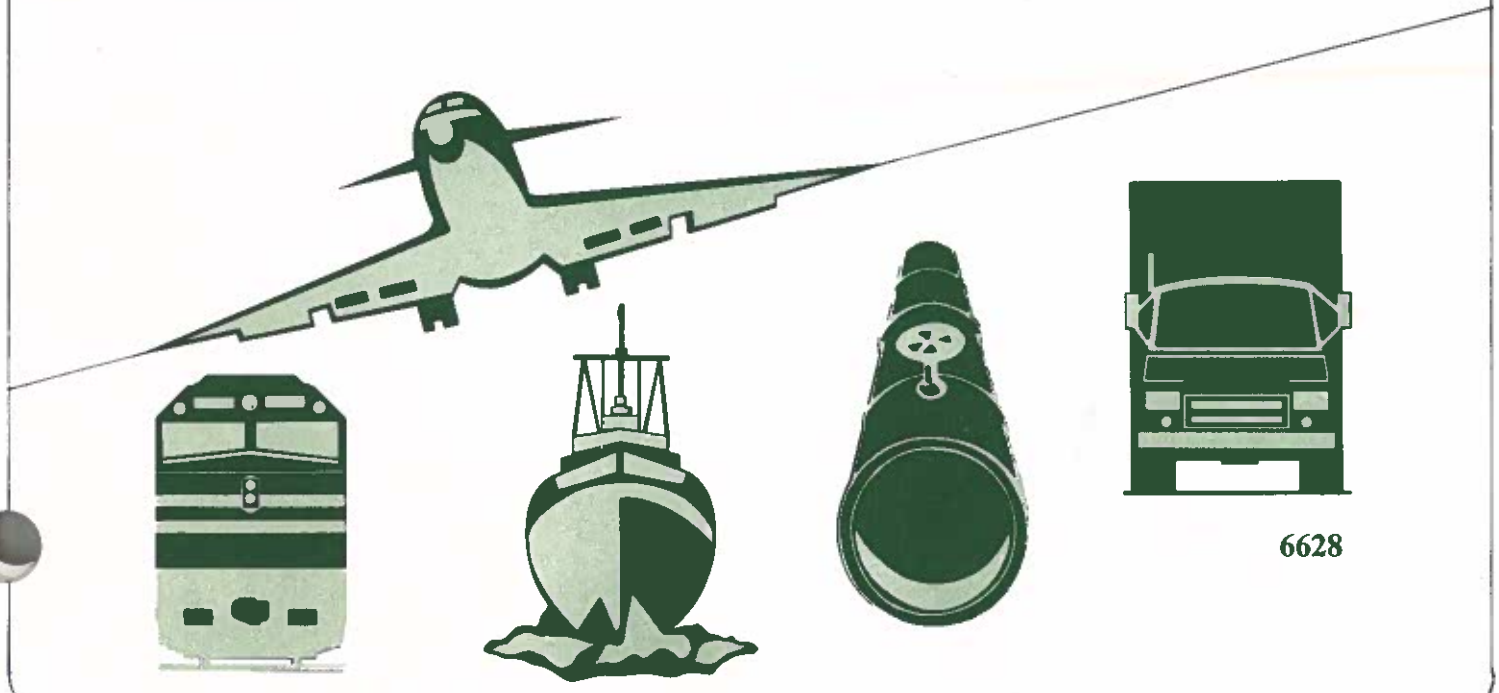
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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

**FIRE ABOARD U.S. SMALL PASSENGER VESSEL
ARGO COMMODORE
IN SAN FRANCISCO BAY, CALIFORNIA
DECEMBER 3, 1994**



6628

Abstract: On December 3, 1994, an engineroom fire occurred aboard the U.S. small passenger vessel ARGO COMMODORE while on a dinner cruise in San Francisco Bay. All passengers were safely evacuated by a U.S. Coast Guard vessel and a passing yacht; there were no deaths or injuries among the 41 passengers and 4 crew members. Insurance adjusters estimated damage to the ARGO COMMODORE at $150,000.

The safety issues discussed in this report are management oversight of vessel repairs; master's response to the fire emergency; fixed firefighting systems on small passenger vessels; fire pump operation on small passenger vessels; crew training in emergency procedures; safety placards and briefings/orientations for passengers; and issuance of proposed regulations for small passenger vessels.

As a result of its investigation, the National Transportation Safety Board issued recommendations to the U.S. Department of Transportation, the U.S. Coast Guard, the Passenger Vessel Association, and Commodore Dining Cruises, Inc.

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

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FIRE ABOARD U.S. SMALL PASSENGER VESSEL ARGO COMMODORE IN SAN FRANCISCO BAY, CALIFORNIA DECEMBER 3, 1994

MARINE ACCIDENT REPORT

Adopted: November 14, 1995
Notation 6628

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C. 20594

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EXECUTIVE SUMMARY

About 8:35 p.m. on December 3, 1994, an engineroom fire occurred aboard the U.S. small passenger vessel ARGO COMMODORE while on a dinner cruise in San Francisco Bay. All passengers were safely evacuated by a U.S. Coast Guard vessel and a passing yacht; there were no deaths or injuries among the 41 passengers and 4 crew members.

The National Transportation Safety Board determines that the probable cause of the accident was a short circuit in the electrical starting system for the starboard propulsion engine caused by a failed insulator separating a solenoid terminal from the solenoid case. A contributing cause was the failure of Commodore Dining Cruises, Inc., to diagnose and correct recurring problems in the starboard engine starting system. Contributing to the severity of the fire was the master's failure to follow proper firefighting procedures.

The Safety Board investigated this accident under the authority of United States Code, Title 49, Chapter 11—National Transportation Safety Board, Subchapter III, Section 1131(a)(1)(F). The accident involved ongoing Safety Board concerns related to small passenger vessels, including the issues of crew emergency training and passenger briefings, both of which are on the Safety Board's list of "Most Wanted Transportation Safety Improvements."

The following major safety issues are discussed in this report:

- Management oversight of vessel repairs;
- Master's response to the fire emergency;
- Fixed firefighting systems on small passenger vessels;
- Fire pump operation on small passenger vessels;
- Crew training in emergency procedures;
- Safety placards and briefings/orientations for passengers;
- Issuance of proposed regulations for small passenger vessels.

As a result of its investigation, the Safety Board made recommendations addressing these issues to the U.S. Department of Transportation, the U.S. Coast Guard, the Passenger Vessel Association, and Commodore Dining Cruises, Inc.

INVESTIGATION

The Accident

On December 3, 1994, at 7:30 p.m., the ARGO COMMODORE (figure 1) departed her pier at Mariner's Square, Alameda, California, with a group charter of 41 passengers for a 3 1/2 hour dinner cruise in San Francisco Bay. The crew consisted of a master, a senior deckhand, a deckhand, and a cook. The skies were overcast with rain; the temperature was 48 °F; winds were from the northwest at 10 to 15 knots; and visibility was 4 miles.

The deckhands stated that during the cruise they engaged in their usual hospitality and catering duties, which included serving drinks and dinner. According to testimony taken after the accident, at about 8:35 p.m., while the passengers were being served dinner and as the vessel was proceeding at about 6 knots past pier 41, San Francisco Bay, (figure 2) the lights in the dining salon flickered, then went out. The deckhand and the cook continued to serve dinner using flashlights and candles, while the senior deckhand went up the exterior stairway to the bridge to notify the master of the power outage. The deckhand said she assured the passengers that the master would correct the electrical problem. She also said that, while some of the passengers expressed concern about the power failure, they continued with their dinner and did not panic.

The master testified that at the time he was notified of the power failure, a vessel was crossing the bow of the ARGO COMMODORE. He said he remained at the helm until the crossing was completed, then placed both engines in neutral, and asked his brother[1] (a guest passenger) to remain on the bridge and maintain a lookout for other vessels while he, the master, went to the stern of the vessel to try to determine the cause of the power failure. The master stated that when he reached the stern, he saw smoke coming out of the engineroom emergency escape hatch and noted that an unusually large amount of smoke was being emitted from the starboard engine exhaust.

Meanwhile, a passenger who identified himself as a firefighter employed by the San Francisco Fire Department became concerned because of the smell of smoke in the dining salon. The passenger/firefighter said he left the salon and went to the aft deck, where he found the master standing near the engineroom escape hatch. He stated that he saw smoke coming out of the escape hatch, and when he opened the hatch cover, dark smoke poured from the opening, and

[1]The master's brother did not possess a vessel operator's license or merchant mariner's documents, although he had previously operated powerboats and sailboats. He had no operational responsibilities aboard the vessel except to maintain a lookout and to monitor the vessel's radio while the master was off the bridge investigating the cause of the power failure.



Figure 1 -- Commodore Dining Cruises, Inc.'s ARGO COMMODORE

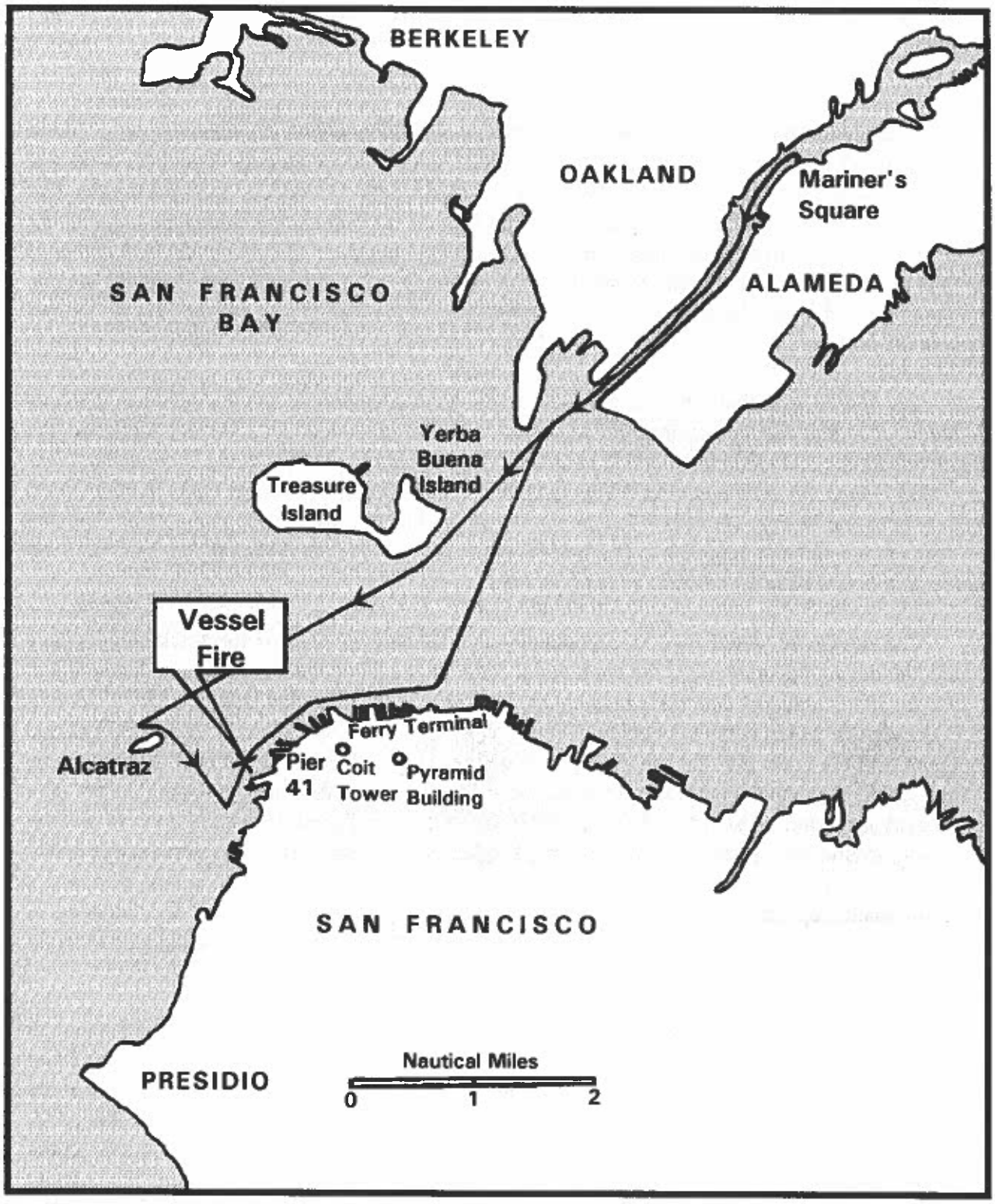


Figure 2 -- ARGO COMMODORE route (approximately 19 miles roundtrip)

he saw an orange glow inside the engineroom. He testified that a crewmember and another passenger each brought him a portable fire extinguisher, which he emptied into the hatch opening in an effort to control the fire.

The master, meanwhile, left the stern of the vessel, went down the stairwell, and opened the engineroom door. He testified that he saw a lot of smoke, so he quickly closed the door and went back toward the bridge to radio the Coast Guard for help. He said he thought the fire had started in the vessel's electrical system and stated that on his way to the bridge he ordered the senior deckhand to instruct the passengers to immediately don their life preservers and gather at the bow of the vessel. On his way to and from the engineroom, the master passed by the manual pull lever for activating the engineroom carbon dioxide (CO_2) firefighting system, but he did not activate the system.

The master said that when he reached the pilothouse, he found that the steering gear was not responding and that he could no longer hold the vessel on a steady course. By this time, the vessel was about 250 yards off pier 39, San Francisco Bay. At about 8:45 p.m., the master called the Coast Guard for assistance on VHF channel 16 and made an attempt to shut down both engines from the bridge. He stated that he successfully shut down the starboard engine, but that the port engine did not respond to the bridge controls and continued to run. He said the port engine shut down 10 to 15 minutes later on its own.

The deckhand stated that, as a precautionary measure in light of the thickening smoke outside the dining salon, she and the cook went to the bow of the vessel outside the dining salon to look for life preservers. She said she went to the bow area because that is where life preservers were stowed on other vessels belonging to the company. The senior deckhand informed the deckhand and the cook that the life preservers on this vessel were not in the bow area but were stowed inside the bench seats on which the passengers were seated in the dining salon. The senior deckhand said he also at that time conveyed to them the master's instructions to get the passengers to don life preservers. The deckhand and cook then took the life preservers out of the bench seats and passed them out to the passengers. Some passengers, including one who was a flight attendant, reported that they assisted the deckhands with the distribution and donning of life preservers. The flight attendant/passenger also provided instructions to the passengers during their evacuation from the dining salon to the open deck area at the bow.

A 41-foot Coast Guard utility boat (UTB) arrived on the scene at about 9:03 p.m., and its crew reported seeing smoke billowing from the engineroom vents of the ARGO COMMODORE. The UTB crew transferred 30 passengers, the deckhand, and the cook from the ARGO COMMODORE to the UTB. About 10 minutes later, a passing yacht, the CAMELOT, arrived on the scene and transferred nine of the remaining passengers to that vessel. Although the passengers became wet from the rain, none entered the water during the evacuation. The ARGO COMMODORE's master, senior deckhand, and two passengers—the master's brother and the passenger/firefighter—remained on board awaiting the arrival of the firefighting vessel PHOENIX, which had been dispatched by the San Francisco fire department. The UTB and the CAMELOT took the evacuated passengers to San Francisco pier 39, arriving by 9:35 p.m.

Paramedics from the San Francisco fire department, who were waiting at the pier, examined the passengers for possible injuries.

The firefighting vessel PHOENIX arrived on the scene about 5 minutes after the passengers had been evacuated. Firefighters from the PHOENIX brought the fire under control in about 40 minutes using carbon dioxide from the PHOENIX to smother the fire. The PHOENIX then towed the ARGO COMMODORE to pier 32, where San Francisco Fire Department personnel were waiting. It was then about 9:55 p.m., and heavy smoke was continuing to emanate from the engineroom. The fire reflashed at 10:10 p.m. Fire department personnel extinguished the fire, after which a fire watch was maintained by the crew of the ARGO COMMODORE. Representatives of the Coast Guard and the company stated that the fire was out shortly after midnight.

Injuries

No one was injured in this accident; however, six passengers complained of burning eyes and sore throats from exposure to smoke.

Vessel Damage

Fire damage to the ARGO COMMODORE was limited to the starboard side of the engineroom, mainly affecting the area outboard of the starboard main engine. The fire extensively damaged the starter motor/solenoid assembly and the wooden battery box containing engine starting batteries, both of which were located near deck level on the starboard side. The fire also ruptured an aluminum hydraulic line for the steering gear, causing a loss of steering control and a leak of hydraulic fluid that helped fuel the fire. Extensive smoke and fire damage resulted from the burning of combustibles such as hull insulation and the wooden overhead deck in the engineroom. The fire also damaged a portion of the vessel's electrical system, including the ship-to-shore power isolation transformer located above the batteries and a shore-power circuit breaker.

Insurance adjusters estimated damage to the ARGO COMMODORE at $150,000. A February 1994 insurance survey had estimated the market value of the vessel at $300,000, with a replacement value of $650,000.

Company and Crew Information

Company -- Commodore Dining Cruises, Inc., of Lafayette, California, the owner and operator of the ARGO COMMODORE, was founded in 1986. In addition to the ARGO

COMMODORE, the company operated three other small passenger vessels[2] certificated by the Coast Guard to carry up to 86, 150, and 450 passengers, respectively. All four vessels were being operated in the dinner-cruise trade in the San Francisco Bay area. At the time of this accident, the company had 35 employees. Except for the management staff, all of the company's employees, including masters and deckhands, were part-time or seasonal workers. The company employed a fleet captain, who was responsible for organizing safety training for the vessel crews, and an operations manager, who was responsible for the maintenance and repair of all company vessels.

Master -- At the time of the accident, the master, 49, was self-employed in a marine repair and boat delivery business and was a part-time employee of Commodore Dining Cruises, Inc. He held a U.S. Coast Guard license as Master of Inland Steam or Motor Vessels of not more than 100 gross tons. He stated that he had first received his license in 1980 and that it had been renewed twice since then. In October 1994, he completed a 6-day combined basic and advanced marine firefighting course sponsored by the Maritime Administration, U.S. Department of Transportation.

In March 1993, the master received radar observer training at Southern California Merchant Marine Training Services in San Diego. Earlier in his career, he served for 7 years in the U.S. Navy as a quartermaster (navigator). He had also received firefighting training in the Navy.

The master joined Commodore Dining Cruises in May 1992 as a relief captain. He stated that he usually worked with the company Thursday through Sunday evenings, a total of 10 to 20 hours per week. He testified that he had served as master on the ARGO COMMODORE 40 to 50 times before the accident.

The master stated that he had gone to bed between 10:30 and 11:00 p.m. on each of the 3 nights prior to the accident. He said that he had arisen at 7:00 a.m. on the day of the accident and was well rested.

Senior Deckhand -- The senior deckhand, 26, had been with the company for 8 months. A part-time employee with no previous marine experience, he worked as steward and bartender during the dinner cruises. He said he usually worked weekends and some weekday evenings. He had served since June 1991 as a volunteer with the local sheriff's department and had worked in the county jail. He stated that he had graduated from a local college with a degree in law enforcement and that he planned to become a police officer. He had received training in CPR and first aid, but as a deckhand, he neither held, nor was he required to hold, any Coast Guard certificates or qualifications. He had worked on the ARGO COMMODORE five to eight times before this trip.

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[2] The term "small passenger vessel" generally includes any vessel of less than 100 gross tons that is certificated to carry more than six passengers for hire.

The senior deckhand stated that he was well rested when he reported for duty at 6:15 p.m. on the day of the accident and had received between 7 and 8 hours of sleep the previous night. He had been awake for about 12 hours at the time of the accident.

Deckhand -- The deckhand, 41, had been with the company for about 3 1/2 months and had no previous marine experience. During the day she worked for an insurance company; in the evenings and on weekends she worked part time on the company's vessels. Most of her time on board was spent as a waitress, welcoming passengers and serving food and drinks. While she had served as senior deckhand on other vessels owned by the company, this was her first trip on the ARGO COMMODORE, and she was assigned as deckhand. She neither held, nor was she required to hold, any Coast Guard certifications or qualifications.

The deckhand stated that she was well rested when she reported for duty on the day of the accident and had received about 7 hours of sleep the previous night. She had been awake for about 11 hours at the time of the accident.

Cook -- The cook had been with the company for 3 months. This was her first time working on one of the company's vessels during a cruise; she usually cleaned the vessels while they were still at the dock. The cook neither held, nor was she required to hold, any Coast Guard certifications or qualifications.

The cook stated that she was well rested when she reported for duty on the day of the accident and had received about 12 hours of sleep the previous night. She had been awake for about 14 hours at the time of the accident.

Vessel Information

General -- The ARGO COMMODORE was built in 1968 in Harbor City, California. It was a small passenger vessel certificated by the U.S. Coast Guard to carry up to 70 passengers in San Francisco Bay and tributaries, and to carry up to 42 passengers when operating on a limited coastwise route.[3] According to its Certificate of Inspection, the ARGO COMMODORE was required to be manned by a master, a senior deckhand, and a deckhand. At the time of the accident, the vessel had a current Certificate of Inspection and was outfitted with lifesaving and safety equipment as required by U. S. Coast Guard regulations for small passenger vessels (46 CFR Subchapter T Parts 175-187).

The vessel had two passenger decks. The main deck had an enclosed passenger dining salon, while the deck above had an open passenger area aft of the wheelhouse. The hull of the vessel was constructed of 5/16th-inch-thick aluminum plate; the decks and superstructure were

[3] A limited coastwise route keeps a vessel within 20 nautical miles of a harbor of safe refuge. This route includes voyages not more than 3 miles from shore.

fiberglass-clad plywood. The vessel complied with Coast Guard regulations permitting the use of wood and fiberglass as construction materials for small passenger vessels carrying fewer than 150 passengers.

The vessel's principal characteristics were as follows:

Length:	62.9 feet
Breadth:	18.0 feet
Gross tons:	80
Net tons:	56
Propulsion:	Two 350-horsepower GM-Detroit Diesel engines

Lifesaving and Emergency Equipment -- The vessel was equipped with two 12-person lifefloats; 80 adult-size life preservers; 11 child-size life preservers, and 1 ring buoy with a light and line attached and with an emergency position indicator radio beacon (EPIRB). A first-aid kit was located in the wheelhouse; liferings were located on the main deck on the starboard side near the bow and on the aft exterior bulkhead of the wheelhouse. All life preservers were stowed in the bench seats in the dining salon on the main deck.

An electric-power-driven fire pump and fire hydrant with attached hose were located in the engineroom, as was the switch for operating the fire pump. The fire pump and its associated equipment met Coast Guard regulations. There were no other fire hydrants or hose stations on the vessel.

According to the Coast Guard Certificate of Inspection for the vessel, two portable B-I CO_2 fire extinguishers and four portable B-II foam fire extinguishers[4] were distributed among locations on the main deck in the forward and aft passageways and in the engineroom, the wheelhouse, and the galley.

Coast Guard regulations allow "portable battery lights" (flashlights) for emergency lighting in passenger areas above the main deck, and the ARGO COMMODORE was so equipped.

Fixed CO_2 Firefighting System -- The engineroom of the ARGO COMMODORE was equipped with a custom-engineered, fixed CO_2 fire extinguishing system. Coast Guard regulations do not require such a system on diesel-powered small passenger vessels such as the ARGO COMMODORE. It is Coast Guard policy, however, that before additional safety systems, such as this CO_2 system, are installed aboard vessels, the system plans must be reviewed and approved by the Coast Guard. Navigation and Vessel Inspection Circular (NVIC)

[4] Roman numeral I indicates the smallest size of portable fire extinguishers, and V indicates the largest size. A B-I CO_2 portable extinguisher is suitable for fires involving flammable liquids as well as oils, greases, and substances that produce flammable vapors. A B-II foam extinguisher is suitable for extinguishing fires involving common combustibles such as wood, paper, cloth, and plastics.

13-83, "Coast Guard Retention of Commercial Vessel Plan Review Case Files," recommends that plans relating to approvals for basic safety systems be retained by the Coast Guard, but it does not specifically list plans for a fixed firefighting system among those to be retained. Coast Guard representatives told the Safety Board that they could find no approved plans or records for the CO_2 system that was installed on the ARGO COMMODORE. Nor were details relating to the design and performance characteristics of the system available from the Coast Guard or from Commodore Dining Cruises, Inc.

Coast Guard inspection records from the vessel's last annual inspection in March 1994 do not indicate that any deficiencies were found in the fixed CO_2 fire extinguishing system. The complete system was serviced annually by the manufacturer's authorized service personnel.

The CO_2 system was equipped with a heat sensor located in the overhead of the engineroom between the two main engines. The sensor was designed to activate the CO_2 system automatically should the temperature in the engineroom begin to rise at a rapid rate.[5] The system did not incorporate a means to automatically shut down the vessel's propulsion engines or turn off the ventilation fan that drew air into the engineroom through a louvered opening on the aft deck of the vessel. The sensor did not activate the CO_2 system during this fire.

The CO_2 system could be activated manually by a pull lever located in the stairwell from the dining salon to the passageway that leads to the engineroom. An instruction placard next to the pull lever read, "In case of engine room fire, secure engine room hatch and cover ventilation."

After the accident, components of the fixed CO_2 fire extinguishing system, including the heat sensor, were checked by an authorized distributor for the system manufacturer and were certified to be in working condition.

Electrical Starting System for the Engines -- The starboard engine on the ARGO COMMODORE was designed to be electrically started using a key-operated, three-position (off/on/start) switch similar to the ignition switch in an automobile. When this starter switch, located in the engineroom, is operated, a 32-volt battery bank mounted on the deck adjacent to, and outboard of, the engine foundation supplies current to a starter motor via a solenoid. As the starter motor begins to spin, its pinion gear engages the teeth on the engine flywheel, causing the engine to turn. Once the engine starts and the starter switch is released, the starter motor's pinion gear disengages from the flywheel and the motor stops. The solenoid is mounted directly on the motor housing, which, in turn, is mounted on the engine.

[5] As the air within the sensor is heated by an engineroom fire, it expands, increasing the air pressure inside the sensor. If this pressure increases by an amount equal to 6 inches of water in a water column within a 5-second period, the sensor activates the CO_2 fire extinguishing system.

The current required by a starter motor while cranking the engine is too high to be routed directly through the starter switch. For that reason, a larger, heavier switch (the solenoid) is used to carry current to the starter motor. When the switch key is turned, a small current flows through the starter switch and energizes the solenoid coil, which, in turn, forces the solenoid plate to close (that is, move and contact the solenoid terminals), completing the circuit to the starter motor. When current flows through the motor, a pinion on the motor shaft engages and turns the flywheel to start the engine. The 32-volt solenoid used on the starboard engine of the ARGO COMMODORE was manufactured by Delco-Remy, model No. 1119861.

Vessel Maintenance -- The Safety Board reconstructed the recent maintenance history of the ARGO COMMODORE by obtaining from the owner all available maintenance receipts and by conducting interviews with various repair contractors who had worked on the vessel. Safety Board investigators learned that the starter motor and solenoid on the starboard engine had been replaced the day before the accident. The operations manager for Commodore Dining Cruises, Inc., stated that a contractor had installed the starter motor and solenoid and had started the main engines and checked the operation of the equipment after the repair. He also said that this contractor had previously performed satisfactory repair work for the company.

The operations manager recalled that the motor and solenoid on the starboard engine had been replaced "about two or three times" since he joined the company in February 1994. He also stated that it was generally known by the masters who operated the ARGO COMMODORE that the starter switch for the starboard engine would sometimes stick in the "start" position. He said that a handwritten sign was attached near the switch reminding the master to shut down the engine and restart it if the switch should stick.

The repairman who replaced the motor and solenoid the day before the fire stated that in his opinion the old solenoid had failed prematurely either because the starting batteries were low, causing the solenoid to overheat, or because the starter switch had stuck in the "start" position, keeping the solenoid closed and the starter engaged after the engine had started. The repairman also recalled noting that two of the bolts securing the starboard engine to its foundation were loose and that the nuts that should have held the bolts in place were missing. Photographs taken after the fire confirmed that the bolts in the outboard foundation for the starboard engine were not secured by nuts and that they had risen out of the bolt-holes by about 1 inch.

A September 1992 letter from Commodore Dining Cruises, Inc., to a repair company documents an engineroom fire that occurred aboard the ARGO COMMODORE on August 23, 1992, while the vessel was dockside. The fire occurred when the vessel's starboard engine was started in preparation for a cruise with passengers on board. The engineroom rapidly filled with smoke, and the cruise was canceled. The fire was traced to a burned-out starter motor on the starboard engine. According to the letter, "The next day the starter was sent to Genstar where it was diagnosed as and [*sic*] overheating problem caused by an engaged starter being driven by the flywheel, the cause of which was either a stuck ignition switch or a stuck solenoid. The key switch was examined and tested many times with no failure."

Tests and Research

The Safety Board examined the solenoid, battery cables, starter motor, and starter switch for the vessel's starboard engine in its Washington, D.C., laboratory. In addition, the Safety Board reviewed detailed photographs, taken after the fire, showing the installation of the outboard side of the starboard engine, including the engine, starter motor, solenoid, and battery cables. (See figures 3 and 4.)

Solenoid -- The solenoid showed evidence of extensive electrical arcing between the end cap of the solenoid and the solenoid body, as shown in figures 5 and 6. Examination revealed that the copper terminal on the solenoid, to which the battery cable was attached, had broken loose. The terminal post is normally connected to and insulated from the solenoid body by an insulating sleeve (grommet). This insulator had broken, freeing the terminal and allowing it to contact the grounded solenoid body and end cap. The arcing that resulted was sufficient to cause part of the terminal to melt and form a pool of solidified copper on the exterior surface of the end cap.

Safety Board examination of the contact plate inside the solenoid showed that the plate had not become "welded" (fused) in the closed position, nor did the contact plate show evidence of pitting, arcing, or being electrically energized over a long period of time.

Battery Cables -- Electrical arcing damage indicated that the positive cable leading from the battery to the solenoid had shorted with the negative cable leading from the starter motor back to the battery. This short was possible because the cables were adjacent to one other, and several inches of electrical insulation had burned off the cable leading to the solenoid. (See figure 4.)

Starter Motor -- Safety Board investigators disassembled and examined the starter motor and found it inoperative. A section of the motor commutator was dislodged, and most of the carbon brushes used to convey current to the commutator were either damaged or completely destroyed. Globules of copper were found on the armature and on the brush support housings. The bearings and armature shaft appeared to be in good condition.

The starter motor pinion teeth showed no evidence of mechanical damage, excessive wear, or discoloration due to overheating. To start the propulsion engine, the starter motor pinion gear, which has 11 teeth, engages the propulsion engine flywheel gear, which has 119 teeth, resulting in a gear ratio of about 10:1. (The engine flywheel rotates at about 2100 rpm at the engine's maximum rating of 350 hp.)

Starter Switch -- The Safety Board staff inspected and tested the starter switch for the starboard engine and found that it worked satisfactorily. Investigators disassembled the switch and found the contacts inside to be in good condition with no evidence of pitting or arcing.



Figure 3 -- Bare battery cables to/from solenoid/starter with visible arcing damage near engine foundation

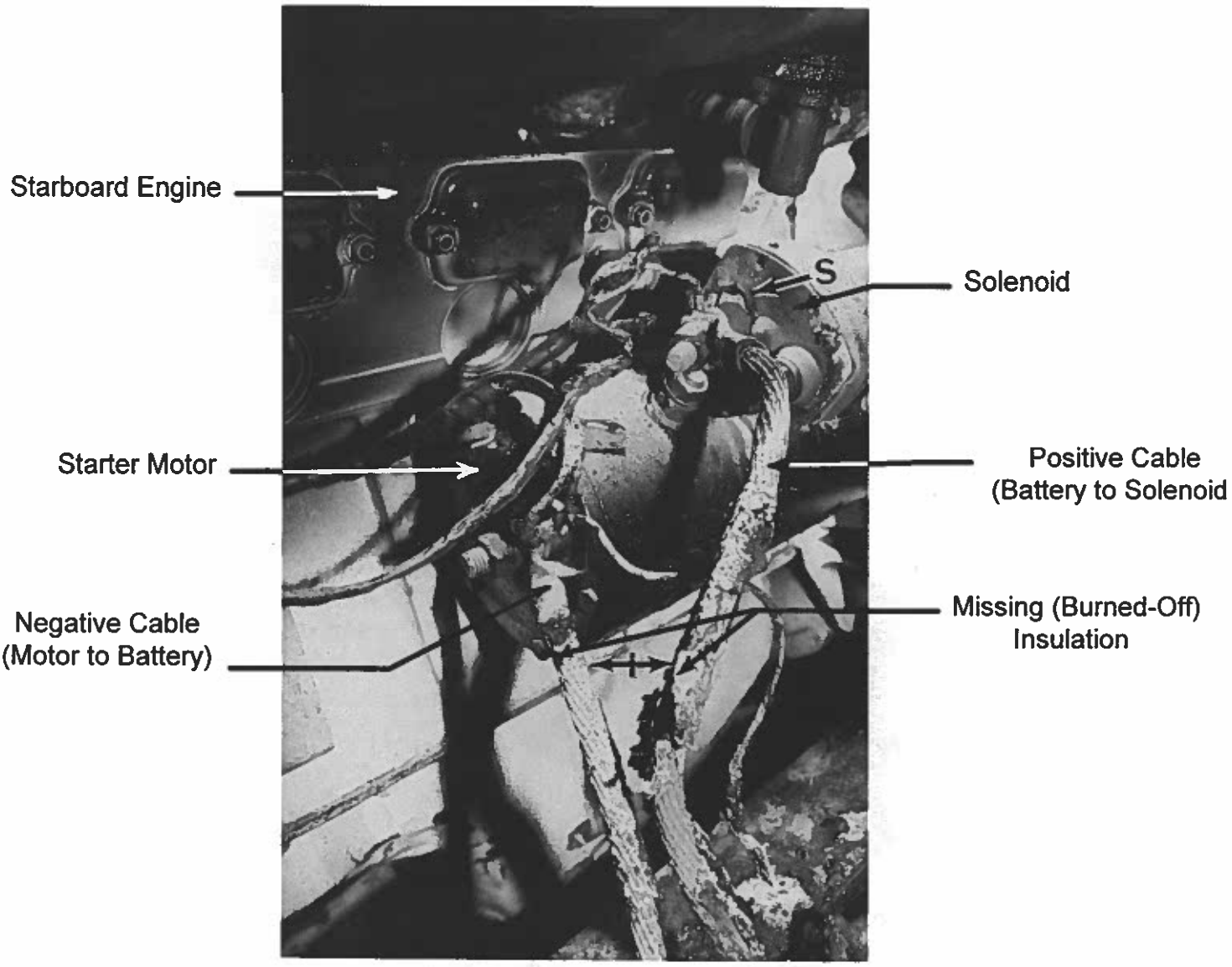


Figure 4 -- Solenoid in place on starboard engine. Solenoid terminal post is partially out of solenoid end cap (S).



Figure 5. -- Damaged solenoid after being removed from starter motor with battery cable still attached. End cap has separated from solenoid body.

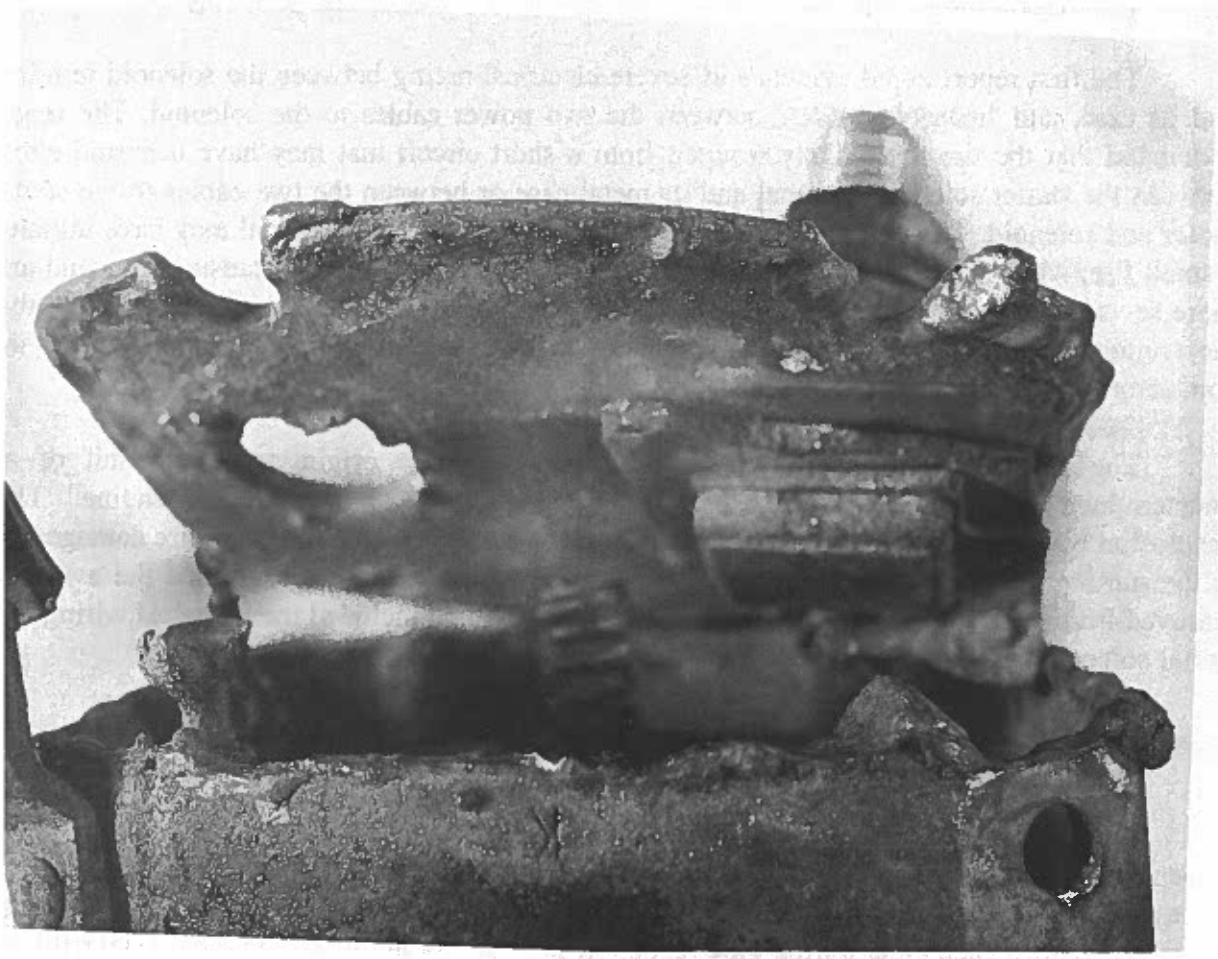


Figure 6. -- Close-up view of separated solenoid end cap showing arcing damage between end cap and solenoid body and around hole where solenoid terminal had been attached to the end cap

Reports by Fire Investigators -- Two independent fire investigators prepared reports concerning the cause of the fire. The first report, dated January 13, 1995, was prepared on behalf of the adjuster for the insurance company of the ARGO COMMODORE. The second report, dated April 3, 1995, was prepared on behalf of the supplier of the solenoid and motor.

The first report noted evidence of severe electrical arcing between the solenoid terminal and its case, and "massive arcing" between the two power cables to the solenoid. The report concluded that the fire most likely resulted from a short circuit that may have occurred either between the starter solenoid terminal and its metal case or between the two cables to the starter motor and solenoid. The report suggested that arcing at the solenoid terminal may have initiated a small fire, which, in turn, damaged the insulation on the cables, thereby causing a second and more severe short circuit between the two cables, resulting in a fire. The report also stated that the arcing between the cables probably ignited the wooden battery box located next to the conductors, causing the batteries to catch fire.

The second report stated, "This fire is accidental in origin and the result of an undetermined electrical failure at the battery located outboard of the starboard engine." This conclusion was based primarily on the observation that the lowest area of severe fire damage was at the starting batteries. The report stated that the investigator had not examined the evidence removed from the vessel earlier by the first investigator, which included the electrical wiring and starter solenoid for the starboard engine.

Survival Aspects

Emergency Actions of the Crew -- The Safety Board sent questionnaires to all 41 passengers on board the ARGO COMMODORE to gather information about the evacuation process and emergency response. A total of 22 responses were received, all of which stated that passengers helped each other during the evacuation and that the flight attendant/passenger helped other passengers locate and don life preservers, evacuate the dining salon, and muster at the bow of the vessel away from the smoke. Ten of the 22 respondents indicated that the crew also distributed life preservers to passengers. Five passengers stated that they were informed by the crew that the master was taking care of the power outage. Twelve passengers noted that the firefighter/passenger was the first to inform them that there was a fire on board the vessel. By all accounts, at no time did the master or a crewmember make a public announcement apprising the passengers of the situation or instructing them to put on lifejackets.

The senior deckhand stated that he guided the passengers in small groups on either side of the deckhouse from their muster locations at the bow to the stern to be evacuated to the UTB or the CAMELOT.

Safety Placards and Briefings -- Coast Guard regulations require that either a suitable instructive placard or a public announcement, or both, be provided to passengers to familiarize them with the type and location of lifesaving devices carried on board the vessel, including the

stowage location and donning procedures for life preservers. No safety briefing was given to the passengers of the ARGO COMMODORE at departure regarding lifesaving devices or procedures to be followed in an emergency.

A safety instruction placard (figure 7) was posted on the bulkhead of the dining salon near the starboard exit. The placard provided instructions on how to don type 1, type 2, and type 3 life preservers,[6] although only type 1 life preservers were carried aboard the vessel. Safety Board investigators found that the diagrams on the placard identifying the various lifejacket types were faded and illegible. The placard instructed passengers to wear the type 1 life preservers like a coat; however, the life preservers on board the vessel were designed to be worn around the neck. The placard indicated that life rings and life preservers were on board, but it did not state their locations. It also stated that a liferaft was on board, although in fact lifefloats were on board.[7] Passengers said they did not notice the safety placard and that it was not brought to their attention by the crew.

Stowage of Life Preservers -- The life preservers were stowed inside the bench seats in the dining salon. The labels indicating the number and size (adult or child) of life preservers stowed within each seat were located low on the benches, near the deck. Passengers stated that the dining tables and chairs were located in front of the bench seats and that they did not notice the labels.

A number of passengers reported that they had had difficulty donning their life preservers because the life preserver straps were tightly wrapped and secured with clips. Many passengers reported that they needed help from other passengers to unfasten the clips. Some passengers stated that they were unable to unfasten all the clips and, as a result, they wore their life preservers improperly. The cook stated that she also had difficulty unfastening the clips.

Firefighting Actions by the Crew -- The master stated that after he became aware of a fire aboard his vessel, his first priority was to radio the Coast Guard to evacuate the passengers. He further stated that he intended to return to the engineroom to fight the fire after the passengers were evacuated. He did not close the ventilation louvers to the engineroom to restrict the air supply feeding the fire, nor did he manually shut off the fuel supply valves to the engines. The ventilation louvers and the fuel shut-off valves were located on deck and easily accessible during the fire. He also did not manually activate the fixed CO_2 firefighting system from the pull lever located outside the engineroom.

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[6] A type 1 life preserver provides the most buoyancy and is designed to turn unconscious persons to a face-up position in the water. It is effective in open and rough waters. A type 2 life preserver is less effective in turning unconscious persons to a face-up position and is intended for use in calmer waters. A type 3 life preserver is intended for persons who can position themselves in a face-up position and is intended for use in calm water.

[7] Liferafts and lifefloats are both flotation devices; however, a liferaft keeps survivors out of the water, whereas a lifefloat does not.

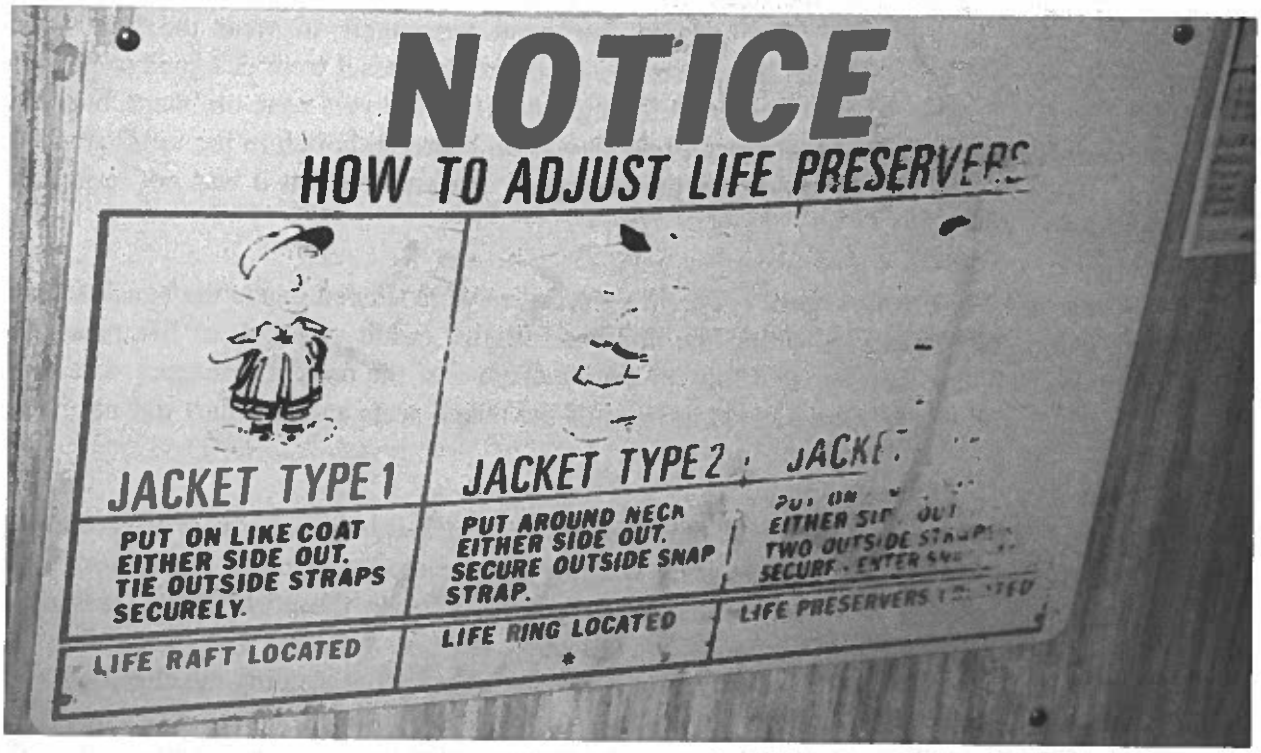


Figure 7 -- Safety placard on board the ARGO COMMODORE

Testimony indicated that the initial firefighting effort was undertaken by the firefighter/passenger, who opened the emergency hatch to the engineroom and emptied at least two portable fire extinguishers into it in an effort to control the fire. The senior deckhand and a passenger assisted the firefighter/passenger by bringing fire extinguishers to him. The deckhand and cook did not fight the fire.

Crew Training in Emergency Procedures

Training Requirements -- Coast Guard regulations do not require deckhands on small passenger vessels to hold Coast Guard licenses or possess formal qualifications; however, Coast Guard NVIC No. 1-91, "Recommended Qualifications for Small Passenger Vessel Deckhands," provides the marine industry with recommended qualifications and training for deckhands to ensure the safe operation of small passenger vessels. The NVIC states that the marine employer is responsible for ensuring that deckhands are physically fit, that they are familiar with emergency procedures and the location of emergency equipment, and that they are trained to respond properly to emergencies, including shipboard fires and ship abandonment.

According to NVIC 1-91, in cases of fire, deckhands should be familiar with the following:

1. Fire detection and alarm systems.
2. Classes of fires and appropriate firefighting technique.
3. Location and operation of firefighting equipment.
4. Location and operation of power, ventilation, and fuel shut-offs.
5. Location and operation of watertight doors, hatches, fire-screen doors, and escapes.
6. Procedures for mustering passengers.
7. Station bill assignments/duties.

In the event of ship abandonment, they should be familiar with the following:

1. The location, launching, and operation of survival equipment and craft (this includes, but is not limited to, lifeboats, liferafts, buoyant apparatus, lifefloats, survival suits, and personal flotation devices).
2. The proper method of abandoning the vessel, including mustering and debarking passengers.
3. Proper emergency communications procedures (EPIRB, distress signals, etc.).
4. Station bill assignment/duties

The NVIC also states that a senior deckhand should possess greater knowledge and experience in emergency procedures than ordinary deckhands. According to the NVIC, the senior deckhand is responsible for supervising other deckhands while the vessel is underway and acting as team leader during emergencies. The NVIC recommends that senior deckhands be capable of operating the vessel in the event the master is incapacitated.

Training Provided by the Company -- The crew and the company fleet captain stated that the company provided training in emergency procedures through informal discussions held during monthly company picnics and barbecues. These informal discussions typically included instructions on donning life preservers, using fire extinguishers, and assisting passengers during evacuations. The company owner, the fleet captain, or the vessel masters who worked for the company usually provided the safety information. Company crewmembers were not required to, and did not always, attend these informal discussions; however, except for the cook, the crewmembers who served aboard the ARGO COMMODORE on December 3, 1994, stated that they had attended such discussions. The company kept no records of the meeting attendees or the subjects discussed.

The master and fleet captain stated that the vessel masters also provided on-the-job training to deckhands during dinner cruises. According to the fleet captain, company policy required that the master, during each cruise, familiarize deckhands with the locations of emergency equipment on the vessel and review the company's safety training checklist. The checklist lists the following topics to be discussed: "Fire; first aid; location of safety equipment; damage control; man overboard; line handling; mechanical problems; misconduct of passengers; personnel and passenger injury; and the importance of keeping the captain informed." (See appendix B.)

The checklist does not provide information about the scope or content of discussion for any of the listed items. According to the fleet captain, items on the list should be checked off after discussion between the master and crew.

The master of the ARGO COMMODORE stated that he had not familiarized the deckhands with the locations or use of safety equipment or reviewed the safety training checklist with the deckhands on the day of the accident.

In addition to its safety training checklist, the company submitted to the Safety Board sample copies of a master's checklist and a senior deckhand's checklist used by the company. The checklists serve to remind the master and the senior deckhand of items to be checked prior to and during a cruise. The master's checklist includes a reminder to check all navigational lights and equipment and to brief the senior deckhand about his responsibilities. According to the crew, the master did not brief the deckhands about their responsibilities during this cruise. The senior deckhand's checklist includes reminders to check the engineroom for smoke and fluid leaks and to be familiar with the use of the ship's radio. The senior deckhand stated that monitoring the engineroom was the responsibility of the master.

The master described how he implemented company procedures for providing on-the-job training to the crew during dinner cruises. He stated that after the passengers had completed their dinner and the tables had been cleared, he selected deckhands at random and showed them where the fire extinguishers were located. He also showed them around the pilothouse, if time permitted. The total time spent on such training was 10 to 15 minutes. The master mentioned the

practical difficulties of conducting such training during dinner cruises, saying the crew's catering duties left little or no opportunity for intensive, meaningful on-the-job training.

With respect to the effectiveness of the company's training, the master stated that crewmembers' emergency duties, as well as their required knowledge levels and capabilities for performing emergency duties, needed to be better defined. He stated that the firefighting ability of the crews was barely adequate and that only half the crewmembers knew what measures to take in an emergency. He said he felt that the turnover in company personnel may have adversely affected the crew's knowledge of emergency procedures. The master stated that a company plan was needed to provide practical training to crewmembers and that this training should take place while their vessels were not engaged on dinner cruises.

Master's Knowledge of the CO_2 System -- According to a written statement by a Coast Guard investigator who surveyed the engineroom with the master shortly after the fire was extinguished, the master stated that he was not aware of a fixed CO_2 system on board the vessel. When the investigator specifically pointed out the CO_2 discharge nozzles to the master, the latter reportedly said that he did not know what they were and added that "they were probably from an old system which does not work." In subsequent testimony to Coast Guard investigators, the master stated that he was aware of the CO_2 system, but that he had misspoken because he was tired as a result of all the activity that had taken place after the fire was discovered. In his testimony to Safety Board investigators, the master further stated that he did not know that the ARGO COMMODORE was equipped with a sensor to activate the CO_2 system automatically in the event of an engineroom fire.

Knowledge and Training of Senior Deckhand -- The senior deckhand stated that, as part of his on-the-job training, various masters had discussed the safety training checklists with him on previous occasions. He said that he had not participated in a man-overboard drill and that he was not aware that the ARGO COMMODORE was equipped with a fire pump and hose. He acknowledged that he was not very knowledgeable about the engineroom and was not certain about the existence of the CO_2 system on board or familiar with its operation. Regarding different types of portable fire extinguishers on board the vessel and their use with different types of fires (electrical fires, grease fires, wood fires, and so forth), he stated that he had only a limited knowledge of firefighting.

Knowledge and Training of Deckhand -- The deckhand stated that she had participated in safety discussions during social meetings held by the company. She had a total of 3 1/2 months of marine experience and had served as a senior deckhand on other vessels belonging to the company. She stated that she was not aware of any drills conducted by the company to familiarize crewmembers with the use of firefighting and lifesaving equipment. She did recall discussions with the company owner about what to do if someone fell overboard.

The deckhand stated that she was not familiar with the use of the fire pump and did not know if the ARGO COMMODORE was equipped with a public address system for use during

emergencies. She said she knew that the vessel was equipped with portable fire extinguishers, but she was unaware of their types or their suitability for fighting different classes of fires.

She said she "believed" that there was a document on board that listed safety equipment aboard the vessel and the duties of individual crewmembers in emergencies, but that she was not personally familiar with the document. A copy of the document provided by the company shows that it does not provide specifics regarding the number of life preservers or fire extinguishers aboard or the capacities of available lifefloats. (See appendix C.) Nor does it specify crewmember duties in an emergency. Coast Guard regulations did not require the posting of a list aboard the ARGO COMMODORE showing individual crewmember duties in an emergency. NVIC 1-91 recommends that deckhands be familiar with those duties.

Toxicological Information

No postaccident alcohol or drug testing of any crewmember was conducted. The investigating Coast Guard officer who responded to the accident arrived at pier 32 about 11:00 p.m. on December 3, 1994. He stated that he discussed postaccident toxicological testing with the master and the president of the company during the approximately 1 1/2 hours that he remained at the pier. The investigating officer determined that postaccident toxicological testing was not required in this instance because the accident did not qualify as a "serious marine accident."[8] The company president stated that he had been prepared to direct the master to undergo testing, but that he elected not to do so when he was informed by the investigating officer that such testing was not required. When Safety Board investigators arrived at the company offices and asked the president to arrange for toxicological testing of the ARGO COMMODORE crew, he declined the request, citing his previous discussion of the matter with the Coast Guard investigating officer.

The Coast Guard officer told Safety Board investigators that he detected no evidence that any member of the crew had ingested alcohol or drugs. The crewmembers all testified that they had not used alcohol or other drugs, including over-the-counter or prescription medication, prior to the accident.

Other Information

Commodore Dining Cruises, Inc., is a member of the Passenger Vessel Association. Members of this group offer a range of services, including dinner cruises, tour and excursion services, car and passenger ferries, private charters, whale-watching trips, overnight cruises, and riverboat gaming. (See appendix D.)

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[8]Title 46 CFR 4.03-2 defines "serious marine accident" as any casualty or accident that is reportable to the Coast Guard which results in a fatality, injury beyond first aid, damage to the vessel in excess of $100,000, actual or constructive total loss of any vessel, discharge of more than 10,000 gallons of oil, or any discharge of hazardous material. Coast Guard regulations do not require postaccident toxicological testing for the crew unless the accident qualifies as a serious marine accident.

According to the Association, it has a Safety and Loss Control Committee that is responsible for assisting members in developing and implementing programs to enhance training and safety, with the goal of improving the loss record for the industry.

ANALYSIS

General

The Safety Board was able to readily exclude weather and crew fatigue as causal factors in this accident. The Coast Guard investigating officer who arrived on the scene about 2 1/2 hours after the accident noted no signs of alcohol or drug use by members of the ARGO COMMODORE crew, but because no toxicological testing was done, the Safety Board was unable, categorically, to exclude alcohol or drug use by crewmembers as either causal to the accident or contributory to its severity. The Safety Board believes that in the interest of marine safety, the employer should have directed all crewmembers aboard the ARGO COMMODORE to undergo postaccident toxicological and alcohol testing, despite the Coast Guard investigating officer's determination that such testing was not required.[9]

The Coast Guard utility boat and the yacht CAMELOT arrived on the scene within 20 to 30 minutes after the master radioed for assistance. The passengers commended the Coast Guard for their expeditious response and for their efficient and safe evacuation of the passengers. The Coast Guard notified the San Francisco Fire Department in a timely manner, and that department responded quickly and effectively. The Safety Board concludes that the emergency response of the Coast Guard, the firefighting efforts of the San Francisco Fire Department, and the assistance of the private yacht CAMELOT were all timely and appropriate.

In this accident, the Safety Board identified the following safety issues, which are examined in this report:

- Management oversight of vessel repairs;
- Master's response to the fire emergency;
- Fixed firefighting systems on small passenger vessels;
- Fire pump operation on small passenger vessels;
- Crew training in emergency procedures;
- Safety placards and briefings/orientations for passengers;
- Issuance of proposed regulations for small passenger vessels.

[9]The Coast Guard investigating officer determined that postaccident toxicological testing was not required because the accident could not be classified as a "serious marine accident." Subsequent detailed damage surveys assessed the damage at $150,000. Although this means that the fire aboard the ARGO COMMODORE would have met the criteria for a serious marine accident, the Coast Guard officer's decision was reasonable given the information available to him at the time.

Cause of the Fire

From an examination of all the available evidence, the Safety Board concludes that the most likely cause of the fire was a short circuit in the electrical starting system for the starboard propulsion engine caused by a failed insulator separating a solenoid terminal from the solenoid case. The broken insulator allowed the terminal post (to which battery current is supplied) to contact or arc with the case of the solenoid. The massive electrical arcing and heat that resulted from this short circuit burned away the insulation from the cable connected to the solenoid terminal, creating a second short circuit between that cable, which was positive, and the negative cable adjacent to it. This second short circuit probably ignited the wooden box containing the batteries. The fire then spread upward on the starboard side, burning the combustible hull insulation and eventually reaching the wooden underside of the deck above. Although large volumes of smoke were observed by the passengers and crew, the fire never reached the center or port side of the engineroom, indicating that it was probably a "smoldering" fire that had grown slowly.

Safety Board investigators considered the possibility that the initial short circuit may have occurred between the two cables rather than at the terminal connection. This theory was discounted because it would not have accounted for the arcing damage to the solenoid terminal and solenoid body.

The Safety Board's conclusions are consistent with the findings of the first fire investigator's report dated January 13, 1995. They do not generally agree with the finding in the second fire investigator's report, dated April 3, 1995, which suggested that the fire originated at the batteries. The Safety Board believes that this finding would not explain the damage at the solenoid terminal and attached cable, or the damage sustained by the starting motor. The starter solenoid and cables had been removed from the vessel by the first investigator, and these components were not considered by the second investigator in reaching his conclusion.

A question remained as to what caused the failure of the insulator that led to the short circuit. Safety Board analysis suggested a number of possible failure modes: (1) the insulator between the solenoid terminal post and the solenoid case was defective as manufactured; (2) the insulator was damaged during installation of the solenoid by excessive tightening of the terminal nut; (3) the insulator broke because of the excessive vibration that the solenoid terminal and cable may have been subjected to while the vessel was underway; (4) the starter switch stuck in the "start" position, keeping the solenoid energized until the insulator failed from overheating; (5) the solenoid itself stuck in the closed position, causing the insulator to fail from overheating; or (6) an intermittent electrical short in the wiring between the starter switch and the solenoid kept the solenoid energized until the insulator failed from overheating.

Safety Board investigators analyzed each of these failure modes and assessed the likelihood that it was the cause of the failed insulator. In regard to failure mode number 4, Safety Board investigators tested the starter switch and found it to be working and its contacts in good condition.

Investigators thus ruled out a stuck starter switch as a cause of the failed insulator. This is not to say that the switch had not malfunctioned occasionally; a warning sign posted near the switch indicated that it was subject to intermittent sticking.

Regarding failure modes 5 and 6, the Safety Board believes that if the solenoid plate had stuck closed or if there had been an intermittent short in the wiring between the switch and the solenoid, the solenoid plate would have shown evidence of high current flow, and the insulators on both solenoid terminals would have been damaged. In fact, there was no evidence of pitting or arcing or any other indication that the solenoid contact plate had been electrically energized over a long period of time, and only one terminal insulator was damaged. Therefore, the Safety Board believes that the solenoid did not stick in the closed position and that a short circuit did not occur in the wiring between the starter switch and the solenoid.

Based on this analysis, the Safety Board believes that the damaged insulator resulted from failure modes 1, 2, or 3, any one of which could have caused the observed arcing damage. While it is impossible to rule out a manufacturing defect or improper installation as the source of the insulator failure, evidence points to failure mode 3, excessive stress on the terminal insulator, as the most likely possibility.

Because the cable from the battery to the solenoid was heavy (stiff) and short and was not supported by a clamp, the cable was able to exert forces that the solenoid terminal and its insulator were not designed to withstand. Engine vibration would naturally increase these forces, especially in this case, because some of the engine foundation bolts were loose. After the vessel had been underway for about an hour, the vibration could have broken the insulator around the terminal and allowed a short circuit to develop between the terminal and the solenoid case. The new solenoid had functioned satisfactorily after it was installed the day before the accident, probably because the engine was started only briefly and the vessel was not underway.

Safety Board investigators were unable to pinpoint the exact cause of the internal damage to the starter motor. Investigators did determine that this damage was consistent with the motor's having been run at excessively high speeds, either by being driven by the engine flywheel or by being energized under no load.

The motor could have been driven by the engine if the motor pinion did not disengage from the engine flywheel in a timely manner after the engine started. The 10:1 gear ratio between the flywheel and the motor pinion would cause the motor to rotate 10 times faster than the engine, far exceeding the motor's safe operating speed. The high centrifugal forces developed at such speeds could cause a section or sections of the commutator to dislodge, which, in turn, would destroy the carbon brushes under impact as the commutator rotated against them. Such damage had occurred, but because the pinion teeth and armature shaft bearings of the motor were in good condition, the starter motor had probably not remained engaged with the flywheel for a long period of time. If the damage to the starter motor did occur in this manner, it probably occurred soon after the engine was started and was likely unrelated to the electrical arcing that started the fire.

The starter motor could have operated under no load if the short circuit at the solenoid had caused the motor to run with its pinion gear disengaged from the engine flywheel. This would have allowed the motor to overspeed, which, in turn, could have caused the damage described.

Diagnosis of Electrical Problems in the Starboard Engine Starting System

As early as 1992, when a similar fire broke out on board this same vessel, the ARGO COMMODORE's owner was aware of problems in the vessel's electrical starting system. But the subsequent pattern of frequent failures and replacements of starter motors and/or solenoids, including as many as "two to three" in the 10 months prior to this accident, shows that underlying problems with the electrical starting system had remained unresolved and that the company's approach of simply replacing parts as they failed had proved ineffective. The company failed to heed the warning signs of this unresolved problem and to systematically troubleshoot all system components in a comprehensive and coordinated manner. The Safety Board concludes that the company management responsible for vessel repairs and maintenance did not diagnose and correct the underlying deficiencies that had been a repetitive source of problems in the vessel's electrical starting system. An accurate diagnosis would have been much easier to accomplish while the system was functioning and before so many of its components had been destroyed by the fire.

In another example of questionable oversight of vessel maintenance, the company allowed a starter switch that was suspected of being a source of electrical problems to remain on board with only a handwritten sign to warn users of possible malfunctions. Although the starter switch probably did not cause the fire on December 3, 1994, its malfunctioning could explain the 1992 fire, as well as the frequent replacements of solenoids and starter motors. The loose engine foundation bolts that were noted during this investigation also exemplify inadequate vessel maintenance. These loose bolts not only may have contributed to this accident, they held the potential for causing other problems as well.

The Safety Board believes that Commodore Dining Cruises, Inc., should conduct a thorough examination and repair of the starting system aboard the ARGO COMMODORE and take steps to ensure adequate management oversight of all its vessel maintenance and repairs so that electrical and mechanical defects or malfunctions are promptly identified and corrected and are not allowed to persist until they become safety hazards.

Master's Response to the Fire Emergency

The master stated that he did not immediately take measures to fight the fire when he became aware of it because his first priority was to evacuate the passengers. His decision to delay firefighting proved to be crucial, as the smoke intensified so rapidly that he was unable to enter the engineroom later to fight the fire.

The Safety Board believes that the master's best option for fighting the fire would have been to manually activate the fixed CO_2 system. This option was clearly available; on at least two occasions, the master passed by the manual pull lever for activating the CO_2 system, but he did not use it. The Safety Board concludes that if the master had first followed the standard firefighting procedures of cutting off engineroom ventilation and shutting down the engine fuel supply and had then manually deployed the CO_2 system, the fire would have been brought under control and probably extinguished.

In fact, securing the ventilation alone would have minimized the air supply to the engineroom and would have helped restrict the growth of the fire. The master did not take this action, even though the ventilation intake louver for the engineroom was accessible from the main deck. Nor did he shut off the fuel supply to the engines, even though the valves for doing so were accessible from the main deck.

One reason the master gave for not activating the CO_2 system was that CO_2 would have been ineffective in fighting a fire sparked by an electrical source. While it is true that the CO_2 may not have extinguished any ongoing electrical arcing, it would certainly have effectively controlled or extinguished the fire and would have reduced the damage that resulted from the burning of combustible materials (wood and insulation) in the engineroom.

Another reason the master gave for not using the CO_2 system was that using it would have shut down the engines. He stated that he needed to run the engines so that he could maneuver the vessel to take the wind and smoke away from the passengers. But the vessel's maneuverability had already been severely impaired by the steering gear failure and the lack of controllability of the port engine. Moreover, the master himself had earlier shut down the starboard engine and had tried unsuccessfully to shut down the port engine. The Safety Board thus finds the master's rationale for not deploying the CO_2 system to be illogical based on the circumstances that prevailed at the time he made his decision. The Safety Board believes that a master who was familiar with his vessel should have been able to recall the existence of the CO_2 system. He should also have been able to identify the CO_2 nozzle during the damage survey of the engineroom. The Safety Board found the master's reasons for not activating the CO_2 system to be contradictory and concludes that he was probably unaware that the ARGO COMMODORE was equipped with a CO_2 firefighting system.

Fixed Firefighting Systems on Small Passenger Vessels

Despite the master's failure to activate the CO_2 system manually, the system's heat sensor should have activated it automatically. Because it did not, Safety Board investigators reviewed the basic features of the CO_2 system in an effort to determine if it had been properly designed for automatic operation.

Evaluation of the ARGO COMMODORE CO_2 Fixed Firefighting System -- Because this was a custom-designed system, it should have been specifically engineered for the configuration and volume of the ARGO COMMODORE engineroom. This would have included

calculating the appropriate size and flow rates for the CO_2 discharge piping, determining the number and physical placement of heat detectors, and incorporating all the features necessary for automating the system. Although tests conducted after the accident by the system manufacturer's authorized distributor showed that the individual components of the CO_2 system were in working order, such tests cannot ensure that the system was properly designed and its components properly integrated to function automatically in this particular environment.

This is why engineering design plans for custom-engineered firefighting systems should be reviewed for design adequacy and approved by the Coast Guard before the system is installed on a passenger vessel. Unfortunately, no Coast Guard records were found relating to approval of the system installed on the ARGO COMMODORE; thus, the basis for the engineering approval of this system—if the system ever received such approval—is unknown.

Lacking plan review records, Safety Board investigators had to evaluate the capability of the CO_2 system to work in the automatic mode based on general facts found in their investigation of the accident. The Safety Board notes that a Coast Guard regulatory proposal contained in Supplemental Notice of Proposed Rulemaking (SNPRM) CGD 85-080[10] would require that a means for automatic engine and ventilation shutdown be incorporated whenever an automatically activated CO_2 system is installed in an engineroom. Because the system aboard the ARGO COMMODORE was not so equipped, even if the heat sensor had worked properly in the automatic mode, the concentration of CO_2 would have been diluted by air drawn from outside the vessel by the ventilator fan, rendering the system ineffective for firefighting. Further, any discharged CO_2 would have been rapidly aspirated by the main engines and would thus have been unavailable for fighting the fire. The Safety Board therefore concludes that the fixed CO_2 firefighting system aboard the ARGO COMMODORE was inadequately designed to function effectively in the automatic mode.

Retention of Plans for Fixed Firefighting Systems -- Although fixed firefighting systems are part of a vessel's basic safety system, Coast Guard policy, as contained in NVIC 13-83, does not require that fixed firefighting system plans be retained for small passenger vessels. This may explain why the Coast Guard could not locate approval records for the fixed firefighting system installed on the ARGO COMMODORE. Unfortunately, in the absence of such records, there can be no assurance that any particular system was ever approved or that, if it was approved, that it has been maintained during the vessel's life to comply with its original design and installation specifications. This accident revealed that the automatic activation system on board the ARGO COMMODORE was inadequate. This points up the importance of retaining records of approvals of fixed firefighting systems.

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[10]"Small Passenger Vessel Inspection and Certification," as published in the Federal Register on January 13, 1994. This SNPRM is a complete revision of the proposed regulations published on January 30, 1989 (CGD 85-080).

The Coast Guard's proposed regulations regarding firefighting systems contained in the SNPRM are extensive in scope. Among other things, they will require the installation of fixed firefighting systems on all new vessels, as well as on all existing vessels with hulls constructed of fiberglass-reinforced plastic (FRP) or wood. The regulation would not apply to a few existing vessels, like the ARGO COMMODORE, that are already equipped with fixed firefighting systems. As noted previously, however, if no information regarding the approval of these systems exists, there can be no assurance that the systems were ever approved or that they have been maintained in accordance with Coast Guard design and installation standards. This regulatory proposal would make the development and approval of fixed firefighting system plans a routine procedure in the future and thus would not place an undue burden on vessel owners in light of the potentially significant safety benefits.

The Safety Board therefore believes that where no records exist regarding the approval of fixed firefighting systems already installed on small passenger vessels, the Coast Guard should require those vessels' owners to submit plans for those systems to the Coast Guard for approval. The Coast Guard should determine the adequacy of the design and installation of fixed firefighting systems currently fitted aboard all existing small passenger vessels—regardless of hull materials—and require that plan approval records for these systems be maintained for the life of the vessels.

In its 1989 Safety Study *Passenger Vessels Operating from U.S. Ports*, the Safety Board issued Safety Recommendation M-89-120 as follows:

> Require a fixed firefighting system in the engineroom without regard to the type of fuel used for propulsion for domestic small passenger vessels.

Because the regulations proposed in the Coast Guard SNPRM require fixed firefighting systems on all new small passenger vessels and are therefore responsive to recommendation M-89-120, the Safety Board classified this recommendation "Open--Acceptable Alternate Response" pending implementation of the regulations. The Safety Board notes that the SNPRM goes further and also proposes that all existing small passenger vessels with hulls constructed of wood or FRP be retrofitted with fixed firefighting systems within 3 years of the effective date of final regulation.

It is of concern to the Safety Board, however, that the SNPRM proposal to retrofit existing vessels would not apply to those vessels whose decks or superstructures are made of wood or FRP while their hulls are constructed either of aluminum, like the ARGO COMMODORE, or of steel. These vessels are equally vulnerable to fires, as the experience of the ARGO COMMODORE attests. As demonstrated by this accident, considerable smoke and toxic gases can be generated by the burning of insulation and combustible materials, such as FRP and wood, that may be used to construct parts of a vessel other than its hull. Clearly, the hazards of smoke arise whenever there is a fire aboard ship, regardless of the vessel's hull construction material. The Safety Board therefore believes that the Coast Guard should amend its regulatory proposal so that its retrofit provision applies to vessels with hulls, decks, or superstructures constructed of wood or FRP.

The fleet of Coast Guard-inspected small passenger vessels have hulls that are constructed primarily of wood, steel, aluminum, or fiberglass (24, 23, 26, and 25 percent, respectively); however, relatively few vessels are constructed of mixed materials where FRP or wood are used in conjunction with non-combustible materials such as steel or aluminum. The Safety Board thus believes that this regulatory proposal would require retrofitting relatively few vessels, yet it would result in a significant increase in safety by targeting those remaining vessels that are the most vulnerable to fires.

Fire Pump Operation on Small Passenger Vessels

The fire pump on the ARGO COMMODORE could only be operated from inside the engineroom. In this respect, it was in compliance with existing regulations that require the fire pump to be operable locally. But in this accident, smoke would have prevented the master from entering the engineroom to operate the fire pump; it is therefore important for the master or a crewmember to be able to operate the fire pump from locations outside, as well as inside, the engineroom. This is particularly significant when one considers that the engineroom is where most marine fires originate, regardless of hull construction material. The engineroom contains ignition sources such as hot surfaces, fuel and lubricating oils, and electrical equipment, all of which can be the source of fires. The Safety Board therefore supports implementation of the SNPRM proposal that the fire pump on all new small passenger vessels be capable of being operated remotely from locations outside the engineroom, as well as locally.

In this accident, smoke not only would have prevented the master from using the fire pump, it also cut off access to the fire hydrant and attached hose with which the master could have fought the fire. The Safety Board thus concludes that smoke in the engineroom would have prevented the master from using the vessel's fire pump and its fire hydrant, both of which could only be operated from inside the engineroom. The Safety Board believes that the Coast Guard should expand the SNPRM proposal relating to the remote operation of the fire pump to also require that at least one fire hydrant with attached hose be located outside the engineroom on all new small passenger vessels.

Crew Training in Emergency Procedures

Because all the passengers were in the vessel's small dining salon, a voice announcement by the master or a crewmember providing guidance to passengers during the emergency would have been audible to them all. The lack of a general announcement caused confusion among the passengers, because they did not know where to find life preservers or how to put them on. In the event the passengers who wore their life preservers improperly had been forced to enter the water, there may have been injuries or deaths.

Inadequate guidance from the crew during the passengers' evacuation from the dining salon also added to the confusion. The crew's inadequate knowledge forced them to rely on

passengers to fight the fire and actively assist in the evacuation. Fortunately, two passengers possessed special skills in emergency procedures and were able to ameliorate the consequences of the fire. It is instructive that the flight attendant and firefighter passengers, though lacking marine experience or training, responded naturally and appropriately to this shipboard emergency. Their actions reflect credit upon themselves and demonstrate conclusively what can be expected of personnel who are properly trained and prepared to handle emergency situations. It is unfortunate that the deckhands aboard the ARGO COMMODORE had not had the benefit of a similar formalized training program and thus were unable to be completely self-reliant in reacting to an accident aboard their vessel. The Safety Board concludes that while the knowledge and training of the flight attendant and firefighter passengers allowed them to take effective action in this accident, the crew's inadequate knowledge of safety systems aboard the vessel prevented them from assuming a leadership role during the emergency.

Although the Safety Board was provided with various company safety checklists and documents, investigation revealed that the deckhands were not aware of these and that they did not sufficiently understand the scope of their safety duties and responsibilities. The Safety Board believes that the company did not ensure that crewmembers clearly understood their roles in an emergency or that they were familiar with the locations, quantities, and proper use of various types of safety equipment on board.

Although the senior deckhand had worked on the ARGO COMMODORE 5 to 8 times before, he stated that he did not know that there was a fire pump and hose in the engineroom. He said that he was not trained in firefighting, and his responses to questions from Safety Board investigators revealed that he did not know which types of fire extinguishers to use with different classes of fires. He had not been asked by the company to participate in emergency drills during his employment with the company. His statements also showed that he possessed minimal knowledge of the CO_2 system aboard the vessel and that he had only a limited knowledge of the engineroom and its machinery; this in spite of the fact that the senior deckhand's checklist stated that it was his duty to monitor the engineroom for smoke or fluid leaks.

The deckhand had been classified a senior deckhand on other company vessels, yet she had less than 4 months of marine experience and was not familiar with the lifesaving and firefighting equipment on board the ARGO COMMODORE. She was not sure if there was a document aboard the vessel that listed the emergency duties of individual crewmembers.

Although the cook was tasked only with catering duties and Coast Guard regulations did not classify her as a crewmember, the passengers did not consider her to be different from the other crewmembers. They expected her to provide them with guidance during the emergency, but because she was unfamiliar with emergency procedures and had not been included in the company's safety meetings or other company safety training, she was unprepared to do so. The Safety Board believes that all crewmembers on small passenger vessels, to include all company employees assigned shipboard duties, should be proficient in the use of emergency equipment and should be trained to deal with emergencies on board.

Because none of the deckhands on the ARGO COMMODORE possessed a background in the marine industry and all were relatively new to the company, having only between 3 and 8 months of part-time employment, they would have benefited especially from a well-structured and continuous safety training program. It is important for the company to ensure that new employees are not put aboard a vessel without first being familiarized with and trained to operate its safety features. Without such training and vessel familiarization, they and future employees of the company are unlikely to be able to ensure the safety of passengers.

While Commodore Dining Cruises, Inc., had no formal training program for its crews, it appears that its on-the-job training was also deficient. Not only was on-the-job training not performed during this cruise, it is unlikely that it was performed routinely on other cruises. As the master stated, the deckhands are extremely busy with their hospitality duties during cruises and have little time for meaningful training.

The master's example of on-the-job training indicated that when such training was given, it was unstructured with no standard curriculum. By thus leaving the scope of training to individual masters rather than using a standard training plan, the company could expect to experience a wide variation in training effectiveness. For example, a master's own lack of familiarity with certain safety systems aboard a vessel, such as the CO_2 system in this instance, would severely limit his ability to train others properly.

The master in this case was one of the company personnel responsible for training the crew. Yet, by his own assessment, the company's crews were inexperienced; they lacked knowledge of firefighting and emergency procedures; and they were unsure of their duties in an emergency. He mentioned the frequent turnover of employees as a factor in their lack of marine knowledge and skills, but this should be accounted for in training provided by the company. The Safety Board concludes that the safety training provided by the company to crewmembers was unstructured and inadequate and that it proved to be ineffective in this accident.

The Safety Board believes that Commodore Dining Cruises, Inc., should develop and implement a well-defined, standardized crew training program following the recommendations provided in NVIC 1-91. Because the crew on board the ARGO COMMODORE had not participated in firefighting or evacuation drills and their on-the-job training was ineffective, their performance during the emergency proved to be inadequate. The Safety Board therefore also believes that crewmembers should demonstrate, through periodic drills, their proficiency in using safety equipment.

After its investigation of a 1985 accident involving the U.S. passenger vessel MISSISSIPPI QUEEN, the Safety Board issued to the Coast Guard Safety Recommendation M-86-73:

> Require the comprehensive training of passenger vessel crews in emergency procedures that includes demonstrating proficiency in the use of emergency equipment.

In the SNPRM, the Coast Guard responded with the following proposal for crew training:

> The owner, charterer, master or managing operator shall instruct each crewmember, upon first being employed and prior to getting underway for the first time on a particular vessel and at least once every two months as to the duties that the crewmember is expected to perform in an emergency. . . .

In its June 8, 1994, letter to the Coast Guard, the Safety Board recognized that this proposal represents a significant improvement over existing regulations, which do not specifically address the scope and frequency of crew training.[11] The Safety Board therefore classified the Coast Guard response "Open--Acceptable Alternate Response" and urged the adoption of the proposal. The accident aboard the ARGO COMMODORE also demonstrated that although crewmembers may have been given some safety instructions, those instructions did not translate into effective performance during the emergency. For that reason, comprehensive training of crews must also include drills that help them develop their skills and require them to demonstrate their proficiency in the use of emergency equipment. The Safety Board notes that the Coast Guard SNPRM also proposes that crews be required to undergo firefighting, abandon-ship, and man-overboard drills, and it urges that this proposal be adopted into regulations.

Because this investigation established that the training provided by the company was unstructured, undocumented, and consequently not effective or easily verifiable, the Safety Board reiterates Safety Recommendation M-89-113 made to the Coast Guard in its 1989 Safety Study *Passenger Vessels Operating from U.S. Ports*:

> Require owners and/or operators of all domestic small passenger vessels to keep records that include information on training provided to crewmembers and emergency drills in use of safety equipment, firefighting and man-overboard rescue, and other safety-related information.

On May 16, 1990, the Coast Guard responded that because the recommendation would make the existing regulations for drills more specific and would facilitate enforcement of those regulations, it would consider the recommendation when developing the SNPRM. In light of this response, the Safety Board classified the recommendation "Open--Acceptable Response" pending publication of the revised regulations.

This accident strongly reinforces the Safety Board's comment in its June 8, 1994, letter to the Coast Guard stating that the proposal for crew training should be expanded to require that a training record for each crewmember be maintained in a log, a personnel folder, or other form as prescribed by the owner/operator of the vessel, and that such records be available for review or inspection by Coast Guard personnel.

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[11] Coast Guard regulations for crew training contained in 46 CFR Part 185.25-10 state that "the master shall conduct drills and give instructions as necessary to ensure that all crew members are familiar with their duties."

According to NVIC 1-91, the Coast Guard officer-in-charge of marine inspection (OCMI) is responsible for verifying that small passenger vessels are manned by competent crews who are trained and qualified according to recommendations contained in the NVIC. The NVIC states that the method of verifying crew competence is left to the discretion of the OCMI. In practice, the OCMI usually makes this verification during vessel inspections by observing crew performance during emergency drills, questioning crewmembers on their assigned duties, and/or by informally reviewing the company's training program.

The Safety Board notes that while NVIC 1-91 provides recommended guidelines for qualifying deckhands, there are no Coast Guard regulations that require deckhands to possess specific qualifications before serving aboard vessels. Guidelines alone are not sufficient to ensure that deckhands are fully qualified to serve aboard vessels. Because guidelines, unlike regulations, are unenforceable, it is difficult for vessel inspectors to require that deckhands be qualified in accordance with NVIC 1-91. Further, the general guidelines in NVIC 1-91 are open to different interpretations by the individual OCMIs charged with assessing deckhand qualifications and competence. The Safety Board believes that mandatory qualification standards for crewmembers would be particularly beneficial for improving the safety of small passenger vessels, especially among those companies with high crew turnover rates where inspectors may not have the opportunity to assess the competence of crewmembers whose entire periods of employment may have occurred between Coast Guard inspections. The Safety Board therefore believes that the Coast Guard should establish mandatory standards for qualifications and training of crewmembers aboard small passenger vessels.

Although the Coast Guard may verify crew competence in some cases through witnessing emergency drills, the crewmembers aboard the ARGO COMMODORE testified that they had not undergone emergency drills. By leaving the method and frequency of verification of crew competence to the discretion of individual OCMIs, NVIC 1-91 allows for non-uniformity between inspectors and OCMIs. The Safety Board therefore believes that the Coast Guard should verify crew competence and company preplanning for emergencies through routinely witnessing emergency drills at every annual inspection, or by some other means of effective regulatory oversight.

Role Of The PVA in Improving Small Passenger Vessel Safety

The Safety Board believes that the Passenger Vessel Association (PVA) can make an important contribution to public safety by making its members aware of the need for proper crew training, well-defined emergency procedures, and periodic emergency drills. This would be consistent with one of the PVA's goals of encouraging enhanced training among its membership in order to improve the industry's loss record. By combining the practical experience of its members with the guidelines for training deckhands contained in Coast Guard NVIC 1-91, for example, the PVA could develop a model program, to include periodic drills, for training shipboard personnel in safety and emergency procedures. This program would benefit the entire

small passenger vessel industry. The Safety Board therefore believes that the Passenger Vessel Association should develop and provide crew drills for on-board crew emergency procedures/standards which include pre-incident planning for a variety of shipboard emergencies, including fires, and the deployment of crew resources for proper response to the emergency without compromising passenger safety.

Safety Placards and Briefings/Orientations for Passengers

The Safety Board concludes that the safety placard aboard the ARGO COMMODORE was illegible, inaccurate, and incomplete, and it failed to fulfill its intended purpose of familiarizing the passengers with the availability and proper use of safety equipment on board the vessel. In this accident, 41 passengers were at risk; on some of the company's other vessels, as many as 450 passengers could be on board, and their safety could depend, at least in part, on the information displayed on the vessels' safety placards. The Safety Board therefore believes that Commodore Dining Cruises, Inc., should periodically review the safety placards aboard all the vessels in its fleet and ensure that they are legible and that they contain accurate and complete information.

Although Coast Guard regulations allow the vessel owner the option of using either a safety placard or a safety briefing, the Safety Board believes that both should be required. The safety placard is a passive device that passengers are likely to overlook unless the crew draws their attention to it through a safety briefing. A safety orientation given at the beginning of this cruise would have made the passengers aware of the location and proper donning procedures for the life preservers and would have familiarized them with the emergency procedures and safety equipment they might have had to use during the evacuation. Further, it would have made the passengers aware of the roles of individual crewmembers and would have prepared them to react more effectively in the emergency. The Safety Board emphasizes that the issue of safety briefings also relates to training, in that proper crew training is essential if the crew is to give an accurate and effective safety orientation.

After its investigation of the 1985 collision involving the passenger vessel MISSISSIPPI QUEEN, the Safety Board issued Safety Recommendation M-86-72 to the Coast Guard:

> Require that all passengers receive a comprehensive safety briefing by a crewmember soon after boarding a passenger vessel.

This is an important safety issue that is currently on the list of the Safety Board's "Most Wanted Transportation Safety Improvements." The Safety Board has long been concerned about the Coast Guard's delay in acting on this recommendation and has previously classified it "Open--Unacceptable Response." As a result of this investigation, the Safety Board has reviewed this recommendation and has noted that it does not indicate the type of safety information that should be included in a safety briefing. The Safety Board is concerned that if the content of required safety briefings is not specified, there can be no assurance that appropriate information will be provided to the passengers whose safety may depend on that information. The Safety Board believes that the

Coast Guard should require that operators of small passenger vessels conduct a passenger safety briefing prior to departure to include: the location of lifesaving equipment; the use of such equipment; and proper procedures to be followed during the course of an emergency evacuation or other on-board emergency. In consideration of the absence of these specific requirements in the original recommendation, the Safety Board has reclassified Safety Recommendation M-86-72 "Closed--Unacceptable Response/Superseded."

Stowage of Life Preservers

Because the life preservers were tightly wrapped and fastened with clips, many passengers had difficulty unfastening the clips and putting the life preservers on, with the result that some passengers wore their life preservers improperly. This would have represented a substantial risk had those passengers been forced to enter the water. An additional risk factor was the fact that the life preserver stowage area was not identified by readily visible labels because they were obstructed by dining tables and chairs. The Safety Board believes that life preservers should be stowed so that they can be easily retrieved and donned in an emergency.

Issuance of Proposed Regulations for Small Passenger Vessels

This accident again underscores the need for the immediate issuance of the regulations relating to small passenger vessel safety that are proposed in SNPRM CGD 85-080, many of which have been directly referenced in this report. Some of these relate to crew training. In February 1995 the United States submitted a paper (MSC 65/15) titled "The Role of the Human Element" to the Maritime Safety Committee of the International Maritime Organization (IMO). The paper stated that analyses of marine accidents occurring worldwide over the past 30 years show that 65 to 80 percent of these accidents were caused by human error. On the other hand, the paper stated that implementation of proper training and procedures can demonstrably reduce human error and allow significant savings to be realized in insurance costs. It can also reduce lost time, while providing gains in safety and corporate reputation.

Research has shown that human error in marine accidents frequently arises from inadequate training and a lack of established procedures for crew and management to follow. Recognizing the risks posed by untrained crews and a lack of proper procedures, the Coast Guard, in partnership with industry, has launched an initiative called "Prevention through People" to address crew competence, among other issues. Additionally, the international community at IMO has incorporated human factors considerations such as training, skills, knowledge, and procedures in its safety regulations.

The Safety Board is concerned, however, that in spite of this heightened awareness of the dangers posed by inadequate crew training and related human factors issues, the Coast Guard has yet to issue its proposed revisions to the regulations for small passenger vessels. The rulemaking process for revising these regulations was initiated in 1982 with the intent of modernizing the

regulations to keep pace with developments in the small passenger vessel industry (see appendix E). The fact is, however, that the slow and uncertain process of regulatory revision is defeating this intent in that the proposed regulations are becoming outdated even as they are being considered. In its June 8, 1994, letter commenting on the proposed rules, the Safety Board again urged the Coast Guard to complete its revision to the regulations for small passenger vessels, but with no results.

As early as 1983, the Safety Board recommended (Safety Recommendation M-83-79) to the Coast Guard that the regulations be revised to make safety briefings for passengers mandatory instead of optional. Because of the Coast Guard's lack of timely response to this recommendation, the Safety Board eventually classified it "Closed--Unacceptable Action/Superseded." There are, however, an additional 55 Safety Board recommendations to the Coast Guard that were classified "Open--Acceptable Action" because the Coast Guard responded that it would take these recommendations into consideration when the regulations were revised. (See appendix F.) Most of these recommendations are more than 5 years old, and one dates back to 1977. Because the Coast Guard's regulatory revision process remains incomplete even after 13 years with no results or improvements in regulations concerning small passenger vessel safety, the Safety Board, based on a lack of timely action, has reclassified these recommendations "Open--Unacceptable Response."

Small passenger vessel operators belonging to the Passenger Vessel Association alone transport approximately 85 million passengers annually within the United States. The U.S. small passenger vessel industry is growing rapidly with the introduction of newer and larger-capacity vessels such as gambling vessels and fast ferries, meaning that small passenger vessels will carry an even greater share of the traveling public in the future. The regulations under revision, such as those that would require passenger briefings and crew training for emergency response, are crucial to passenger safety and are on the Safety Board's list of "Most Wanted Transportation Safety Improvements." In the interest of improving the safety of this large sector of the public transportation system in the United States, the Safety Board believes that the U.S. Department of Transportation should direct the U.S. Coast Guard to issue the proposed regulations for small passenger vessels without further delay.

CONCLUSIONS

1. Neither weather nor crew fatigue was a causal factor in this accident.

2. The emergency response of the Coast Guard, the firefighting efforts of the San Francisco Fire Department, and the assistance of the private yacht CAMELOT were all timely and appropriate.

3. The most likely cause of the fire was a short circuit in the electrical starting system for the starboard propulsion engine caused by a failed insulator separating a solenoid terminal from the solenoid case.

4. The company management responsible for vessel repairs and maintenance did not diagnose and correct the underlying deficiencies that had been a repetitive source of problems in the vessel's electrical starting system.

5. If the master had first followed the standard firefighting procedures of cutting off engineroom ventilation and shutting down the fuel supply to the engines and had then manually deployed the CO_2 system, the fire would have been brought under control and probably extinguished.

6. The master was probably unaware that the ARGO COMMODORE was equipped with a CO_2 firefighting system.

7. The fixed CO_2 firefighting system aboard the ARGO COMMODORE was inadequately designed to function effectively in the automatic mode.

8. Smoke in the engineroom would have prevented the master from using the vessel's fire pump and its fire hydrant, both of which could only be operated from inside the engineroom.

9. Safety training provided by the company to crewmembers was unstructured and inadequate and proved to be ineffective in this accident.

10. While the knowledge and training of the flight attendant and firefighter passengers allowed them to take effective action in this accident, the crew's inadequate knowledge of safety systems aboard the vessel prevented them from assuming a leadership role during the emergency.

11. The safety placard aboard the ARGO COMMODORE was illegible, inaccurate, and incomplete, and it failed to fulfill its intended purpose of familiarizing the passengers with the availability and proper use of safety equipment on board the vessel.

12. If the crew had given the passengers a safety orientation at the beginning of the cruise, they would have been aware of the location of life preservers and would have known how to don them properly.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the accident was a short circuit in the electrical starting system for the starboard propulsion engine caused by a failed insulator separating a solenoid terminal from the solenoid case. A contributing cause was the failure of Commodore Dining Cruises, Inc., to diagnose and correct recurring problems in the starboard engine starting system. Contributing to the severity of the fire was the master's failure to follow proper firefighting procedures.

RECOMMENDATIONS

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

--to The U.S. Department of Transportation:

Expedite the adoption of the proposed U.S. Coast Guard regulations for small passenger vessels. (Class II, Priority Action) (M-95-36)

--to the U.S. Coast Guard:

Determine the adequacy of the design and installation of fixed firefighting systems fitted aboard existing small passenger vessels regardless of hull materials, and require that plan approval records for fixed firefighting systems be maintained for the life of the vessels. (Class II, Priority Action) (M-95-37)

Amend the regulatory proposal for retrofitting small passenger vessels with fixed firefighting systems to also include vessels whose decks and superstructures are constructed of wood or fiberglass-reinforced plastic. (Class II, Priority Action) (M-95-38)

Require that at least one fire hydrant with attached hose be located outside the engineroom on all new small passenger vessels. (Class II, Priority Action) (M-95-39)

Establish mandatory standards for qualifications and training of crewmembers aboard small passenger vessels. (Class II, Priority Action) (M-95-40)

Require that the operators of small passenger vessels conduct a passenger safety briefing prior to departure to include: the location of lifesaving equipment; the use of such equipment; and proper procedures to be follow during the course of an emergency evacuation or other on-board emergency. (Class II, Priority Action) (M-95-41)

Verify crew competence and company preplanning for emergencies either by routinely witnessing emergency drills at every annual inspection or by some other effective means of regulatory oversight. (Class II, Priority Action) (M-95-42)

--to the Passenger Vessel Association:

Develop and provide to your members crew drills for on-board crew emergency procedures/standards which include pre-incident planning for a variety of shipboard emergencies, including fires, and the deployment of crew resources for proper response to the emergency without compromising passenger safety. (Class II, Priority Action) (M-95-43)

Recommend to your members that they routinely provide pre-departure safety orientations to passengers describing the procedures to follow in an emergency. (Class II, Priority Action) (M-95-44)

--to Commodore Dining Cruises, Inc.:

Conduct a thorough evaluation and repair of the electrical starting system of the ARGO COMMODORE and implement a management oversight program to ensure adequate maintenance for all vessels in your fleet. (Class II, Priority Action) (M-95-45)

Familiarize all masters and crewmembers with the layout, function, and operation of all firefighting and emergency equipment on each company vessel on which they are to serve. (Class II, Priority Action) (M-95-46)

Develop and implement a training program to ensure that deckhands are trained in accordance with the recommendations of U.S. Coast Guard Navigation and Vessel Inspection Circular (NVIC) No. 1-91. (Class II, Priority Action) (M-95-47)

Include in safety training and drill programs those cooks and other catering staff who may be called upon to serve aboard the vessels, whether or not they are classified as deckhands by the Coast Guard. (Class II, Priority Action) (M-95-48)

Require crewmembers to demonstrate their knowledge of emergency procedures through periodic drills that simulate their roles in emergencies. (Class II, Priority Action) (M-95-49)

Develop company operating procedures and safety checklists that are complete and accurate, and ensure that masters and crews are familiar with their contents. (Class II, Priority Action) (M-95-50)

Review the safety placards aboard all vessels in your fleet and ensure that they are legible and that they contain accurate and complete information. (Class II, Priority Action) (M-95-51)

Provide passengers, at departure, with safety orientations that include the procedures to be followed during an emergency. (Class II, Priority Action) (M-95-52)

Stow life preservers so that they can be easily retrieved and donned in an emergency. (Class II, Priority Action) (M-95-53)

In addition, the National Transportation Safety Board reiterates the following safety recommendation, originally issued on October 11,1989, to the U. S. Coast Guard:

M-89-113

Require owners and/or operators of all domestic small passenger vessels to keep records that include information on training provided to crewmembers and emergency drills in use of safety equipment, firefighting and man-overboard rescue, and other safety-related information.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

ROBERT T. FRANCIS II
Vice Chairman

JOHN A. HAMMERSCHMIDT
Member

JOHN J. GOGLIA
Member

November 14, 1995

APPENDIXES

APPENDIX A

INVESTIGATION

The National Transportation Safety Board was notified of this accident at 4:30 p.m. on December 5, 1994. The Safety Board dispatched three accident investigators from its Washington, D.C., headquarters to Oakland, California, to begin the investigation. Those investigators gathered information and took testimony at Oakland, California on December 6-9, 1994.

The Safety Board investigated this accident under the authority of United States Code, Title 49, Chapter 11—National Transportation Safety Board, Subchapter III, Section 1131(a)(1)(F).

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

The following parties participated in the investigation: the U.S. Coast Guard, Commodore Dining Cruises, Inc., and the Passenger Vessel Association.

The Safety Board did not conduct a public hearing during the investigation.

APPENDIX B

COMMODORE DINING CRUISES, INC.
SAFETY TRAINING CHECKLIST

Commodore Dining Cruises
3266 Elvia St. Lafayette Ca.
510•256•4000

Safety Training

Please initial each individual trainina section and sign on the bottom when completed. you should insure that each section of training is entered into the Captains log by the safety officer.

#1	The importance of keeping the Captain informed	_____
#2	Personnel and Passenger injury	_____
#3	Location of safety equipment	_____
#4	First Aid	_____
#5	Fire	_____
#6	man overboard	_____
#7	Damage control	_____
#8	Line handling	_____
#9	Misconduct of passengers	_____
#10	Mechanical problems	_____
#11	Waste disposal	_____
#12	Drug testing	_____

Signature _____ Date _____

Signature _____ Date _____

APPENDIX C

EMERGENCY EQUIPMENT LOCATIONS ON THE ARGO COMMODORE

Argo commodore

Emergency Equipment Locations

FIRST AID KIT

In the wheelhouse

LIFERINGS

First deck starboard side near the bow
First deck on the aft bulkhead of the house facing aft, outside

PFDS

First deck

Inside the salon adult and children

FIRE EXTINGUISHERS

First deck forward and aft passageways going down stairs

Engine room

In the wheel house

FIRE HOSES

In the engine room

LIFERAFTS

On top of the wheel house

APPENDIX D

PASSENGER VESSEL ASSOCIATION

The Passenger Vessel Association (PVA) serves the interests and concerns of over 350 vessel owners and operators in the domestic passenger vessel industry, representing about 65% of the owner-operators nationwide. Association members operate more than 1,100 vessels within the United States, carrying approximately 85 million passengers annually. The members of PVA are typically vessel owners having small businesses, many of which are family owned. PVA members offer services including dinner cruises, tour and excursion services, car and passenger ferries, private charters, whale watching trips, overnight cruises and the new but rapidly growing industry segment of riverboat gaming.

The PVA has a Safety and Loss Control Committee responsible for reviewing, developing and implementing programs to encourage enhanced training and safety capability among its members, designed to improve the loss record for the industry. The PVA has published the Passenger Vessel Safety Audit Guide with the objective "to address the industry's most frequent, costly and correctable accident experiences. They are an important step in controlling your business losses and interruptions." This guide cites slips and falls as a frequent source of injuries that significantly affect insurance premiums and provides checklists for vessel operators to assess potential safety problems such as slips and falls.

APPENDIX E

HISTORY OF REGULATIONS FOR SMALL PASSENGER VESSELS

The term "small passenger vessel" generally includes any vessel of less than 100 gross tons that is certified to carry more than six passengers for hire. The first federal regulations governing these vessels became effective June 1, 1958, as Subchapter T (46 CFR Parts 175-187). As these regulations became outdated, the Coast Guard initiated an effort to revise Subchapter T in 1982 and established a regulatory docket in 1985. On January 30, 1989, the Coast Guard issued a notice of proposed rulemaking (NPRM), titled "Small Passenger Vessel Inspection and Certification," proposing a complete revision to the regulations. Based on the numerous comments received in response to this NPRM, including those from the Safety Board, the Coast Guard revised the NPRM extensively and published the new proposed regulations in its supplemental notice of proposed rulemaking (SNPRM) on January 13, 1994. Coast Guard plans called for issuing interim final rules for small passenger vessels in the fall of 1995 with another comment period before finalizing the regulations.

APPENDIX F

SMALL PASSENGER VESSEL OPEN SAFETY RECOMMENDATIONS

1. **M-77-025 PEARL C**
   Require inspected passenger vessels to have a means to alert the operator at his control station, by both visual and audible signals, of unsafe water levels in each decked-over compartment which, if flooded would have a significant effect on stability.

2. **M-83-080 SAN MATEO**
   Amend 46 CFR Part 185 to require that children carried on board small passenger vessels wear life preservers while the vessel is departing protected waters and until such time as the operator determines that it is safe to remove them.

3. **M-83-081 SAN MATEO**
   Amend 46 CFR 180.25 to require that one approved child-size life preserver be provided for each child less than 90 pounds in weight carried on board small passenger vessels that operate on other than protected waters.

4. **M-84-013 JOAN LA RIE III**
   Amend 46 CFR Subpart 180.40 to eliminate the present exception from the requirement to carry an Emergency Position Indicating Radio Beacon (EPIRB) on coastwise vessels carrying passengers for hire that carry radiotelephone communication equipment that complies with Federal Communication Commission requirements.

5. **M-84-014 JOAN LA RIE III**
   Require that operators of charter fishing boats making an offshore trip or voyage to prepare a crew and passenger list and deposit the list, or copy thereof, at a suitable location ashore before departure.

6. **M-84-025 YANKEE**
   Require that passenger vessels with more than one passenger deck have installed an adequate loudspeaker system suitable for announcing passenger advisories, instructions, and emergency alerts from the navigation bridge.

7. **M-84-027 YANKEE**
   Require that all passenger vessels post conspicuously in passenger spaces passenger safety bills or equivalent instructions for emergencies, written in language understandable to nonmariners.

8. **M-84-028 YANKEE**
Require operators of all passenger vessels in coastwise, bays, sounds, or offshore service on extended routes to prepare an accurate list or count of embarked passengers, including non-revenue adults and children, and to have the list or count reported or delivered to a place ashore prior to a vessel's departure.

9. **M-85-045 SCIANTIC**
Review and reevaluate the Basis for Stability Criteria Contained in 46 CFR 170.170 which are a maximum wind speed of about 37 knots for protected waters and about 43 knots for partially protected waters for small vessels, since these values frequently are exceeded during thunderstorm activity.

10. **M-85-084 FANTASY ISLANDER**
Require more stringent inspection of dry exhaust piping installations on small passenger vessels, and include in the inspection books an appropriate check-off item for this purpose.

11. **M-85-085 FANTASY ISLANDER**
Require on small passenger vessels that emergency air shutdown controls on diesel engines be remotely operable from outside the engine compartment, preferably at the control station.

12. **M-85-089 FANTASY ISLANDER**
Require that small passenger vessels install a placard near the radio transmitter containing vessel information to be used when initiating a distress broadcast, verify during inspections of radio equipment that the placard is in place and currently updated, and that the vessel operators are familiar with radio distress procedures to be used in an emergency.

13. **M-86-055 PILGRIM BELLE**
Require that masters and watchstanding officers on all passenger vessels that have overnight accommodations for 50 or more passengers on other than river routes comply with navigation procedures similar to those found at 33 CFR 164.11.

14. **M-86-060 PILGRIM BELLE**
Require fire and boat (abandon ship) drills which include passengers reporting to their emergency muster station on all passenger vessels within 24 hours of departure on cruises that are more than 1 day's duration.

15. **M-86-061 PILGRIM BELLE**
Require that all passenger vessels except for ferries on river routes on short runs of 30 minutes or less have primary lifesaving equipment that prevents immersion in the water for all passengers and crew.

16. **M-86-064 PILGRIM BELLE**
Require all passenger vessels that have overnight accommodations for 50 or more passengers to meet the construction, licensing, and manning requirements for a passenger vessel over 100 gross tons.

17. **M-86-066 PILGRIM BELLE**
Amend the certificates of inspection on small passenger vessels that have overnight accommodations for 50 or more passengers to indicate that the master/operator must be examined in 46 CFR subchapter H regulations.

18. **M-86-068 MISSISSIPPI QUEEN**
Require that the licensed operators of small passenger vessels exclude, whenever practical, passengers from the pilothouse and navigator's bridge while the vessel is underway.

19. **M-86-073 MISSISSIPPI QUEEN**
Require the comprehensive training of passenger vessel crews in emergency procedures that includes demonstrating proficiency in the use of emergency equipment.

20. **M-86-075 MISSISSIPPI QUEEN**
Require that all passenger vessels which carry 50 or more passengers be equipped with at least one motorized rescue boat carried in a position for rapid launching.

21. **M-86-076 MISSISSIPPI QUEEN**
Require that the master or licensed operator of all passenger vessels, except ferries on short routes, deposit an accurate passenger and crew manifest ashore before each sailing, and update the manifest during the voyage. Require the master of ferries on short routes to keep an accurate count of all persons aboard.

22. **M-86-077 MISSISSIPPI QUEEN**
Require that the master or operator of passenger vessels in river service maintain logbooks or records as required for all other passenger vessels.

23. **M-86-113 MERRY JANE**
Require that life preservers be worn by passengers of small ocean and coastwise passenger vessels up to 65 feet in length, while on open decks during the time that these vessels are leaving or entering ports which are susceptible to breaking waves similar to Bodega Bay, California.

24. **M-87-115 FISH-N-FOOL**
Amend 46 CFR Part 187 to establish qualification standards for deckhands on small passenger vessels.

25. **M-87-116 FISH-N-FOOL**
Amend 46 CFR Part 185 to require that small passenger vessels be navigated by licensed operators or by persons under the immediate supervision of a licensed operator.

26. **M-88-009 JACK W - JAMEY DOWNEY**
Require that operators of all inspected radar-equipped passenger vessels under 300 gross tons be qualified as radar observers.

27. **M-88-010 JACK W - JAMEY DOWNEY**
Require, in the current regulatory project (CGD 85-080) concerning small passenger-carrying vessels, that safety standards relative to construction, lifesaving equipment, firefighting equipment, and manning and licensing be based on the number of passengers carried rather than the gross tonnage of the vessel.

28. **M-88-011 JACK W - JAMEY DOWNEY**
Require, in the current regulatory project (CGD 85-080) concerning small passenger-carrying vessels, that all inspected passenger vessels that carry 50 or more passengers be equipped with radar.

29. **M-88-012 JACK W - JAMEY DOWNEY**
Establish, in the current regulatory project (CGD 85-080) concerning small passenger-carrying vessels, a criterion for the number of persons that can safely exit through a standard 30-inch-wide door in a given time period.

30. **M-88-044 NORTH STAR - CAPE HENLOPEN**
Establish watch and duty time limitations for crewmembers on board ferries and other inspected passenger vessels.

31. **M-89-111 Passenger Vessel Safety Study**
Establish and administer examinations to test the competency of masters operating domestic small passenger vessels carrying six passengers for hire; areas to be tested are: damage stability, firefighting systems equipment and regulations, emergency steering, emergency procedures prior to and after grounding, and electronic navigation including radar.

32. **M-89-112 Passenger Vessel Safety Study**
Develop and implement regulations to require that domestic small passenger vessels carrying more than six passenger have appropriate operating and emergency manuals for crew members explaining the owner's and operator's policies and procedures.

33. **M-89-113 Passenger Vessel Safety Study**
Require owners and/or operators of all domestic small passenger vessels to keep records that include information on training provided to crewmembers and emergency drills in use of safety equipment, firefighting and man-overboard rescue, and other safety-related information.

34. **M-89-118 Passenger Vessel Safety Study**
Require All domestic passenger vessels that operate on all routes other than rivers be equipped with an operating fathometer.

35. **M-89-119 Passenger Vessel Safety Study**
Require all domestic passenger vessels that operate on all routes other than rivers be equipped with an operating electronic position-fixing device such as Loran or a satellite receiver.

36. **M-89-120 Passenger Vessel Safety Study**
Require a fixed firefighting system in the engineroom without regard to the type of fuel used for propulsion for domestic small passenger vessels.

37. **M-89-121 Passenger Vessel Safety Study**
Include in the final rule on "Small Passenger Vessel Inspection and Certification" a phase-in period of 3 years for the full implementation of float-free 406.025 Mhz satellite Emergency Position Indicating Radio Beacons (EPIRBs) for small passenger vessels operating on ocean or coastwise routes.

38. **M-90-011 COUGAR**
Provide in the *Marine Safety Manual* additional written guidance to all marine inspectors explaining the importance of determining that freeing ports are maintained to allow rapid drainage of water from the exposed decks in all probable conditions of list and trim.

39. **M-90-013 COUGAR**
Require that all uninspected passenger vessels be required to carry survival craft capable of supporting 100 percent of the persons permitted on board out of the water.

40. **M-90-014 COUGAR**
Require that life floats and buoyant apparatus aboard passenger vessels be replaced with lifeboats, liferafts, and inflatable buoyant apparatus within 5 years.

41. **M-90-015 COUGAR**
Require that all life preservers aboard inspected small passenger vessels operated a coastwise route (not more than 20 miles from a harbor of safe refuge) and all Ferries (regardless of route) have personal flotation device lights attached.

42. **M-90-016 COUGAR**
Require the master and operator of inspected and uninspected passenger vessels making an oceans or coastwise voyage to deposit at a suitable location ashore, prior to departure, information about the destination of the vessel, the intended route to and from the destination, and the vessel's estimated time of arrival at the next harbor of safe refuge.

43. **M-90-017 COUGAR**
Require all uninspected passenger vessels that operate on an ocean or coastwise route to carry on board an EPIRB that operates on a frequency of 406.025 Mhz.

44. M-90-020 COUGAR

Require that inspected small passenger vessels operate within the route restrictions on their certificate of inspection even when they are carrying six or fewer passengers.

45. M-90-021 COUGAR

Discontinue the practice of allowing vessels that are certificated under the laws and regulations for inspected vessels to operate under certain conditions as uninspected vessels.

46. M-91-011 GAMBLER

Amend 46 CFR 185.25-1(d) to require that before getting underway the master or other licensed crewmember present a verbal passenger safety briefing to all passengers that includes all of the subjects listed in 46 CFR 185-25-1(d)(1) through (4) and an advisory that during rough water or other hazardous conditions passengers will be required to don life preservers.

47. M-94-015 YORKTOWN CLIPPER

Require that radar by gyrostabilized on any small passenger vessel that is constructed after the final rule for 46 CFR, subchapter T, becomes effective if the vessel carries more than 49 passengers and operates on routes other than rivers.

48. M-94-016 YORKTOWN CLIPPER

Require that radar be gyrostabilized on any existing small passenger vessel that carries more than 49 passengers and operates on routes other than rivers.

49. M-94-017 YORKTOWN CLIPPER

Require manhole covers installed in watertight double bottoms on small passenger vessels to meet a suitable watertight reliability performance standard.

50. M-94-021 EL TORO II

Expedite, with the assistance of the wooden vessel industry, the revision of the Navigation and Vessel Inspection Circular 1-63 and ensure that the revision includes effective inspection policies and procedures for maintaining the structural integrity of wooden vessels, particularly for hull fasteners.

51. M-94-022 EL TORO II

Research and develop, with the assistance of the wooden vessel industry, nondestructive inspection techniques for inspecting fasteners on wooden vessels.

52. M-94-023 EL TORO II

Consider requiring the refastening of wooden-hulled passenger vessels that are over 15 years old as a remedial action until reliable inspection methods can be developed.

53. M-94-024 EL TORO II

Require that the critical inspection history, such as the condition of fasteners and hull construction materials, of inspected wooden-hulled vessels be maintained where readily available to field inspectors.

54. M-94-025 EL TORO II

Require for wooden passenger vessels that bilge alarms be fitted in the bilges of all compartments that extend below the load waterline.

55. M-94-026 EL TORO II

Require that out-of-the water survival craft for all passengers and crew be provided on board small passenger vessels on all routes.

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