U.S. Department
of Transportation

United States
Coast Guard

MARINE CASUALTY REPORT

SS OMI YUKON, D.N. 547919

EXPLOSIONS AND FIRE ON 28 OCTOBER 1986 IN THE PACIFIC OCEAN APPROXIMATELY 1000 MILES WEST OF HONOLULU, HAWAII WITH MULTIPLE LOSS OF LIFE AND PERSONNEL INJURIES

U.S. COAST GUARD

Marine Board of Investigation Report
and
Commandant's Action

Report No. USCG 16732/0002 HQS 88

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
USCG 16732/0002HQS88		

4. Title and Subtitle	5. Report Date
Marine Casualty Report, SS OMI YUKON, O.N. 547919, Explosion and fire on 28 October 1986 in the Pacific Ocean with multiple deaths and injuries	6. Performing Organization Code G-MMI-1/24
7. Author(s)	8. Performing Organization Report No. 16732/0002 HQS 88
9. Performing Organization Name and Address U. S. Coast Guard Washington, DC 20593-0001	10. Work Unit No. 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Commandant (G-MMI-1/24) U. S. Coast Guard Washington, DC 20593-0001	13. Type of Report and Period Covered Marine Casualty Report 30 September 1987 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

At approximately 1025 local time on 28 October 1986, the U.S. tank vessel SS OMI YUKON suffered major explosions and fires in the starboard fuel oil storage tanks and engine room while enroute to Ulsan, South Korea from Barbers Point, Hawaii. The explosions extensively damaged the engine room and blew the stack deck and stack completely off the vessel. Two men working on deck near the starboard side of the stack deck and two men on watch in the engine room are missing and presumed dead. An additional four crew members were injured. The survivors abandoned ship at about 1600 in a lifeboat and an inflatable life raft. A distress signal from their electronic position-indicating radio beacon (EPIRB) was detected by commercial aircraft and confirmed by Search and Rescue Satellite (SARSAT). Coast Guard aircraft located the survivors at about 2030 and maintained surveillance until they were rescued by the Japanese fishing vessel SHOICHI MARU at 0700 the next morning.

The Commandant has determined that the cause of the casualty was both the contamination of the vessel's bunkers with flush oil during bunkering through a subsea pipeline and the absence of a flame screen in the after starboard fuel oil tank vent.

This report contains the U.S. Coast Guard Marine Board of Investigation Report and the Action taken by the Commandant to determine the proximate cause of the casualty and provide a response to the recommendations to prevent recurrence.

17. Key Words	18. Distribution Statement
Fire;explosions;flush oil;sub-sea pipeline;flame screen;hot work;hot slag;fuel oil tank;EPIRB;SARSAT;ballast; lifeboats	This document is available to the public through the National Technical Information Service, Springfield, Virginia 22121

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

Form DOT F 1700.7 (8-69)

SS OMI YUKON, O.N. 547919; EXPLOSIONS AND FIRE
ON 28 OCTOBER 1986 IN THE PACIFIC OCEAN APPROXIMATELY
1000 MILES WEST OF HONOLULU, HI, WITH MULTIPLE
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U.S. Department of Transportation
United States Coast Guard

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United States Coast Guard

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16732/OMI YUKON

AUG 12 1988

Commandant's Action

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The Marine Board of Investigation convened to investigate the circumstances surrounding the explosions and fire on the SS OMI YUKON in the Pacific Ocean on 28 October 1986 with multiple loss of life

The report of the Marine Board of Investigation convened to investigate the subject casualty has been reviewed and the record, including the findings of fact, conclusions and recommendations, is approved subject to the following comments.

CAUSE OF THE CASUALTY

The Board concluded that the proximate cause of the casualty was the contamination of the vessel's bunkers with distillate products (flush oil) during bunkering through a subsea pipeline, and that contributing to the casualty was the absence of a flame screen in the after starboard fuel oil tank vent. I partially concur with that assessment, but have determined that the contamination of the fuel oil and the absence of a flame screen were equally significant causal factors. Because of the low flashpoint of the flush oil, combustible vapors were vented through the aft starboard fuel oil tank vent. Following ignition of the vapors, the absence of a flame screen permitted the unimpeded propagation of flame directly into the fuel oil tank. Although the source of ignition could not be positively identified, it was probably related to an oxy-acetylene cutting operation being conducted in the vicinity of the fuel oil vent. The ensuing explosions and fire took the lives of four persons and resulted in the vessel being declared a constructive total loss.

COMMENTS ON FINDINGS OF FACT

Finding of fact 74: Hot work regulations (46 CFR 35.01-1) pertain to performing riveting, welding, burning or other like fire producing actions within or on the boundaries of fuel oil tanks; or to pipelines, heating coils, pumps, fittings or other appurtenances connected to such cargo or fuel tanks. The regulations do not address falling slag or sparks onto a tank boundary or in the vicinity of tank vents.

Comment: I do not concur with this finding of fact. 46 CFR 35.01-1 addresses falling slag and sparks through use of the general phrase "like fire producing actions." While slag and sparks are not specifically mentioned, they are clearly actions capable of producing fire.

COMMENTS ON CONCLUSIONS

Conclusion 32: The failure of the chief engineer to designate a fire watch, to have charged fire hoses led out and to have portable extinguishers in the immediate area of the hot work was not following established safety procedures

in the ISGOTT [International Safety Guide for Oil Tankers and Terminals]. With the explosions occurring prior to the fires, and without warning, the presence of a designated fire watch and having fire extinguishing equipment ready for immediate use in the area of the hot work would not have prevented or changed the outcome of this casualty. However, if a fire broke out initially, the proper fire fighting equipment immediately at hand may have made a difference.

Comment: I concur with this conclusion. In addition, there is evidence that the chief engineer failed to comply with the requirements of 46 CFR 35.01-1 concerning hot work. This matter has been referred to Commander, Eleventh Coast Guard District for appropriate action.

Conclusion 37: The exact reason for the lifeboat motor not getting cooling water cannot be determined because the lifeboat was set adrift and was never examined. The most probable cause was an inoperative cooling water pump.

Comment: I concur with this conclusion. Finding of fact 59 does not indicate that water drained from the cooling system when the hose was removed. Therefore, it can be assumed that the system was empty. A faulty cooling water pump is the most probable explanation, although blockage of the cooling water passage is another possibility.

Conclusion 44: The proximate cause of this casualty was bunkers becoming contaminated with distillate products (flush oil) during its delivery to the vessel through a subsea pipeline. Contributing to the casualty was the absence of a flame screen on the starboard aft fuel oil storage tank vent which permitted a source of ignition to enter vapor space above the contaminated bunkers. The exact source of ignition could not be determined.

Comment: I partially concur with this conclusion. While the contamination of the fuel oil with flush oil caused the venting of combustible vapors, that event should not overshadow the absence of a flame screen in the after starboard fuel oil tank vent. Had a flame screen been in place and in proper condition, it would have prevented the propagation of flame into the fuel oil tank. Therefore the absence of a flame screen is as significant as the presence of the flush oil contaminant in the fuel oil. Furthermore, while various ignition scenarios are possible, I feel that the oxy-acetylene burning operation probably provided the ignition source.

ACTION ON RECOMMENDATIONS

Recommendation 1: The use of a common bunker/cargo line from a facility for bunkering vessels may be an exception rather than the rule within the maritime community. A survey of worldwide bunkering procedures should be initiated in order to identify if this bunkering practice is widely used. If bunkering through a common bunker/cargo line is an accepted practice, international standards should be established and our regulations amended to cover receipt of bunkers under this practice. These standards should require at least the

sampling of bunker tanks in addition to the sampling of each lot taken at the bunker manifold during loading. Test results should then be provided to the chief engineer prior to sailing and burning of received bunkers. The samples taken from the bunker tanks would be indicative of the actual condition of bunkers received aboard the vessel after bunkering.

Action: I concur partially with this recommendation. The Coast Guard will consult with the owners of U.S. tank vessels to determine the extent to which common bunker/cargo lines are used worldwide. Based on this consultation, appropriate actions will be identified and implemented.

However, both 46 CFR 58.01-15 and SOLAS 1974, as amended, Regulation II-2/15.1, limit the use of boiler fuel oils based on flashpoint. The responsibility for compliance with these rules, and for establishing any specific procedures to ensure compliance, rests with the vessel operator or representatives.

Recommendation 2: Examination of flame screens on bunker tanks should be reemphasized to all field units and the examinations should occur during inspections for certification, mid-periods, reinspections and foreign vessel examinations. The maritime community should also be informed of the importance of flame screens on bunker tanks.

Action: I concur with this recommendation. Copies of this report will be provided to Officers-in-Charge, Marine Inspection, to reemphasize the importance of closely examining flame screens.

In addition, an article discussing the need for inspecting and maintaining flame screens on vessel fuel oil tanks will be prepared for publication in the Proceedings of the Marine Safety Council. The Coast Guard will also bring this casualty to the attention of the international maritime community at the next meeting of the International Maritime Organization (IMO) Subcommittee on Fire Protection.

Recommendation 3: Consider promulgating regulations to require the hot work procedures outlined in the ISGOTT be followed whenever hot work is performed anywhere aboard a tank vessel.

Action: I concur with the intent of this recommendation. 46 CFR 35.01-1 indicates that the provisions of "Standard for the Control of Gas Hazards on Vessels to be Repaired," NFPA No. 306 (published by the National Fire Protection Association), shall be used as a guide for conducting hot work. NFPA No. 306 provides a more detailed and thorough standard than ISGOTT. The Coast Guard will continue to use NFPA No. 306 as its standard in the future. The appropriate regulations will be amended as this standard is periodically updated.

Recommendation 4: A study should be considered to simplify the design of lifeboat motors to require minimum maintenance and eliminate potential overheating problems. Strong consideration should be given to air-cooled and geared start-up systems for lifeboat motors instead of water-cooled and hydraulic start-up motors.

Action: I concur with the intent of this recommendation. Although a study is not considered necessary at this time, the Coast Guard has continued to encourage lifeboat manufacturers to design lifeboat systems as simply as possible to enhance reliability. In recent years, more open lifeboats have been equipped with air-cooled engines. However, most new lifeboats will be of the totally enclosed type. No manufacturer has yet designed a totally enclosed lifeboat with an air-cooled engine due to the difficulty of ducting cooling air in and out of the engine box. New quarterly inspection requirements (discussed in the comments on Recommendation 5) should improve the operational reliability of lifeboat engines and their cooling systems.

Manual crank, geared starting systems have been employed on relatively small engines. Larger engines must have some type of mechanical cranking system. A revised Chapter III, "Lifesaving Appliances and Arrangements," of SOLAS 1974, as amended, came into force on 1 July 1986. This new chapter includes standards for lifeboat engine starting systems, including a requirement for starting systems to have two independent power sources. Coast Guard approved lifeboats currently being manufactured comply with this requirement. More frequent inspection and improved equipment should result in greatly improved lifeboat engine starting reliability.

Recommendation 5: The regulations for periodic testing of lifeboat motors should be modified to require releasing of lifeboats from the falls into the water and conducting an in-water operational test of lifeboat motors as required by SOLAS. Operating the lifeboat for 5 minutes in the davits without benefit of cooling water or with water from the vessel's pressurized water system does not properly test the cooling pump's ability to take a suction.

Action: I concur with this recommendation. A regulatory project now in progress, CGD 84-069, will propose incorporation of the 1983 SOLAS Amendments into the Code of Federal Regulations. The proposed regulations include requirements for launching each lifeboat with its assigned operating crew aboard and for maneuvering in the water at least once every three months during abandon-ship drills. These requirements would ensure that all critical components of the boat and engine are maintained in proper operating condition. A faulty cooling water pump impeller would be evident during such a test.

An Advance Notice of Proposed Rulemaking on this project was published on December 31, 1984 (49 FR 50745). Publication of a Notice of Proposed Rulemaking is anticipated in the fall of 1988. These requirements are currently in effect for all U.S. vessels subject to SOLAS, as discussed in Coast Guard Navigation and Vessel Inspection Circular (NVIC) 3-87.

Recommendation 6: The SARSAT receiving station planned for the Central Pacific should be programmed for installation and operation as soon as possible.

Action: I concur with the intent of this recommendation. However, funding for the installation and operation of this station is not available. The requirement for all merchant and passenger vessels subject to SOLAS to carry a new type of emergency position-indicating radiobeacon (EPIRB) is being debated by the IMO. The carriage of this 406 MHz EPIRB, which can be detected worldwide regardless of the location of the receiving station, is likely to be required by the mid-1990's.

Recommendation 7: Forward a copy of this report to the International Maritime Organization (IMO).

Action: I concur with this recommendation. A copy of this report will be provided to IMO.

ADDITIONAL REMARKS

While Coast Guard regulations, specifically 46 CFR 56.50-85(a)(7), currently require flame screens on fuel oil tank vents, SOLAS does not. The Coast Guard will, at a future meeting of the IMO Subcommittee on Fire Protection, propose requiring flame screens on fuel tank vents for all passenger, cargo and tank ships.

Clyde T. Lusk, Jr.

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Vice Admiral, U.S. Coast Guard
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16732/OMI YUKON
30 SEPTEMBER 1987

From: U. S. Coast Guard Marine Board Of Investigation
To: Commandant (G-MMI)

SUBJ: SS OMI YUKON, O.N. 547919; EXPLOSIONS AND FIRE ON 28 OCTOBER 1986 IN THE PACIFIC OCEAN WITH LOSS OF LIFE.

FINDINGS OF FACT

SUMMARY

1. At approximately 1025 (all times are zone description +11, unless otherwise noted, and are based on a 24 hour clock) on 28 October 1986, the SS OMI YUKON while enroute, in ballast, from Barbers Point, HI to a shipyard in Ulsan, South Korea suffered major explosions and fires in the starboard fuel oil storage tanks and engine room, approximately 1000 miles west of Honolulu, HI. The explosions extensively damaged the engine room and removed the stack deck and the stack completely off the vessel. Two men working in the vicinity of the starboard side of the stack deck and the two men on watch in the engine room are missing and presumed dead. Four other crewman were injured. The starboard lifeboat was damaged as a result of the explosions and rendered unusable. The master feared further explosions and asked for volunteers to lower the port lifeboat and move it forward to the port bow. At approximately 1600, the master decided to abandon ship and the survivors were evacuated from the vessel using lines leading over the side of the port bow into the port lifeboat. The inflatable life raft stowed at the bow was launched and used. A distress signal from the Emergency Position Indicating Radio Beacon (EPIRB) was detected by commercial aircraft flying over the Pacific and confirmed by Search And Rescue Satellite (SARSAT), and a search and rescue effort was undertaken. The first rescue aircraft was on scene at approximately 2030, but the crew aboard the aircraft was unable to communicate with the survivors. Rescue aircraft maintained surveillance throughout the night. At approximately 0700 the next morning, the survivors were rescued by the FV SHOICHI MARU (Japanese Flag) and transferred to the MV DRESDEN (Singapore Flag) and taken to Midway Island. The survivors were subsequently flown to Honolulu, HI. The vessel was towed to a shipyard in Tsuneishi, Japan, where it was declared a total constructive loss.

VESSEL DATA

2. Vessel Data:

Name:	OMI YUKON (Ex OGDEN YUKON, renamed on 31 January 1986)
Official Number:	547919
Call Sign:	KFLC
Service:	Tank Ship
Gross Tons:	37784
Net Tons:	27073
Dead Weight Tons (DWT):	82417
Length:	774.1'
Breath (molded):	125.2'
Depth (molded):	57.8'
Propulsion:	Steam Turbine Reduction
Horsepower:	18680
Home Port:	Philadelphia, PA
Hailing Port:	Wilmington, DE
Date built:	15 December 1973
Built by:	Sun Shipbuilding and Drydock Company; Chester, PA
Owner(Trustee):	On the Certificate of Documentation the owner is: The Connecticut National Bank 777 Main Street Hartford, CT 07115 (ATTN: BOND AND TRUSTEE ADMINISTRATION)
Owner:	On the Certificate of Inspection is: OMI Corp 280 Park Avenue New York, NY 10017
Operator:	OMI Missouri Transport Inc. 280 Park Avenue New York, NY 10017
Master:	Terry J. Kotz
Age:	39
License:	Master, Steam and Motor Vessels, any gross tons, upon Oceans, Radar Observer
License number:	No. 557555
Issue:	2-5
Merchant Mariner's Document:	Z-1252992

Coast Guard Certificate of Inspection (COI) data:

Vessel Name:	OGDEN YUKON
Biennial Inspection:	8 Nov 84; Jacksonville, FL
Expiration date:	8 Nov 86
Total persons allowed	32 persons
Persons in addition to crew:	6 persons

Drydocked:	8 Nov 84; Jacksonville, FL
Inspected for the carriage of:	Crude Oil, Products and Flammable or Combustible Liquids, Highest Grade B
Capacity:	594837 bbls
Route:	Oceans
Last Inspection:	Mid-period
Date of Inspection:	20 Dec 85
Inspection Zone:	Los Angeles-Long Beach, CA

Three Coast Guard inspection discrepancies remained outstanding at the time of the casualty. They were issued by the OCMI in Los Angeles/Long Beach. These requirements stated:

1) Provide an approved test procedure for propulsion boiler automation. Issued 20DEC85. Compliance Date 30NOV86.

2) Provide information showing approval of alterations to boiler fuel oil stop valves, and air register controls. Valve limit switches have been removed and replaced with air line pressure switches. If approval has not been obtained, return to original or provide plans to OCMI LA/LB for approval. Issued 01APR86. Compliance Date 30NOV86.

3) Furnish OCMI LA/LB a copy of the next ABS survey of the #1 turbo generator reduction gears. Issued 27SEP85. Compliance Date 30MAY87.

PERSONNEL

3. Crew - missing and presumed dead:

Name:	Ed Roy Connolly
Age:	62
License:	Second Assistant Engineer
License No.:	425889
Merchant Mariner's Document Number:	215 28 9243
Home Address:	P. O. Box 129, Sinton, TX 78387
Next of Kin:	Wife - Virginia
Position in which serving:	Second Assistant Engineer 8-12 watch

Name:	James W. Duffy
Age:	52
Merchant Mariner's Document Number:	025 24 2796
Home Address:	521 Trinidad Circle Union City, CA 94587
Next of Kin:	Wife - Louanna
Position in which serving:	QMED - 8-12 watch

Person in addition to the crew - missing and presumed dead:

Name:	Jerry N. Baker
Age:	37
SSN#:	418 72 2534
Home Address:	Route 2, Box 88 Sweetwater, AL 36782
Next of Kin:	Father - George
Position in which serving:	Contract worker

Name:	James Turk
Age:	43
SSN#:	424 54 5771
Home Address:	Route 1, Box 17 Marvin, AL 36762
Next of Kin:	Brother - Stanley
Position in which serving:	Contract worker

Crew - injured and incapacitated for a period in excess of 72 hours:

Name:	David B. Dawson
Age:	44
Merchant Mariner's Document Number:	553 54 7737
Home Address:	7017 Toro Creek Road Atascadero, CA 93422
Position in which serving:	Chief Engineer
Injury:	Neck and back

Name:	Jimmy W. Devitt
Age:	42
Merchant Mariner's Document Number:	174 34 5196
Home Address:	P. O. Box 189 RD #2 Zelianople, PA
Position in which serving:	First Assistant Engineer
Injury:	Leg (Broken)

Name:	Gordon Lee
Age:	59
Merchant Mariner's Document Number:	561 42 2368
Home Address:	4239 Ulloa Street San Francisco, CA 94116
Position in which serving:	Chief Cook
Injury:	Fingers (Broken)

Name:	Richard D. Fairbourne
Age:	64
Merchant Mariner's Document Number:	124 28 5803
Home Address:	2172 Rockridge Drive Grand Junction, CO 81503
Position in which serving:	Radio Electronics Officer
Injury:	Neck and back

LIFESAVING EQUIPMENT

4.

	Number	Persons	Material
Total Equipment For		32	
Motor Lifeboat (port)	1	42	FRP
Motor Lifeboat (starb)	1	42	"
Inflatable Raft (fwd)	1	8	Rubber
Inflatable Raft (aft)	1	15	"

	Required
Life Preservers	38
Ring Buoys	24
Equipped with EPIRB	Yes

FIRE-FIGHTING EQUIPMENT

5.

Total Hose Length	1650 Feet
Number of Fire Axes	5
Number of Fire Pumps	2

Fixed Foam System protecting the engine room, pump room and the cargo block.

Fixed CO2 Systems for the paint lockers, emergency generator room, and standby generator room.

WEATHER

6. On 28 October 1986, at approximately 1025, the wind was out of the Northeast 3 to 4 knots, air temperature was approximately 85° F and the sea temperature was approximately 86° F. Unlimited visibility. Seas were calm. The vessel was on a course of 279° T and making approximately 13.5 knots.

DESCRIPTION OF THE VESSEL

7. The OMI YUKON was a tank vessel of steel construction and had a typical tank ship configuration with the deckhouse aft and above the machinery space. It contained the navigation bridge, the radio room and quarters for the entire complement of officers

and crew. Immediately aft of the deckhouse was the machinery house separated by a breezeway. The upper engine casing was located in the starboard side of the machinery house and contained the boiler uptake, force draft blowers, and some of the auxiliary machinery including the inert gas scrubber and blowers. In the port side of the machinery house were the emergency generator room and the foam room at the main deck level and the standby diesel generator on the level above the main deck. The only pump room was located immediately forward of the deckhouse. The vessel had five transverse cargo tank sections. Each tank section consisted of; a port wing tank, center tank and starboard wing tank. The number 4 center tank was divided into a cargo tank in the forward part with the designated slop tank in the after part. The number 3 wing tanks were dedicated ballast tanks. The cargo tank area was protected by an inert gas system (IGS). The OMI YUKON was a single screw vessel with one main boiler. The vessel had an auxiliary fire tube boiler, which had a maximum steam pressure of 150 psi. The vessel was equipped with two steam turbine generators, a standby diesel generator capable of providing the vessel's entire electric load and an emergency generator.

8. The OMI YUKON's fuel oil storage tanks (port and starboard) were located outboard of the engine room in wing tanks. The fuel oil storage tanks' inboard bulkheads were common to the engine room. The OMI YUKON had two fuel oil settler tanks (port and starboard) that were located forward of the storage tanks and outboard of the pump room and forward part of the engine room. The original design plans of the vessel indicated two salt water ballast tanks (port and starboard), which were located immediately aft of the two fuel oil storage tanks. Sometime during construction of the vessel, the salt water ballast tanks were made common with the fuel oil storage tanks on their respective sides. Lightening holes were cut into the common oil tight bulkheads separating the tanks and heating coils were added. The purpose of this modification was to increase the fuel oil carrying capacity of the vessel. Each fuel oil storage tank had a capacity of approximately 8,840 barrels(bbls) and each settler tank had a capacity of approximately 5,225 bbls. Aft of the engine room and fuel oil storage tanks was a transverse ballast tank running the entire width of the vessel. The outboard forward bulkheads of the transverse ballast tank were common with the aft ends of the fuel oil storage tanks.

9. The aft access trunk of the starboard fuel oil storage tank was identified by the letters "WBS" outlined in weld bead. The aft vent for the starboard fuel oil storage tank was an approximate 2 1/2 inch diameter pipe with a gooseneck and ball check valve. The base of the 2 1/2 gooseneck vent was welded to a flange that was connected with bolts and a gasket to another flange that was connected to an eight inch diameter vent pipe. The mouth of the gooseneck vent was designed to have a hinged flap attached that could be manually closed. The aft vent for the port fuel oil storage tank was similar in construction to the aft vent for the starboard fuel oil storage tank.

10. The aft vent for the starboard fuel oil storage tank was located inboard and approximately a foot aft of the garbage chute. The garbage chute went through the after end of the storage tank to the skin of the ship. The OMI YUKON had two permanent chief engineers assigned, Mr. Dawson and Mr. Varn. Both chief engineers and the first assistant engineer testified that the fuel oil tank hatch trunks and covers were painted green and were labeled with "F.O." in white letters to indicate that the tanks were used for fuel oil storage. The vents for the fuel oil tanks were not marked.

11. Located on the starboard side of the machinery house was a stores boom. The "I" beam structure of the boom was hinged against the aft outboard end of the accommodations and the free end was secured to the machinery house with a pin and bracket arrangement when in the stowed position. The boom was located approximately 20 feet above the main deck and approximately 10 feet below the stack deck. Two cables provided support for the boom. The boom could swing through a 180^{0} arc and was equipped with a hoist.

USE OF PERSONS IN ADDITION TO THE CREW FOR MAINTENANCE AND REPAIRS

12. Chief Engineer Varn (not aboard on the day of the casualty) testified that contract workers were routinely employed aboard the vessel. He had been assigned as a chief engineer aboard the OMI YUKON since 5 December 1979, when Ogden Marine purchased the vessel. The contract workers were involved in welding and burning in connection with repairs and renewals to pipelines in the engine room, such as bilge lines, and also worked on cargo piping and hull structure. The contract workers engaged in other routine maintenance and repairs aboard the vessel not necessarily involving hot work. Varn was not sure if Turk or Baker, the contract workers, had Coast Guard or American Bureau of Shipping (ABS) welders' qualifications. Varn testified that he understood that Coast Guard certified welders must be employed for welding on boilers and high pressure steam lines. He testified that the contract workers did welding on the hull structure which included bulkheads and structural members. Larry King, another contract worker employed aboard the OMI YUKON, testified that he did not have ABS or USCG welder qualifications.

INSPECTIONS OF FLAME SCREENS FOR THE FUEL OIL TANKS

13. The OMI YUKON was last inspected by a US Coast Guard marine inspector on 20 December 1985 in Long Beach, California for a mid period examination. LT Jonathan Sarrubi, USCG, from the Marine Safety Office LA/LB, conducted the deck side inspection. He testified that he examined all the fuel oil tank flame screens and found no discrepancies.

14. On 21 August 1986, Mr. Kaufmann, an American Bureau of Shipping (ABS) Surveyor boarded the OMI YUKON at Crockett, CA to conduct an annual survey of the vessel. He testified that he inspected all the fuel oil tank flame screens during the course of his survey. Mr. Kaufmann was accompanied by Larry King, one of the contract workers aboard the vessel. King took notes concerning discrepancies found during the inspection. Mr. Kaufmann did not require any of the flame screens to be opened up. He examined the vents using a mirror and flash light. Based on his examination, he told Larry King to have the port fuel oil settler tank vent screen cleaned or replaced and to clean all the storage tank vent flame screens, port and starboard sides. Chief Engineer Varn was in attendance during the ABS inspection of the flame screens and he recalled Kaufmann bending down and looking up into the vents using a flashlight. He claimed Mr. Kaufmann looked at the aft vent of the starboard storage tank. Chief Engineer Varn testified that he looked at a couple of the flame screens. Mr. Kaufmann indicated only one problem with the flame screens for the fuel oil tanks in his inspection report; however, King recorded on his work list the additional work items concerning the flame screens on the other fuel oil tanks. King testified that he was told by Mr. Kaufmann to clean the flame screens or replace the screens, if necessary, on the port and starboard fuel oil storage tank vents.

15. King was assigned to correct the deficiences on the list prepared during the ABS inspection, including the items concerning the flame screens. He was assisted by Baker, another contract worker. King claims that all six fuel oil tank gooseneck vents were taken apart and new flame screens installed. King cut out all the new flame screens from a roll of material. He and Baker reassembled the gooseneck vents, but King could not specifically recall reassembling the aft vent flame screen of the starboard storage tank. King believes Baker put the flame screen assembly together and put it on the opening of the gooseneck for the aft vent of the starboard fuel oil storage tank. King also testified that he checked all the fuel tank vents and they had flame screens in place after the work was performed.

16. On 4 September 1986, Mr. Avilla, another ABS Surveyor boarded the OMI YUKON to follow up on the inspection started by Mr. Kaufmann. Mr. Avilla only checked those discrepancies indicated in Kaufmann's report and not all the items noted by King on behalf of Kaufmann. Avilla's report indicated that he only examined the port fuel oil settler tank vent. He did not examine any of the other five vents for the fuel oil tanks.

VOYAGE FROM VALDEZ, AK TO BARBERS POINT, HI

17. The OMI YUKON departed Valdez, Alaska to discharge its load of approximately 550,000 bbls of Alaskan North Slope crude oil at Hawaiian Independent Refinery, Inc (HIRI) at Barbers Point, Hawaii. After completing discharge of cargo, the vessel was

scheduled to proceed to Ulsan, South Korea for drydocking and U.S. Coast Guard inspection for certification. In preparation for the shipyard period the owners hired Japanese workers to clean the tanks on the voyage to the Far East. The master received a cable from OMI Corporation advising him that ten Japanese workers to clean tanks would be joining the vessel at Barbers Point and to make necessary preparations aboard the vessel. The master testified that he believed that the office had cleared the boarding of the Japanese workers with the appropriate authorities because it was a standard company practice. In preparation for the arrival of the Japanese workers, the master instructed the third mate to inventory the survival suits and life jackets to insure that there was sufficient equipment aboard the vessel for the additional persons.

FIRE AND BOAT DRILLS

18. On 21 October 1986, both lifeboats were lowered to the water at Barbers Point, but were not released due to strong currents. During the drill, the forward fall on one of the boats released because a wave lifted the boat off the releasing hook. The crew had to reconnect the forward fall before lifting the boat.

ORDER FOR BUNKERS (FUEL OIL)

19. Normally, the bunkers (fuel oil) for the OMI YUKON would be ordered by the charterer of the vessel. Since the vessel was going off charter for the upcoming shipyard period, OMI Corporation, rather than the charterer, ordered the bunkers from Hawaiian Independent Refineries Inc. (HIRI) at Barbers Point, HI. On 16 October 1986, HIRI sent a telex to OMI Corporation stating that they would provide 1220 metric tons (7,950 barrels) of 380 cst (Bonded) bunkers.

BLENDING OF BUNKERS

20. On 17 October 1986 at approximately 2330, HIRI refinery personnel commenced mixing approximately 6000 bbls of Alaskan North Slope residual with 16,500 bbls of fuel oil in tank 307, to fill the order for the OMI YUKON. The viscosity of the fuel oil in tank 307 was 169 centistokes and the viscosity of the Alaskan North Slope residual was approximately 110,000 centistokes. The blending was completed at 0500 on 18 October 1986. The blending process was assisted with the use of a cyclone mixer, but no heat was applied. The starting temperature in tank 307 was 190° F and when the blending was completed the temperature in tank 307 was approximately 132° F. The test results of samples taken of the product in tank 307 after the mixing indicated a flash point of 260° F. The exact method of sampling the product in tank 307 is not known.

21. The OMI YUKON arrived off Barbers Point, HI on 21 October 1986 but did not moor at the HIRI eight point mooring until 1212

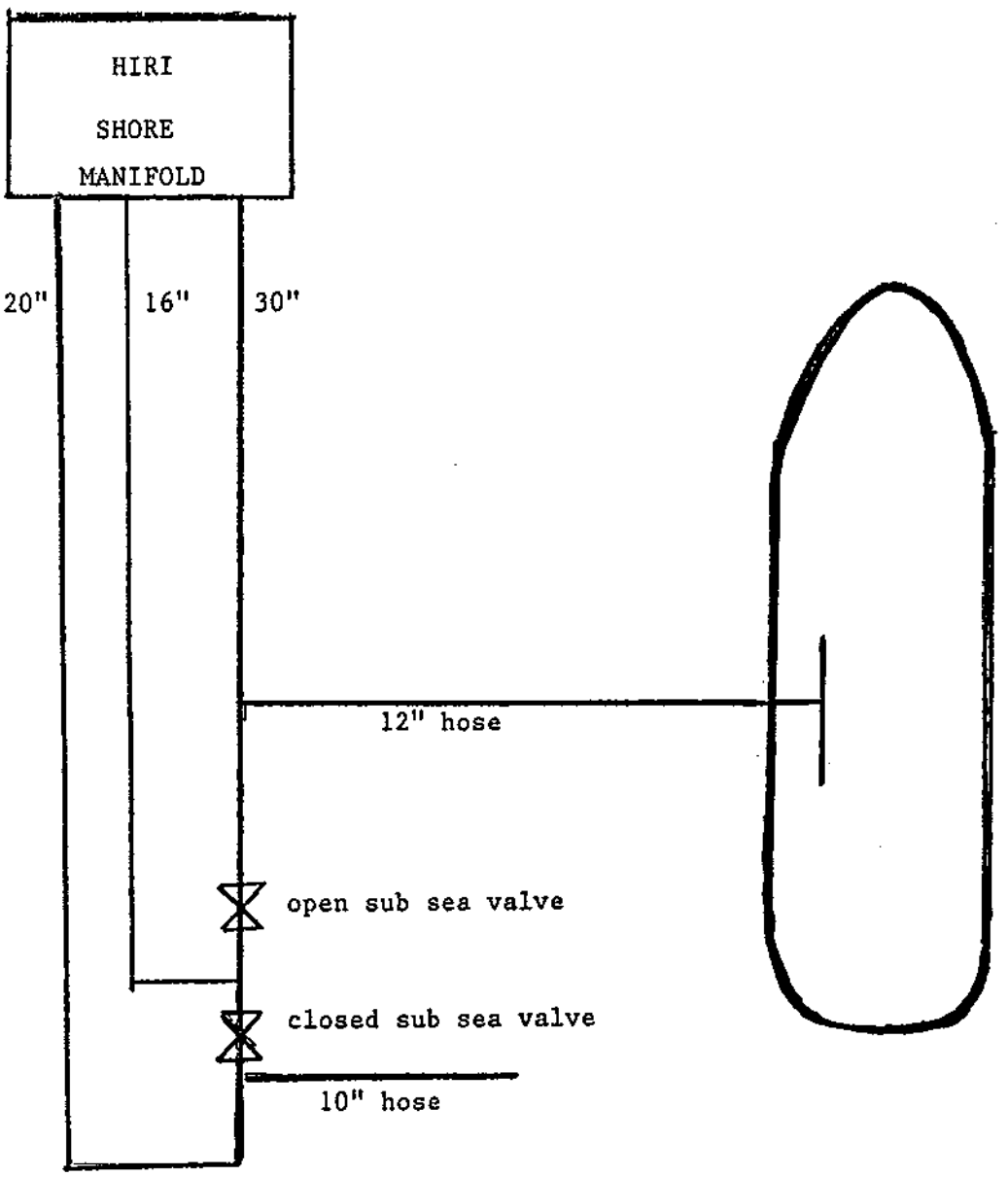
on 23 October 1986 because of adverse weather and current conditions.

LOADING OF BUNKERS AT HIRI

22. HIRI utilizes an offshore mooring system for loading and discharging tankers. The system consists of three 13,000 foot long sub-sea pipelines leading to a sub-sea manifold. Two valves at the sub-sea manifold are used to cross connect the 16", 20" and 30" lines. Divers are required to change the valve positions on the sub-sea manifold. Connected to the sub-sea manifold are two hoses which are used for loading and discharging vessels. The 12" hose is connected between the 30 inch line and 16 inch line on the sub-sea manifold. The 16 inch line is available as a return line for recirculating product or flushing the 30 inch line. The 30 inch line with the 12" hose is normally used for receipt of crude oil and is also used for bunkering. The 10" hose is connected to the 20 inch line and used for transferring white or clean products. Normally the 20" line is isolated from the other two lines to prevent contamination.

23. In preparation for bunkering the OMI YUKON using the sub-sea pipeline, HIRI personnel pumped flush oil into the 16 inch sub-sea line and recirculated it back through the 30 inch sub-sea line to clear a prior load of crude oil. Flush oil starts out as diesel grade distillate, but as it is used to push other products through the refinery it becomes contaminated with the other products it comes in contact with; such as crude oils, gasolines and other distillate products. Eventually, contaminated flush oil is pumped into a crude oil tank and processed through the refinery again.

24. At 1350 on 23 October 1986, the 30 inch line was reported to be filled with 10,325 bbls of bunkers from tank 307 (the tank used to blend the ordered bunkers for the vessel) and behind that in the 30 inch line was flush oil to push the bunkers out to the vessel. The 30 inch line holds approximately 12,500 bbls. The vessel only ordered 7,950 bbls but additional bunkers were put in the line to insure that the expected mixing of the flush oil with the bunkers at the interface was pushed well beyond the sub-sea hose connection. Refinery personnel determined the locations of the interface between products based on tank gaugings. The refinery pumps the leading interface between the flush oil and fuel oil past the location of the hose connection at the sub-sea manifold recirculating it back to the refinery through the 16 inch line.



Redrawn from Exhibit #41 originally prepared by Captain Kuntz

25. The first step in bunkering the OMI YUKON was for the crew to hook up a specially manufactured jumper line between the cargo manifold and the midships bunker manifold. Prior to discharging cargo, bunkers were taken aboard using the same facility hose for off loading cargo. The 12" hose from the sub-sea manifold was connected to the cargo manifold. A jumper was connected to the cargo manifold, then to the bunker manifold. The jumper was used rather than transferring the refinery's hose between the two manifolds. Whatever product remained in the refinery's hose from its prior use, was flushed into the slop tank. It was easier to handle the residual product in the hose as part of the cargo discharge, rather than having to deal with it as a separate discharge operation. When good bunkers were observed at the cargo manifold, the valves on the cargo manifold system were changed to direct the flow of bunkers from the offshore hose past the first header through a cross over between cargo manifold lines, out of the cargo manifold header, into the temporarily installed jumper line to the midships bunker manifold.

26. At approximately 1455 on 23 October 1986, the product in the hose from the last discharge and flush oil were being transferred to the slop tank. The chief engineer was monitoring the hose flush operation by opening a sampling petcock and observing the color and feel of the product. He then could determine when bunkers were being received. After approximately 10 minutes, the vessel was still receiving flush oil and not bunkers. The refinery personnel investigated the problem and discovered that less bunkers were placed in the line because shore personnel miscalculated the shore side tank quantity. To provide the ordered amount of bunkers, additional bunkers were added to the 30 inch line. The second segment of bunkers was placed in the 30 inch line behind the flush oil used to push the first segment to the vessel. Additional flush oil was added to the line behind the second segment of bunkers. After loading of the second segment, the bunker tanks were sounded. The chief engineer reviewed the quantity of bunkers received and requested an additional 400 barrels of bunkers. The refinery personnel indicated that sufficient bunkers remained in the sub-sea pipeline and provided the additional bunkers.

27. Prior to April 1986, bunkers taken from HIRI were loaded directly into the settler tanks to preclude having to transfer after bunkering. These bunkering procedures were changed after the vessel received an off specification load and all the bunkers aboard the vessel had to be off loaded to the terminal. Mr. Mesaris, Superintendent Engineer for OMI Corporation, testified that samples of the bunkers received from HIRI in April 1986 were tested and the flash point was below the 140^{o} F minimum that is acceptable. He added that he seemed to remember the flash point was something around 75^{o} F to 80^{o} F. He further testified that the off specification bunkers were contaminated with the flushing oil or buffer stock. Bunkers received from HIRI after April 1986 were put into the storage tanks in case of a similar problem, and if there was no obvious problem with the new bunkers, they were transferred to the settlers when needed.

28. The US Coast Guard Regulations concerning requirements for fuel oil for tank vessel, 46 CFR 35.25-10, states that "Oil to be used as fuel to be burned under boilers on tankships shall have a flashpoint of not less than 140° F (Pensky-Martens Closed Cup Method, ASTM D 93)."

SAMPLING OF BUNKERS

29. During the two segment loading of bunkers on 23 October 1986, two samples were taken at the cargo manifold. One sample was taken at the beginning of the first segment and the second sample was taken 10 minutes into the second segment. The chief engineer testified that he checked the condition of the bunkers by touch, smell and sight. He did not test the bunkers, nor did he have the equipment aboard the vessel to test them. Samples of the bunkers in the storage and settler tanks were not taken before or after loading of bunkers.

GAUGING OF BUNKERS

30. At approximately 1435 on 23 October 1986, Robert Lewis, a Caleb Brett Inspector, completed his preliminary bunker survey. He determined that the port and starboard storage tanks were empty. Mr. Lewis's report indicated that the port settler had 1,982.4 bbls and the starboard settler had 2,103.1 bbls of bunkers. After bunkering was completed, Mr. Lewis again gauged the bunker tanks and after making the necessary calculations, he determined that the vessel had received 8406 bbls of bunkers. The gauging of shore tanks indicated that the refinery delivered 8793 bbls of bunkers. The vessel received 387 bbls less than what the refinery claimed was delivered. Mr. Lewis testified that the difference of 387 bbls is normal for this class of vessel based on his experience.

CARGO OPERATIONS

31. Bunkering of the OMI YUKON was completed at 2220 on 23 October 1986. The jumper used during the bunkering operation was disconnected at 2230 on 23 October 1986. The discharge of cargo, through the same 12" hose bunkers were taken with, commenced at approximately 2254 on 23 October 1986 and was completed at 1230 on 25 October 1986. The crude oil wash (COW) and the IGS were used and functioned properly. Only 37 bbls of cargo remained on board the vessel after discharge was completed.

PERSONS IN ADDITION TO THE CREW

32. On 25 October 1986, 11 Japanese workers, and a replacement contract worker came aboard the vessel. The master testified that he did not look at the vessel's Certificate of Inspection to determine the total number of person allowed. The master testified that OMI Corp. arranged for the 11 Japanese workers to come aboard to assist in gas freeing the vessel for the upcoming shipyard period. (The master was originally advised that 10

Japanese workers would be joining the vessel at Barbers Point, HI) The OMI YUKON's normal crew complement was 23 and they signed on foreign articles on 20 September 1986. The two contract workers were not signed on as crew but were persons in addition to the crew. Ship's stores and the Japanese workers were transported by launch to the vessel and the vessel's agent cleared the vessel with US Customs ashore. The OMI YUKON departed Barbers point, HI at 1624 on 25 October 1986 with 37 persons which consisted of 24 crew members (including an extra chief mate who boarded while the vessel was at Barbers Point), 11 Japanese workers, and two independent contract workers.

VOYAGE FROM BARBERS POINT, HI

33. The chief engineer testified that bunkers were transferred from the storage tanks to the settlers after departing Barbers Point, HI and before 28 October 1986.

34. On 26 October 1986, at approximately 0615, the boiler shut down due to a malfunctioning 50 volt circuit breaker on the boiler control system. The emergency generator came on the line and the lights were out for only a few moments. Sometime after the emergency generator came on, the chief engineer put the standby generator on the line to carry the vessel's normal electrical load. The malfunctioning breaker was replaced and the boiler was restarted manually. Steam pressure was restored to operational levels at 0735. Once the boiler was stabilized, boiler control was switched from manual to automatic.

35. A fire and boat drill was held on 27 October 1986. The port lifeboat was lowered to the embarkation deck. The entire crew, including the Japanese workers, were mustered and a demonstration on how to properly don the survival suits was performed.

THE CASUALTY

36. On the morning of 28 October 1986, the first assistant engineer was standing the 0400 to 0800 watch. The first assistant engineer's watch was routine, except for two events. At approximately 0630 a steam driven cargo pump was put on the line to be used in connection with tank cleaning operations. When the cargo pump was put on the line, shaft revolutions were reduced. At about the same time, the chief engineer, who was on the bridge, heard a little pop and saw a slight feather or whisper of steam from the sky pipe and called the engine room. The first assistant engineer could not find any indication that there was a problem with a steam relief valve. The first assistant engineer believes that when the cargo pump was put on the line, a 150 psi relief valve may have lifted.

37. The first assistant engineer testified that the relief of the watch was normal and that Mr. Connolly seemed fine. The first assistant engineer left the engine room to have breakfast and then returned to the engine room to discuss work items with the chief engineer.

38. The chief engineer spoke to Mr. Connolly at approximately 0900 during the course of a routine inspection of the engine room. No problems were reported.

39. The chief engineer checked with the chief mate concerning the status of the cargo tanks before commencing hot work. The cargo tanks were either gas free or inerted. The chief engineer testified that he did not designate an individual as a fire watch, but that it was common practice that the other contract worker was the fire watch. The chief engineer assumed this to be the case on 28 October 1986. He also testified that he did not conduct a special inspection prior to the start of hot work and that no fire extinguishers or charged fire hoses were in the immediate vicinity of the hot work.

40. Shortly before coffee time, the chief engineer asked the first assistant engineer to help him and the two contract workers with the removal of the old stores boom on the starboard side of the engine casing.

41. The 2nd mate came out on deck between 1020 and 1030 to observe work in progress. He remembers feeling no breezes or smelling anything. The Japanese workers were involved in tank cleaning operations forward as were the two chief mates, and the master. The radio officer was working in the radio office and the third mate was standing the 0800 - 1200 bridge watch.

42. At approximately 1020, the chief engineer and the first assistant engineer were on the main deck near the starboard rail. The stores boom was supported by three chain falls for the purpose of lowering it to the deck once the hinge pin and supporting cables were cut or removed. The first assistant engineer had a tag line from the stores boom led through the deck bit near the starboard rail just aft and outboard of the breezeway, and the chief engineer was standing forward of him. The first assistant engineer saw Turk standing on the aft end of the old stores boom. Turk lit the torch but it went out. Turk relit the torch and knelt down near the aft end of the boom. The boom is normally secured to the aft end of the engine casing with a pin and bracket arrangement. The first assistant engineer testified that he thought Turk was either going to cut the attachment off the engine casing or just cut the pin to release the boom. Beneath the aft end of the boom and a few feet outboard was the aft vent to the starboard fuel oil storage tank. The chief engineer and the first assistant engineer both testified that Turk was cutting something, but they both also testified that they did not see any sparks or hot slag fall to the deck. The first assistant engineer last saw Baker going up to the stack deck. The chief engineer testified that he saw Baker on the stack deck prior to the explosion.

43. The first assistant engineer recalls that Turk climbed up to the stack deck from the end of the old stores boom. Turk appeared to be reaching to cut the support cables that went from

the free end of the boom to the aft starboard corner of the accommodations house. The first assistant engineer believes that the torch in Turk's hand was lit, but he then looked away and was heading towards the breezeway between the two houses when he heard a whoom. The next thing he remembers was that he was on the deck and covered with oil. He claims he remembers little else about the explosion. The chief engineer recalls seeing Turk climbing over the handrail, but he was unsure in which direction Turk was going and whether he had a torch in his hand or not. The next thing the chief engineer recalls was "this big ball of fire and then....I saw that ball of fire up there, stack deck level and possibly the side, just this big yellowish ball of fire, and just right over here to my right and forward a bit, this tremendous noise or possible ball of fire, very black and orange flames." The chief engineer remembers being blown towards the starboard rail and almost going over the side. His neck hit the handrail, his chest hit the middle rail and one of his feet broke out the lower rail.

44. At approximately 1025, the time of explosion, the master was at #3 starboard ballast tank ducking underneath piping. He heard one explosion which sounded like a sharp crack, and then he saw a fireball and flames, higher than the starboard bridge wing. He immediately ran forward to escape falling shrapnel and continued to the bow to call the bridge, but he couldn't find the phone. He then went aft to organize the fire fighting effort and recalls seeing flames and smoke coming out of vents for port bunker tanks. The flames were 3-4 feet high and heavy smoke was coming from the breezeway between the house and the engine casing. The master ordered the crew to break out the fire hoses to fight the fire. Hoses were laid out but there was no pressure on the firemain. Prior to the casualty the firemain had 70 psi because of tank cleaning operations in progress. With no water pressure on deck, the master attempted to activate the foam system, but could not get into the foam room because of flames and smoke. The fireman's outfit stored in the bow area was taken aft by the crew in an attempt to enter the deckhouse, but without water pressure, the attempt was aborted due to the heat.

45. After the fire fighting effort was aborted, the master went to the starboard side and observed that the starboard bunker tank had exploded and the starboard lifeboat was hanging by the forward fall only. He saw the chief engineer on the raised deck above the starboard bunker tank slipping and staggering. The first assistant engineer was on the deck. The master then went to the starboard side of the pump room and yelled up to the third mate on bridge. The third mate reported that the vessel had no power, steerage, or engines. There were no communications with the engine room. The mate also reported that two ABs and the radio officer were trapped on the bridge with him.

46. Chief Mate Engemann was about to proceed aft when he heard a large bang. He recalls seeing a large fireball engulf the starboard side. He then ran aft, saw the chief engineer on all

fours on the deck, covered with oil and disoriented. He and other crew members helped get the chief engineer and first assistant engineer forward. Engemann held a muster of the crew about ten minutes after the explosion and determined from his knowledge of assigned vessel personnel that the two contract workers and the two men on watch in the engine room were missing. Engemann directed the crew members to secure all the open hatch covers, ullage openings and inert gas tank valves.

47. The 3rd Mate on the bridge, heard a pop and a loud bang. He turned and looked through the aft wheel house windows and saw dense black smoke and an orange fireball. He rang the general alarm and told the able seaman (AB) on watch to don his life jacket. AB Kane donned his life jacket and moved the emergency lifeboat radio from its bracket in the bridge and put it on the bridge wing. The third mate tried to go below but was forced back by the heat and smoke. He then checked the starboard side, saw oil on the buckled deck and some of the crew wandering around dazed. He checked the steering and found that it was not operating. There was no power on the bridge and he does not recall hearing any alarms before the explosion. The third mate tried to go below again, but was again repulsed. The only exterior ladder from the bridge was located aft and in the breezeway between the houses. It was engulfed in smoke and flames. AB Zimmerman, who was in his stateroom at the time of the explosions, made it to the bridge, followed a few minutes later by the radio officer. Prior to going to the bridge, the radio officer attempted to send a distress signal using the emergency transmitter, which had power, but no signal was transmitted. The radio officer assumed that the antennas were damaged and this was confirmed after he made his way to the bridge.

48. The 2nd Mate, from his position near the port cargo manifold, saw a piece of metal flying off to port with smoke trailing behind it. He then saw flames, which appeared to originate from either midships or starboard side of the house, shoot out 20-30 degrees from the horizon towards port, followed by a fire ball, then a second much larger fireball, followed by a jet of flame which originated on the starboard side below the stack deck area and shot forward in a twisting motion.

49. The crew trapped on the bridge rigged a Bosun's chair over the starboard wind dodger. The line and Bosun's chair were stored in a locker on the bridge deck. With the help of the crew on the main deck, the two ABs, the radio officer and the third mate were lowered from the bridge. Prior to leaving the bridge, the third mate lowered to the main deck the following; log books, charts, navigational tables, dividers, a sextant, two jugs of drinking water, the lifeboat radio, and the EPIRB.

50. The master sent all the crew and the equipment removed from the bridge forward. Another explosion occurred 40 minutes after the initial explosions. This explosion was reported as being

more muffled than the initial explosions. After this explosion, the master checked the port side bunker tank vents and there were no flames.

51. The master then discussed lowering the port lifeboat and he asked for volunteers. A number of the crew volunteered to lower the boat in spite of flames and heavy smoke on the port side in the area of the breezeway. The crew lowered the boat to the embarkation deck and the bosun, an AB, a QMED, the third mate and the third assistant engineer boarded the lifeboat. The lifeboat was then lowered to the water. The releasing gear mechanism was activated, but both falls did not release. The hooks did not open when the lifeboat release lever was activated. The crew had to bend the preventer bars and pull the blocks from the hooks. The aft fall was released first then the forward fall.

52. The lifeboat's diesel motor with a hydraulic starting system would not start. The master, concerned about further explosions, directed the crew to move the lifeboat up to the bow using the sea painter to tow it. The crew was able to start the motor after the boat had been towed to the bow. The crew in the lifeboat was lifted aboard the OMI YUKON using a line with a french bowline led through a snatch block. The first aid kit in the lifeboat was brought aboard for treating the injured crewmen.

53. The injured personnel were brought up to the bow area and first aid was rendered by the crew. The first assistant engineer's broken leg was splinted and oil was washed from his eyes with the eye bath from the lifeboat first aid kit. The chief engineer was complaining of pain and discomfort and was made as comfortable as possible. The chief cook's cut and bleeding fingers were bandaged. The radio officer was complaining of distress, and was suffering from smoke inhalation.

54. The EPIRB removed from the bridge was put into the water and the attached lanyard was tied to the rail. The crew believed that the EPIRB was a water activated type device. The EPIRB was trailing aft with the vessel's movement and the antenna was in the water. The EPIRB was retrieved and placed in the upright position on the deck and continued to transmit a signal. The lifeboat radio was set up by the crew and activated. When the radio officer felt better he sent out a distress call on 8364 and 500 kilohertz. The radio officer transmitted the vessel's name and the vessel's position in morse code. The second mate gave the radio officer the vessel's position as 22.5° N, 174.2° W. The radio officer testified that the lifeboat radio was radiating a signal.

55. One of the two cranks on the lifeboat radio broke just inside the case after approximately two-three hours of cranking. Prior to the crank breaking, the radio officer was unable to contact anyone using the auto signal and keying an SOS on low and high frequencies. The crew opened up the lifeboat radio and determined that the crank broke when the chain inside jumped off a gear.

56. At approximately 1345 a vessel was seen on the horizon, but the vessel did not come to assist. From approximately 1415-1430 a rain squall passed through the area and afterwards the vessel seen earlier was no longer in sight.

ABANDONING SHIP

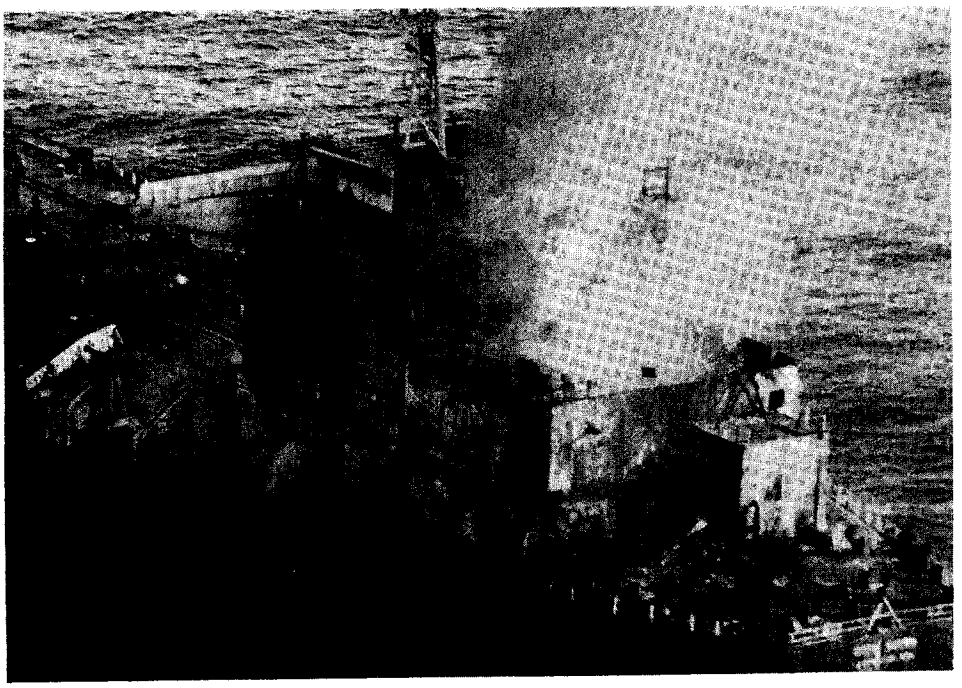
57. At approximately 1430, after the passing rain squall, several more minor explosions occurred. No other vessels or aircraft were sighted. The fire appeared to be spreading and increasing in intensity. Flames were observed in the forward windows of the house and in the bridge area. The master was concerned that the earlier explosions may have compromised the inert atmosphere in the cargo tanks and he feared that they would explode as well. The master saw no further need to remain aboard the vessel because staying aboard a burning tanker at night was scary, it was very dangerous abandoning ship at night, the weather was worsening and the swell was increasing. He decided to abandon the vessel and he planned the evacuation so they could board the next morning, if necessary.

58. In preparation for abandoning the vessel, the inoperative lifeboat radio was quickly reassembled and lowered into the lifeboat. The 8 man inflatable life raft located at the bow was launched and it inflated right side up. The injured crew men were lowered into the lifeboat using the french bowline rigged earlier. The freeboard at the bow was estimated by the crew to be approximately 50 feet. The last crew men aboard, including the master, climbed down lines into the lifeboat. Three crew men went into the life raft and 30 men were in the lifeboat. No one entered the water or was injured in the evacuation. When the crew completed the evacuation, they cast off from the burning vessel.

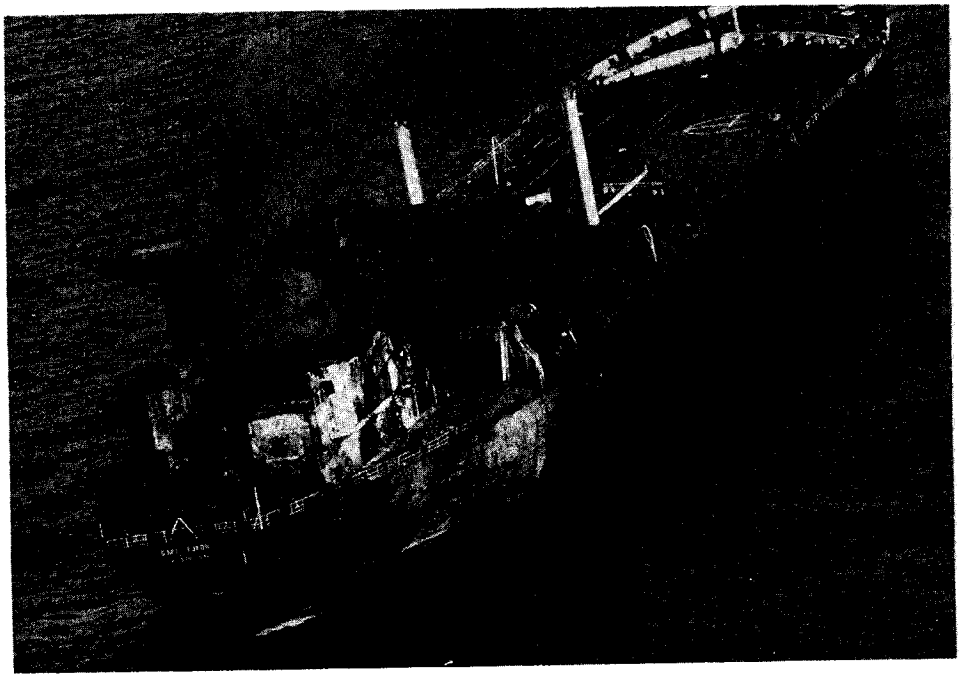
59. After casting off from the vessel the lifeboat engine was started after a couple of tries. The lifeboat engine was operated for five minutes before it overheated. The crew used the oars to continue moving clear of the burning OMI YUKON. The crew was able to restart the lifeboat motor two or three more times until they were well clear of the burning vessel. The master tried to keep the vessel in sight so they could board in the morning. The engineers examined the sea cock and the water pump. The hose from the sea cock to the water pump was removed, the sea cock was opened and water entered the boat. The hose was replaced. The engineers believe that the problem with the overheating was the inability of the pump to take a suction because either the rubber impeller was worn out or the pump was air bound; however, the water pump was never taken apart to check the impeller. It was never definitively determined what caused the overheating problem.

60. While in the lifeboat, the crew continued sending a signal using the EPIRB and they attempted to fix the lifeboat radio again without success. At about 2100 - 2130, the survivors first heard then saw an aircraft. The second mate fired rocket propelled flares to get the aircraft's attention. The aircraft turned around and circled overhead. The second mate reported having problems disengaging the safeties of three Kilgore rocket parachute flares. He threw the three inoperative flares over the side to prevent panic. The survivors could not make out the markings on the aircraft. The aircraft continued to circle but did not otherwise indicate that they were aware of the survivors. The first aircraft stayed about 45 minutes. Then another aircraft or the same one would circle and then go away and return again. During the early morning hours of 29 October 1986, a US Navy aircraft was spotted.

61. At 1350 (all times in this paragraph are zone description +10) on 28 October 1986, LT Terrence Walsh, Senior Watch Officer at the Coast Guard Operations Center in Honolulu, HI received a call from the Federal Aviation Administration Air Route Traffic Control Center in Oakland, CA reporting that several high flying commercial aircraft had heard Emergency Locator Transmitter (ELT) signals in the vicinity of what turned out to be the OMI YUKON. LT Walsh testified that he then called for a printout of vessels from the Automated Mutual Assistance Vessel Rescue System computer in New York that would be within 300 miles of the reported ELT position. Only one vessel was identified and it was the MV DRESDEN. At 1550, FAA in Oakland was called to see if any more ELT signals had been reported. An additional aircraft had reported signals in that area. At 1601 LT Walsh directed USCG Air Station Barbers Point, HI to launch a C-130 long range search aircraft to investigate the position of reported signals. One minute later at 1602, LT Walsh received a SARSAT alert. The satellite had picked up the EPIRB signal at 1421 and transmitted the data to a receiving station at Kodiak, AK. A second satellite report was processed through a receiving station at San Francisco, CA. At 1630 an Urgent Marine Information Broadcast was issued to notify mariners in the area that there was persistent emergency beacon signals on 121.5 megahertz. At 1739 after loading additional fuel for the 900 mile flight the C-130 aircraft was airborne. At 2135 the aircraft had located the burning vessel and the lifeboat. Because of darkness and lack of communications with the lifeboat the identity of the vessel was not determined until daylight on the 29th.



Photograph of the port side of the OMI YUKON taken on 29 October 1986 by LT. Kelly, USCG, C-130 pilot.



Photograph of the starboard side of the OMI YUKON taken on 29 October 1986 by LT. Kelly, USCG, C-130 pilot.

THE RESCUE

62. At 0500 on 29 October 1986, the survivors sighted the lights of a surface vessel to the north. The aircraft continued to circle. At 0600, the survivors sighted the lights of a second vessel, to the east of the first sighting and they fired hand held flares to attract attention. The fishing vessel (later identified as the SHOICHI MARU) went over to the burning vessel and then to the lifeboat and life raft. The survivors were about 1.5-2 miles away from the burning OMI YUKON. The Master instructed the men to don available life jackets but that was mostly ignored by the survivors.

63. At approximately 0700, the survivors boarded the Japanese fishing vessel, SHOICHI MARU. The OMI YUKON's Master went to the bridge to report the casualty to the U. S. Coast Guard and his company in New York. The master experienced difficulty communicating with the master of the fishing vessel even with Mr. Uno, the foreman for the Japanese workers, acting as a translator. The master tried to contact the DRESDEN, the other vessel sighted and standing by. The FV SHOICHI MARU did not have channel 16 VHF FM or other frequencies to talk to the DRESDEN or the U. S. Coast Guard. The fishing vessel had no flashing light to send morse code. The FV SHOICHI MARU took the survivors to the bulk carrier DRESDEN. The DRESDEN lowered her starboard lifeboat and went alongside the fishing vessel. The survivors boarded the DRESDEN's lifeboat and were taken back to the DRESDEN. The uninjured survivors boarded the DRESDEN by using the pilot ladder and the injured were brought aboard with the lifeboat when it was recovered in the davits. The OMI YUKON's Master went to the bridge of the DRESDEN and contacted the U. S. Coast Guard and his company. The OMI YUKON's lifeboat with the inoperative lifeboat radio and with the life raft attached were set adrift.

64. The DRESDEN diverted to Midway Island and the survivors were transferred ashore with the assistance of a US Navy Tug. The survivors were flown from Midway Island to Honolulu, HI aboard a US Coast Guard C-130.

65. During his testimony, LT Terrance Walsh said that he was surprised that a SARSAT report had been received from the EPIRB of the OMI YUKON. He stated that the report range to Kodiak was over 2200 miles and the San Francisco report range was even further. He stated that 2200 miles is pretty close to a maximum range for SARSAT reports. The working cutoff is 1600 to 1800 miles. LT Walsh testified that a SARSAT receiver terminal is planned for Honolulu but it has never received budget approval. A local receiver in the Central Pacific area would insure more complete coverage. All signals detected from the OMI YUKON were from the EPIRB. No reports of signals from the emergency radio transmitting on 500 kilohertz or 8364 kilohertz were made to the Coast Guard Operations Center in Honolulu.

INITIAL EXAMINATION OF OMI YUKON AT SEA

66. On 3 November 1986, members of the Marine Board of Investigation boarded the Panamanian ocean going tug SCHUMAL, call sign HPOQ, to conduct an on-scene investigation. On 8 November 1986, the tug arrived at the OMI YUKON which was approximately 1400 miles west of Honolulu, HI. The fires were out and the salvage tug SMIT NEW YORK was standing by. Examinations of the vessel were made on 8 and 9 November 1986 and the results were relayed to the remaining members of the Marine Board of Investigation in Honolulu, HI. This initial report stated the following: that explosions occurred in the boiler's firebox/uptake areas, starboard fuel oil storage and settler tanks; that fire had consumed the entire engine room spaces and accommodation spaces; and that the No. 5 starboard cargo tank, pump room, and port fuel oil storage and settler tanks were also involved in the fire.

67. This boarding focused on a possible boiler explosion scenario and a belief that something other than a normal grade of bunkers with a flash point above 140° F had been supplied to the boiler. The fuel oil tanks were not considered safe for entry and only fuel oil samples could be extracted from these tanks. The lower engine room was flooded to approximately the 30 foot level and further examinations could not be conducted.

68. After the initial boarding, the tug SMIT NEW YORK took the OMI YUKON under tow to Japan, a trip which lasted over a month and a half. Mr. Mesaris, Superintendent Engineer for OMI Corporation, testified that the vessel had gone through two typhoons while under tow. A review of the towing vessel SMIT NEW YORK's record of weather observations during the towing of the OMI YUKON to Japan, revealed that the highest sustained winds were reported to be 40 knots for two days. The weather log did not indicate sea state.

69. Chief Varn testified that after storms at sea he would have to inspect the flame screens on the bunker tanks because the seas would wash them out. He further testified that he had not had this problem on the OMI YUKON. On the vessel he had experienced the problem with the vents, they were located forward of the house.

SUMMARY OF DAMAGE AND MATERIAL CONDITIONS OF THE VESSEL

70. Members of the Board examined the OMI YUKON in Tsuneishi, Japan during the later part of December 1986 and early part of January 1987. The vessel was dewatered and staging was rigged while the vessel was in Japan. The following is a summary of the Board members findings:

a. The stack and stack deck were gone.

b. The fidley (upper engine room casing) was open to the weather. The forward port corner of the fidley had been subjected to extreme heat compared to the rest of the fidley.

c. The aft fidley power exhaust vents were blown out.

d. The lower engine room supply blowers were blown out.

e. The accommodations were totally gutted.

f. The bridge was totally gutted.

g. The starboard settler and the forward section of the starboard storage tank top (main deck) were raised approximately 4 feet.

h. The starboard lifeboat was missing.

i. The aft life raft was missing.

j. The hatch covers for the starboard settler and storage tank were blown off. Two hatch covers were accounted for and one was missing. (The starboard storage tank had two hatches)

k. The starboard aft storage tank top (main deck) was slightly distorted.

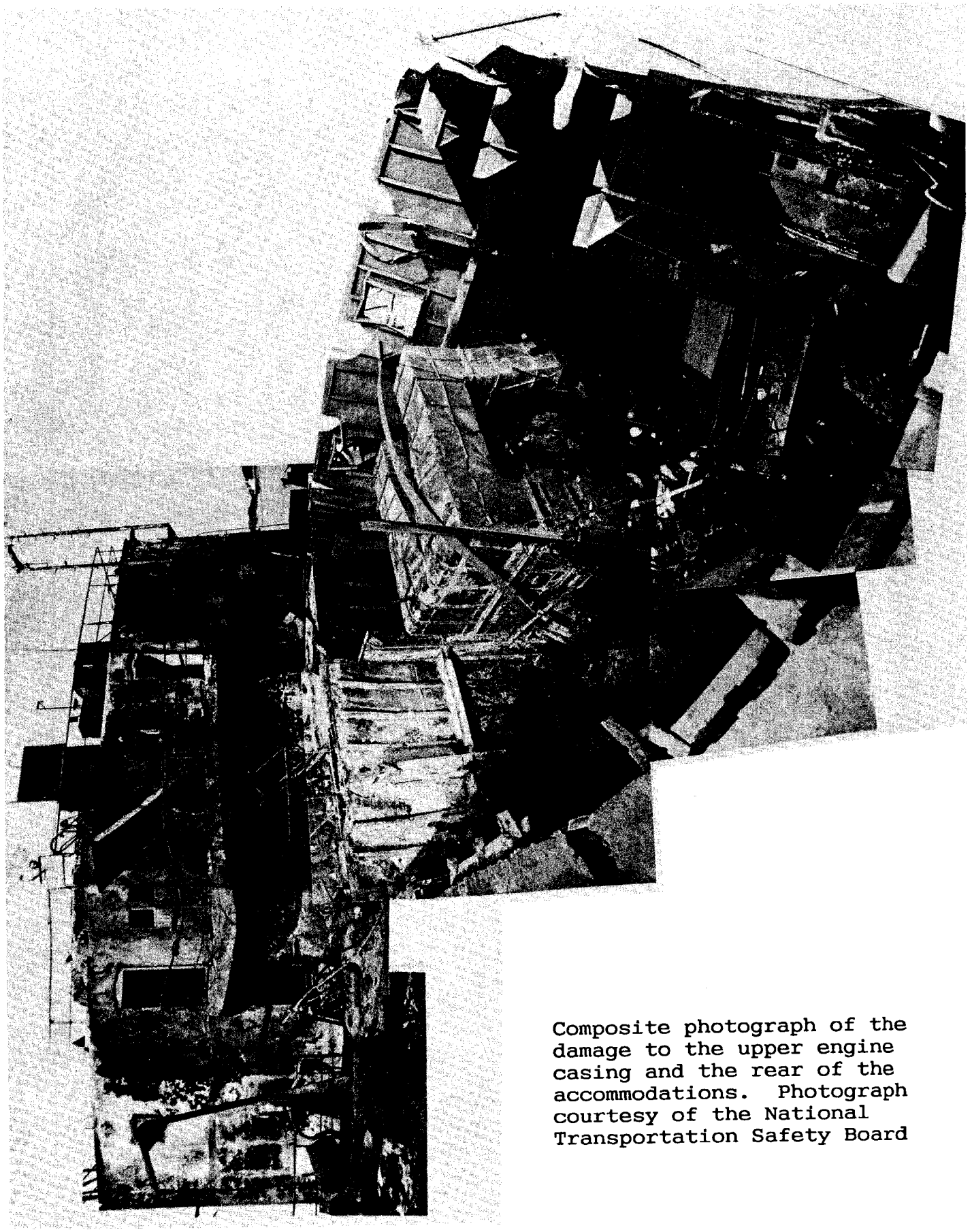
l. Debris found on the starboard aft deck in the immediate vicinity of the aft vent of the starboard fuel oil storage tank included: a burner's ignitor, sheet metal from vent louvers, the pin used for securing the storage boom to the side of the house, partially cut securing bracket for the stores boom, and small metal clamps and fittings used to connect section of oxyacetylene hoses. A section of portable electrical cord was found wrapped around a valve wheel on the accommodation house bulkhead in way of the forward hatch of the starboard storage tank.

m. The friction ignitor was found on the deck within ten feet of the aft vent for the starboard storage tank. The flint end of the ignitor was out of the cup. The ignitor was rusted and appeared to have been affected by heat.

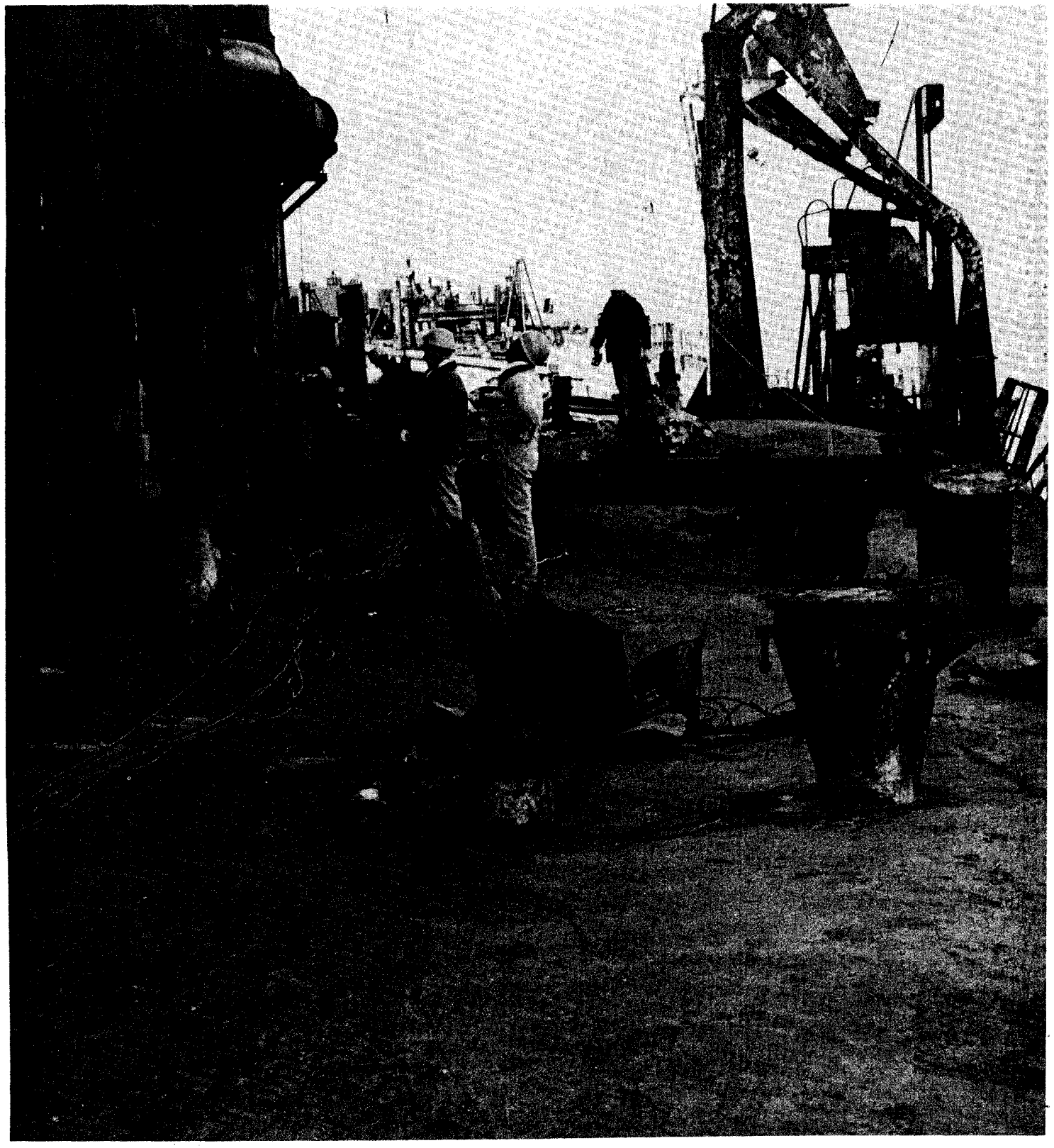
n. Damaged deck lighting fixtures were in close proximity to the aft vent for the starboard storage tank.

o. The old stores boom was found on the deck in the vicinity of the breezeway. It appeared to be end-for-ended from its original orientation because the hinge end was leading aft and the free end was leading forward.

p. The pin and a portion of the securing bracket were found on the deck near the starboard side of the engine casing. The bracket appeared to have been partially cut away and had been finally separated from the machinery house by a tearing or bending action.

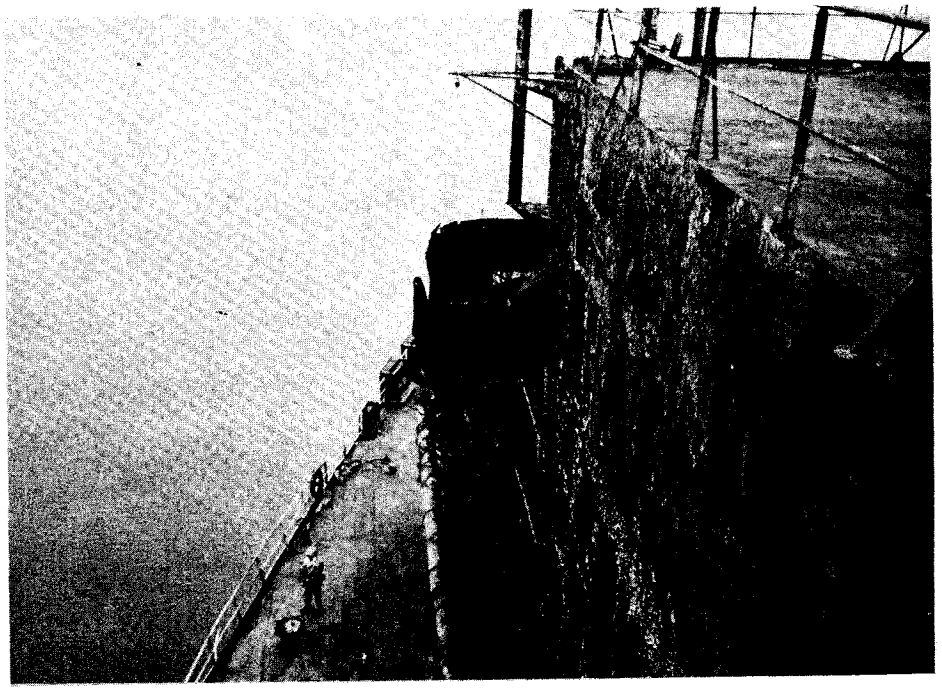


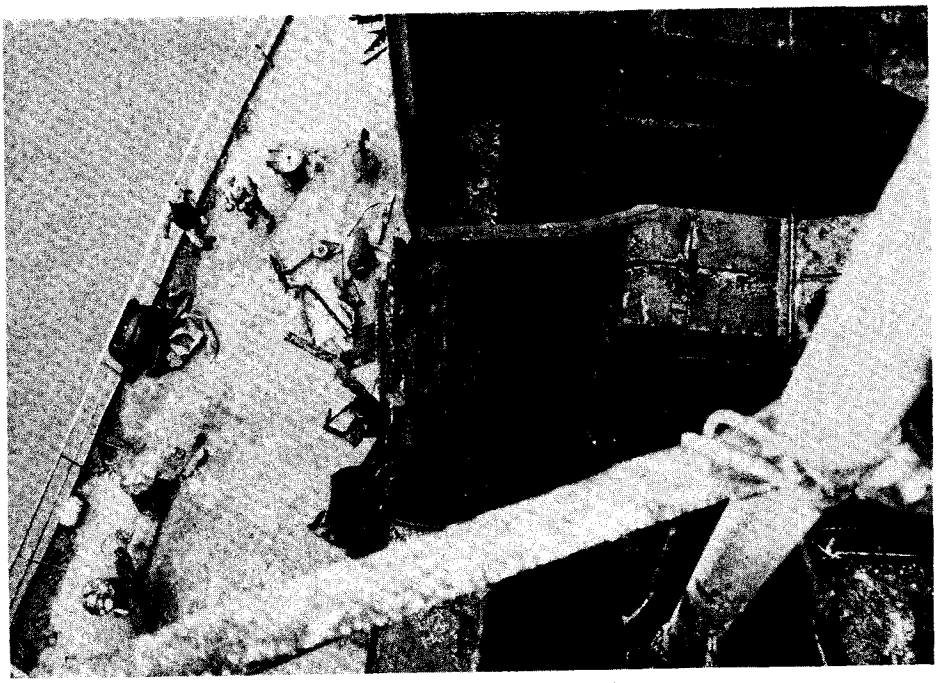
Composite photograph of the damage to the upper engine casing and the rear of the accommodations. Photograph courtesy of the National Transportation Safety Board



Photograph of the starboard side of the OMI YUKON depicting the damage to the main deck above the bunker tanks. The gooseneck vent in the foreground is the aft vent for the starboard fuel oil (bunker) storage tank. The object to the right of the vent is the garbage chute. The "I" beam laying on the deck diagonally is the fallen stores crane. Photograph courtesy of the National Transportation Safety Board

Photograph of debris on the starboard main deck above the aft end of the starboard storage tank. The chain fall shown had been rigged to lower the stores boom during the removal process. A friction ignitor, with the flint end out of the cup, is in the center of the picture. Photograph courtesy of the National Transportation Safety Board.





Photographs taken from the bridge deck of the OMI YUKON while the vessel was in Japan depicting an overview of the starboard storage tank. The top picture depicts two cables hanging down from the aft end of the starboard side of the accommodations house. Those cables were the stores boom support cables. The man in the top picture is standing aft of the garbage chute and the aft vent of the starboard storage tank. The lower picture gives a better perspective of the main deck above the starboard storage tank.

q. The gooseneck vent assembly for the aft vent on the starboard fuel oil storage tank was taken apart and there was no flame screen in the assembly. The course protective grid was intact. The ball check was split in half. On the circumference of the gooseneck mouth, above the flame screen assembly, there was an imprint in the paint residue of a previously installed flame screen.

r. The flame screens for the gooseneck vents on the forward vent for the starboard storage tank and starboard settler tank were blown out of the vent openings. Although the flame screens were breached, portions of the screen material remained between the inner and outer retaining rings. No such flame screen residue was found in the aft vent for starboard fuel oil storage tank.

s. The fire spread to the stern of the vessel and gutted the steering flat and storerooms aft of the engine room.

t. The upper portion of the transverse ballast tank forward bulkhead in way of the boiler was significantly bulged forward.

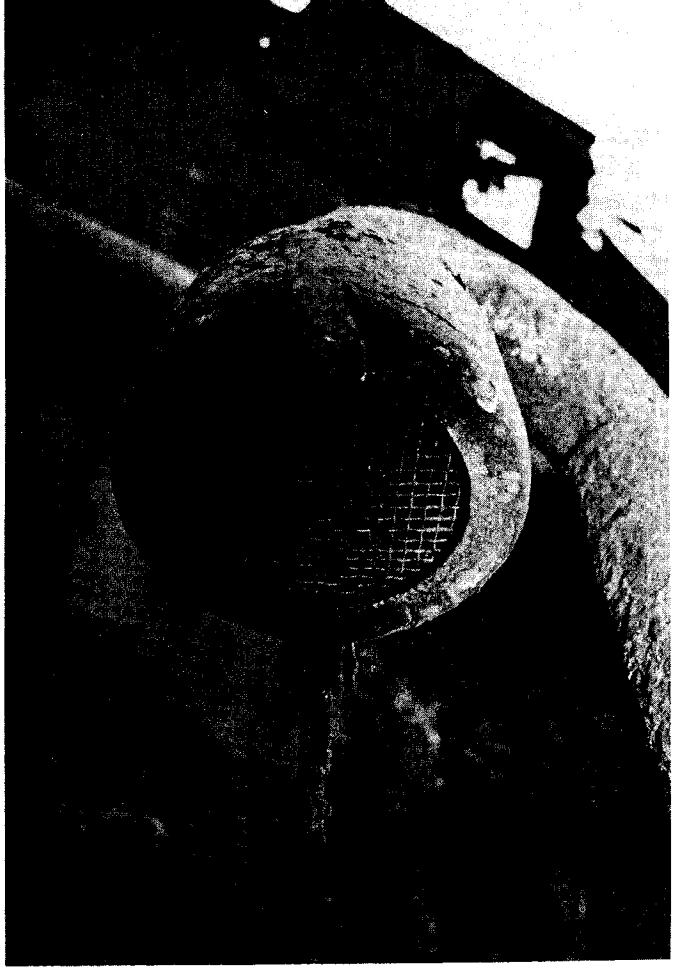
u. The lower portion of the transverse ballast tank forward bulkhead, common with the aft bulkhead of the starboard storage tank, was blown forward into the storage tank. The upper portion of this bulkhead was blown aft into the transverse ballast tank. The attachment area for this bulkhead with the starboard side shell and the inboard corner where the two tank bulkheads joined had jagged tears pointing aft.

v. The aft vent for the starboard fuel oil storage tank, with the missing flame screen, was located just forward of the forward starboard bulkhead of the transverse ballast tank.

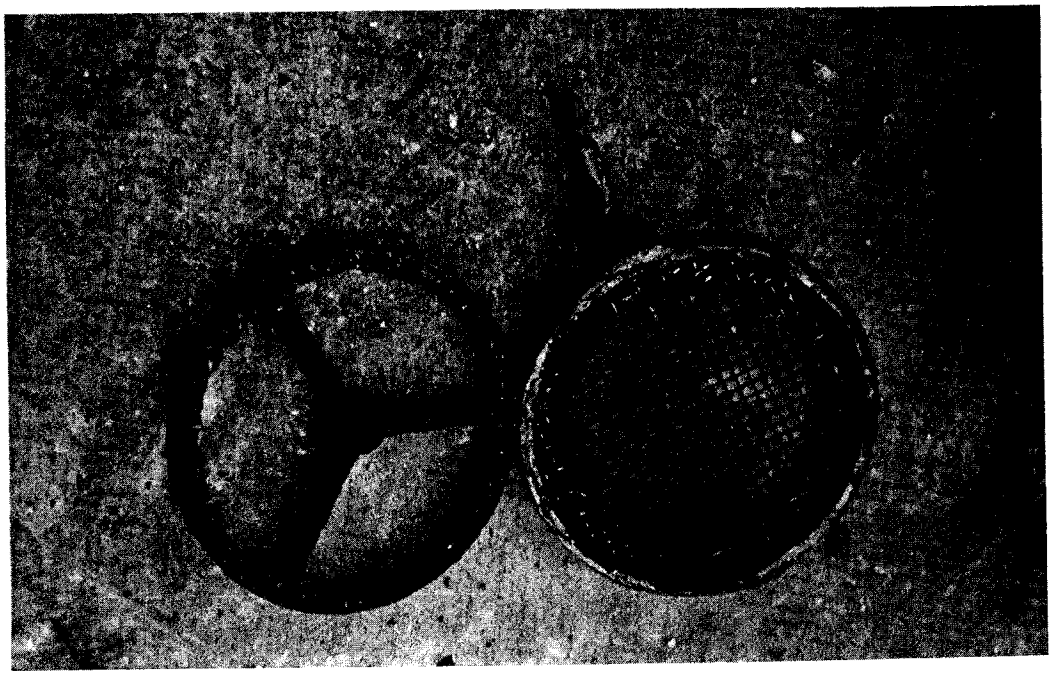
w. The transverse swash bulkhead separating the two sections of the starboard storage tank was blown forward almost 90^{o} from its original orientation.

x. Internal examination of the starboard fuel oil storage tank revealed that the aft one of the two upper transverse web frames, located forward of the swash bulkhead was blown aft, where as the swash bulkhead originally located aft of this web was blown forward.

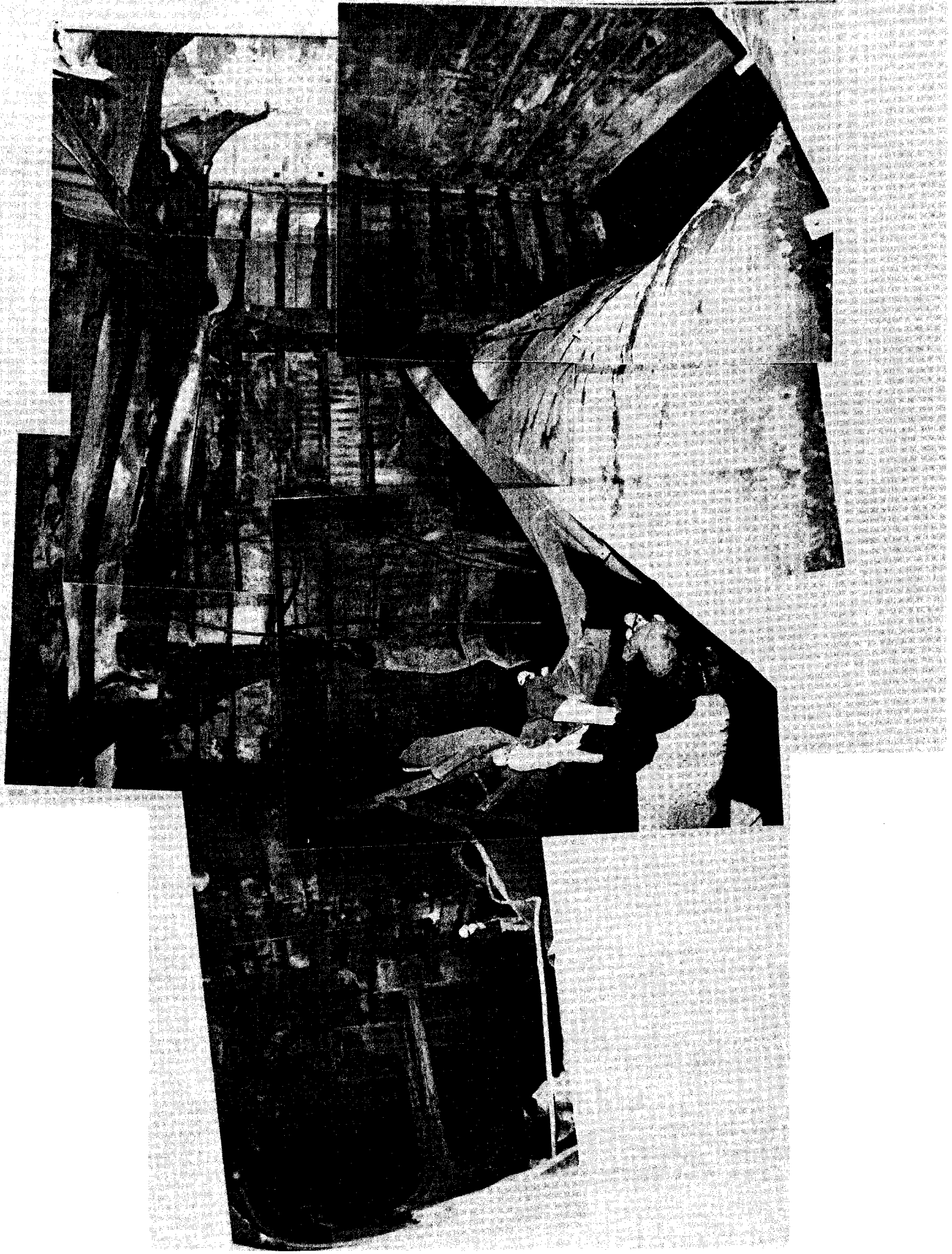
y. The starboard storage tank was opened to the sea when the swash bulkhead angle brackets ripped away from the side shell during the swash bulkheads movement forward as a result of the explosions. There were similar openings in the longitudinal bulkhead separating the engine room and the storage tank where the swash bulkhead was connected and ripped away during the explosions.



Picture of the aft vent for the starboard fuel oil (bunker) storage tank taken by a HIRI representative showing the gooseneck and flame screen assembly in place.



Picture of the removed and taken apart flame screen assembly from the aft vent of the starboard storage tank. Above photographs taken by a HIRI representative.



Composite photograph depicting the damage to the starboard settler, storage and transverse ballast tanks. The damaged transverse ballast tank starboard forward bulkhead is located at the far left of the picture. Photograph courtesy of the National Transportation Safety Board.

z. The bulkhead common with the engine room and the starboard storage tank had a significant breach large enough to drive a car through. The longitudinal bulkhead was blown into the engine room. The breach into the engine room was immediately forward of the original position of the transverse swash bulkhead in the storage tank.

aa. The major bulkhead penetration into the engine room created by the explosion within the starboard bunker tank was directly outboard of the control room and in way of the main electrical switchboard and automation console. The path of the explosion force which created this penetration was also directly in-line with the casing damage noted on the forward port corner of the boiler casing.

bb. The engine room was totally gutted above the thirty foot level. Machinery in line with the major breach from the bunker tank into the engine suffered impact damage.

cc. The pumpman's workshop was located on the port side main deck and provided access from the main deck to the engine room. A horizontally sliding weather deck hatch provided access into the pumpman's workshop for moving large equipment. In the pumpman's work shop was a cargo type hatchway that opened into the forward port corner of the engine room. The pumpman's workshop could also be accessed from a door in the accommodations thwartship passageway. This door was found blown into the house and the hatchway was blown open.

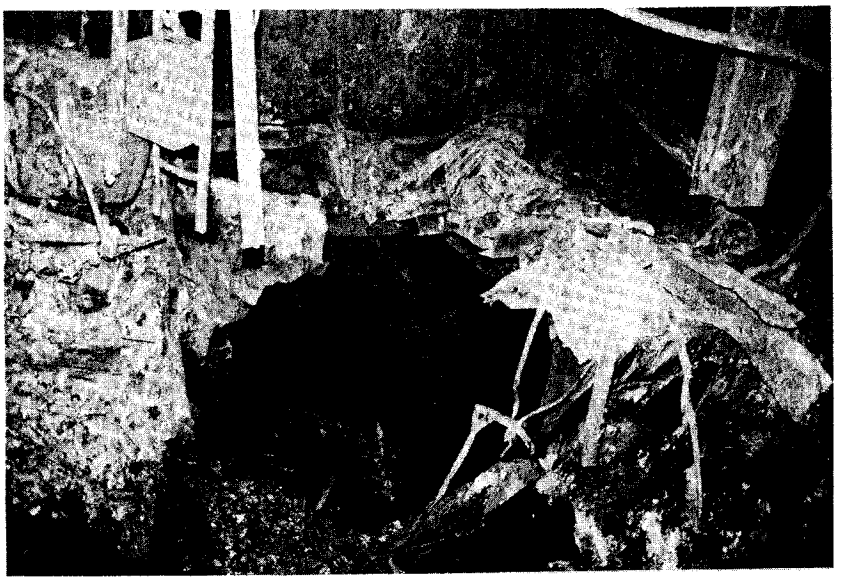
dd. The elevator, located in the forward end of the engine room near the centerline, was found near the bottom of the shaft in the engine room. The elevator was twisted and crushed inward. The elevator shaft runs from the engine room into the accommodations.

ee. The engine room was flooded below the thirty foot level with fuel oil and sea water. (The engine room was dewatered while the vessel was in Japan)

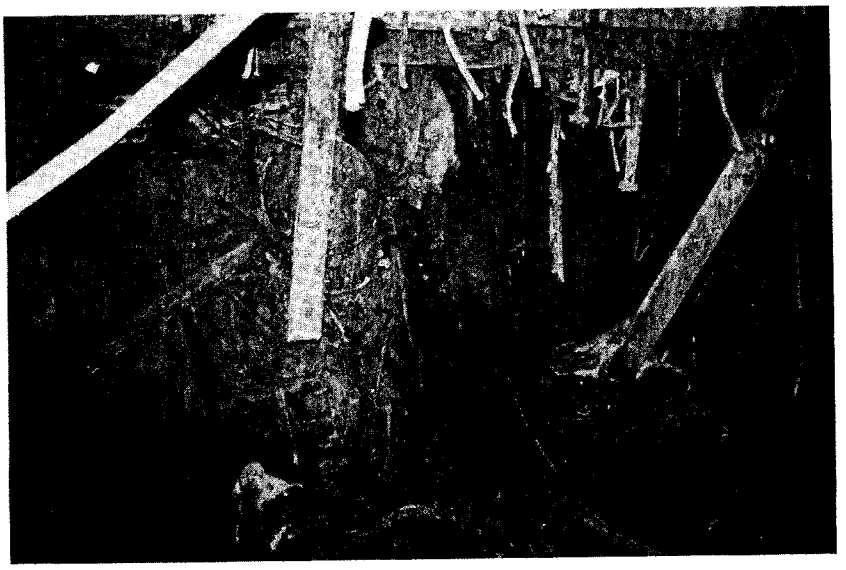
ff. Machinery, steam piping, ladders, and intermediate decks above the thirty foot level were totally destroyed. Small diameter piping hung like spaghetti and was fused solid.

gg. The engine room control console was crushed by the collapsed decks above it.

hh. The outside casing on the boiler was generally intact but showed warpage from fire. However, the port forward corner of the boiler casing was extensively damaged as if it was blown outward from the boiler furnace area.



Photograph depicts the breach into the engine room from the starboard storage tank. The control room was located behind the debris in the right corner of the picture. Photograph courtesy of the Tsuneishi Shipyard, Tsuneishi, Japan.



Photograph depicts the front of the OMI YUKON's main boiler. The large cylindrical object to the right of the main boiler is what remained of the auxiliary fire tube boiler. Photograph courtesy of the Tsuneishi Shipyard, Tsuneishi, Japan.

ii. The economizer had fallen in on the port side of the boiler in way of the above mentioned casing damage and was tilted at a downward forward angle and was being supported at the rear by the economizer inlet and outlet connections.

jj. The drum seal at the junction of the furnace roof and the steam drum was intact except at the boiler front where the steam drum settled.

kk. The boiler stack was missing. The remaining section of the boiler uptake gave an appearance that the stack was torn away at a point just above the air heater as if it had been pulled upward and away from the boiler casing along with the stack deck.

OIL SAMPLES AND TESTING

71. Fuel oil samples were received from the Hawaiian Independent Refinery, Inc/ (HIRI) in order to obtain a representative sample of fuel oil transferred to the OMI Yukon on 23 October 1986. These samples were taken by HIRI personnel or the Caleb Brett inspector during actual blending or bunkering process on the dates indicated. Additional fuel oil samples were obtained from the OMI Yukon's tanks or piping systems during the subsequent Coast Guard boardings at sea (NOV 86) and at the Tsuneishi Shipyard in Japan (DEC 86/JAN 87). Those fuel oil samples were drawn in order to explore possible fuel oil contamination. Appropriate samples were delivered to Phoenix Chemical Laboratory, Inc. Chicago, IL for testing. The following table provides representative test results with interpretive notes.

Samples	Flash Point (Note 1) PMMC (ASTM D93) ^{o} F	Viscosity @ 100^{o} C ASTM D445 Centistokes (cst)
Barber Point		
HIRI's TANK 307 (10/18/86)	285^{o} F	35.92 cst
BUNKERING START (10/23/86)	230^{o} F	33.61 cst
BUNKERING END (10/23/86)	196^{o} F	26.09 cst
COMPOSITE OF BUNKER SAMPLES	212^{o} F	30.43 cst

OMI YUKON, AT SEA	(After Fire/Explosion and exposure to extensive fire and heating)	
Port Settler (11/8/86)	152° F	-
Port bunker (fwd) (11/8/86)	170° F	-
Port Bunker (aft) (11/8/86)	176° F	-
OMI YUKON, TSUNEISHI SHIPYARD	(Enclosed piping systems exposed to some degree of heating by fire.)	
Bunker Connection, Port side near the midships manifold (12/30/86)	22° F	15.57 cst
Bunker connection, Port side immediately forward of the house (1/5/87) (Note 2 & 3)	68° F 1st test 78° F 2nd test	14.57 cst
F.O. Suction Strainer Engine. room (1/10/87)	180° F	27.83 cst (Note 4)

Notes: (1) ASTM sets a minimum flash point of 150° F for NO. 6 fuel oils. 46 CFR 35.25-10 permits a Flash Point of 140° F.

(2) Sample tested was the first sample obtained from the lowest non-circulation point within the on-deck bunker piping system.

(3) Infrared spectra analysis conducted on this sample only. Phoenix provided the following interpretation of the Infrared Spectra.

> (a) The infrared spectrum of the sample, as received, is typical of that which might be expected for a residual fuel oil which contained a significant fraction of water.
>
> (b) The infrared spectrum of the lower liquid layer of the distillate recovered from sample indicates that fraction of the sample consists of water.

(c) The infrared spectrum of the organic distillate fraction of the sample (IBP to 600 dg F) indicates that fraction of the sample consists of a mixture of aliphatic and aromatic hydrocarbons which is typical of that found in distillate fuels such as No. 2 Diesel Fuel or No. 2 Burning Oil . Such hydrocarbon fractions are commonly employed as cutter stocks in the No. 4 and No. 5 grades of residual fuel. The amount of such material found in the present sample (ie 42%) is unusually high for a No. 6 Fuel Oil. Gasoline Fractions, if present, cannot be distinguished from the other distillable fuel components solely by infrared analysis.

(4) Babcock & Wilcox optimum recommended burning viscosity is 135 seconds, Saybolt universal; (28.62 Centistokes)

72. On 3 April 1987, the OMI YUKON was boarded again at the Tsuneishi Shipyard in Japan by LTjg Gerrity, USCG (Boiler Inspector from Marine Safety Office, Honolulu, HI and not a member of the Marine Board) and representatives from OMI Corporation, HIRI and Aspen Controls Inc. for the purpose of examining automation controls and the main boiler. The following observations were made:

a. The boiler's furnace was covered with fuel oil residue from floor level to approximately three feet above floor level.

b. A large amount of the boiler refractory, brickwork and tubing lay in the middle of the furnace.

c. The front wall tubes had pulled away from their wall and the roof collapsed in a pile in the middle of the furnace. A majority of the front wall tubes showed severe heat damage causing them to break away from the water drum. Not one tube remained intact on the furnace front wall.

d. The side wall tubes also pulled away from their wall and the roof. These tubes, like the front wall tube, collapsed into the furnace, intertwining with the front wall tubes. These tubes were also baked and showed the same external and internal heat damage. Tubes from the side wall also broke away from the water drum.

e. The tubes from the front and side walls were so brittle it was possible to break parts off with your hand without using much effort.

f. The rear wall tubes were also severely damaged by the heat. Some of the rear wall tubes were burned open at approximately three feet above the furnace floor, however, they remained in position in the rear wall lower header.

g. The interior of the burner register revealed no damage to the diffusers or the brickwork around the cones other than a large amount of fuel oil congealed around the lower registers.

h. The furnace corners were intact and not cracked or deformed.

i. The front and side walls revealed moderate warpage outward.

j. Both force draft fan inlet vanes were in the light off position (20% open).

k. Burner air register #1, 2, and 4 were in the fully closed position and burner air register #3 was fully open.

l. Fuel oil header valve was fully closed.

m. Fuel oil burner valves #1 and 2 were fully closed, and mounting bracket for actuator was in place.

n. Fuel oil burner valve #3 was approximately 50% open, mounting bracket for actuator was in place.

o. Fuel oil burner valve # 4 was approximately 50% open, mounting bracket for actuator was missing and mounting bolts were broken off.

p. Throttle control was approximately 60 RPMs.

73. Past history of the automation system was reported as being reliable with very few problems.

UNDERWAY REPAIRS REQUIRING WELDING AND/OR BURNING

74. Hot work regulations (46 CFR 35.01-1) pertain to performing riveting, welding, burning or other like fire producing actions within or on the boundaries of fuel oil tanks; or to pipelines, heating coils, pumps, fittings or other appurtenances connected to such cargo or fuel tanks. The regulations do not address falling slag or sparks onto a tank boundary or in the vicinity of tank vents.

75. Chief Engineer Dawson testified that there was an International Safety Guide for Oil Tankers and Terminals (ISGOTT) aboard. Section 2.8.3 of the ISGOTT outlines the following procedures to be followed prior to commencing hot work aboard a vessel:

"Before approval for hot work is given, the responsible officer should test and examine the area to ensure that:

No flammable or toxic gases is present at the work site and the oxygen content is 21% by volume.

No oil impregnated scale or other material is present at the work site which is likely to generate flammable or toxic gases

No flammable material is present at the work site or adjacent to it within another compartment.

Adjacent compartments have been washed and either gas freed to a safe for hot work standard; or purged of hydrocarbons to less than 2% by volume and inerted; or completely filled with ballast water; or their condition is any combination of these.

All interconnecting pipelines have been flushed through with water, drained, vented, and isolated from the compartment to be worked. Cargo lines may be subsequently inerted or filled with water if considered necessary.

The area will be well ventilated throughout the work period and periodic testing will be carried out to check that no concentrations of flammable or toxic gases develop.

Adequate fire extinguishing equipment is ready for immediate use."

76. Chief Engineer Dawson and First Assistant Engineer Devitt testified that they both were smokers, but that they were not smoking while on deck the day of the casualty. The chief further testified that smoking was permitted on the stack deck and on the poop deck. Chief Engineer Varn testified that there was no written company policy concerning smoking aboard the vessel.

77. 46 CFR 35.10-5 (e)(3) requires that during weekly fire and boat drills that: "The motor lifeboat, where fitted, shall be operated for at least 5 minutes." 46 CFR 35.10-5 (e)(6) requires that: "The Master shall be responsible that each lifeboat is lowered to the water at least once in each 3 months."

CONCLUSIONS

1. The fuel oil in the starboard and port storage tanks at the time of the casualty were HIRI bunkers only.

2. Fuel oil received from HIRI on 23 October 1986 was transferred to the settler tanks from the storage tanks prior to the casualty.

3. The fuel oil going into the boiler at the time of the casualty was a combination of the bunkers that were in the settlers prior to bunkering at HIRI and the bunkers put aboard on 23 October 1983.

4. The properties of the fuel oil samples taken from the bunker tanks after the casualty may not be indicative of the fuel oil properties in those tanks at the time of the casualty because of the heat applied to the tanks during the intense fires that burned for approximately 9 days. Due to the intense heat of the fire, the actual flash point was most likely lower than the fuel oil samples extracted from the vessel after the fire.

5. The flash point test results of some of the samples taken from the vessel after the casualty show flash points significantly lower than the test results of the samples taken of the bunkers blended for delivery to the OMI YUKON.

6. The results of the testing of the fuel oil sample taken in Japan from the midship bunker manifold area are indicative of fuel oil contamination but may not be representative of the actual flash point of the fuel oil in the storage or settler tanks at the time of the casualty.

7. The water noted in the infrared spectrum analysis of the bunker connection (Aft Port) sample was most probably due to the normal water accumulation trapped at the lowest point within the main deck bunker piping system.

8. The test results of a flash point of 22^{o} F, from the sample taken at the midship bunker manifold when the vessel was in Japan, indicates that the last part of the bunker load was something other than bunkers and is further evidence of probable contamination of the bunkers during the loading at Barbers Point, HI.

9. The locations of the interfaces between the flush oil and the bunkers were not accurately known by refinery personnel because of a miscalculation of the quantity of product in the shore tank 307.

10. The two segment bunkering process increased the extent of potential contamination by subjecting the bunkers to additional interfaces with flush oil.

11. The decreased amount of bunkers initially put in the sub-sea line resulted in a reduced safety margin separating bunkers and flush oil.

12. The findings of the Caleb Brett inspector that the vessel received 387 bbls less than the refinery delivered indicates that product from the slop tank or cargo tanks was not drawn into the bunker line during the bunker operation.

13. To the extent determinable, the use of the jumper between the cargo manifold and the bunkering manifold did not cause the contamination of the bunkers.

14. The source of the contamination of the bunkers was from the flush oil used to move the bunkers through the sub-sea pipeline.

15. The source of explosive mixture in the starboard bunker tanks was bunkers with a below specification flash point due to contamination.

16. The extent of damage to the starboard bunker tanks and the result of the testing of the fuel oil samples taken outside of the engine room are strong evidence of contaminated bunkers with a flash point well below U. S. Coast Guard specifications and low enough to create an explosive atmosphere in the bunker tanks on the day of the casualty.

17. The crew was lulled into a false sense of safety by working in the vicinity of a bunker tank with the knowledge that bunkers normally have a flash point well above ambient temperature.

18. At the time of the explosion the fuel oil being provided to the boiler (F.O. Suction sample) was most likely within Coast Guard regulations for the required flash point and within the Babcock and Wilcox recommended burning viscosity.

19. An extensive explosion or flare back did not occur within the boiler furnace. All of the usual signs were missing, ie, no diffuser damage, no corner damage nor any register brickwork damage.

20. The major damage to the boiler below the economizer was the result of the engine room and bunker tanks explosions and intense fire, and not the result of an internal boiler explosion.

21. It could not be determined whether a boiler automation malfunction occurred.

22. The boiler automation system may have been in a light off phase; however, this could not be conclusively determined.

23. The Boiler Automation System deficiencies noted by the Coast Guard requirements that were outstanding on the date of the casualty did not contribute to the casualty.

24. The bulkhead separating the aft end of the starboard storage tank and the transverse ballast tank was initially blown aft into the transverse ballast tank and then the lower portion of that bulkhead was either blown forward after the initial series of explosions or fell forward due to heating.

25. Examination of the extent and nature of the damage in the starboard bunker tanks in way of the engine room can only be reasonably explained with an initial explosion in the aft end of the starboard storage tank. A subsequent explosion in the starboard storage tank caused the major structural damage.

26. The testimony given by Mr. King and Chief Engineer Dawson concerning the existence of a flame screen in the starboard aft storage tank gooseneck after the second ABS inspection is inconsistent with the evidence discovered by the Board while examining the vessel in Tsuneishi, Japan.

27. The flame screen for the aft vent of the starboard fuel oil storage tank was not washed out by boarding seas because debris such as the ignitor, sheet metal from a louvered vent, pin and bracket for the storage boom, section of portable electrical wires, and the flame screens on other fuel oil tanks were still aboard the vessel.

28. The only reasonable explanation for the absence of a flame screen in the starboard aft storage tank gooseneck vent when it was opened in Tsuneishi, Japan, was that it was never replaced by King and Baker, after the first ABS inspection in August 1986. The possibility that either of the contract workers may have believed that the vent without the flame screen was for a ballast tank can not be ruled out. The vent being located aft of the garbage chute may have misled someone working in the area into believing that the vent was for a ballast tank or void space instead of a fuel oil tank.

29. The physical condition of the ignitor found on the starboard side of the main deck indicates that it was aboard the vessel during the fire.

30. The extent of fire and explosion damage limited the ability to determine the source of the ignition.

31. The exact source of ignition for the massive explosions aboard the OMI YUKON can not be positively determined. The possible sources of ignition are as follows:

a. Hot slag or sparks from the burner's torch falling into the vapor plume from the unprotected fuel oil storage tank vent.

b. The Burner dropping his friction ignitor on the deck in the vicinity of the plume of the unprotected fuel oil storage tank gooseneck vent and the ignitor activated when it impacted with the deck.

c. Careless discard of smoking material by a member of the crew.
d. Short in an on deck electrical fixture located near the unprotected vent.

32. The failure of the chief engineer to designate a fire watch, to have charged fire hoses led out and to have portable extinguisher in the immediate area of the hot work was not following established safety procedures in ISGOTT. With the explosions occurring prior to the fires, and without warning, the presence of a designated fire watch and having fire extinguishing equipment ready for immediate use in the area of the hot work would not have prevented or changed the outcome of this casualty. However, if a fire broke out initially, the proper fire fighting equipment immediately at hand may have made a difference.

33. The use of a contract worker for welding without ABS or USCG qualifications did not cause or contribute to the casualty.

34. The machinery access hatch located on the port side at the main deck level where it opened into the pumpman's workshop from the engine room and the elevator shaft running vertically through the accommodations and engine room were most likely primary paths of fire into the accommodations.

35. The reason for the chain coming off the crank gear inside the lifeboat radio could not be determined because the radio was set adrift in the lifeboat and was never examined.

36. The reason for the releasing gear on lifeboat not working properly could not be determined because the lifeboat was set adrift and was never examined.

37. The exact reason for the lifeboat motor not getting cooling water can not be determined because the life boat was set adrift and was never examined. The most probable cause was an inoperative cooling water pump.

38. The 1 hour and 40 minutes to route the SARSAT report from the receiving station at Kodiak, AK to the Operations Center in Honolulu did delay the Controller's decision to launch a search aircraft.

39. On 28 October 1986, at approximately 1025, Jerry Baker and James Turk were working in the vicinity of the starboard stack deck when massive explosions ripped through the vessel and completely removed the stack and stack deck off the vessel.

40. On 28 October 1986, at approximately 1025, Second Assistant Engineer Ed Roy Connolly and QMED James W. Duffy were on watch in the engine room when massive explosions ripped through the engine room.

41. Mr. Connolly, Mr. Duffy, Mr. Baker and Mr. Turk are missing as a result of the explosions and intense fires aboard the OMI YUKON on 28 October 1986 and they are presumed dead.

42. There is evidence that Terry Kotz, the Master of the OMI YUKON violated the conditions of the certificate of inspection by permitting the carriage of the 11 Japanese workers. The vessel was carrying 5 more people than permitted by the certificate of inspection. The vessel was permitted to carry 6 persons in addition to the crew and the vessel was carrying 13 persons in addition to the crew, which included the two welders. The carriage of 37 persons, did not cause or contribute to the casualty. This matter has been forwarded to the Commander, Thirteenth Coast Guard District for further investigation.

43. There is evidence that officers of OMI Corporation, operators of the OMI YUKON violated the conditions of the certificate of inspection by arranging for the carriage of the 11 Japanese workers resulting in the vessel carrying 5 more people than permitted by the certificate of inspection. The carriage of 37 persons, did not cause or contribute to the casualty. This matter has been forwarded to the Commander, Thirteenth Coast Guard District for further investigation.

44. The proximate cause of this casualty was bunkers becoming contaminated with distillate products (flush oil) during its delivery to the vessel through a sub-sea pipeline. Contributing to the casualty was the absence of a flame screen on the starboard aft fuel oil storage tank vent which permitted a source of ignition to enter vapor space above the contaminated bunkers. The exact source of ignition could not be determined.

RECOMMENDATIONS

1. The use of a common bunker/cargo line from a facility for bunkering vessels may be an exception rather than the rule within the maritime community. A survey of worldwide bunkering procedures should be initiated in order to identify if this bunkering practice is widely used. If bunkering through a common bunker/cargo line is an accepted practice, international standards should be established and our regulations amended to cover receipt of bunkers under this practice. These standards should require at least the sampling of bunker tanks in addition to the sampling of each lot taken at the bunker manifold during loading. Test results should then be provided to the chief engineer prior to sailing and burning of received bunkers. The samples taken from the bunker tanks would be indicative of the actual condition of bunkers received aboard the vessel after bunkering.

2. Examination of flame screens on bunker tanks should be reemphasized to all field units and the examinations should occur during inspections for certification, mid-periods, reinspections, and foreign vessel examinations. The maritime community should also be informed of the importance of flame screens on bunker tanks.

3. Consider promulgating regulations to require the hot work procedures outlined in the ISGOTT be followed whenever hot work is performed anywhere aboard a tank vessel.

4. A study should be considered to simplify the design of lifeboat motors to require minimum maintenance and eliminate potential overheating problems. Strong consideration should be given to air cooled and geared start-up systems for lifeboat motors instead of water-cooled and hydraulic start-up motors.

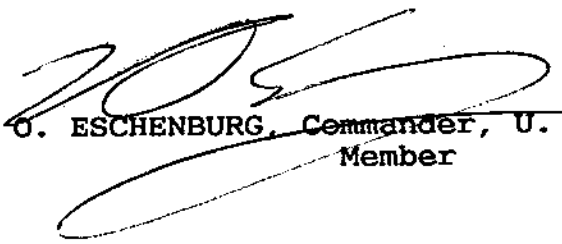
5. The regulations for periodic testing of lifeboat motors should be modified to require releasing of lifeboats from the falls into the water and conducting an in-water operational test of lifeboat motors as required by SOLAS. Operating the lifeboat for 5 minutes in the davits without benefit of cooling water or with water from the vessel's pressurized water system does not properly test the cooling pump's ability to take a suction.

6. The SARSAT receiving station planned for the Central Pacific should be programmed for installation and operation as soon as possible.

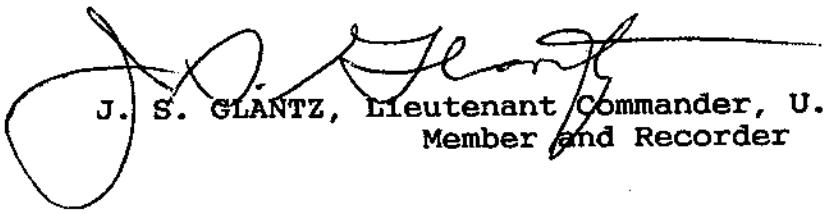
7. Forward a copy of this report to the International Maritime Organization.

8. No further action be taken and this investigation be closed.

D. L. FOLSOM, Captain, U. S. Coast Guard
Chairman



V. O. ESCHENBURG, Commander, U. S. Coast Guard
Member



J. S. GLANTZ, Lieutenant Commander, U. S. Coast Guard
Member and Recorder

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