintenance in preparation for an annual Coast Guard inspection. Placing this lifeboat out of service was permitted by Coast Guard regulations, based on the fact that the remaining operable lifeboats had sufficient capacity to accommodate all persons on board the ship. After the starboard lifeboat had been destroyed, the crew restored the No. 4 port lifeboat to an operating condition and made it ready for launching in the event the stern had to be abandoned. However, at about 2030, Saturday evening, heavy seas carried this lifeboat away.

The Lifeboat Emergency Radio Transmitter:

Shortly after the TEXACO-OKLAHOMA split, the crew set up the lifeboat emergency radio transmitter. This radio is a manually operated Mackay Type 401 manufactured by International Telephone and Telegraph, Inc. In the automatic mode, it transmits alternately SOS and auto-alarm signals on 500 KHz and SOS and direction finder signals on 8364 KHz. The power output is 1.7 watts on 500 KHz and 0.4 watts on 8364 KHz when properly connected and tuned. In the manual mode, the unit acts as a receiver on either frequency selected and acts as a transmitter for Morse Code when the manual key is operated. An antenna with support halyards, a collapsible mast, a ground wire, instructions, and the Morse Code are provided with the unit.

The radio transmitter was normally serviced and tested by the radio operator who was lost with the bow section. None of the crewmembers on the stern were familiar with this unit nor with the Morse Code. However, they did read the detailed instructions that were furnished with the equipment for rigging and operating the transmitter. The antenna and ground were rigged on the poop deck. The transmitter itself was tuned inside on the mess deck; it is not known if, or how, the antenna was attached during the tuning. Proper attachment of the antenna and ground wire and operation of the tuning dials were critical to the operation of the transmitter. Four controls had to be manipulated in the proper sequence to tune the transmitter. The unit was also equipped with a neon light which flashed in synchronism with the transmitted signal and with earphones to listen to the receiver when operating in the manual mode. For testing purposes, an artificial antenna was provided which insured that no emergency signals were transmitted while the unit was being checked. Inspection of a duplicate unit showed that the transmitter could be stowed without removal of this "artificial antenna" and that the regular antenna could also be attached with it in place.

After tuning the transmitter on the mess deck, it was set on automatic and moved outside to the poop deck where it was hand cranked in relays by pairs of crewmembers. At some undetermined time, the neon indicator light went out for unknown reasons. The crew continued to crank the transmitter because they reported hearing code signals on the earphones, although the set was not designed to receive signals in the automatic mode. Code signals were also heard on a recreational radio receiver, and the crew thought these signals came from their transmitter. They also heard a news radio broadcast reporting that a tanker had broken up at sea and concluded that their SOS signals had been received. This news report actually was related to an alleged distress about 600 miles away from the TEXACO-OKLAHOMA, and after a search by the Coast Guard, was identified as a hoax. Operation of the radio transmitter ceased when one of the two crank handles broke and the shaft seized. Although it had been cranked for a period reported to be between 12 to 24 hours, no ship or shore station reported receipt of the distress signals. The optimum range of the transmitter on 500 KHz was estimated at about 100 miles. Between 18 and 30 ships were within 120 miles of the TEXACO-OKLAHOMA during this period.

Abandonment and Rescue:

Three ships passed within view of the stern section on Saturday, March 27, after the casualty. The first passed about 8 miles away at about 0630, and the second passed at about 1700. In each case, the crew fired several flares which apparently were not seen. The third vessel appeared at about 1900. The crew fired several additional flares, blew the ship's whistle signal repeatedly, rigged a large red light which they blinked, and blinked some of their white deck lights. The master of this vessel, later identified as the M/S BOUGANVILLE, stated that he could not change course to come closer than 5 miles to the stern section because of dangerous sea conditions. The BOUGANVILLE tried without success to communicate by radio and by flashing light in response to the observed blinking from the stern section. The

BOUGANVILLE then communicated with the Coast Guard and asked if any vessel was in distress in its area. The Coast Guard reply was negative. The BOUGANVILLE then reported that the light signal had changed to red over white (international lights for fishing vessels), and that nothing appeared wrong. The Coast Guard checked and found no special Navy operations in that area and concluded that the ship was probably a foreign fishing vessel and so informed the BOUGANVILLE. The BOUGANVILLE spent a total of 2½ hours in the vicinity of the stern section.

After 2400 on Saturday, March 27, the forward end of the stern section began to sink gradually. By about 0330 Sunday morning, the trim was 30° and the engineers commenced securing the machinery. The emergency generator was started about 0400. At about 0530, the deck was inclined about 50° and the 31 crewmembers assembled at the stern to abandon ship. The wind was still strong and the waves were 20 to 30 feet high. The air temperature was about 55° F. and the water temperature was 74° F. All crewmembers wore life preservers and some also carried ring buoys. The crew earlier had made two rafts, one consisting of three empty oil drums, and one of two empty oil drums. These were thrown overboard and held to the side of the ship with lines. The 15-man inflatable rubber liferaft was also thrown over the side and inflated. The crew descended into the water on a Jacob's ladder. The men and rafts became covered with oil and it was virtually impossible to hang on to the drum rafts which tossed and flipped in the rough seas. About 14 or 15 men had gotten into the rubber liferaft when the painter broke. Then a cargo tank ruptured and released a large wave of oil which washed all the men from the rafts. The men were then very weak and sick from swallowing oil and sea water. Eleven men managed to get back into the rubber liferaft. Four others clung to a large board and the rest drifted off. The stern section assumed a vertical position and sank at 0605 March 28, having been afloat 26½ hours after the fracture.

The 11 survivors in the liferaft sighted two vessels and one aircraft before they were rescued about 1700 Sunday afternoon by the tankship SASSTOWN, which came upon them by accident. The SASSTOWN's message to the Coast Guard about the rescue initiated an extensive aerial and surface search by Coast Guard, Navy, and Marine Corps planes and by six Coast Guard, one Navy, and six Texaco vessels. The tankship TEXACO-NEBRASKA found and rescued one survivor about 1320 Monday and another about 2 hours later. Of the original crew of 44, 31 perished, 13 with the bow section, and 18 after leaving the stern section.

Reporting Systems:

The routine coastwise voyages made by the TEXACO-OKLAHOMA normally took 5 to 7 days from Port Arthur to the northeast coast ports. Following company procedure on departure from Port Arthur, the TEXACO-OKLAHOMA filed an ETA of 0600 Sunday, March 28, with its Boston marine superintendent. The vessel was required to send another ETA 72 hours before arrival. Thereafter, revisions were required only if a change greater than 2 hours was anticipated between 24 and 48 hours before arrival, or a change greater than 1 hour was expected within 24 hours before arrival. Between 0800 and 0900 Sunday, the Boston Texaco marine superintendent was notified that the TEXACO-OKLAHOMA had not arrived to pick up her pilot as scheduled. The superintendent's inquiry to the local Coast Guard showed there had been no communication from or about the TEXACO-OKLAHOMA. His attempts to communicate with the vessel by commercial marine radio also failed. At about 0900, he notified the Texaco operations office at Port Arthur, Texas of the situation. At 1500, this information was received by the TEXACO's fleet superintendent at Port Arthur who attempted to telephone the Coast Guard Rescue Coordination Center in New York. He was unable to complete his calls due to circuit difficulties, and about 1530 he called the Coast Guard station at Sabine Pass, Texas, and requested a search for the TEXACO-OKLAHOMA.

The Coast Guard also operates a reporting system called the Automated Mutual Assistance Vessel Rescue System (AMVER). The TEXACO-OKLAHOMA was voluntarily operating under this system which requires an initial filing of a "sailing plan" which is thereafter only amended for significant changes. The TEXACO-OKLAHOMA filed her last message with AMVER about 1900 on March 23. If a vessel fails to send an arrival message, the AMVER program automatically scrubs that vessel voyage from its plot 6 hours after the computed arrival time.

Controls on Loading:

One of the methods for regulating the safe loading of the TEXACO-OKLAHOMA was by means of the "Load Line Certificate" issued by ABS under authority of the Coast Guard. This certificate specified the minimum freeboard required. The seasonal and geographic variations permitted are shown on load line grid markings on the side of the hull. These markings are intended to adjust the freeboard requirements in accordance with the probable severity of the seas. The severest restriction on loading is made for a winter voyage in the North Atlantic. However, tankships over 328 feet long, considered by ABS to be of adequate structural strength, which sail anywhere along the U.S. East Coast are permitted to load down to the summer draft regardless of the season of the year. Further, as a result of the International Convention of Load Lines, 1966, ABS granted a reduction in freeboard to the TEXACO-OKLAHOMA in January 1967. The effect of all the changes in load line standards since the ship was built was to increase the permissible draft of the ship from 34 feet, 1-3/4 inches to 35 feet 8 inches, this increase of 1 foot 6½ inches, representing an increase in authorized load of 2,130 tons.

Another concurrent method used for regulating the safe loading of the TEXACO-OKLAHOMA was a loading manual called the "Trim and Stability Booklet." This manual contained a section approved by ABS and intended to prevent overstressing of the ship by improper loading. The remaining portion of this booklet was approved by the Coast Guard and provided loading information for minimum stability. The ABS criteria for preventing overstressing the TEXACO-OKLAHOMA by improper loading was to limit the principal hull stress to a maximum of 3.70 tons per square inch with the ship lying in still water. In this conventional method, only the midship bending moment created by the longitudinal distribution of the ship's weight, stores, cargo, and buoyancy is considered to produce this stress. The Trim and Stability Booklet provided a simplified indirect means whereby a "stress numeral" on a scale 0 to 100 could be calculated for any condition of loading. A stress numeral of 100 corresponded to the maximum allowable stress of 3.70 tons per square inch and was not to be exceeded. A stress numeral calculation was normally made at the beginning of every voyage of the TEXACO-OKLAHOMA. The calculation for the last voyage was lost with the ship, but a calculation based on the loading record and the testimony of the survivors resulted in a stress numeral of 91.03 (sagging) when the ship departed Port Arthur. Because of consumption of fuel, water, and stores, the stress numeral was calculated to be 94.15 (sagging) at the time of the casualty.

Coast Guard Structural Strength Review:

The Coast Guard conducted additional post accident reviews of the structural strength of the TEXACO-OKLAHOMA. In the first review, a comparison was made of the midship section modulus required by ABS, the section modulus shown on the shipbuilder's plans at midships, and at the suspected fracture location across the after end of No. 5 tanks. The results were as follows:

	Deck	Bottom
Midships - ABS	84,270 in ^{2} ft	90,169 in ^{2} ft
Midships - Plans	89,237 in ^{2} ft	90,420 in ^{2} ft
Fracture Area - Plans	90,299 in ^{2} ft	91,496 in ^{2} ft

A check of longitudinal strength of the ship under static conditions in still water and balanced on conventionally accepted waves gave the following results.

Wave Form and Height		Max. Stress and Location		Max. Stress at Fracture Location
Still Water	- 0 ft.	3.4 tons/in^2	- Midships	3.2 tons/in^2
LBP*/20	- 31.50 ft.	10.42 "	- 3.6 ft. Aft	9.8 "
$1.1\sqrt{LBP}$	- 27.60 ft.	9.53 "	- 3.1 ft. "	8.9 "
$0.6\ LBP^{0.6}$	- 28.78 ft.	9.79 "	- 3.2 ft. "	9.2 "

The above computed stresses occurred in the deck plating with the ship in the sagging condition.

A further computational refinement of the static forces with the ship in sag on an L/20 wave included 3 thousand pounds per square inch (Ksi) of transverse stress in the bottom and deck plating due to hydrostatic heads on the sides and the longitudinal bulkheads. It also included 8.5 Ksi normal stress in the bottom due to hydrostatic loads. The combination of these primary static stresses resulted in a value of 11.6 tons/in^2 in the bottom and 10.5 tons/in^2 in the deck.

A calculation of wave-induced loads, using a hydrodynamic strip theory computer program (SCORES), also was performed for the Coast Guard. This statistical approach considers the ship response forces to an assumed sea spectrum. The computer program was developed as part of the Ship Structure Committee research program. The input data for this program included the ship's hull form data, hydrostatic calculations, loading conditions, and longitudinal weight distribution. Values had to be assumed for natural roll period, roll damping factor, and local vertical radius of gyration. The sea was assumed to be fully developed and irregular. Such a wave frequency distribution was represented by a Pierson-Moskowitz spectra. The directional distribution was assumed to be a cosine square function to represent a short-crested or confused sea. Calculations were made for various wave headings, and ship speeds up to 5 knots. The results were varying bending moment values for increasing wave severity and varying wave headings. The bending moments were largest amidships, generally insensitive to ship speed to 5 knots, and tended to level off at high sea states. The results of these calculations showed that the average of the one-third highest wave-induced bending moment amplitudes amidships was 250,000 to 300,000 foot-tons for vertical bending moment, 80,000 to 85,000 foot-tons for lateral bending moment, and 11,000 to 12,000 foot-tons for torsional bending moment.

Inspection Procedures:

Tankships are periodically inspected by the Coast Guard, ABS, the Federal Communications Commission, and the operator's maintenance

*Length of ship between perpendiculars

personnel. Coast Guard regulations (46 CFR 31.10) require inspection of tankships thoroughly once every 2 years to insure that the ship is suitable for the service intended. This inspection includes the hull structure, boilers, machinery, and other equipment. Instructions on the internal examination of cargo tanks are contained in Chapter III of the Coast Guard Merchant Marine Safety Manual. If the results of this biennial inspection are satisfactory, the ship is issued a "Certificate of Inspection" which authorizes its operation. Such a certificate was issued to the TEXACO-OKLAHOMA after inspection on April 21, 1969. The ship was to receive its next biennial inspection upon return from its trip to Boston. The Coast Guard also conducts a less rigorous "mid-period" reinspection of tankships generally between the 10th and 14th month following the inspection for certification. Tankships operating in salt water are required to be drydocked at minimum intervals of 24 months. Such drydocking often coincides with the inspection for certification. All gas free compartments on the ship must be inspected internally at each drydocking, inspection for certification, or mid-period inspection.

The Coast Guard inspection in April 1969, included inspection of cargo tanks, 3, 4, 6, and 8 port; 2, 3, 5, and 7 starboard; and 3, 5, and 7 center. The inspector noted in the record that the tanks had been inspected and were satisfactory. The mid-period inspection was conducted on June 17, 1970, and was satisfactory. No cargo tanks were entered at this inspection, nor was tank inspection required or feasible, because the tanks were not gas free. A drydock examination was conducted by the Coast Guard on July 10, 1970. Cargo tanks 5 and 8 port and starboard, and 1, 3, and 5 center were not gas free and therefore were not examined. The remaining accessible cargo tanks were examined by Texaco maintenance personnel and found in good condition. During this drydock period, about 20 feet of riveted seam were recaulked, some 600 rivets were welded and about 10 feet of eroded seam weld was rewelded. The stern tube bearing was repaired and a new tailshaft was installed. The overall inspection showed the hull to be in good condition.

For ships that it will class, ABS sets structural strength standards through its scantling and construction requirements, inspects the ships during construction, makes special surveys of the material conditions at about 4-year intervals, and makes annual inspections to ascertain compliance with load line requirements. In the case of the TEXACO-OKLAHOMA, the ABS certificates for hull and machinery had been issued March 3, 1968 for its highest classifications. The load line certificate, issued October 30, 1968, was valid until June 3, 1973. The ABS annual survey was conducted during the drydock examination in July 1970. ABS normally gauges (measures the hull steel thickness) a vessel at the third special survey which was not due on the TEXACO-OKLAHOMA until 1973.

The Federal Communications Commission (FCC) makes annual inspections of the radio equipment on certificated ships. The FCC issued a "Safety Radiotelegraph Certificate" to the TEXACO-OKLAHOMA on July 14, 1970, following such an inspection.

Repair History of TEXACO-OKLAHOMA Class Vessels:

The repair history for the TEXACO-OKLAHOMA showed significant repairs were made to the hull in 1960 and 1963 following grounding and collision damage. In 1968, repairs were made to localized cracks in the web frames in center tanks 1, 2, 3, 6, 9, and 10 and in tank 8 port and starboard. At the same time, about 600 feet of eroded hull seam weld was repaired. In November 1970, collision with a barge necessitated replacement of a small shell plate on the port bow, and in October 1970, a cracked gusset weld was repaired in the starboard bunker tank.

The repair records of the 13 remaining American tankships of this class were reviewed by the Coast Guard. The amount and location of repairs varied with the damage history and the type of products carried. Correlation with the TEXACO-OKLAHOMA casualty was not evident.

Special Inspections:

Following the loss of the TEXACO-OKLAHOMA, the Coast Guard conducted a special inspection of that class of ships. The tanks generally had moderate to heavy corrosion. The steel wastage was generally within Coast Guard limits. Where the tanks were used exclusively for ballast, the steel wastage ranged between 25 to 35 percent, and some renewals were scheduled for the next drydocking. Minor cracks were common in certain structural joints. One tankship which had been transporting gasoline between foreign ports arrived in a U.S. port 1 year after its certificate had expired and was found to be in extremely deteriorated condition. In fact, this loaded vessel at dockside had its main deck set up about 3 inches across its entire beam in the area between No. 5 and No. 6 tanks. Seven of the deck longitudinals in each wing tank had broken and separated from their welds under the influence of the sagging stresses.

One of the sisterships given a special inspection was the TEXACO-WISCONSIN which was built at the same shipyard at about the same date and was also operated by TEXACO in the black oil trade. One significant difference was that the TEXACO-WISCONSIN had wing tanks 5 and 7 piped exclusively for ballast, whereas the TEXACO-OKLAHOMA rotated these tanks between ballast and black oil to avoid concentrating the wastage in one area. These ballast tanks on the TEXACO-WISCONSIN were in an advanced state of deterioration, with average wastage of 30 to 40 percent. Also, approximately 14 small cracks were found in the side longitudinals near the bracket connections to the bulkhead stiffeners. The remainder of the tanks had insignificant wastage and only one crack. Some steel samples from the TEXACO-WISCONSIN were subjected to chemical and physical tests, radiographic, and metallurgical examinations. The basic steel was found to comply with the tensile requirements of ASTM A131 "Structural Steel for Ships," and with standard good practice for composition, and basic metallurgical structure. The welds appeared to be of minimal quality for structural applications.

ANALYSIS

An important question in this casualty is whether the combined static and the dynamic loads imposed on the TEXACO-OKLAHOMA would have fractured any similarly loaded ship which met design, maintenance, and operational standards, or whether the TEXACO-OKLAHOMA was uniquely deficient in design, maintenance, or operation. If the former were the case, the adequacy of the design, maintenance and operational standards themselves should be reevaluated, whereas if the latter were true, failure of the enforcement of these standards would be indicated.

The longitudinal strength design of the TEXACO-OKLAHOMA was based on a "standard analysis" method of determining the bending moment of the ship in a quasi-static condition afloat on an L/20 wave. The required section modulus for resisting such bending moments was then obtained from classification society rules and also from the load line rules in effect at that time. These values are derived from empirical data accumulated from ships considered to have proven of adequate strength throughout their life span. The calculating procedures are well defined, but the standards are in reality a statistical evolvement of acceptable levels of ship losses, and the latter are not well defined. The resulting stress values do not represent actual anticipated stresses and are useful only for strength comparison with similarly designed ships. The TEXACO-OKLAHOMA was representative of a class of ships designed with a section modulus of 96,000 in^2 -ft for a maximum stress of 8.4 $tons/in^2$, using an L/20 wave. However, the actual construction of the ship intervals varied considerably to suit owner requirements so that the section modulus was not uniform for the class. The TEXACO-OKLAHOMA's section modulus of 90,000 in^2 -ft with a maximum stress of 10.4 $tons/in^2$ apparently met the then required ABS and Coast Guard standards even though they represented a somewhat lower strength level than the class design.

Although section modulus is the major parameter for longitudinal strength of tankships, many other factors are important and are reviewed by ABS and the Coast Guard. These include properties of the steel, detailed design of joints, location and design of strength members, and quality of workmanship during construction. Inspection of sisterships and construction drawings available did not reveal any violations of standards to which the TEXACO-OKLAHOMA was built.

Retention of the structural integrity of a tanker requires an inspection and repair cycle which is shorter than the period in which the structural steel deteriorates to minimum allowable limits. This period varies with the cargo, ballasting procedures, sea routes, and various other factors. The apparent intent of Coast Guard regulations and instructions is to perform an internal inspection of each cargo tank at a maximum interval of 2 years. The wording of the instructions, however, would allow a period of up to 4 years between inspections. In fact, tankships that do not return to a U.S. port have operated without such inspections and with an expired certificate, sometimes in a dangerously deteriorated condition. In the case of the TEXACO-OKLAHOMA, cargo tank No. 5 port had not been inspected within the 2-year period, although Nos. 5 center and starboard had been inspected 23 months before the casualty and were found satisfactory. It also appears that Nos. 4 center and starboard, Nos. 6 center and starboard had not been inspected for over 2 years. Tank Nos. 1, 2, 7, 9, 10 P; 1, 8, 9, 10 S; and 1, 2, 8, 9, 10 C also had not been inspected for over 2 years, but the center tanks were much more critical to the structural integrity of the ship. The Coast Guard had stated in this report that changes will be made to its directives relating to inspection of ocean and coastwise tankships and that changes will be proposed to the applicable regulations.

Tanks are normally inspected visually with a flashlight. The inspector observes the extent of rust, buckling or other deformations, leaks, thinning of structural members from chemical attack by the cargo or ballast, cracks, or other abnormalities. Except for the tank bottom, inspection is normally made while the inspector is descending the vertical access ladder. Consequently, the capability for detection of defects depends on their location with respect to the ladder. It is a difficult and dangerous job. Defects such as cracks in structural members can be missed, and it is not unusual for a tanker to operate with quite a few minor cracks. Based on the general preservative properties of the "black oil" which the TEXACO-OKLAHOMA normally carried, the ballast rotation procedures used, the overall condition of the tanks at the last inspection, and the comparative structural condition of her sisterships, particularly the TEXACO-WISCONSIN, it is highly probable that the structural condition of the tanks, including No. 5 port, on the TEXACO-OKLAHOMA was not deficient by the current standards.

Compliance with operational standards is also necessary to reduce the probability of exceeding the design loads. The system that has evolved to avoid having the total cargo, water and bunker weights, and their distribution, contribute excessive loads to the hull structure, is contained in the "Trim and Stability Booklet." The computed stress numeral is directly related to the still water bending moment. It is normally computed for the final loaded or ballasted condition with the vessel floating freely although, unless care is taken, the maximum numeral of "100" can be easily exceeded near the end of the loading or beginning of the unloading processes when the sag stresses are highest.

This limit could also be exceeded at the Port Arthur dock if the bow or stern were supported in the bottom silt. The fact that the drafts recorded at Port Arthur show a draft 1 foot less at the bow, while the calculated drafts show the ship on an even keel, suggests that the bow was supported on the bottom. This would have increased the sagging bending moment by about 56,000 ft-tons, and would have been well above the limit represented by the stress numeral of 100. However, this added bending moment would have been small compared to that imposed by a "standard wave" and had no further effect once the ship left the dock. In all probability, the TEXACO-OKLAHOMA commenced her voyage with an approved loading and did not exceed this loading during the voyage.

The administrative procedures associated with the "Trim and Stability Booklet" tend to diffuse the accountability for its contents. A design agency or shipyard prepares it. ABS reviews and approves the loading stress portion. The Coast Guard reviews and approves the stability portion and then issues a latter directing compliance with (but not approval of) the section approved by ABS.

The load line regulations are also part of the operational standards to set safety minimums. The present day rules are primarily aimed at maintaining a measure of reserve buoyancy. They address the structural strength standards indirectly by permitting the deepest load line allowable provided the structural adequacy is ascertained to be sufficient by "other means," i.e., ABS rules or their equivalent. The TEXACO-OKLAHOMA was in compliance with the load line rules during its last voyage.

Lacking evidence of any significant violations in the design, maintenance, or operation of the TEXACO-OKLAHOMA, the adequacy of the standards require evaluation. One overall gross evaluation could be performed by reviewing the general performance of the 14 remaining American ships in this class. However, the ships vary in section modulus, types of cargo carried, ballasting procedures, maintenance standards, and trade routes, so as to make such a comparison inconclusive. The fact that one such ship buckled its main deck amidships in still water alongside the dock is noteworthy. This dangerous result in the 1-year-after expiration of its certificate, indicates a small margin of safety in the combined design-maintenance safety requirements.

The semi-empirical design standards used in shipbuilding evolved because of the difficulty in defining the behavior of waves and their cumulative, instantaneous contribution to the ship stresses at all locations on the hull. However, it is now possible by use of statistical techniques to make short-and long-term predictions of the maximum bending moment to be expected for a given ship in a mathematically defined sea spectra. Although this method is a more rational approach, many more actual sea surface records are needed to make the predictions realistic. Its use has also been limited to prediction of wave-induced bending moments, and other factors such as hydrostatic, thermal, slamming, and combined loads have not been analyzed in similar fashion. However, the existing design standards adopted from past "successful" designs in fact account for all loads, fatigue, normal material and construction tolerances, and acceptable variances in maintenance and operational procedures. These factors are all interrelated in unknown complex fashions so that the contribution of each to the success or failure of a design is unknown. Hence, building a sister to a "successful" ship design is no assurance of success if the maintenance and operational factors are not similarly related.

The statistical analysis of wave-induced loads on the TEXACO-OKLAHOMA represented a short term examination of the problem and cannot be used in evaluation of existing design standards. Also, it cannot be used to determine probable cause of the casualty because of the speculative nature of the assumptions used for inputs. Some of these assumptions perhaps may be too severe, i.e., the sea spectrum and period it acted on the ship. On the other hand, the full design section modulus was assumed, allowing no reduction for wastage. However, the study makes certain observations as to relative importance of several factors. The wave-induced loads were relatively unaffected by variation of ship speed in the low range of ship speeds. Thus, slowing the ship down below 50 RPM prior to the casualty probably would not have prevented the ship from splitting. This study also confirmed that the maximum vertical and lateral bending moments occurred at midships. Since the fracture occurred about 50 feet forward of midships, the ship was either weaker in that area, or the other undetermined loads combined to produce the maximum stress forward of midships. The study also showed that about one-third reduction in vertical bending moment could result when the predominate wave heading was changed from dead ahead to abeam. This suggests that sufficient evasive action was available to avoid the casualty if the increased ship roll was tolerable. However, in a storm, most ship masters would be reluctant to place the major swell pattern on their beam. The master of the TEXACO-OKLAHOMA had no guides or criteria to indicate he should do so.

Because of the statistical nature of the factors that determine the survivability of a ship, the newly developed techniques for making statistical predictions of wave-induced load, when coupled with actual sea spectra data for ocean routes, will produce a more logical basis for selecting design parameters. Various universities, technical societies, governmental organizations, and classification societies world-wide are pursuing this effort. However, the selection of any design values must be preceded by national or international acceptance of risk levels as expressed by probabilities that certain design stress values will be exceeded during the ship's life. Such risk levels have in fact always existed and have been tacitly accepted although not clearly defined. The acceptable risk level for the TEXACO-OKLAHOMA was tacitly increased in 1967 when she was assigned a deeper load line as a result of the International Convention on Load Lines, 1966. Although it was determined that her strength was adequate to accept the deeper load line, the increased incidences of larger static and dynamic loads which resulted thereafter, did increase the statistical probability that any given stress value would be exceeded.

Generally, an attempt is made to equalize the risk levels where there are distinctive seasonal weather changes, by requiring a reduced draft during the stormy seasons. However, by designating the seas off the U.S. East Coast as a year round "summer zone", the inherently higher risks of winter are accepted and consequently the TEXACO-OKLAHOMA was not required to reduce its loading for this winter voyage. In addition to the seasonal variations applicable to given ocean areas, geographical designations are also made which correspond to draft limitations required. These "zone" and "area" designations are justified by the general overall wind conditions and by the need for relaxation in certain areas for practical reasons. The ocean area off Cape Hatteras is designated as the summer zone under this system. However, there is no body of actual measured sea data, particularly during storms, off Cape Hatteras in the area of the casualty which could be used to determine relative risk levels. The history of storms and ship losses off Cape Hatteras would imply that the "summer zone" classification for this area probably was justified for "practical reasons."

The increased draft resulting from the designation of the coastal area north of 36^{o} latitude as a continuous summer zone may have been influenced by greater availability of rescue facilities. However, for the crew in the forward deckhouse, this was a nonsurvivable accident and this will be true for any similar failure of any loaded ship of this class. In addition, past safety rules were based largely on protection of the ship and its crew. Present day concerns for protection of the environment would probably lead to greater efforts to prevent the casualty rather than to rely on some means to minimize the losses after the accident.

In summary, it is evident that although the load line is not considered a structural strength criteria, it does allow the acceptance of higher or lower risk levels by controlling the general level of loads imposed on the ship.

Measurement of ship stresses at sea are not uncommon as an aid in ship design. Instrumentation is now available also to provide the master with ship stress information which can guide him in making operational decisions. These devices provide not only a measure of present stresses, but more importantly can be used to predict with fair accuracy the extreme stress which will occur within the next 10-15 minutes in accordance with the generally accepted wave distribution patterns. Such hull stress monitors can provide the master with a measure of the effectiveness of evasive actions by speed and course changes. They can be configured also to monitor stresses during loading and unloading, and can be sensitive to influences such as silt-produced bottom pressure. Although not responsive to localized high stresses, locked-in stress, vibratory loads, low-cycle fatigue limits, and a variety of other loads, they would give more realistic resulting stresses including such factors as wasted structural members and weight loads from waves washing over the deck.

Failure of all attempts to tramsmit a distress signal undoubtedly contributed to the high loss of life of crewmembers on the stern section. Although the reason for the failure of the emergency transmitter cannot be determined, some factors that reduced its reliability are evident. The setting-up and tuning procedures are involved and critical to the proper performance of the instrument, increasing the probability for errors. The artificial antenna can remain attached with the transmitting antenna in place, rendering the transmitter ineffective. The equipment was designed for use in lifeboats and is not suitable for use in liferafts which constitute a large portion of the lifesaving equipment in use today. Miniaturized watertight floatable radio transmitters which can be carried aboard ship or packed on liferafts are available and can be activated without set up or tuning procedures. Such Emergency Position Indicating Radio Beacons (EPIRB's) are used in the aviation field and by some foreign merchant vessels. Successful use by ships depends largely upon aircraft or satellite monitoring. Administrative, rather than technical problems need to be resolved to make this an effective marine safety alerting, identifying, and locating system. The Coast Guard, FCC, and the Radio Technical Committee, Marine have made proposals at the International Telecommunication Union World Administrative Radio Conference for Space for allocation of frequency for EPIRB's. Progress in setting up an international system has been extremely slow. The crew's experience indicates that emergency flares are inefficient in attracting attention in stormy conditions. The flashing of a large incandescent light was effective in alerting the M.S. BOUGANVILLE, but the inability of the crewmembers using the light to make an SOS lost another opportunity for rescue. A greater effort, and more participation by other crewmembers in sending flashing light signals probably was not made because most crewmembers were confident that their radio distress signals had been received and that rescue efforts had begun.

By Texaco reporting procedures, the TEXACO-OKLAHOMA did not become "unreported" until 0700 Sunday, 1 hour after the ship's scheduled ETA. This was 27½ hours after the ship had split and 1 hour after the crew on the stern had abandoned ship. No decision to request a Coast Guard search was made for about 8 hours. The persons first aware of the over-due situation appeared to be constrained by the lack of specific instructions and limited authority to "making inquiries" and "notifying the home office." The AMVER system does not serve as a backup to initiate any alarm or assure any search responsibilities upon failure to receive an arrival report. In this particular case such an alarm from the AMVER computer would have been redundant since the Coast Guard had been informed that the ship was overdue and did not assume any responsibility for further action because none had been requested.

The drum raft reacted so violently to the storm waves as to render them useless. None of the crewmembers who remained with those rafts survived. Fatigue appears to have been the greatest factor in determining who survived or perished. Those who survived were aided by support from the raft, a plank of lumber, and a lifering in addition to their life jackets.

The liferaft prematurely broke free from the TEXACO-OKLAHOMA before it was filled to capacity, probably due to parting of the weak link in the sea painter. This failure has been discussed in several previous marine casualties by the National Transportation Safety Board. The Coast Guard will soon issue regulations to increase the strength of these sea painters and relocate the position of the weak link.

CONCLUSIONS

1. Possible structural weakness of the TEXACO-OKLAHOMA as a result of corrosion wastage beyond acceptable limits could not be ruled out through recent inspection. However, the available inspection evidence, the type of cargo carried for many years, and the ballast rotation procedure used indicate that excessive corrosion wastage was not a probable factor.

2. The possibility of the existence of significant undetected cracks or other structural damage could not be ruled out because of incomplete periodic inspections and because the inspection procedures cannot assure detection of all significant defects. However, the absence of any pattern of serious crack development in vessels of this class, even when subjected to a special inspection, indicates a low probability that the failure was due to an undetected local defect.

3. The TEXACO-OKLAHOMA was designed and built to the requirements of the Coast Guard and the highest classification of ABS. In comparison with similar tankships of the same dimensions built about the same time, the TEXACO-OKLAHOMA had lower longitudinal strength as represented by a 7 percent lower section modulus and a 24 percent higher maximum stress when computed by traditional methods.

4. It is apparent that the inspection of sister vessels conducted in this investigation was more complete in scope and closeness of examination than in the supposedly definitive routine inspections of the

TEXACO-OKLAHOMA. Existing instructions for vessel inspection do not define sufficiently either the details of the inspection, the defects which are required to be ascertainable, or the defects which can be allowed to remain unrepaired.

The fact that cracks and defects can occur between inspections and can be undetected during inspection requires sufficient structural strength margin to assure that the ship will not be jeopardized. Present design methods, requirements of the Coast Guard, and the classification system of American Bureau of Shipping do not provide any definition of such a margin, so that a gap exists in the logic of safety control.

5. The post-accident study of wave-induced loads on the TEXACO-OKLAHOMA indicated that the tactic of reducing longitudinal bending stresses by reducing ship speed is ineffective below about 5 knots. However, changing course to accept maximum roll in lieu of maximum pitch would have significantly reduced the stresses which produced the failure. The master lacked this information on predictive hull stress selection which was determined after the casualty. He also lacked information of the measurable actual stresses being produced in his vessel. Therefore, the master did not know the magnitude of the danger to the ship and lacked the means to experiment to find the least hazardous mode of operations. These information deficiencies are potentially correctible by performing computer studies in advance of such hazardous situations and by the permanent installation of strain gauges and associated instruments to show selected ship stresses. The National Transportation Safety Board has pointed out the lack of such information in its 1968 report on the loss of the cargo ship DANIEL J. MORRELL.

6. This was a non-survival accident for the crew asleep on the first two levels of the forward deckhouse. This will be true also for any similar future failure to a loaded tankship of this class.

7. The increase in load line in 1967 increased the incidence of larger static and dynamic loads on the TEXACO-OKLAHOMA and thereby increased the probability of exceeding the failure stress of the ship.

8. The TEXACO-OKLAHOMA was also subjected to larger static and dynamic loads during winter voyages off the U.S. East Coast because reductions in cargo load are not required in that area despite increased sea conditions during the winter months. Although the relative risks in the frequent winter storms off Cape Hatteras appear high, this area is classified as a year round summer zone for all ships.

9. The type of emergency radio transmitter carried aboard the TEXACO-OKLAHOMA was unreliable under the circumstances. The more suitable and reliable equipment presently available has not been adopted due to procedural delays.

10. No effective system exists for detection of an overdue ship which has lost radio transmitter capability. Such an alerting system could have functioned to save additional lives during the 26½ hours the stern section remained afloat.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the TEXACO-OKLAHOMA hull fracture was the high stresses produced by heavy seas and other forces on the relatively lightly constructed, fully loaded ship. The design, maintenance, and operating standards inherently contained risk levels which were excessive for vessels of this type transiting the seas off Cape Hatteras in winter storms.

The following are considered to be contributing causal factors:

1. The use of a section modulus (a measure used in evaluating longitudinal strength) which results in a relative stress near the upper end of the "acceptable" limit and, therefore, a relatively high risk level.

2. The increase in the load line of the TEXACO-OKLAHOMA in 1967, without change in section modulus thereby increasing the loaded sagging stresses and the wave-induced loads, with the consequent increase in risk level.

3. The year-round designation of seas off Cape Hatteras as a "summer zone" for load line purposes without knowledge of measured sea conditions in the winter storms that frequent that area.

4. The low probability with the techniques used during annual drydock and biennial inspections, of detecting all cracks and assuring that steel wastage for all portions of tank interiors has not exceeded permissible limits.

The following contributed to the loss of life subsequent to the splitting of the TEXACO-OKLAHOMA:

1. Failure of the lifeboat radio transmitter to broadcast a distress signal.

2. Lack of sufficient rubber liferafts to accommodate the remaining 31 crewmembers after both lifeboats were lost.

3. Failure of the crew to make an SOS signal by flashing light after they attracted a passing ship.

4. Lack of an effective alerting and appraising procedure for an overdue ship.

RECOMMENDATIONS

The National Transportation Safety Board recommends that:

1. The Coast Guard, with the assistance of ABS, reevaluate the structural adequacy of the TEXACO-OKLAHOMA class of tankships with a view towards strengthening these vessels to reduce their long-term risk levels.

2. The Coast Guard, with the assistance of the National Oceanic and Atmospheric Agency, develop a program to obtain sea spectra data for winter storms off Cape Hatteras to be used as a rational basis for determining wave-induced loads and probabilities of exceeding any given bending moment values.

3. The Coast Guard require all ship owners of this class tankship to install a hull stress monitor capable of indicating hull bending stresses at the most critical region of the ship. A means should also be provided for making short-term predictions of the probable maximum bending moments to enable the master to make evasive ship maneuvers or to allow the crew sufficient warning to vacate the lower two levels of the forward deckhouse.

4. The Federal Communications Commission (FCC) require modification to lifeboat radio transmitters on all ships where necessary to insure that the artificial antenna cannot remain installed when the transmitting antenna is installed. In the interim, written notices should be provided for attachment to all such equipment warning of the need to remove the artificial antenna before connecting the transmitting antenna. We concur with the Coast Guard, in their forthcoming recommendations to the ship owners, to provide their crews with training in the proper operation of the lifeboat radio transmitter.

5. The Coast Guard, with the assistance of FCC, proceed without delay with a mandatory program for a U.S. alerting, identifying and locating system (EPIRB), unless it can determine now that an international system will be operational within the next year. In the absence of such a determination, proceed to have such a national system operational within 1 year.

6. The American Petroleum Institute assist the tanker industry to devise and implement a ship position reporting

system which will effectively alert operating personnel when a ship becomes overdue. This system should become operational without delay and remain effective until an operational EPIRB system is established. The need for an improved position reporting system was also demonstrated in the loss of the "MARINE SULFUR QUEEN" somewhere between Beaumont, Texas and Norfolk, Virginia, in February 1963. In that case the ship was not missed for nearly 4 days after its probable time of sinking. Similarly, in the case of the DANIEL J. MORRELL, lost in Lake Huron in 1966, NTSB commented on the lapse of 1½ days before the sinking was discovered.

7. The Coast Guard require another inflatable liferaft to be installed on the after section of tankships either in addition to or in lieu of one of the lifeboats now required.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

Adopted this 24th day of May 1972:

[redacted] Chairman

[redacted] Member

[redacted] Member

[redacted] Member

[redacted] Member

DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

Address reply to:
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WASHINGTON, D.C. 20590

5943/TEXACO OKLAHOMA
A-3 Bd
3 JAN 1972

Commandant's Action

on

The Marine Board of Investigation convened to investigate circumstances surrounding the loss of the SS TEXACO OKLAHOMA in the Atlantic Ocean off Cape Hatteras, North Carolina on 27 March 1971 with loss of life

1. The record of the Marine Board of Investigation convened to investigate subject casualty has been reviewed; and the record, including the Findings of Fact, Conclusions and Recommendations, is approved subject to the following comments and the final determination of the cause by the National Transportation Safety Board.

SYNOPSIS OF FINDINGS OF MARINE BOARD OF INVESTIGATION

1. On 27 March 1971, the tankship SS TEXACO OKLAHOMA broke in two and subsequently sank about 120 miles northeast of Cape Hatteras, North Carolina resulting in loss of thirty-one lives. The TEXACO OKLAHOMA together with her cargo is a total loss.

2. At the time of the casualty there were forty-four crew members on board the TEXACO OKLAHOMA. The TEXACO OKLAHOMA was enroute from Port Arthur, Texas, to Boston, Massachusetts with a cargo of black oil. Eleven survivors from the TEXACO OKLAHOMA were rescued from a fifteen-man inflatable life-raft by the Liberian tankship SASSTOWN. Two survivors were rescued directly from the sea by the SS TEXACO NEBRASKA.

3. The TEXACO OKLAHOMA was a tankship of 20,084 gross tons and 12,385 net tons. She was 632.0 feet in length, 90.4 feet wide, 45.4 feet deep. The TEXACO OKLAHOMA finished loading her 220,000 barrel cargo at the Texaco dock at Port Arthur, Texas at 1510 on 22 March 1971. She then departed Port Arthur, Texas with a crew of forty-four men including the Master at 1600 on 22 March 1971 bound for Boston, Massachusetts. The voyage progressed without incident as the ship proceeded through the Gulf of Mexico

and then northward in the Atlantic Ocean until the 25th of March when heavy weather was encountered. At or about 0330 on the 27th of March the ship took a heavy roll to starboard and without warning broke in two aft of the midship house in way of the number five cargo tank. After the vessel broke the bow section drifted clear and assumed an attitude of about 45 degrees with the bow high and the midship house awash.

4. About 0600 on the morning of 27 March 1971, the bow section drifted down on the stern section and the engine was used to back away from it. The two sections then drifted apart and the survivors on the stern lost sight of the bow which subsequently sank and was never located.

5. The stern section had been maintaining the same trim but sometime before 1100 on the 27th of March 1971 it developed a 10 degree starboard list which was corrected by gravitating fuel oil from the starboard settling tank and by rigging the hose to pump out water which had accumulated in the engine room away from the bilge pump suction.

6. The SS TEXACO OKLAHOMA was equipped with two 37 person lifeboats forward, two 37 person lifeboats aft, one 10 person rubber inflatable liferaft forward, and one 15 person rubber inflatable liferaft aft. The vessel had fifty-six life preservers and twenty-four ring buoys. At the time of the casualty number four lifeboat on the port side of the after section was stripped for maintenance in anticipation of the biennial inspection that was scheduled when the ship returned to Port Arthur from the voyage to Boston. The number three lifeboat on the stern section had been demolished by the bow section when it drifted down on the stern, and the number four lifeboat which had been stripped for maintenance was the only one available for use. The air tanks and other equipment which had been removed were replaced and the lifeboat was swung out and made ready for launching. By this time, it was apparent that the stern section would remain afloat at least for the time being so the boat was not launched. Subsequently, it was washed away by heavy seas.

7. The vessel had a portable lifeboat radio designed to transmit on 500 KHz and 8364 KHz. The normal range on 500 KHz was approximately 100 miles. The radio was operated continuously until one of the two crank handles broke. The length of time the equipment operated was estimated between twelve and twenty-four hours total. The survivors recall the antenna being rigged but were hazy concerning tuning and rigging of the ground wire. In any case the equipment failed to activate any auto alarms on any vessels and no ship or shore station reported hearing a distress signal which could be attributed to the vessel.

8. Several attempts to indicate the distress of the TEXACO OKLAHOMA to the passing ships which were sighted were unsuccessful. These efforts included flares, smoke signals, whistle signals, and blinking of lights. Several of the pyrotechnic signals which were located in deck lockers,

on the stern section, failed to function. These signals were not from the lifeboat equipment or from the pyrotechnics locker which was located on the bow section.

9. By 0200 on the 28th of March 1971, it was apparent to the engineers, from the indications provided by the pendulum which they had rigged in the engine room, that the trim of the stern section was gradually increasing forward and down and that eventually the stern section would sink. At about 0520 on the 28th of March as daylight was beginning to break it was decided to abandon ship. The fifteen-man inflatable liferaft and two rafts which had been improvised from empty oil drums, were thrown over the side from the poopdeck and were held alongside by painters. A Jacob's ladder rigged from the poopdeck permitted debarkation. The inflatable liferaft inflated properly in the water, but drifted under the davit arm for the number three lifeboat which was projecting over the side of the ship and this collapsed the raft's canopy. Consequently, the first crew members down the ladder could not go inside the raft but had to remain on top of the collapsed canopy. Fourteen or fifteen persons had boarded the inflatable liferaft when the painter broke. As it drifted away, a wave of oil released by the sudden rupture of one of the ship's tanks washed the occupants from the raft. Of these, only eleven were able to get back on the raft. All thirty-one crew members on the after section abandoned the ship. Only thirteen survived.

10. As a precautionary measure, after the casualty, the Commandant of the Coast Guard ordered that all vessels in the same class as the TEXACO OKLAHOMA be inspected internally as soon as practicable. All fourteen vessels of the class in addition to several other tankships of like dimension under U. S. Flag were inspected and examined internally. Those examined in U. S. ports were inspected by the Coast Guard Headquarters Traveling Inspector Staff. Those examined overseas were inspected by officers from the Merchant Marine Detail Staff. Although minor defects and structural failures were found in some vessels, the inspections have revealed no startling conditions or any major defect of a type common to the class which can be directly related to the TEXACO OKLAHOMA casualty.

REMARKS

1. Concurring with the Marine Board of Investigation, it is considered that the primary cause of the casualty was a structural failure in the way of the number five cargo tanks. However, it is not considered an unusual situation for a loaded tanker to be buffeted in a storm and one can normally expect that the structural integrity and reserve strength built into a vessel would prevent its breaking in two. Other than reductions in speed, very little is known about the handling of the vessel in the storm due to the loss of all the deck officers and most of the unlicensed deck crew.

2. In concurrence with the Board's Conclusion No. 2, though there is no evidence to indicate that the TEXACO OKLAHOMA was excessively deteriorated or had structural defects, it is considered possible that the vessel may have had recent internal damage which might have been detected by internal examination of the cargo tanks. It appears that the letter of the instructions in the Merchant Marine Safety Manual were, in fact, carried out in the series of examinations conducted by the Coast Guard of the TEXACO OKLAHOMA during 1968 and 1969. That is to say, a literal reading of the then existing instructions provided only that if an examination of the tanks did not occur during a dry docking or interim inspection, that an examination of all tanks would be required at the inspection for certification. The record indicates that all tanks were inspected during a dry docking in 1968. Therefore, an examination of all tanks would not specifically have been required in the inspection for certification in 1969. During the year 1970, two possible opportunities for tank inspections occurred, that is, the dry docking and the interim examination. The dry dock inspection presented an opportunity to inspect some gas free tanks. It is noted that the internal examination called for in the Merchant Marine Safety Manual was not conducted by Coast Guard Inspectors during the dry dock period in July 1970. However, inspection at that time by Texaco maintenance and repair personnel did not find any noteworthy defects when they entered the accessible cargo tanks. In that not all tanks were examined during these opportunities, an examination of all tanks would have been required in the inspection for certification in 1971. Unfortunately, the accident under investigation occurred immediately before the due date of the 1971 inspection for certification.

3. It seems clear that the intent of the instructions appearing in the Merchant Marine Safety Manual prior to December 1970 were to require more tank inspections than were explicitly called for. In December 1970, a clarification consisting of an amendment to the Manual was published which emphasized that all gas free cargo tanks must be inspected internally at the vessel's dry docking, during inspection for certification, and in the mid-period inspection, without regard to the date that the tanks were last inspected. It was made clear that the basic requirement is now that all tank interiors of all tank vessels be examined at least once during every two year period, in addition to the foregoing inspection of opportunity.

4. The stowage requirements for inflatable liferafts are being reevaluated in light of the apparent failure of the inflatable liferaft which was stowed on the midship super structure of the TEXACO OKLAHOMA to float free when the bow section sank.

5. The pyrotechnic signals used by the crew of the TEXACO OKLAHOMA were not part of the required lifeboat equipment or the ship's distress signals which were stored in a magazine chest on the bridge, but were out-dated pyrotechnics which had not been removed from the vessel. The evidence shows that some of these signals failed to operate. Present regulations require that pyrotechnic distress signals shall be replaced after three years from the date of manufacture. Consideration will be given to amending

the regulations to provide that, when replaced, these pyrotechnics shall be removed from the vessel and to a requirement for a second set of distress signals to be stored in a magazine chest aft on vessels with widely separated berthing and working spaces.

ACTION CONCERNING THE RECOMMENDATIONS

1. The recommendation that regulations or directives relating to the inspection of ocean and coastwise tankships be revised is being acted upon at this time and appropriate changes to existing regulations will be proposed for consideration.

2. The recommendation that a central management information system be utilized to disseminate inspection information is presently being incorporated as a part of the Office of Merchant Marine Safety's new Information and Analysis Staff.

3. The recommendation that the specification for the painter required as a part of the inflatable liferaft equipment be revised to provide greater strength has already been acted upon as a result of information from previous casualties. At the public hearing in March 1971, the proposal was adopted and will be published as regulation shortly, providing for greater strength in this painter and changing the location of the weak point from the point of attachment to the raft to the point of attachment on board the ship.

4. The recommendation that a copy of the report of the Board of Investigation be furnished to the Federal Communications Commission has been acted upon. In addition, a Navigation and Vessel Inspection Circular recommending shipboard training of personnel in the proper operation of the emergency radio transmitter is being drafted.

5. The recommendation that a portable position indicating distress beacon be required on ocean and coastwise vessels is being considered at this time. The Coast Guard is working with other agencies toward the development of standards for a beacon suitable for marine use. When such standards are established regulation changes to require this equipment will be proposed.

6. The conclusion of the Board speaking to the commendable efforts of the MS SASSTOWN and SS TEXACO NEBRASKA will be acted on by appropriate recognition from the Office of the Commandant.

[redacted]
C. R. BENDER
Admiral, U. S. Coast Guard
Commandant

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDANT
U.S. COAST GUARD
WASHINGTON, D.C. 20591

5943/TEXACO
OKLAHOMA MARINE BOARD
26 October 1971

From: Marine Board of Investigation
To: Commandant (MVI)

Subj: SS TEXACO OKLAHOMA, loss of in Atlantic Ocean off Cape Hatteras, North Carolina on 27 March 1971

FINDINGS OF FACT

1. At or about 0330 EST on 27 March 1971 the tankship SS TEXACO OKLAHOMA broke in two about 120 miles northeast of Cape Hatteras, North Carolina while laboring in extremely heavy seas. The casualty occurred after encountering a storm while enroute from Port Arthur, Texas to Boston, Massachusetts with a cargo of black oil. The forward section drifted away within a few hours of the casualty and subsequently sank with no survivors. The after section remained afloat for about 27 hours. During this time the crew on the after section tried unsuccessfully to communicate their plight by use of the portable lifeboat radio apparatus and by making visual and whistle signals to passing ships. Shortly before the after section sank it was abandoned utilizing one 15 person inflatable raft and two rafts improvised from empty oil drums. Approximately ten hours later eleven of the crew members were picked up from the inflatable liferaft by the Liberian tankship SASSTOWN. Thirty-two hours after the stern section sank, two more crew members were rescued from the sea by the tankship SS TEXACO NEBRASKA. The casualty resulted in the loss of life of thirty-one of the forty-four crew members of the TEXACO OKLAHOMA. The TEXACO OKLAHOMA, together with her cargo, is a total loss.

2. The following thirty-one crew members are missing and presumed dead as a result of the casualty.

[redacted] Master

Chief Mate

2nd Mate

3rd Mate [redacted]

[redacted]

Radio Officer/
Clerk

Bos'n

Quartermaster

Quartermaster

Quartermaster

AB

AB

AB

OS

Deck Maint.

Deck Maint.

Deck Maint.

Chief Engineer

2nd Asst. Engr.

Oiler

Oiler

[redacted]

[redacted]

Chief Wiper

FWT

FWT

Wiper

Wiper

Chief Steward

Officers Mess

Utility (Pantry)

Utility (bedroom)

Stew. Util.

2nd Cook & Baker

[redacted]

The ratings of the thirteen licensed and certificated survivors were as follows: First Assistant Engineer, Third Assistant Engineer, ordinary seamen (two), deck maintenance, First Pumpman, Second Pumpman/Machinist, oiler, fireman/watertender, wiper, chief cook, galleyman, crew mess.

3. The TEXACO OKLAHOMA, Official Number 275882, was a tankship of 20,084 gross and 12,385 net tons. She was 632.0 feet in length, 90.4 feet breadth, and 45.4 feet depth. She was of steel construction and powered by a steam turbine unit of 15,000 horsepower geared to a single propeller. The ship had a typical tank vessel configuration with a midship house containing the navigation bridge, the radio room, and the deck officers' quarters. The remainder of the crew were quartered at the stern of the vessel directly over the machinery spaces. The ship was divided longitudinally into 10 cargo sections and each section was divided transversely

into three cargo tanks thus providing a total of 30 individual cargo tanks. There was no inner bottom under the cargo tanks, but there was additional subdivision in the form of peak tanks, deep tanks, fuel oil tanks, and pump rooms. The ship was built by the Bethlehem Steel Company, Sparrows Point, Maryland, in 1958. Her home port was New York, N. Y.. She was owned by Wilton Shipping Company, Inc., New York, N. Y. and operated by Texaco, Inc., on an 18 year bareboat charter beginning 27 October 1960. The vessel was manned by a crew of 44 including the master, [redacted], who had served on the TEXACO OKLAHOMA as relief master for approximately two weeks. He had been employed by Texaco as a licensed officer since 1950 with approximately six years of that time as master. The TEXACO OKLAHOMA had the following pertinent documents all of which were valid at the time of the casualty:

a. U. S. Coast Guard Certificate of Inspection
Inspected 21 April 1969
Expiration date 21 April 1971

b. U. S. Coast Guard Safety Equipment Certificate
Issued Port Arthur, Texas, 21 April 1969
In force until 21 April 1971

c. Safety Radiotelegraphy Certificate (F.C.C.)
Issued 14 July 1970
Expires 14 July 1971

d. Load Line Certificate
Issued New York, N. Y., 30 October 1968
Valid until 5 June 1973

e. A.B.S. Certificates of Class for Hull and Machinery
Issued 3 March 1958

4. At the biennial inspection of the SS TEXACO OKLAHOMA on 21 April 1969 at Port Arthur, Texas, cargo tanks No. 3, 4, 6, & 8 P; 2, 3, 5, & 7 S; and 3, 5, & 7 C were inspected internally by the Coast Guard and found to be in satisfactory condition. The inspector made a notation on the vessel inspection record posted on the ship that the cargo tanks had been inspected. Since the certificate of inspection was to expire on 21 April 1971, the next inspection for certification was scheduled at Port Arthur upon return from the voyage upon which she was engaged at the time of her loss.

The most recent inspection of the vessel prior to the casualty was a drydock examination conducted by the Coast Guard on 10 July 1970 at Portsmouth, Virginia. At this time, also, the annual survey was made by the American Bureau of Shipping. The decks, hull plating, welds and riveted seams were examined externally and found or placed on good condition. The tailshaft weardown was found to be excessive and several cracks, one-inch to five-inches in length were found in the liner in way of the packing gland. The stern tube bearings were re-wooded and a new tailshaft was installed. Approximately 20 feet of riveted seam were recaulked and

576 rivets were welded or caulked as necessary. Approximately 10-feet of wasted seam welding was re-welded. The accessible cargo tanks were examined internally by Texaco maintenance and repair personnel and found in good condition. No cracks or excessive deterioration were observed. Number 5 and 8 port and starboard tanks and numbers 1, 3, and 5 center tanks were not examined internally since they contained ballast and were not accessible.

A mid-period inspection was conducted by the Coast Guard on 17 June 1970, at Philadelphia, Pennsylvania. Additionally, in the period since December 1970, number 2 center tank and numbers 1, 3, and 8 port, center and starboard tanks had been cleaned. These tanks were noted to be in good condition by the Chief Mate during the cleaning operations.

5. Tank vessel regulations (46 CFR 31.10) require the Officer in Charge, Marine Inspection to carefully inspect tank vessels within his jurisdiction at least once in every two years and satisfy himself that every such tank vessel so inspected is of a structure suitable for the carriage of flammable or combustible liquids in bulk and for the proper grade or grades of such cargo in the service in which she is employed. The inspection for certification includes an inspection of the structure, boilers, and other pressure vessels, machinery and equipment. At least one reinspection must be made on each vessel holding a certificate of inspection valid for two years, (between the 10th and 14th months when possible), and the inspection shall examine all accessible parts of the vessel's hull, machinery and equipment to be assured that it is in satisfactory condition. Tank vessels operating in salt water must be drydocked or hauled out at intervals not to exceed 24 months. In actual practice, tank vessels are drydocked by the owners at more frequent intervals.

Detailed instructions for the internal examination of cargo tanks are promulgated in the Merchant Marine Safety Manual (Section 3-7-10). The basic requirement is that all tank interiors of all tank vessels will be examined either during the vessel's drydocking period, at some time between inspections for certification, or at the time of inspection for certification. Unless tanks are gas freed and complete examinations of the internal structure are made at the time of the drydocking or mid-period inspection, the Officer in Charge, Marine Inspection, shall require such gas freeing and examination at the time of inspection for certification. In any case all gas free compartments of tankships must be examined internally at the time of the vessel's drydocking, during inspection for certification, and during mid-period reinspections. The instructions were re-emphasized in an amendment to the Merchant Marine Safety Manual promulgated in December 1970 advising that attention had been focused upon, but not limited to, aggravated unsatisfactory conditions found on tankships built prior to 1946.

The major unsafe or unsatisfactory conditions pointed out in the amendment included deteriorated underdeck and side shell longitudinals; fractures in bottom transverses, bilge brackets, and web frames; and severe general wastage of internals in compartments used exclusively for ballast or as cofferdams.

6. On 28 March 1960 the vessel suffered grounding damage at Piraeus, Greece. In December 1960, this damage was repaired on drydock at Baltimore, Maryland 24 bottom plates were renewed and the internals in way of these plates were repaired or renewed as necessary. The damaged plates were in the forward and after parts of the vessel but there was no damage in way of the Number 5 Cargo Tanks. At the time of this drydocking the name of the vessel was changed from ATLANTIS to TEXACO OKLAHOMA.

On 22 May 1963, while drydocked at Baltimore, Maryland, plates A-3 and A-4 starboard were renewed. These plates in the forward part of the vessel had been heavily set in due to striking damage. Approximately 800 feet of wasted hull weld was repaired and approximately 100 wasted rivet heads in the bottom plating were ring welded and made tight.

On 3 June 1968, while drydocked at Baltimore, Maryland, localized cracks in the web frames were repaired in center tanks Nos. 1, 2, 3, 6, 9 and 10, and in the Number 8 port and starboard wing tanks. Approximately 600 feet of wasted hull weld was repaired. A slight indentation of the shell plating in way of the double bottom tanks under the machinery space was noted for the record but did not require repair.

On 12 November 1970, a 4'-0" x 1'-3" x 3/4" insert plate was welded into the shell in way of the Number 1 Port Deep Tank. This repair was necessitated by a collision with a barge which occured in October 1970. A cracked gusset weld in the starboard bunker tank was repaired at New Orleans, La., on 19 July 1970.

In addition to the repairs listed above, the TEXACO OKLAHOMA had received the normal maintenance and annual repairs to be expected on a vessel of this type. She had undergone the biennial inspections, mid-period inspections, and drydock examinations required by the Coast Guard as well as the annual surveys and special surveys prescribed by the American Bureau of Shipping. There is no record that the vessel had ever been gauged. Normally this is not required until the Third Special Survey by the American Bureau of Shipping which is conducted not later than the 15th year of service. This survey was not due until 1973.

7. The TEXACO OKLAHOMA finished loading her 220,000 barrel cargo at the Texaco Dock, Port Arthur, Texas at 1510 on 22 March 1971. The cargo was a black, low sulphur oil, 17.8 A.P.I., designated by the company as "867 Fuel Oil LS". It was loaded at a temperature of 138°F. All tanks were filled except numbers 3 and 5 port and starboard which remained empty. Number 9 port, center and starboard were only about half full. There was no shoreside record of the loading sequence.

Upon completion of loading the draft, 34 feet forward and 36 feet aft, was recorded in the Port Log and on the loading diagram prepared on the company form designated "Gauge and Inspection of SS TEXACO OKLAHOMA". A condition exists at the Texaco Dock whereby soft silt is deposited in the slip by the current and ships may ground on this soft cushion causing inaccurate draft readings. Since this condition is known it is the normal operating procedure for the assisting tug to read the correct draft after the tanker is clear of the slip and relay this information to the vessel for its log book record of departure draft. There was no shoreside record of this final reading, however, the draft in salt water by calculation from the loading condition was 35' 4.4" forward and 35' 3.6' aft. This represented a mean draft which was 4" less than the maximum mean draft permitted by the load line assignment.

In addition to the restriction on the amount of cargo that the ship may load which is imposed by the load line there is, also, a restriction on the longitudinal distribution of the cargo. This is imposed by the "Stress Numeral" which must be calculated for each voyage in accordance with a mathematical procedure described in the vessel's Trim and Stability Booklet, approved by the Coast Guard on 13 February 1967. This calculation procedure and the design data upon which it was based, approved by the American Bureau of Shipping on 18 January 1967, established 100 as the maximum permissible Stress Numeral for the TEXACO OKLAHOMA. This numeral represented 100% of the stress which would be permitted in the ship's hull when subjected only to the bending moment created by the longitudinal distribution of the ship's weight, including lightship and deadweight, while afloat in calm water. For TEXACO OKLAHOMA the Stress Numeral 100 was equivalent to a stress of 3.70 tons per square inch. So long as the calculation of the Stress Numeral from the parameters of amount and longitudinal distribution of cargo and other weights such as fuel and stores, resulted in a number equal to or less than 100, the allowable still water stress would not be exceeded and the ship would have the reserve of strength necessary to sustain the more severe stresses which would be imposed at sea. Although records of the stress numeral calculation are not maintained ashore, it was standard practice for the TEXACO OKLAHOMA to make these calculations for each loading in accordance with specific instructions from the company. Reconstruction of the calculation based on the loading records and the testimony of survivors indicates that the Stress Numeral at the time of departure was 91.03 (sagging), at the time of the casualty 94.15 (sagging), and anticipated for arrival at Boston 94.82 (sagging).

8. The TEXACO OKLAHOMA, with a crew of 44 men including the master, departed Port Arthur, Texas with her cargo at 1600 on 22 March 1971 bound for Boston Massachusetts. The voyage progressed without incident as the ship proceeded through the Gulf of Mexico and then northward in the Atlantic Ocean until 25 March when heavy weather was encountered. As the vessel progressed northward, the wind and sea conditions became more severe. On 26 March, during the latter part of the 4-8 p.m. watch, the engine speed was reduced to 75 rpm. The vessel had already been running at reduced speed for about one and one half days since her normal full speed of 93 rpm had been lowered to 86 rpm due to steam requirements when it became necessary to heat the cargo. At approximately 2015 on 26 March the speed was further reduced to 65 rpm followed by a reduction to 50 rpm about 15 minutes later. The engine speed remained at 50 rpm until the

time of the casualty. The vessel was in confused seas at least 30 feet height with the wind from the northeast quadrant at approximately 60 knots. Due to the loss of all navigation personnel on the bridge the sea conditions and the heading of the vessel could not be more accurately determined. There was no evidence to indicate whether or not she had diverted from her northerly course towards Boston to seek a more favorable heading. The ship was rolling heavily and pitching to some extent. As the ship encountered successive high seas, she was laboring in a manner described as "shuddering" by some of the survivors.

At or about 0330 on 27 March the ship took a heavy roll to starboard and, without warning, broke in two aft of the midship house in way of number 5 cargo tank. Some of the crew members heard a loud noise which they described by the use of such words as "crack" or "bang". Others heard two distinct "cracks", the second shortly after the first. Some merely felt a vibration or jar in the vessel or a change in her motion as the "shuddering" ceased. Some of the survivors slept through the noises of the failure and had to be awakened. All of the witnesses who had heard the noises were convinced that there was neither a collision nor an explosion.

After the vessel broke the bow section drifted clear and assumed an attitude of about 45 degrees with the bow high and the midship house awash. Shortly thereafter it drifted down on the starboard side of the stern section destroying number 3 lifeboat. Friction between the two sections as they remained alongside each other generated heat on the machinery space shell plating. The paint begain to peel and the compartment began to fill with smoke. The engineers, not knowing the cause, evacuated the machinery space. When they recognized there was no fire and identified the cause of the heat, they returned to the engine room and approximately 15 minutes after the casualty, backed the stern section clear of the bow.

There was no sign of life on the forward section except for a light from an undetermined source in the vicinity of the bridge. The stern section was slightly down by the head but at the time did not appear to be getting worse and it was decided that due to the rough seas, it might be better to remain aboard rather than abandon ship. The engineers maintained the engineering plant to keep the engines, the generator, and the lights in operation. A makeshift indicator inclinometer was fabricated in order to determine if the stern section was going further down by the head.

During the morning 0600 the bow section again started to drift down on the stern section and the engines were used once more to back away. There was no sign of life on the forward section. The two sections then drifted apart and the survivors lost sight of the bow section which subsequently sank and was never located.

The stern section had been maintaining the same trim but sometime before 1100 it developed a ten degree starboard list which was corrected by gravitating fuel oil from the starboard settling tank to the port wing tank and by rigging a hose to pump out water which had accumulated in the engine room away from the bilge pump suctions.

9. The SS TEXACO OKLAHOMA was equipped with two 37 person lifeboats forward and two 37 person lifeboats aft, one 10 person rubber inflatable-liferaft forward, and one 15 person rubber inflatable liferaft aft. The vessel had 56 life preservers and 24 ring buoys. At the time of the casualty number 4 lifeboat, on the port side of the after section, was stripped for maintenance in anticipation of a biennial inspection that was scheduled when the ship returned to Port Arthur from the voyage to Boston. Applicable regulations for tank vessels, 46 CFR 33.25-15 require all lifeboats to be stripped, cleaned and thoroughly overhauled at least once in every year. These regulations allow those tank vessels in ocean or coastwise service having a sufficient number of lifeboats on each side to accommodate all persons on board, to care for their lifeboats at sea; providing that a number of lifeboats sufficient to accommodate all persons on board are fully equipped and ready for use at all times.

After the Number 3 lifeboat had been demolished by the bow section, the Number 4 lifeboat, the only one available for use, was swung out and made ready for launching. The air tanks were re-secured and the oars and equipment which had been removed were replaced. By this time it became apparent that the stern section was remaining afloat so the boat was not launched. Subsequently, it was washed away by the heavy seas. Lifeboats Numbers 1 and 2 apparently went down with the bow section. The forward inflatable liferaft was never recovered although it was designed to float free when the vessel sank. It was stowed on the starboard side of the boat deck in the open and was fixed in position by four stanchions arranged to retain horizontally but not vertically.

10. While the engineering personnel maintained watches in the engine room other crew members under the direction of the Boatswain broke out the emergency lifeboat radio transmitter from its stowage in the after house and set it up on the poop deck. The survivors reported that the antenna was rigged between two small king posts on the after end of the boat deck but none could describe the tuning of the equipment nor recall how or whether or not the ground wire was rigged.

The portable lifeboat radio set was a Mackay type 401 A apparatus manufactured by International Telephone and Telegraph, Inc. It was designed to transmit on 500 KHz (1.7W) and 8364 KHz (0.4W). The normal range on 500 KHz was approximately 100 miles. The transmitter was powered by an integral generator which had to be cranked by hand.

The transmitter could be manually keyed or it could be switched to the automatic mode for sending SOS signals on both frequencies and the auto alarm signal of 500 KHz. After transmitting the auto alarm signal followed by a series of SOS signals on 500 KHz, it would automatically switch to 8364 KHz and transmit a series of SOS signals. The transmitter would then automatically switch back to 500 KHz and the sequence would be repeated.

Detailed instruction for rigging and operation were provided on waterproof cards affixed inside the cover of the apparatus. These were keyed to an explanatory diagram which was included with the instructions. Compliance with the directions for use was critical to the proper operation of the equipment. As an example of the format, the instructions for tuning the transmitter are printed here verbatim:

1. Turn cranks in direction of arrows at about one turn a second.

2. Set operation selector, Fig. 1 (11), to man. 8.364.

3. Allow 20 seconds for the tubes to warm up.

4. Press transmitting key, Fig. 1 (4) and adjust antenna tuning 8.364 MC control (9), for brightest glow of tuning indicator (1).

5. Set operation selector (11) to man. 500.

6. Press transmitting key (4) and rotate antenna tuning 500 KC control (8) for brightest glow. Two complete revolutions of the control may be necessary.

These were similar instructions for rigging the antenna, rigging the ground, and for operating the equipment in the manual mode to transmit messages in Morse code. A copy of the code was provided, also.

After the radio was rigged on the poop deck watches were set and two men at a time cranked the transmitter which was set in the automatic mode. The only means for indicating satisfactory operation to the user was the neon tuning light. This was a red light, recessed into the face of the equipment, which glowed with an intensity proportional to signal strength when the transmitter was keyed either manually or automatically. Little notice was given to this indicator by the survivors who had cranked the apparatus. Some of the witnesses were of the opinion that it burned intermittently, one observed that it flickered only once and one thought the neon light was white. The radio was operated continuously until one of the two crank handles broke. The length of time the equipment performed could not be definitely established from the testimony of the survivors. Some thought it worked for about 24 hours and others said it worked for about 12 hours. In any case the equipment did not activate the auto alarms on any vessel and no ship or shore station reported hearing the distress signal which was transmitted. There were a considerable number of ships in the vicinity during the period of transmission. A manual plot reconstruction of vessels in the region of the casualty as of 1900 local time on 27 March 1971 shows that there were 18 vessels which were participants of the AMVER system within 120 miles of the calculated position of the after section. It is estimated that this listing probably represents about 60% of the total shipping in the area.

11. Several attempts to indicate the distress of the TEXACO OKLAHOMA to passing ships which were sighted were unsuccessful. These efforts included the use of parachute flares, hand-held flares, smoke signals, whistle signals, rigging a red light from the deck lighting system, and blinking the deck lights. Several of the pyrotechnics which were obtained from a deck locker failed to function. These signals were not from the lifeboat equipment nor from the pyrotechnic locker which was located on the bow section. One of the passing ships, the M/S BOUGAINVILLE, was in the vicinity of the stern section for about two and one-half hours on the night of 27 March. Due to the severe storm conditions she was hove to when radar contact was made with the stern section at a range of 13 miles. At a range of approximately five miles the BOUGAINVILLE sighted flashing red and white lights. The signal which had been rigged on the stern section of the TEXACO OKLAHOMA consisted of a red light on a portable cable which was hoisted to a position above the poop deck. It was plugged into one of the deck house light sockets so that when the deck house light switch was turned on and off the white deck house lights and the red signal light blinked together. Individual deck lights were also blinked by screwing them in and out of their suckets. The BOUGAINVILLE tried to communicate by radio and by morse code on her signal lamp but was unsuccessful. Then transmitting to the Coast Guard in Boston, she received a negative reply to a message giving her best estimated position and inquiring if any distress had been reported in the area. Later, these lights appeared to the BOUGAINVILLE as a fixed red light over a white light and this signal was taken to be the navigation lights of a fishing vessel. In a message exchange this interpretation was concurred in by the Coast Guard in Boston which did have reports of possible fishing vessel activity in the area. The BOUGAINVILLE drifted away from the lights eventually losing visual contact and when the weather abated, she proceeded on her voyage.

12. During this period while the crew members on the stern section were trying to obtain assistance, a spurious distress message caused a search effort to be made approximately 600 miles away from the estimated position of the TEXACO OKLAHOMA. At 1215 EST on 27 March a distress message was heard on 500 KHz by Halifax Radio, Coast Guard Radio Boston, a Coast Guard cutter and an Italian vessel which relayed the message to another Coast Guard cutter. The message indicated that a ship with the call sign ZBZE had blown up at position 35-30 North, 61-10 West. The call sign, which was not similar to the TEXACO OKLAHOMA's call sign, KAHM, could not be authenticated; however, a distress broadcast with an auto alarm signal was issued by the Coast Guard. A Coast Guard air-sea rescue plane was dispatched and a Navy aircraft was requested to be sent from Bermuda, the base closest to the scene. The Navy aircraft was on scene by 1520 and the Coast Guard plane arrived at 1645. Additionally three merchant vessels joined the search. After an 11,250 square mile area had been searched with negative results, the distress broadcast was cancelled. The merchant vessels were released and at 2012 on 27 March all search and rescue forces were secured, the incident being evaluated as a hoax.

This reported casualty was the subject of radio news broadcasts from cities in the eastern seaboard. Several of the survivors listening to the news on a radio receiver on the after section heard these broadcasts which reported that a ship had blown up 900 miles off Cape Hatteras and that a search was in progress. Some of the crew members erroneously assumed that the search was for the TEXACO OKLAHOMA which was only 120 miles off Cape Hatteras and that help was on its way.

13. By 0200 on 28 March it was apparent to the engineers from the indications provided by the pendulum which had been rigged in the engine room, that the trim of the stern section was gradually increasing, forward end down, and that eventually the stern section would sink. By 0330 the pitch angle was 30 degrees and the boilers were secured. At 0410 the steam driven generators kicked out and the emergency generator picked up the load. At this time the engine room was still dry and there was only a small amount of water at the forward ends of the passageways in the deckhouse. This had leaked through the watertight doors in the forward face of the house. At about 0520, as daylight was beginning to break, it was decided to abandon ship. At this time the stern section was down about 50 degrees by the head. The seas were still 20 to 30 feet in height and some were breaking. The water temperature was about 74°F., and the air temperature was between 55° and 65°F.

The inflatable liferaft and the two rafts which had been improvised from empty oil drums were thrown over the side from the poop deck and were held alongside by painters. A Jacob's ladder was rigged from the poop deck to permit debarkation. The inflatable liferaft inflated properly in the water but it drifted under the davit arm for the number 3 lifeboat, which was projecting over the side of the ship, and this collapsed the raft's canopy. Consequently, the first crew members down the ladder could not go inside the raft but had to remain on top of the collapsed canopy. After about 14 or 15 persons had boarded the inflatable liferaft the painter broke. As it drifted away a wave of oil, released by the sudden rupture of one of the ship's tanks, washed the occupants from the raft. Of these, only 11 were able to get back on the raft.

All of the 31 crewmembers on the after section abandoned ship. Some of them who climbed down the ladder held on to the improvised rafts for a while but were unable to get aboard them because the rafts repeatedly turned over due to the action of the sea. Eventually, these crew members drifted away from the stern section supported by their life preservers or, in some cases, by their life preservers and ring buoys. Personnel in the inflatable liferaft observed the stern section assume an angle of 90° and sink at about 0605.

14. The 11 survivors in the inflatable liferaft remained afloat for about 11 hours until rescued by the Liberian tankship SASSTOWN which sighted the raft. Two passing ships and one aircraft were sighted by the survivors before they moved inside the raft after succeeding in erecting the canopy. The equipment kit became accessible after the canopy was erected and some of the food and water was used and the flares were set aside ready for use at night.

The survivors remained inside the raft until they were alerted to the presence of the SASSTOWN by her whistle. After several passes the SASSTOWN was able to throw a line to the raft and rescue the survivors who came aboard by means of a Jacob's ladder. At 1642 on 28 March the SASSTOWN reported the rescue, in position 36-00 North 74-43 West, to the Coast Guard at Portsmouth, Va. This was the first notification that the TEXACO OKLAHOMA had been sunk. During the search effort that ensued, two more survivors were rescued directly from the sea by the SS TEXACO NEBRASKA. This rescue was affected at 1410 on 29 March in position 36-28 North, 72-09 West.

15. By standard Texaco operating procedure vessels in the coastwise trade proceeding north send a 72 hour ETA message to the northern terminal where the vessel is bound. If this ETA becomes more than two hours in error, the vessel would amend it with a 48 hour message. If delayed within 24 hours of her ETA she would keep the northern terminal advised of the time of arrival of the nearest hour. In accordance with this procedure the TEXACO OKLAHOMA was expected at the Boston pilot station at 0600 on 28 March. Between 0800 and 0900 the Texaco marine superintendent in Boston became aware that the ship had not arrived as scheduled and was overdue. Attempts to contact the vessel were made by messages sent through a commercial radio station. The marine superintendent notified the Coast Guard at Boston that the TEXACO OKLAHOMA had not arrived and inquired if any messages had been received by the Coast Guard. Also, he notified the Texaco operations office in Port Arthur. This office was on weekend schedule and the employee who had the duty received the notification at about 0900. At 1500 the Texaco fleet superintendent at Port Arthur was notified that the ship was overdue and he decided to request a search effort. He tried for half an hour to telephone the U. S. Coast Guard Rescue Coordination Center at New York but due to difficulties with the long distance telephone circuits he could not get through. Then, by way of the Coast Guard Station Sabine Pass, he relayed a request that a search and rescue mission be started.

An extensive day and night coordinated aerial and surface search was initiated. A Coast Guard search plane was enroute at 1725 and on scene by 1800. Subsequently, a total of 53 sortis were flown by U. S. Coast Guard U. S. Air Force and U. S. Marine Corps planes. Five Coast Guard cutters were assigned to the search and these were assisted by one U. S. Navy ship, six Texaco tankships and the tankship THOMAS M. The search was continued until the afternoon of 3 April 1971 and covered an area of more than 70,000 square miles. Two survivors, afloat in life preservers were found by the TEXACO NEBRASKA. Two bodies without life preservers were sighted but not recovered. An oil slick was sighted and some debris from the TEXACO OKLAHOMA was located and recovered. Neither the bow section nor the inflatable liferaft stowed on the bow section were sighted.

16. As a precautionary measure after the casualty the Commandant of the Coast Guard ordered that vessels of the same class as the TEXACO OKLAHOMA be inspected whether or not they were due for inspection. There are 14 such vessels under the U. S. flag. Seven of these have been inspected internally since the date of the casualty and the remainder are scheduled for inspection when available. The inspections have revealed no startling conditions or major defects. In those vessels in clean product service,

there is a noticeable general reduction in the thickness of the steel but not of sufficient degree to require replacement of the plating or internal structural members. Those vessels examined which have been predominantly in black oil service were found in good condition with slight reduction of original scantlings in ballast tanks. Some localized cracks in the transverse and logitudinal frames were required to be repaired and some local deterioration has been noted which will be required to be repaired at the next scheduled repair period. One additional vessel of the class that was inspected a week before the casualty was required to have extensive repair and renewal of internals.

The Merchant Marine Technical Division of the U. S. Coast Guard at Washington, D. C., made a study of the longitudinal bending moments and the resultant stresses which could have been induced in the TEXACO OKLAHOMA's hull if subjected to the various arbitrarily sized waves usually employed to evaluate a ship's structure. For this purpose they utilized the Lines plan of the vessel, the lightship weight curve furnished by the builder, the actual distribution of the deadweight at the time of the casualty, and the vessel's midship section plan. The results of the study may be summarized as follows:

a. The midship section modulus, making no allowance for wastage, was 90,420 in.^{2} ft. for the bottom and 89,237 in.^{2} ft. for the deck. This compared with 90,169 in.^{2} ft. bottom and 84,270 in.^{2} ft. deck as required for a tankship of this size by the rules of the American Bureau of Shipping. At the estimated location of the fracture, in the vicinity of the after bulkhead of the No. 5 cargo tanks, the section modulues was 91,496 in.^{2} ft. for the bottom and 90,299 in.^{2} ft. for the deck.

b. The results of the still water and wave bending moment calculations were as follows:

Wave Form	Wave Height	Maximum Stress	Location
Still Water	0 ft.	3.4 tons in.^{2}	Midships
LBP/20	31.50 ft.	10.42 " in.^{2}	3.6 ft. Aft
$1.1\sqrt{LBP}$	27.60 ft.	9.53 " in.^{2}	3.1 ft. Aft
$0.6\ LBP^{0.6}$	28.78 ft.	9.79 " in.^{2}	3.2 ft. Aft

At the estimated location of the fracture:

Wave Form	Maximum Stress
Still Water	3.2 tons in.^{2}
LBP/20	9.8 tons in.^{2}
$1.1\sqrt{LBP}$	8.9 tons in.^{2}
$0.6\ LBP^{0.6}$	9.2 tons in.^{2}

In all cases the maximum stresses would have occurred in the deck with the trough of the wave centered amidships and the ship in the sagging condition.

c. A further analysis at the maximum bending moment location showed that the usual transverse and vertical hydrostatic loads were contributing approximately 1.5 tons $in.^2$ (from tranverse loadings) and 4.25 tons $in.^2$ (from vertical loading) to the deck and bottom stress condition. Although both of these stresses act at right angles to the main longitudinal stress and to each other, the combined resultant of all these could have been 11.6 tons $in.^2$ in the bottom and 10.5 tons $in.^2$ in the deck if the ship had actually encountered an L/20 wave. While these stress levels are high they did not exceed the minimum yield strength of the steel used in the construction of the ship, namely 14.3 tons $in.^2$, and consequently, in themselves, do not account for the fracture.

Three members of the Marine Board of Investigation visited the TEXACO WISCONSIN on 10 April 1971, while it was being inspected by the Coast Guard at Jacksonville, Florida. This vessel is a sistership to the TEXACO OKLAHOMA and had been in the same black oil trade. They differed significantly in that the WISCONSIN used No. 5 and 7 wing tanks exclusively for water ballast whereas the OKLAHOMA rotated the cargo tanks that were used for ballast in order to better preserve them by maintaining a coating of black oil. Several tanks of the TEXACO WISCONSIN were examined by members of the Marine Board of Investigation. Special attention was given to searching out such defects as cracks or fractures, gauging determining the general extent of wastage by gauging the internals, and examining the structural configuration with a view towards discovering design details which could have contributed to the casualty. One crack was found in the tanks that had been used to carry black oil and the wastage was insignificant. As expected more cracks and greater deterioration were noted in the tanks that had been used for salt water ballast. With the exception of the ballast tanks, which did not exist as such on the TEXACO OKLAHOMA, the TEXACO WISCONSIN did not require any significant structural repairs or replacements.

CONCLUSIONS

1. The cause of the casualty to the extent determinable was a massive structural failure due to stresses imposed on the hull girder as the ship labored in extremely heavy seas. The failure occurred in way of the No. 5 cargo tank within 50 to 60 feet of the midpoint of the vessel. This is an area where maximum bending stresses are anticipated. The actual stress experienced was undoubtedly a summation of several stresses. In addition to bending these included torsion, hydrostatic loading and impact loading. It is probable that, due to the extreme sea conditions, an unusual combination of these factors occurred which overstressed the vessel and caused the structural failure. It is probably, also that the effect of this extraordinary stress was intensified by the general deterioration which would be expected in a vessel of this age and, possible, by some previously undetected defect such as minor cracks in the structural members. There was no evidence that the fracture of the vessel was caused by an explosion or a collision with any object or that faulty material construction, or repairs contributed to the casualty.

2. Although there is no evidence whatever to indicate that the TEXACO OKLAHOMA was excessively deteriorated or had structural defects the possibility remains that the vessel might have had recent internal damage which may have been detected by internal examination of the cargo tanks. During the last drydock examination in July 1970, No. 5 & 8 P & S, and No. 1, 3, & 5 C tanks, which were not gas free, were not examined by the owner's inspector and none of the tanks were examined internally by the Coast Guard inspector. At the last biennial inspection in April 1969, only representative tanks were examined internally and tanks No. 1, 2, 5, 7, 9, & 10 P; 1, 4, 6, 8, 9, & 10 S; and 1, 2, 4, 6, 8, 9, & 10 C, were not examined by the Coast Guard inspector. The cargo tanks were not gas free and accessible for internal examination at the mid-period inspection in June 1970. The requirements in the Merchant Marine Safety Manual were not followed explicitly at the biennial inspection and the drydock examination. In March 1970, it had become apparent to Coast Guard Headquarters that in some cases cargo tank internal examinations conducted in the field were limited in scope and instructions were prepared to emphasize the importance of thorough and frequent internal examinations. These instructions, promulgated as an amendment to the Merchant Marine Safety Manual which was furnished to Marine Inspection Offices in December 1970, emphasize that all cargo tanks must be inspected internally at least once every two years and that, in addition, all gas free tanks must be examined internally at the time of the vessel's drydocking, during inspection for certification, and at the mid-period inspection.

It is possible, also, that if the Coast Guard had better procedures for collecting and analyzing inspection and repair records there might have been a timely indication of a deficiency or condition the repair of which may have prevented the casualty. At present the Coast Guard's analysis of operational experience receives its input mainly from the reports of casualties (Form CG 2692) and the records of Boards of Investigation. These deal only with the more significant casualties. The extensive experience derived from routine inspections and general shipyard overhauls is contained in the records of individual marine inspection offices. It is not centrally collected, correlated, and analyzed. Consequently, it is not generally available to make inspection procedures more effective by identifying areas which may require special attention.

3. The loss of life resulting from this casualty may have been significantly reduced if the portable lifeboat radio transmitter had been effective in alerting shore stations and nearby ships of the TEXACO OKLAHOMA's distress. There was ample time for rescue and more than adequate resources to carry it out but the distress message was never received. This may have been due to the atmospherics incident to the storm but, more probably, it was caused by the equipment being incorrectly rigged and/or improperly tuned. Without the expertise of the radio officer who was lost with the bow section and under the crisis conditions prevailing on the stern section, it was unlikely that the crew members could follow each and every instruction precisely. The neglect of any single detail would result in improper operation and the failure of the equipment to function effectively would not be clearly apparent except to someone knowledgeable in radio transmission.

More lives may have been saved if the available fifteen man inflatable liferaft had been utilized to its authorized capacity. Although the life raft was full before the occupants were washed out by a wave created by oil from the ship's tanks, it was effective in saving the lives of only eleven men. More lives may have been saved if the painter had not parted and the raft had remained alongside for sufficient time to enable these and other crew members to get into or hold onto the inflatable raft.

4. There is no evidence that any act of misconduct, negligence, inattention to duty or incompetence on the part of licensed or certificated personnel caused or contributed to the casualty. The loading and the distribution of the cargo is considered to have been proper and in accordance with instructions. The vessel was loaded so as not to submerge her load line marks and the cargo and consumables were distributed so as not to exceed her allowable stress numeral.

Although the vessel was laboring in a manner described as "shuddering" by some of the survivors the vessel's speed had been substantially reduced by the master. A reduction in speed from a maximum of 93 propeller RPM during the early part of the voyage to 50 RPM at the time of the casualty is well established by the evidence. After a decrease of this magnitude there is no reason to suspect that the master operated the vessel above the optimum safe speed set in accordance with his best judgment in order to meet a sailing schedule.

In view of the change already made in the ships schedule it is also probable that the best course, in the judgment of the master for the conditions prevailing, was steered although the heading of the vessel at the time of the casualty could not be determined due to the loss of all bridge personnel.

5. The efforts of the ships and aircraft participating in the exhaustive search for survivors are considered to be most commendable and in the best traditions of the sea. The MS SASSTOWN and the SS TEXACO NEBRASKA are especially commended for their praiseworthy efforts in successfully rescuing the thirteen survivors from the sea.

RECOMMENDATIONS

1. It is recommended that the regulations or directives relating to the inspection of Ocean and Coastwise tankships be revised to include specific requirements for a special examination to be made of the internals in way of the cargo tanks and the ballast tanks and for gaugings to be taken of the shell and deck plating at a certain point in the life of the vessel. It is suggested that for tankships with uncoated or partially coated tanks, this special inspection be made in the year of the fifth biennial inspection. For tankships with fully coated tanks, the examination would be required in the year of the seventh bienniel inspection. The inspection would differ from the examination normally made at each drydocking or bienniel inspection in that it would require, regardless of any other considerations, that all tanks in the midships four-tenths length of the ship be gas-freed and otherwise prepared so that all internal structure is directly and safely accessible for close examination. Additionally, it would be required that the deck and shell plating be gauged at this time in not less than two complete girths; the gaugings to be taken in the presence of, and in locations selected by a Coast Guard marine inspector.

2. It is recommended that a centralized management information system, utilizing modern communications and data processing techniques, be set up within the Office of Merchant Marine Safety to collect, correlate, analyze, and disseminate inspection information. Such a system, if it is to improve the effectiveness of Coast Guard marine inspection, should be capable of absorbing the inspection and repair records from all marine inspection offices and integrating this data with the information obtained from the present casualty analysis program so as to identify trends and direct attention to possible trouble spots. It should be capable, also, of getting this information relative to a particular ship into the hands of the Coast Guard inspector before he boards that ship for any inspection purpose in any port.

3. It is recommended that the specification for the painter presently required as part of the equipment of the U. S. Coast Guard approved inflatable liferaft be revised so as to provide greater strength.

4. It is recommended that a copy of the report of this Board of Investigation be furnished to the Federal Communications Commission and that the agency consider the following proposals pertaining to the Mackay Type 410A portable lifeboat radio transmitter:

a. That the operating crank be re-examined to ascertain the adequacy of its design.

b. That the antenna tuning light be relocated to a position on the equipment where it will be readily visible to the operators at all times while the transmitter is being used.

c. That the operating instructions attached to the cover of the equipment be re-written so as to be capable of being understood and followed by a person unskilled in radio operation and completely unfamiliar with this equipment.

5. It is recommended that there be required, as additional safety equipment on Ocean and Coastwise vessels; a portable, position-indicating, distress beacon which will operate automatically when manually triggered or when immersed in the sea.

[redacted]

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