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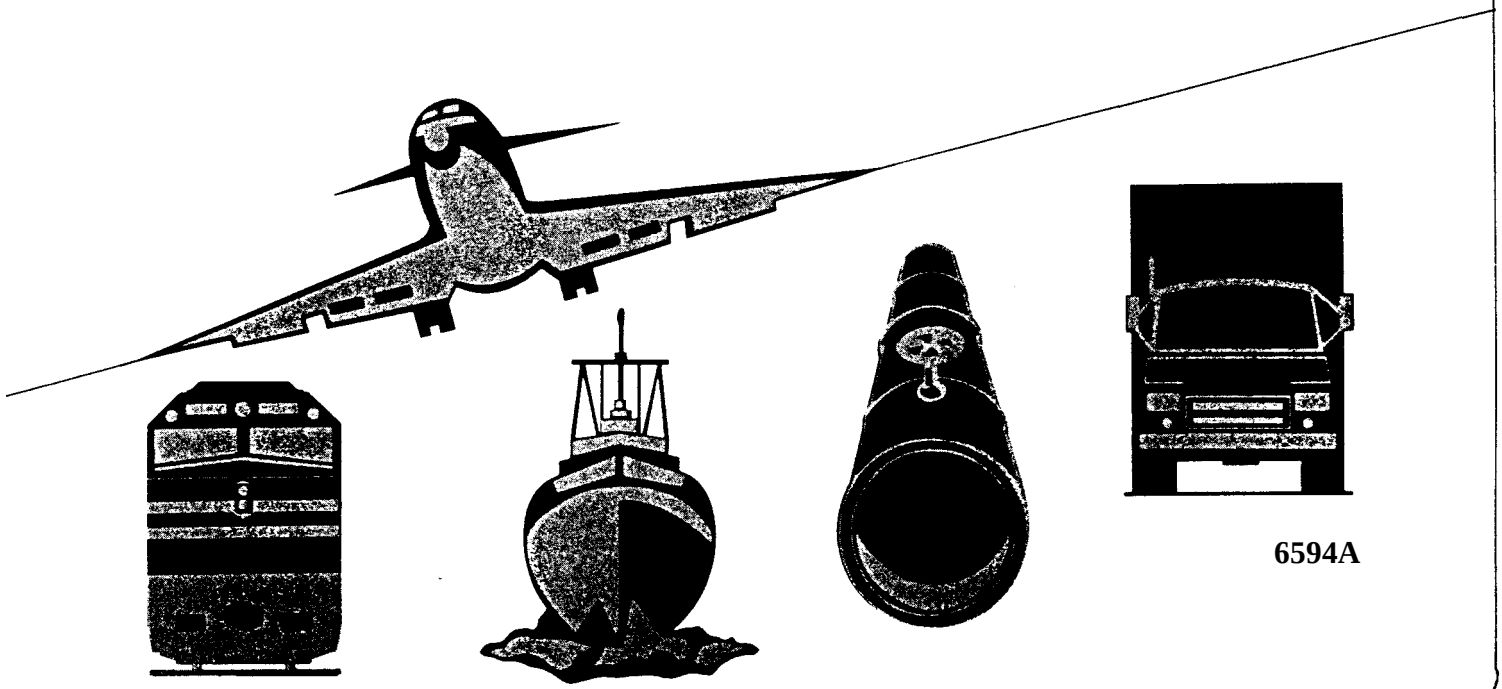
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

FIRE ON BOARD THE U.S. FISH PROCESSING VESSEL ALASKA SPIRIT, SEWARD, ALASKA, MAY 27, 1995



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Abstract: About 0200 on May 27, 1995, the U.S. fish processing vessel ALASKA SPIRIT caught fire and burned while moored alongside a dock at the Seward Marine Industrial Center, Seward, Alaska. Firefighters extinguished the fire at 1100. The master of the vessel died, and damage to the vessel was estimated at $3 million.

The safety issues addressed in the following report are: adequacy of noncombustible construction standards for uninspected commercial fishing industry vessels; adequacy of fire detection and fire suppression equipment; drills and readiness of on-board firefighting hoses; and existing vessel fire safety standards.

As a result of its investigation, the National Transportation Safety Board made safety recommendations to the U.S. Coast Guard, The Fishing Company of Alaska, Incorporated, the Commercial Fishing Industry Vessel Safety Advisory Committee, and the National Fire Protection Association.

FIRE ON BOARD THE U.S. FISH PROCESSING VESSEL ALASKA SPIRIT, SEWARD, ALASKA, MAY 27, 1995

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Adopted: June 11, 1996
Notation 6594A

National Transportation Safety Board

Washington, DC 20594

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ACRONYMS

ABS ---------- American Bureau of Shipping

ASTM ---------- American Society for Testing Materials

BAC ---------- blood alcohol concentration

BOCA ---------- Building Officials and Code Administrators International

CFR ---------- Code of Federal Regulations

CHT ---------- Center for Human Toxicology

CO ---------- carbon monoxide

COHb ---------- carboxyhemoglobin

COTP ---------- Coast Guard Captain of the Port

DNV ---------- Det Norske Veritas

EPIRB ---------- Emergency Position Indicating Radio Beacon

FCA ---------- Fishing Company of Alaska, Inc.

ICBO ---------- International Conference of Building Officials

LSC ---------- Life Safety Code

NBC ---------- National Building Code

NFPA ---------- National Fire Prevention Association

NVIC ---------- Navigation and Vessel Inspection Circular

RPU ---------- rigid polyurethane

SBC ---------- Standard Building Code

SBCCI ---------- Southern Building Code Congress International, Inc.

SCBA ---------- self-contained breathing apparatus

SECC ---------- Seward Emergency Communications Center

SMIC ---------- Seward Marine Industrial Center

SVFD ---------- Seward Volunteer Fire Department

UBC ---------- Uniform Building Code

USC ---------- United States Code

USCG ---------- United States Coast Guard

USSG ---------- United States Standard Gauge

EXECUTIVE SUMMARY

About 0200 on May 27, 1995, the U.S. fish processing vessel ALASKA SPIRIT caught fire and burned while moored alongside a dock at the Seward Marine Industrial Center, Seward, Alaska. Firefighters extinguished the fire at 1100. The master of the vessel died, and damage to the vessel was estimated at $3 million.

The National Transportation Safety Board determined that the probable cause of the fire aboard the ALASKA SPIRIT was the failure of The Fishing Company of Alaska, Incorporated, to address the inadequate fire safety conditions and practices on the vessel. Contributing to the severity of the damage and the loss of life was the lack of fire safety standards for commercial fishing industry vessels.

The safety issues discussed in this report are:

- Adequacy of noncombustible construction standards for uninspected commercial fishing industry vessels.
- Adequacy of fire detection and fire suppression equipment.
- Drills and readiness of on-board firefighting hoses.
- Existing vessel fire safety standards.

As a result of this accident, the National Transportation Safety Board makes safety recommendations to the U.S. Coast Guard, The Fishing Company of Alaska, Incorporated, the Commercial Fishing Industry Vessel Safety Advisory Committee, and the National Fire Protection Association.

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INVESTIGATION

Accident

Following a fishing voyage, the U.S. fish processing vessel[1] ALASKA SPIRIT (see figure 1) arrived in Dutch Harbor, Unalaska Island, Alaska, on May 19, 1995. Prior to the vessel's departure, 35 crewmembers and a U.S. National Marine Fishery Service observer debarked, reducing the vessel complement (including the master) to 11 persons. According to the engineroom log, the vessel departed from Dutch Harbor about 1100[2] on May 21. It arrived at the Seward Marine Industrial Center (SMIC) docks (also known as the Fourth of July docks), located north of the Fourth of July Creek and across Resurrection Bay from downtown Seward (see figure 2), at 1130 on May 24. At Seward, 3 crewmembers debarked, reducing the crew to 8 persons: the master, chief engineer, assistant engineer, cook, and 4 processor-deckhands (deckhands).

The remaining crew stayed on board to repair, maintain, and prepare the vessel for the next fishing voyage, which was scheduled for about July 1. No deck or engineering watches were stood during this period, but work in various parts of the vessel was carried out during the day. Some engineroom equipment remained operating to provide vessel hotel services.

A company-hired night watchman (watchman) testified that he made rounds about every hour from 1900 to 0700 to check on the safety and security of the ALASKA SPIRIT and the ALASKA RANGER.[3] The watchman said he would meet with the ships' master or mate and chief engineer or assistant engineer each evening. These officers would advise the watchman about specific items to check on that night and tell him who he should notify if he found something out of the ordinary. He would routinely adjust mooring lines as necessary, check operating engines, and look for indications of flooding and any other factors that could adversely affect the vessels' safety.

[1] A fish processing vessel is defined under Title 46 United States Code (USC) 2101 (11b) as "a vessel that commercially prepares fish or fish products other than by gutting, decapitating, gilling, skinning, shucking, icing, freezing, or brine chilling." Processing activities can include mincing, filleting, preparation of fish meal, boiling (crab), or a combination of these which prepares the seafood for direct marketing and often includes packaging the product. This type of fish processing vessel also catches fish with a trawl net and is also known as a "factory-trawler." The term "factory" refers to the fish processing operation, while "trawler" refers to the method of fishing it uses. A trawler catches fish in a net (which can be compared to a funnel) towed astern.

[2] All times noted herein are given in Alaska daylight time.

[3] The ALASKA RANGER was a trawler-fish processing vessel operated by The Fishing Company of Alaska, Inc., that was moored at an adjacent dock, preparing for its next fishing voyage.

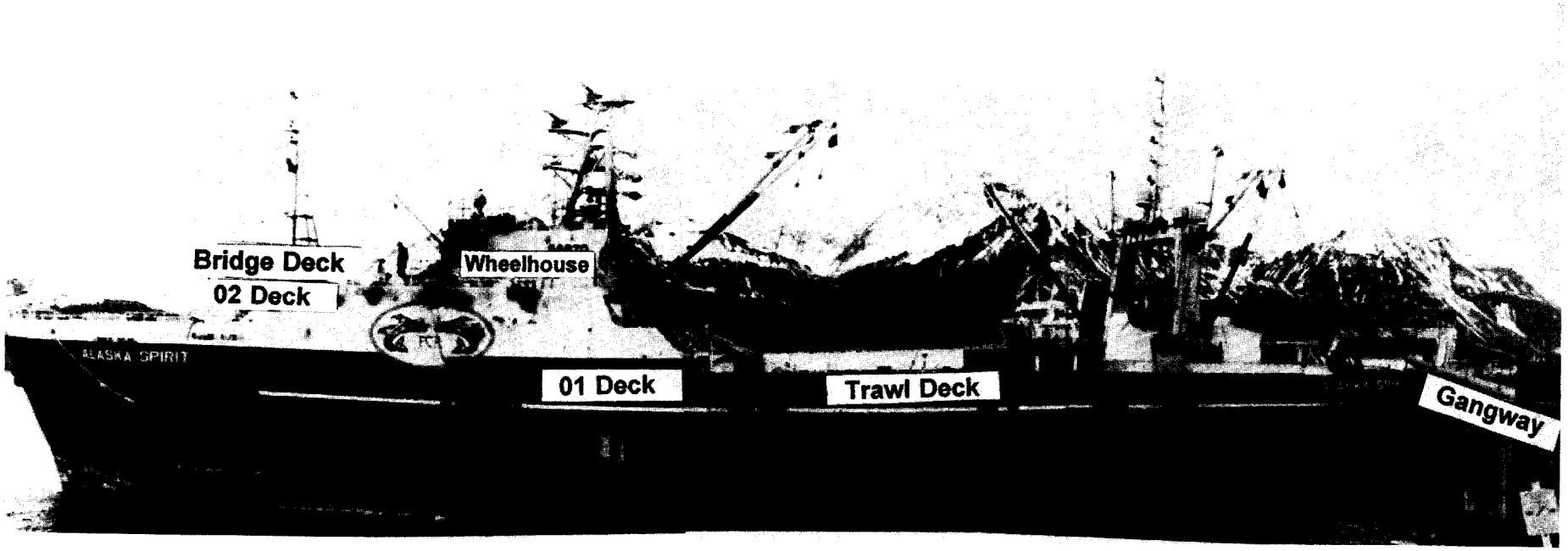

Figure 1 — Port side view of the ALASKA SPIRIT while moored at Seward, Alaska

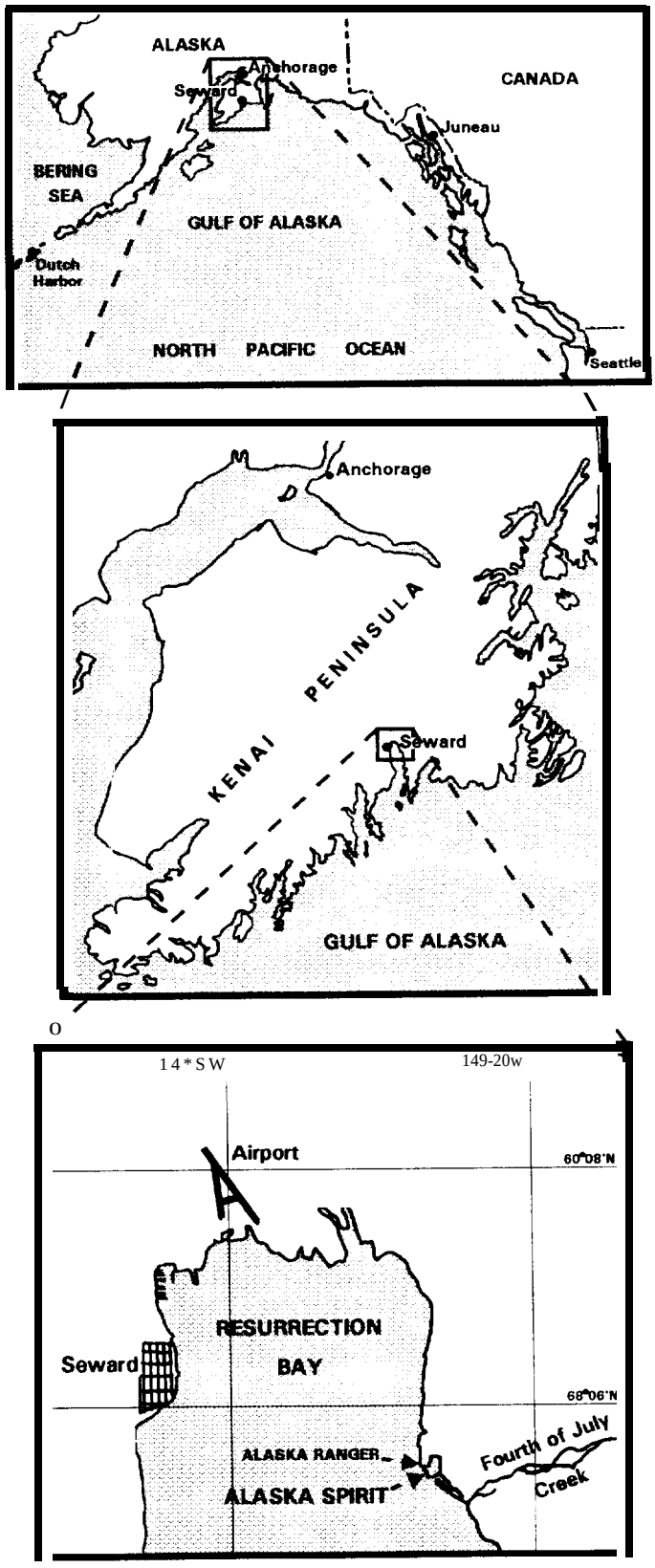

Figure 2 — Accident site

After completing his security check on the ALASKA RANGER, the watchman would board the ALASKA SPIRIT to conduct a similar security check of that vessel. A complete security check would include a walk through the engineroom, factory deck, accessible accommodation spaces, and the wheelhouse. He would also check mooring lines and the gangway. Each round on a vessel took about 10-15 minutes. The watchman reported that, after completing rounds on both vessels, he would station himself in the wheelhouse of the ALASKA RANGER. From there, he would observe the gangways of both vessels and stop unauthorized persons from boarding.

According to the ALASKA SPIRIT's cook, on May 26 he first spoke with the vessel's master about 0800, when the master came to the galley for coffee. The cook next saw the master when he went to the wheelhouse around 1100 or 1130 to chat. At that time, however, the master was on the telephone to his wife, so the cook returned below. The cook said that he went back upstairs about 1210 to take the master his lunch. The cook testified that the master went to town after lunch and returned about 1500. The cook's last conversation with the master took place in the galley sometime between 1700 and 1730. The cook told the master that he would like to go to Anchorage that evening, to which the master replied, "Okay, James. See you later." The cook left the vessel about 1810.

The chief engineer had several conversations with the master on the day before the accident. He stated that he spoke with the master about 1000, when he went to the wheelhouse to borrow a tool, and again at 1100 when he returned the tool to the master. After completing work sometime after 1900, the chief engineer and the master met on the bridge deck, where they talked about sport fishing. The chief engineer last saw the master about 2000, when he went to the master's room to borrow a videocassette. According to the chief engineer, the master said that he intended either to read a book or watch a movie before going to bed.

The chief engineer said that after leaving the master he watched a movie, played an electronic game, and went into the engineroom about midnight to check the engineroom and operating equipment. He found nothing out of the ordinary. He checked the power board (switchboard) and found no indication of any electrical short circuits. He then went to the galley for a snack, picked up an audiocassette from the factory deck, and returned to his room. He listened to some music, played some more electronic games, and went to sleep.

The assistant engineer testified that, after finishing his day's work about 1700, he went to bed and read in his room—located forward of the galley in the athwartships (cross) corridor. About midnight, he went to the engine control room and looked through some manuals. About 0130-0145, he went to his room and read. At no time during this entire period did he see, hear, or smell anything out of the ordinary.

About 2130 on May 26, the four deckhands were in the port-forward crewroom on the 02 deck (see figures 3, 4, and 5) discussing their off-duty plans for the evening. Three of the four deckhands decided to go into town. They departed the vessel about 2200. The remaining deckhand left the crewroom, stopped briefly in the galley, and went to his room (a four-person room on the forward starboard side of the 01 deck) to sleep. About 0100 on May 27, one of the three deckhands who had gone into Seward returned to the vessel and signed in on a chalkboard in the galley. He retired to his room on the 01 deck port side aft (at the foot of the inside stairwell to the 02 deck) and apparently went to sleep.

Fire -- Shortly before 0200, after completing his round on the ALASKA RANGER, the watchman walked to the ALASKA SPIRIT, about 500 feet away. When asked by investigators about his previous round that evening on the ALASKA SPIRIT, he stated that

> It just seemed like there was nothing unusual or anything to make me cause any attention. It just seemed like everything was OK that night.

He also testified that he did not notice anything unusual as he made his way to the ALASKA SPIRIT and commenced his round in the engineroom. After checking the engineroom wearing ear protection, he went up to the starboard side of the factory deck and took his ear plugs out. At this time, he heard the fire alarm. He went up to the net retrieval area (trawl deck) and walked toward the chief engineer's room on the port side aft on the 01 deck accommodation area. He saw the door to the chief engineer's room ajar, indicating to him that the chief engineer was awake. The watchman then went out to the trawl deck and saw the cook.

The cook testified that he returned by car from Anchorage at 0204[4] on May 27 and parked near the ALASKA SPIRIT's gangway. He was walking towards the ALASKA SPIRIT's gangway when he noticed flames and smoke on the 02 deck aft port door and in the wheelhouse (see figure 1). As the cook headed toward the 01 deck, he met the watchman, who had just exited the engineroom stairwell on the trawl deck. He climbed the outside stairwell from the 01 deck and looked into the 02 deck aft doors (see figure 6).

The cook saw flames on the port side corridor in the overhead, and heavy smoke about a third of the way down from the overhead. He saw flames in the toilet to the left and inside the port door. The flames extended along the overhead of the port corridor down to the toilet to the right of the door. The stairwell to the wheelhouse was filled with thick smoke. On the starboard side corridor, he noticed a little smoke along the overhead but no fire.

The watchman left the vessel and ran to the ALASKA RANGER, where he telephoned the Seward Emergency Communications Center (SECC) to notify them of the fire. The call was logged in about 0213.

[4]The cook noted the time from a clock in his car. A Seward fire investigator later checked the clock and verified that it was accurate to within 30 seconds of the dispatch clock.

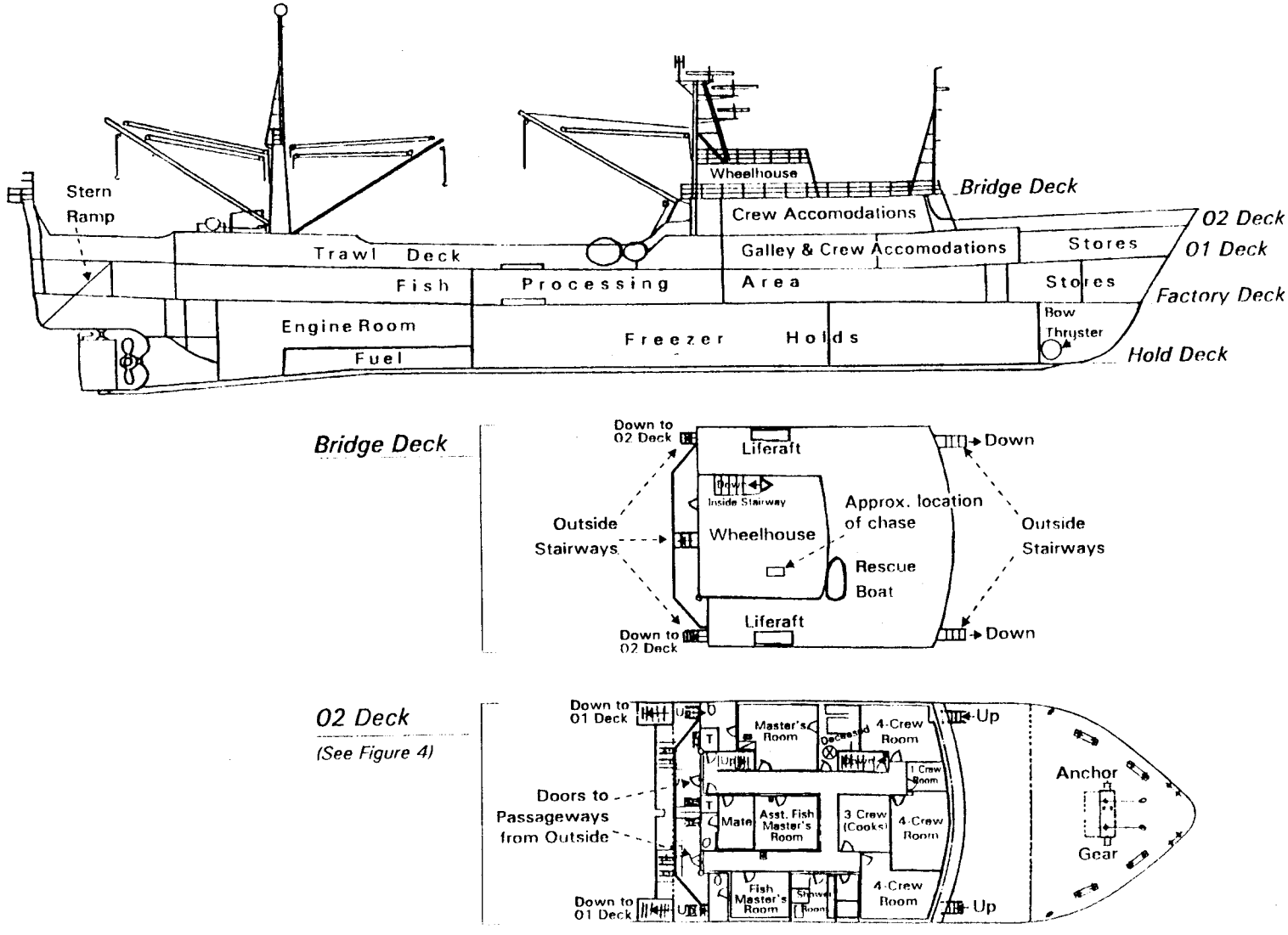

Figure 3 — Plan of the ALASKA SPIRIT

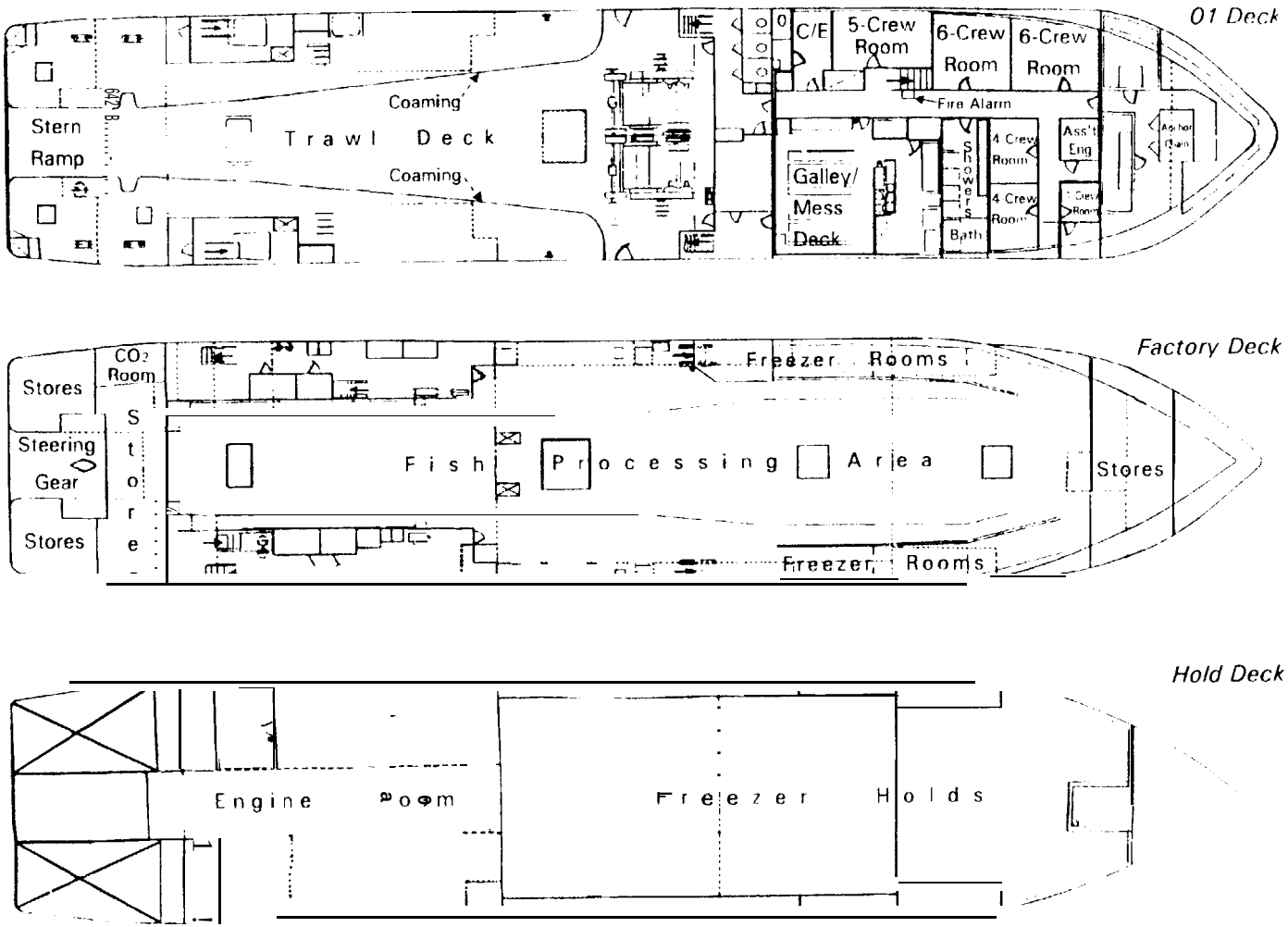

Figure 4 — Plan of the ALASKA SPIRIT (continued)

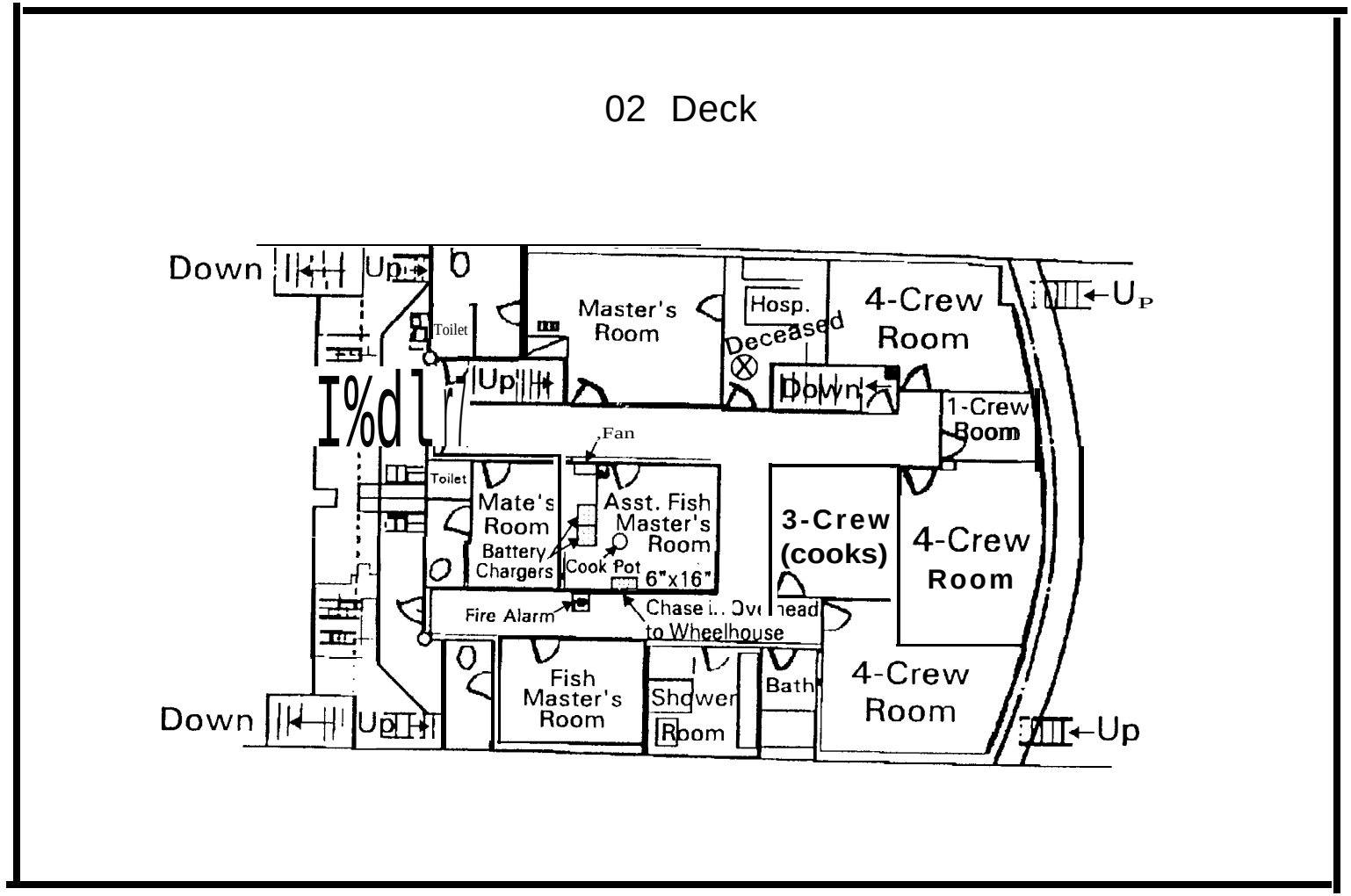

Figure 5 — Enlarged plan view of the 02 deck

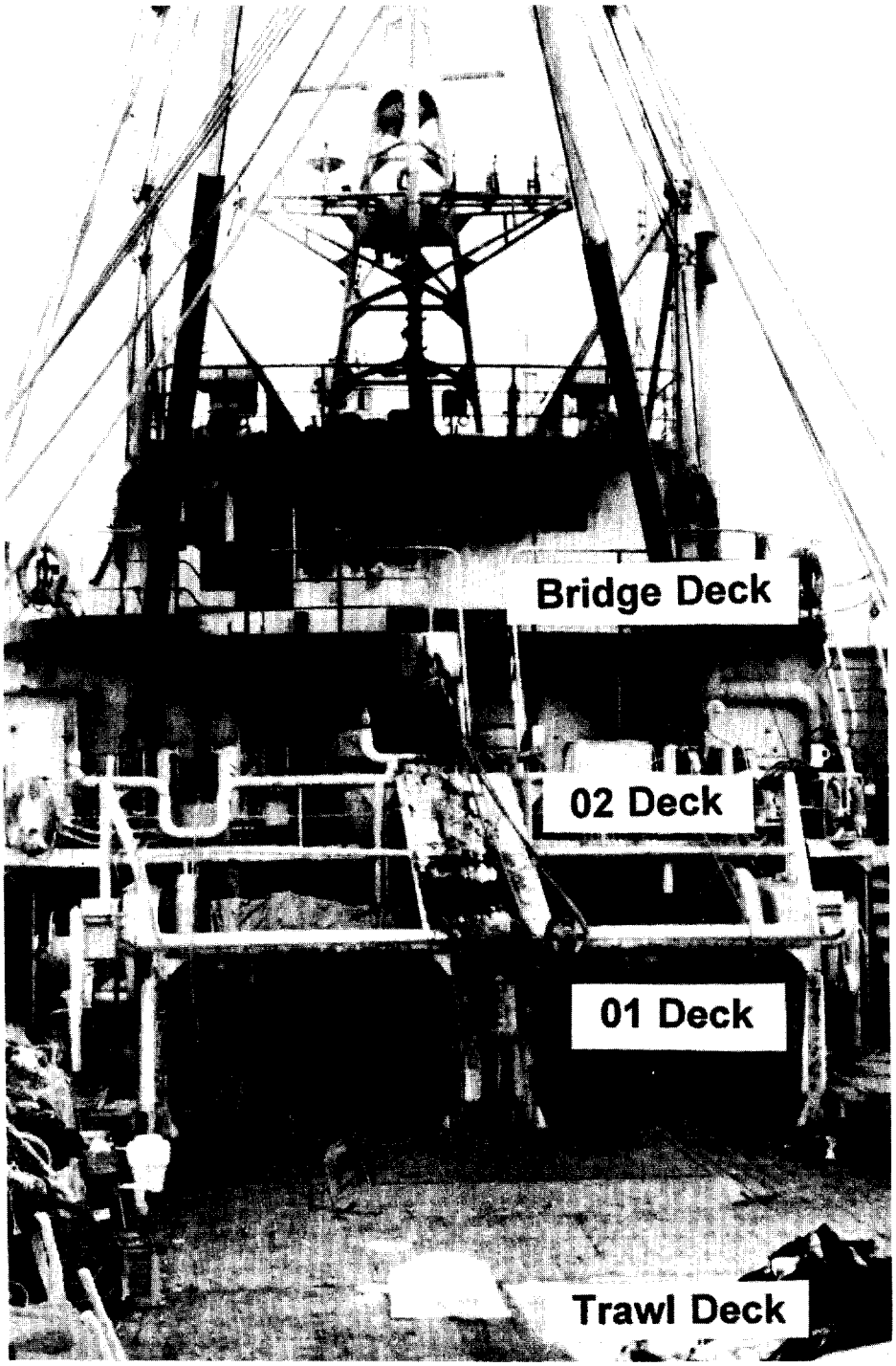

Figure 6 — View of the deckhouse from the trawl deck, looking forward
(courtesy NFPA, Quincy, Massachusetts)

The watchman only asked if SECC knew about the fire. After receiving an affirmative reply, the watchman hung up. He provided no further information, nor did the SECC operator request that he provide any or identify himself. While on the ALASKA RANGER, the watchman woke the vessel's two engineers, who returned with him to the ALASKA SPIRIT to assist in the firefighting activities.

The chief engineer testified that the fire alarm woke him. He dressed and left his room. He saw the assistant engineer and a deckhand in the corridor outside his room on the port side aft on the 01 deck. (The assistant engineer testified that he had been reading in his room when he heard the alarm at 0200 and got up to investigate.) The chief engineer attempted to go up the inside stairwell on the port side to the 02 deck where he noticed "smoke, fumes, and felt the heat, and saw the glow through the smoke of fire." He retreated and told the assistant engineer that "we were in trouble, we were on fire." The assistant went to the engineroom and started the fire pump.

The deckhand who had not visited Seward that evening said he was asleep in the four-person room forward on the starboard side of the 01 deck when the vessel's fire alarm woke him. He dressed, went into the corridor, and followed the assistant engineer aft on the 01 deck. On the way, he checked the door to the five-person room on the port side by the stairwell to the 02 deck and found it locked. He smelled smoke and remarked to the assistant engineer that the door of the room was locked, and he thought a deckhand was inside. The assistant engineer kicked the door open, removed the sleeping deckhandand carried him to the trawl deck.

The deckhand who had been awakened by the alarm attempted to go up the inside stairwell to the 02 deck. He said that he "wanted to have a look" because he thought that the other two deckhands might be sleeping in their room on the port side forward. He went up far enough to peer through the doorway on the 02 deck. From there he saw something burning on the deck to the left of the doorway. He testified that "I said burning floor, but now that I think about it, it was probably boots, 'cause I'd seen them in the hallway." He also saw a single row of flames in the overhead of the 02 deck corridor.

He stated that "…there was black stuff dripping[5] out of the ceiling (overhead in the stairwell)" and "there was a lot of heat." The smoke was not thick or heavy. He further stated that "soon as I saw flames on top (overhead), I forgot about going up there (onto the 02 deck)." He retreated down the stairwell and exited aft on the port side of the 01 deck. He assisted the cook in putting water on the fire until the shoreside firefighters arrived. He then assisted them as requested.

The chief engineer attempted to survey the fire from the exterior decks.

[5]Thermoplastics (such as polystyrene and polyurethane foam insulation) will melt and drip in a fiery environment. Also, the thin coating on the bulkhead paneling was a plastic type of material that, when heated, could have resulted in a black liquid.

As he was climbing the exterior stairway and approaching the 02 deck port door, the door window blew out. He returned to the 01 deck and attempted to survey the fire from the trawl deck. He also had the crew lay out (unroll) fire hoses from the port and starboard midships fire stations.

The ALASKA SPIRIT was equipped with two different types of fire hose — a 1 ½-inch standard hose and a nonstandard Armtex hose. The hose[6] that the cook selected for use on the port fire station hydrant was an Armtex hose, which has a nonstandard coupler, smaller in diameter than the vessel's hydrant hose connection. To attach Armtex hoses to such hydrants required an adapter hose coupling. Recognizing this incompatible situation, the chief engineer immediately returned to his room on the 01 deck and retrieved an adapter to mate the 1 ½-inch hydrant hose connection to the smaller Armtex coupling. The vessel carried at least three such adapters, which were kept in the chief engineer's room.

The chief engineer handed the cook a fire hose and told him to spray water onto the 02 deck outside port door. The cook stated that the fire intensified within the first 5 minutes of this spraying. About 5-10 minutes later, he saw flashing lights from a police car; about 5 minutes after that, he heard a fire truck siren, signaling the arrival of shoreside firefighters at 0220. The cook assisted the shoreside firefighters until the fire was extinguished.

[6]"Hose" refers to one or more sections of hosing that may be connected to form a single hose unit.

After handing the hose to the cook, the chief engineer went to the engineroom and aligned the ship's general service and seawater service pumps to operate with the fire pump. The two engineers from the ALASKA RANGER arrived and assisted in laying out hose and spraying water inside the port 01 deck inside stairwell to prevent fire from "walking down" from the 02 deck.

In the first 20 minutes after the fire erupted and as land-based firefighters responded, the crew of the ALASKA SPIRIT and two engineers from the ALASKA RANGER conducted the firefighting operations. Guided by the ALASKA SPIRIT's chief and assistant engineers, the crew attempted to spray water into the interior stairwell between the 01 and 02 decks using two 1 ½-inch hose lines.

The crew fought the intensifying fire at the 02 deck port side door and at the 01 deck interior stairwell. The chief engineer also had the two deckhands move about 30-40 cans of oil-based paint from the aft 01 deck corridor to the trawl deck.

Emergency Response and Fire Extinguishing -- About 0209, while listening to a CB scanner, a Seward taxi driver overheard persons aboard two unidentified vessels discussing a fire that they could see. According to them, the fire appeared to be aboard a vessel at the SMIC docks. The taxi driver phoned the information to the SECC.

At 0211, the Seward Volunteer Fire Department (SVFD) dispatched a fire pump truck and a medical rescue vehicle

from the main fire station in Seward, approximately 7-8 miles from the dock. Additionally, the deputy fire chief and four firefighters responded to the SMIC area, where a fire pump truck and a medical rescue vehicle were already pre-positioned at a fire station within several hundred yards of the moored ALASKA SPIRIT. Fire response personnel drove these units directly to the dock.

At 0217, the SVFD fire chief told the SECC dispatcher to request mutual aid from the Bear Creek[7] Volunteer Fire Department. Eventually, 30 firefighters from the two volunteer fire departments were involved in the firefighting effort.

About 0220, the deputy fire chief of the SVFD arrived on-scene at the ALASKA SPIRIT dock. He observed brownish-gray smoke coming from the upper deck of the vessel, but no flames.

Shortly afterwards, the SVFD fire chief arrived on-scene and saw heavy smoke and flames coming from the 02 deck and wheelhouse access. As the incident commander, the fire chief boarded the vessel to assess on-board conditions and met with the ALASKA SPIRIT's chief engineer. He established a command post, manned by the deputy fire chief, at the fire pump truck, which was positioned at the shoreside hydrant.

The chief engineer said three crewmembers were unaccounted for (the master and two deckhands), and he thought they were trapped on the 02 deck. Additionally, the chief engineer showed the hull arrangement plan entitled "safety plan" to the fire chief. He advised the fire chief that the crew had searched all of the lower decks, but fire kept them from searching the accommodation area on the 02 deck. (Later that morning, during the shoreside firefighting operation, the two deckhands who had been in Seward arrived at the vessel.) The crew continued to fight the fire by spraying water onto the interior port side 01 deck stairway and onto the exterior port side 02 deck door.

Following his survey of the accident scene, the fire chief decided:

- To use all land-based fire suppression equipment rather than the equipment on the ALASKA SPIRIT, because he did not know if the fire suppression equipment on the ship was reliable. In addition, the land-based firefighters wore self-contained breathing apparatus (SCBAs) and were more familiar with their own equipment than the shipboard apparatus. (The assistant engineer later stated that, although there were two SCBAs on the ALASKA SPIRIT, the crew had had no time to don them.)
- To attack the fire at the port side door on the 02 deck in an attempt to rescue the master.
- To continue the hose attack at the interior stairwell to prevent the fire from walking down the stairs to the 01 deck.

While the fire chief was making his survey, the deputy chief pulled hoses from the fire engines and laid a supply

[7] A community to the north of Seward and about 9 miles from the fire.

line between the engine and the closest fire hydrant, which was several hundred feet away.[8] The hoses were laid from the engine to the gangway area to the trawl deck. The 1 ¾-inch hose attack lines were used rather than larger hose lines because they allowed firefighters greater mobility within the narrow corridors on the vessel.

About 0230, firefighters preparing for entry into the port door on the 02 deck found the corridor filled with a "thick, dark-black, gritty smoke" extending from the overhead to the deck. As the firefighters crawled into the port side corridor, they heard crackling noises coming from all sides, but no flames were visible due to the heavy smoke. About 2 feet from the assistant fish master's room door, the firefighters adjusted their nozzle to provide a semi-fog pattern, but they could not endure the intense heat in this area and returned to the open deck. The firefighters attempted two or three more attacks using various water streams through the port door on the 02 deck, but they could not reach the master's room (which was across the corridor from the assistant fish master's room). The fire continued to burn out of control.

The fire chief later stated that, because intense heat forced the firefighters off the 02 deck and the firefighters on the 01 deck could not go up the inside stairwell due to heat, they could not reach the ship's master at that time. He focused tactical efforts on fire control.

As evidenced by the heat-caused breaking of the wheelhouse windows, the fire intensified in the wheelhouse and on the 02 deck at about this time. The fire chief decided that he could not attack the fire in the wheelhouse because it was being fed by the flames coming from the 02 deck. Firefighters in the starboard corridor saw that the steel bulkhead on the starboard side of the assistant fish master's room was glowing red. They realized that there was an intense fire in the room.

Eventually, the vessel's fire pump failed, as the fire consumed the wheelhouse and the circuitry for the fire pump. Because responding firefighters had already charged their hose lines from shore, fire suppression efforts were not interrupted. Crewmembers reported that, with both the general service and seawater pumps on-line, there was no noticeable interruption in flow rate when the vessel's fire pump failed. They directed hose streams on the vessel's fuel tank vents on the 02 deck near the deckhouse to dissipate heat and disperse fuel oil vapors to prevent fuel tank ignition.

At 0326, the fire chief had the SECC operator notify the U.S. Coast Guard (USCG) Cutter MUSTANG, in port at Seward, of the ALASKA SPIRIT fire situation. He did not request Coast Guard assistance. The cutter duty officer in turn notified the USCG Marine Safety Office in Anchorage, in accordance with the Western Alaska Marine Firefighting Plan. This plan was developed and

[8]Engine 4 laid a 5-inch supply line from the hydrant to the pier where the vessel was moored. The deputy chief had two 2 ½-inch hose lines laid to the deck of the vessel and connected four 1 ¾-inch hose lines.

promulgated in 1987 by the Coast Guard Captain of the Port (COTP)[9] of Western Alaska to coordinate firefighting activities for marine disasters posing a risk to vessels, facilities, or harbors in the COTP's zone.

The fire chief felt that during the first 6 hours of the effort to get the fire under control, the unfamiliar and confined configuration of the ALASKA SPIRIT's accommodation area created an environment that taxed firefighting resources. Of the 30 firefighters at the scene, approximately 20 were involved in suppression operations. The other 10 firefighters were advisory and support personnel who performed such tasks as refilling an estimated 100 air bottles with the cascade air resupply system.

About 0900, the fire chief established an arbitrary target time of 0945 for fire control. If the team had not gained control by that time, he planned to remove the firefighters from the fire area to a distance from which they could work to suppress the fire with minimum risk to themselves. About 0930, firefighters controlled the fire. They continued their suppression activities, focusing on hot spots, for another 30 to 40 minutes. About 1100, the fire chief declared the fire out.

At 1123, the master's body was found lying face-down inside the door to the hospital adjacent to his quarters. He was dressed in his underwear. About 1330, the fire department completed overhaul[10] of fire debris. The fire chief set a reflash watch on the vessel, and all units departed the scene at 1356. (See appendix A for Safety Board investigation information.)

Injuries

Injuries	Vessel Complement
Fatal	1
Serious	0
Minor	0
None	7
Total Crew	8

Vessel Damage

The Fishing Company of Alaska, Inc. (FCA), owner of the ALASKA SPIRIT, reported that damage to the vessel from this accident was estimated at $3 million. Before the fire, the vessel had been valued at $6 million. Replacement cost was estimated at $14 million.

In September 1995, the vessel was towed to Japan for repair. It returned to service on January 18, 1996. A company spokesman told the Safety Board that portable heaters were not reinstalled in crewrooms, combustible insulation was replaced with fiberglass insulation, and a Coast Guard-approved marine smoke detection system was installed on the vessel.

[9]The Coast Guard officer (under the command of a District Commander) so designated by the Commandant to give immediate direction to Coast Guard law enforcement activities within an assigned area.

[10]The process of moving and separating burned material to locate any hot or smoldering debris and to cool it or wet it down to prevent reflash of the fire.

Crew Information

Staffing -- At sea, the ALASKA SPIRIT carried a maximum crew of 48 persons—a National Marine Fisheries Service observer and about 47 crewmembers. Of these crewmembers, typically about 12 were in the deck department, 2 were in the engineering department, 31 were in the processing department, and 2 were in the galley (the cook and cook's assistant). Staffing information is approximate, as no fixed staffing regulations are in effect for such vessels.

Only the master, mate, chief engineer, and assistant engineer must be licensed by the Coast Guard on fishing vessels over 200 gross tons. No licensed persons were required to be on board during the in-port period. The ALASKA SPIRIT's master and its two engineers were, however, properly licensed by the Coast Guard for operating this vessel (see appendix B for crew licensing information). Personnel information for the six crewmembers who made up the vessel's complement at the time of the fire and the watchman follows.

Master -- The master, age 44, began his maritime career in 1972 as an unlicensed seaman. He sailed in that capacity aboard various fishing vessels for the next 9 years. In June 1981, he received his first license as a mate of uninspected motor fishing vessels. He increased the grade and scope of his license over the next several years before joining the FCA in May 1989.

He was initially assigned as mate to the trawler ALASKA I. He was reassigned to the ALASKA SPIRIT in November 1991 and served as its master until the accident. The National Driver Registry has no record of suspensions or revocations against his driver's license.

Chief Engineer -- The chief engineer, age 33, had held that position aboard the ALASKA SPIRIT since joining the FCA in March 1992. His testimony to Safety Board investigators described a variety of previous engineering work that he had performed, dating to 1982. This experience included about 1 ½ years of serving on offshore supply vessels in construction diving support, over 4 years of operations and maintenance on vessels with multiple moorings (anchors), and another 4 years on diving support vessels.

Assistant Engineer -- The assistant engineer, age 46, stated that he began sailing about 1970, first on fishing vessels out of Kodiak and then on tankers operated by the Military Sealift Command. From October 1976 to December 1983, he worked as an engineer aboard offshore supply vessels operating in domestic and foreign waters. He then worked about 7 years with a towing company out of Dutch Harbor, before joining the FCA in March 1991. He initially worked as chief engineer on the ALASKA RANGER for about 2 ½ years, and then conducted shipyard maintenance work and ship-board relief work for the company. Sometime prior to the fire, he had relieved the regular chief engineer on the ALASKA SPIRIT. At the time of the accident, he was relieving the regular assistant engineer.

Cook -- The cook, age 46, began to work as a cook aboard FCA vessels in May 1990. After working for 6 months

on the ALASKA PIONEER, he transferred to the ALASKA SPIRIT, where he remained until the fire.

Processor-deckhands -- The two processor-deckhands on board at the time of the fire, aged 26 and 25, joined the FCA in January and March 1992, respectively. They worked in that capacity for about 200 days each year until the accident. The older deckhand had no other seagoing work experience, but the younger had in 1989 served for 5 months as a processor-deckhand aboard a fish processing vessel owned by another company.

Watchman -- The watchman, age 38, had worked for the FCA intermittently since 1988, mostly as a processor-deckhand. He learned to perform his rounds through on-the-job training. He was taught that if he found anything unusual, he should notify the chief engineer, and that if he needed assistance in adjusting mooring lines, he was to notify the mate or the master.

Vessel Information

The ALASKA SPIRIT was originally built in March 1974, at Lockport, Louisiana, as a 166.4-foot-long offshore supply vessel for the oil industry. The vessel was named the GULF FLEET NO. 10. The American Bureau of Shipping (ABS) certified that the supply vessel had been built in accordance with ABS rules. In 1987, the vessel was taken out of service. It was sold to the Palmco Pacific Corporation on January 5, 1988, converted into a trawler-fish processing vessel (also known as a factory-trawler), at Ishinomaki, Japan, and renamed the NORTHERN HERO in February 1990. During the conversion, the vessel was lengthened by 37.3 feet to a total length of 202.7 feet.

The vessel was not required to be inspected by the Coast Guard to operate as a fish processing vessel. (See section on ***Coast Guard Regulations***.) It was not required to meet international Safety of Life at Sea convention regulations (structural fire protection, etc.) because it was not engaged in international voyages,[11] although it fished in international waters.

On November 25, 1991, the FCA purchased the vessel and renamed it the ALASKA SPIRIT. Because the vessel was engaged in domestic voyages by sea, it was required to have a load line.[12]

The Det Norske Veritas (DNV) classification society issued a certificate for the ALASKA SPIRIT on December 26, 1992, attesting that the vessel complied with the International Convention on Load Lines of 1966. The principal characteristics of the ALASKA SPIRIT were:

Length Overall	202.7 feet
Breadth	38.0 feet
Depth	21.6 feet
Gross Tonnage	1,418
Net Tonnage	425
Horsepower	3,600

[11]Voyages between U.S. and foreign ports.

[12]Lines marked on the sides of a vessel that show the maximum depths to which the vessel may be safely loaded, as determined by the rules of the International Convention on Load Lines.

From the keel up, the ALASKA SPIRIT had five decks: the hold deck (two freezer holds forward and engineroom[13] area aft); the factory deck (processing area); the main or 01 deck (galley and crew accommodations (for 28) were forward, and the trawl deck was aft); the 02 deck (crew accommodations for 20); and the bridge deck.[14] The only exterior openings in the 01 and 02 decks were two weathertight doors (one on the port and one on the starboard side) at the aft end of each deck. These decks had no portholes or other hull openings.

Firefighting Equipment -- A fire pump, a general service pump, and a seawater service pump could be connected at a manifold that could distribute water to fire stations throughout the vessel. A remote control located in the wheelhouse could start the fire pump and pressurize the fire main.[15] The fire pump and fire stations were not required by regulation. Seventeen portable fire extinguishers were distributed throughout the vessel. A fixed carbon dioxide (CO_2) firefighting system, consisting of 14 100-pound compressed CO_2 cylinders, was piped into the engineroom spaces.

A fire detection alarm control panel, with audio and visual alarms, was also located in the wheelhouse on the starboard side aft. The detection system consisted of 27 heat detectors located in the overhead throughout the vessel (1 in each of the 17 crewrooms, 4 in the galley-mess room, 1 in the processing area, 1 in the wheelhouse, and 4 in the engineering spaces), and 3 smoke detectors in the freezer holds. The fire detection system was not required by regulation.

The heat detectors activated when the heat in the vicinity exceeded 70 ^{o}C (158 ^{o}F). The circuit would remain closed until the heat lessened to about 60 ^{o}C (140 ^{o}F), at which time the detector would open and reset. It would then be ready for reactivation if the heat rose above the preset temperature.

Aural fire alarm warning buzzers were located on the bulkhead in the starboard corridor on the 02 deck outside the assistant fish master's room, on the bulkhead in the port corridor on the 01 deck adjacent to the port inside stairwell across from the galley, and in the engineroom. A fire alarm from an activated sensor could be heard outside as well as inside the wheelhouse.

Survival Equipment -- The ALASKA SPIRIT was fully equipped with all of

[13]It had a 20-cylinder diesel engine driving a single propeller shaft with a controllable pitch propeller. The vessel was also equipped with a bow thruster.

[14]The navigation and communication equipment in the wheelhouse included satellite communication equipment, direction finders, fish finders, echo sounders and recorders, a gyro-compass, a magnetic compass, radars, radio telephones, electronic position fixing devices, including global positioning system (satellite) equipment, other electronic equipment used for fishing or fish processing operations, and a public address system. A console in the wheelhouse controlled the main engine, the propeller pitch, and the bow thruster. The console had audio and visual alarms.

[15]A seawater pipeline that provides an adequate water supply for vessel fire hydrants and hoses.

the routinely necessary survival equipment.[16]

The FCA -- The FCA formed in 1985. It purchased 1 vessel in 1986 and 10 others through 1992. At the time of this accident, the company operated 10 vessels, including the ALASKA SPIRIT. An 11th FCA vessel was not in service. The company's main office is in Seattle, Washington, and the FCA has field offices in Anchorage, Dutch Harbor, and Seward, Alaska. On an annual basis, the company employs about 2,000 people. It has 12 employees on its management staff and 20 in support functions.

Coast Guard records show that during the period from 1992 through 1994, the ALASKA SPIRIT had one reportable personnel injury, one equipment failure, and one pollution incident. The records also show that between 1986 and 1994, the 10 other vessels owned by the FCA experienced 4 personnel injuries and 6 vessel accidents. Of the 6 accidents, 1 was a loss of engine propulsion from equipment failure, 1 was a steering gear equipment failure, 1 was a collision with another vessel, and 3 were engine reduction gear failures.

The FCA director of operations described the operation of the ALASKA SPIRIT in the following manner: "The master is in charge of all operational decisions regarding the vessel at sea and in port. The fish master on the vessel is in charge of the fishing operation…". The director further stated that the FCA had no operating or safety manuals and that the vessel was not routinely visited by company managers. The company provided the Safety Board with a copy of its 1995 Human Resources and Claims Guide.[17]

Waterway Information

The fire aboard the ALASKA SPIRIT occurred while the vessel was moored at SMIC, Seward, Alaska, at latitude 60°05.4' N, longitude 149°21.8' W. The dock is situated on Resurrection Bay, about 2.2 miles east-southeast of mid-town Seward. By road, the dock is 7-8 miles from mid-town Seward. The bay is a deep waterway extending south from Seward for about 16 miles to the Gulf of Alaska.

Meteorological Information

From 0800 on May 26 to about 1400 on May 27, skies were mostly cloudy in the accident locale. Visibility varied from 5 to 20 miles and was generally 5

[16]The ALASKA SPIRIT carried flares, an emergency position indicating radio beacon (EPIRB), 4 ring life buoys with lights, 4 other ring buoys, 2 inflatable liferafts (which could accommodate 50 persons each), an 18-foot-long inflatable rescue boat with a 30-horsepower engine, 48 life preservers, and 50 immersion suits.

[17]The guide contained sections for a sample emergency station bill; guidelines for reporting injuries and illnesses; guidelines for completing Coast Guard marine accident, injury, or death reports; guidelines for completing crew departure forms; FCA policies against harassment; guidelines for completing crew evaluation forms; guidelines for completing payroll disbursement requests; work rules and duties; employment contracts for new employees; a copy of 46 CFR 28; and University of Alaska marine advisory program bulletin 27 on tendinitis and related afflictions affecting fishermen and processing workers.

miles in light rain and fog. The winds ranged between southeast to north-northwest, with wind speeds averaging about 10 knots. Temperatures varied from 39 to 51 °F.

Postaccident Vessel Examination

Hull Structure and Construction -- To provide thermal insulation in the accommodation spaces, the steel hull on the accommodation decks was covered with about 2 inches of sprayed-on rigid polyurethane (RPU) foam before the wood overhead and bulkhead finishes were installed. The steel bulkheads in the assistant fish master's room (originally a radio room) were covered with plywood paneling. (see figure 7). The overhead and the bulkheads had been finished on the interior with 1- by 3-inch wood strips (furring strips) fastened to the steel hull framing. The furring strips were covered by ¼-inch plywood paneling. The exposed paneling surface appeared to have a vinyl veneer.

Figure 7 — Forward bulkhead of 02 deck. Shows construction details of wood framing over polyurethane foam insulation *(courtesy NFPA, Quincy, Massachusetts)*

Sheets of polystyrene insulation (Styrofoam) appeared to have been used in some overhead and bulkhead locations. In other areas, the bulkhead had fiberglass insulation in the spaces between the paneling and in the overhead. The foam insulation was not covered with noncombustible material.[18]

The furnishings in each room consisted of wood cabinetry, wood paneling, wood bunks, and wood lockers. Rooms were not centrally heated; instead, each room had an electric resistance-type heater.

Investigators found the heaters in some of the rooms, but none was found plugged into an electrical source. An air ventilation ducting system provided outside air to each room.

Wreckage -- The ALASKA SPIRIT's entire wheelhouse, including all of its electronic and navigation equipment, was destroyed in the fire (see figure 8).

The hull and steel deck plating in the area of the wheelhouse and 02 deck were buckled and distorted, and showed discoloration consistent with intense heat. Masts and associated rigging in the area of the fire sustained heat damage.

The rooms on the port, forward center, and forward starboard sides of the 02 deck were gutted (see figure 9). The RPU foam insulation and woodwork in the 02 deck were burned and, in most areas, completely destroyed. The fish master's room in the starboard corridor aft was significantly burned, but not as extensively as rooms on the port side. The crew shower/toilet on the starboard side sustained only heat and smoke damage. The fire damage in the starboard side corridor decreased from forward to the aft doorway exit.

The inside stairwell to the wheelhouse (on the port side) from the 02 deck was burned extensively and partially collapsed. A door at the top of this stairwell separated it from the wheelhouse. This was not a fire door, and crewmembers reported that it stood open most of the time. The door appeared to have been open during the fire, although most of it was destroyed by the fire. The upper bulkheads of the inside stairwell between the 02 deck and the 01 deck (port side) were destroyed, but the stairwell suffered only heat and smoke damage and remained intact and usable. The 01 deck accommodation area near the inside stairwell to the 02 deck (port side) sustained limited damage, mainly caused by heat and smoke. Some interior finish vinyl veneer on the paneling was melted and had dripped. The galley sustained smoke damage from the fire and some water damage from the firefighting operations.

The assistant fish master's room (center aft on the 02 deck) had steel bulkheads and a wood door with a louvered vent in its bottom section. The door was completely destroyed in the fire. A small ventilation fan (8- by 8-inch opening) was located about 6 feet above the deck aft of the door in the port aft part of the bulkhead to the corridor (the door to the master's room was across the corridor). A 6- by 16-inch

[18]Materials that neither burn nor produce flammable vapor in sufficient quantity for self-ignition when heated to 1350 ^{o}F or above.

Figure 8 — Fire-damaged wheelhouse, revealing overhead construction
(courtesy NFPA, Quincy, Massachusetts)

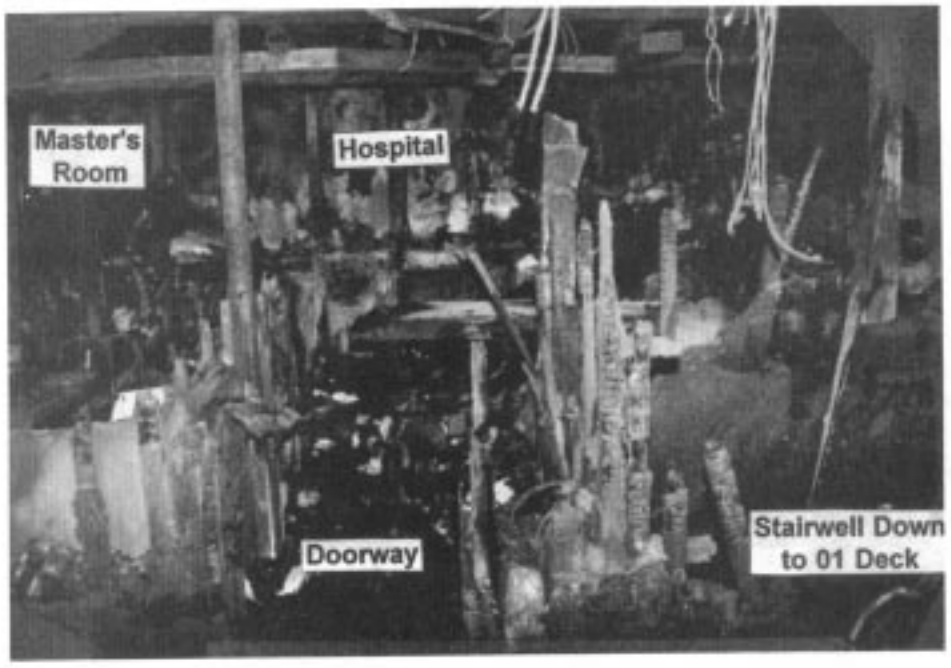

Figure 9 — 02 deck fire damage, looking into master's room
(courtesy NFPA, Quincy, Massachusetts)

chase[19] was located above the bed in the overhead on the starboard side that led to the wheelhouse.

In the wheelhouse, the chase went from the deck to the overhead. The chase was constructed of sheet metal on three sides, and the fourth side was covered with plywood. The remains of this plywood were found leaning against the chase, and the screws for fastening the plywood to the chase were still in place on the chase (see figure 10). The metal interior of the chase had RPU residue on its surface. No wires were found in it.

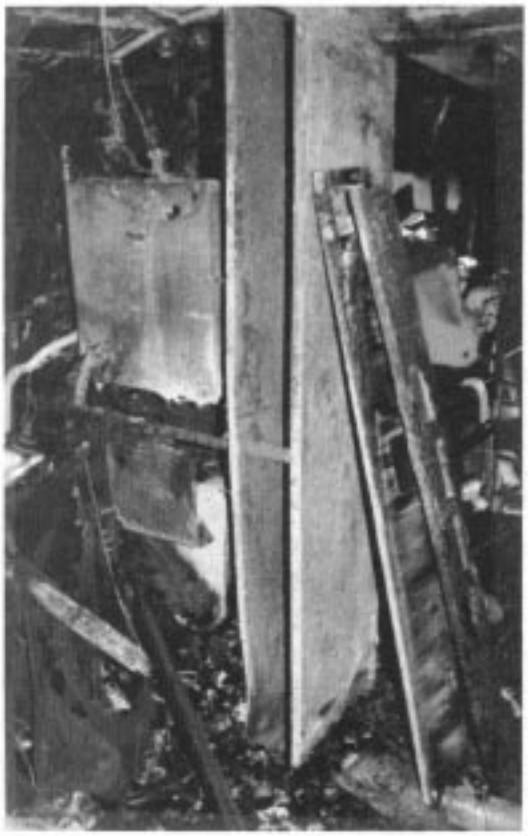

Figure 10 — Chase in wheelhouse
(courtesy NFPA, Quincy, Massachusetts)

When Safety Board investigators examined the ALASKA SPIRIT's sister vessel, the ALASKA VICTORY, they found that on that vessel the interior of the three metal sides of the chase was lined with sprayed-on RPU foam insulation about 1 inch thick; the fourth side had a removable wood panel. An electrical wire, possibly an antenna, extended from the overhead in the wheelhouse to the assistant fish master's room on the deck below.

In the assistant fish master's room on the ALASKA SPIRIT, two battery chargers were found sitting on a wooden platform raised about 2 inches above the deck. This platform, similar to one found on the ALASKA VICTORY, was the remains of a wooden desk or cabinet enclosure destroyed in the fire.

The left (when facing aft) charger stood next to another wooden box, the corner of which was burned through. The shelf supporting the chargers was burned through under the left half of the left charger. A round concentric metal object was found sitting on the carpet forward of the left battery charger. Investigators removed the chargers and the cylindrical object—which was tentatively identified as a cook pot that had been used by the assistant fish master—for further examination (see figure 11).

[19]A channel for wiring.

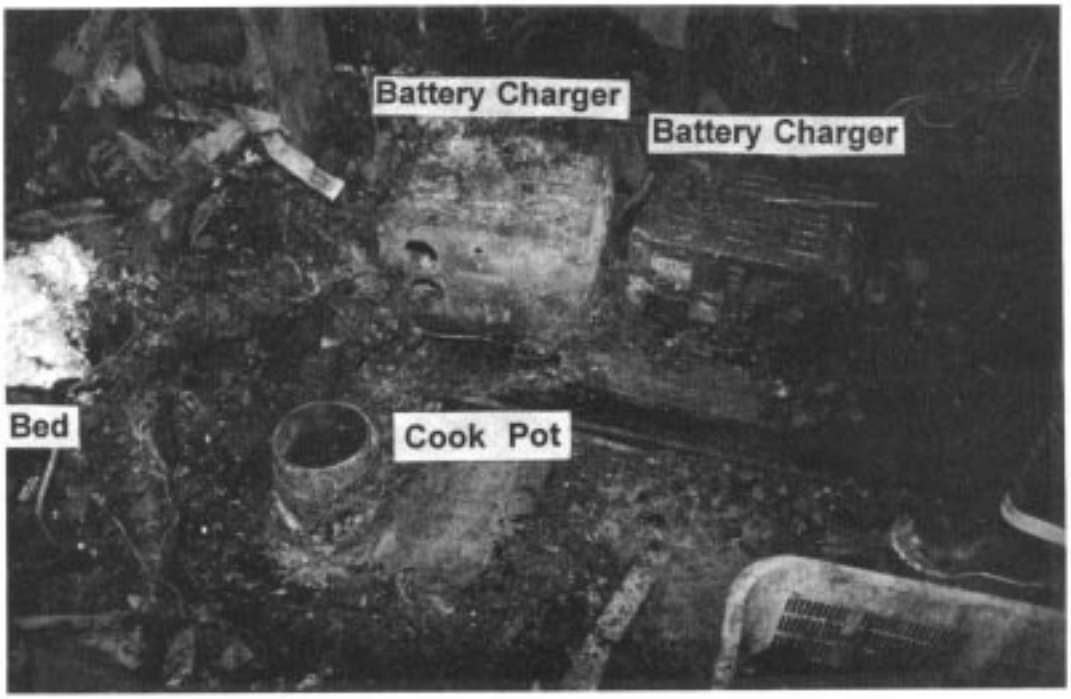

Figure 11 — Fire pattern around cook pot
(courtesy NFPA, Quincy, Massachusetts)

The burn patterns in the support shelf and the box next to it were more clearly visible after the chargers were removed. A metal reinforcement strip was found under the wooden shelf, and solidified molten aluminum was found under this shelf, directly below a round opening in the bottom frame of the left charger. The wires to and from the chargers were examined before the chargers were removed. No evidence of electrical arcing[20] was noted.

The cook's room—located on the centerline just forward and across the athwartships (cross) corridor from the assistant fish master's room—was the second area which investigators examined. A space heater was found (unplugged), and an electric refrigerator stood at the center of the aft bulkhead. No obvious shorting or other electrical malfunction was noted. Carpeting under the refrigerator was undamaged, as was most of the carpeting on the deck. The corridor bulkhead and wood studs were burned to deck level.

The third area examined was the corridor outside the four-person crewroom forward of the stairwell on the port forward side of the 02 deck. Here investigators found the melted remains of a boot warmer or dryer outside the room doorway. An electrical extension cord ran from a multiple-plug receptacle over the threshold from this accommodation space to the boot warmer. The wires in the extension cord had been crimped by the closing door,

[20] A discharge of electrical current crossing a gap between two electric wires or electrodes. The discharge is often indicated by a scorch mark and/or a melting of the electric wires where the arcing occurred.

but investigators found no evidence of electrical arcing. Power cords from several other pieces of electrical equipment in the accommodation space were plugged into the multiple-plug receptacle just inside the door.

The stairwells between the 01 and 02 decks, and between the 02 deck and the wheelhouse, were constructed of wood risers, treads, and stringers. Both stairwells were finished on the interior with plywood paneling. The stairwell between the 02 deck and the wheelhouse was extensively burned and partially collapsed. The stairwell between the 01 and 02 decks exhibited heat and smoke damage but was still intact and usable. The corridor that led into the stairwell between the 01 and 02 decks had heat and smoke damage. Some of the interior finish vinyl veneer that had been installed over the plywood paneling was melted and hanging down.

Medical, Pathological, and Toxicological Information

The master lost his life in the course of the accident. The SVFD reported that the master's body was located on May 27 at 1123 and removed from the vessel at 1247. The body was found in the hospital room just inside the closed door from the 02 deck port corridor.

The SVFD deputy fire chief said that, from the position of the body, it looked as if the master had been headed back into the hospital room when he collapsed. The hospital room adjoined the master's room through an interior door (see figure 5). Directly opposite the corridor door to the master's room was a ventilation fan opening in the assistant fish master's room at a height of about 6 feet above the floor. Just forward of the fan opening was the door to the assistant fish master's room.

The deputy fire chief reported that he asked a crewmember what the master's standard response would have been if he had heard the alarm. The crewmember replied that the master would normally go to the wheelhouse. The deputy fire chief surmised that:

> Assuming that he (the master) was in his stateroom, he would go out his stateroom door, turn to the right and go up the stairway to the wheelhouse; where he would go ahead to the alarm panel and determine where the alarm was coming from.

The deputy fire chief also told Safety Board investigators that:

> My assumption is that if he (the master) heard the alarm or was woken up by smoke, he opened up his door to go see toward the wheelhouse, and it had a whole bunch of smoke. He said, 'no, that's not the way to go.' (He) closed his door, because the door was closed. (He) went back through the medical area and... came up and got another blast of air right in that passageway. (He) turned and fell down.

On May 30, 1995, the deputy chief medical examiner, Office of the Alaska State Medical Examiner, autopsied the master's body. The autopsy report stated that the cause of death had been smoke inhalation. The deputy chief medical examiner also collected a fluid blood

sample for toxicological analysis. The deputy fire marshal, who attended the autopsy, told investigators that the blood sample had been difficult to obtain due to coagulation. He said that neither urine nor vitreous humor was available for sampling. Analysis of the blood sample found a blood alcohol concentration of 0.353 gm/dL[21] and a carboxyhemoglobin (COHb) saturation of 90.6 percent.

At the request of the Safety Board, the Office of the Alaska State Medical Examiner sent a portion of the master's blood sample to the Center for Human Toxicology (CHT), University of Utah, for further toxicological analysis. The CHT findings were: blood alcohol concentration, 0.36 gm/dL; COHb, 84 percent saturation; hemoglobin, 6.8 gm/dL; cyanide, negative; and phenethylamine, detected as a decomposition product. The CHT detected no other common drugs.

The cook said that he had known the master for 3½ years and considered him a very disciplined person who never overreacted. He also considered the master physically fit. The chief engineer noted that the master would often work out on an exercise machine or jog in place before beginning his day (frequently well before 0600) in the wheelhouse. In summary, the chief engineer said that the master "took care of himself." Safety Board investigators also talked with the master's wife about his lifestyle. She said that he was physically fit and that at home he only drank socially. She also reported that her husband did not drink on the vessel and that he did not permit alcohol on board.

[21]Grams per deciliter.

Drills

According to U.S. Coast Guard requirements (see 46 Code of Federal Regulations (CFR) 28.270), fishing vessels must hold drills monthly. The regulations list 10 contingencies that must be covered in such drills, including "abandon ship" and firefighting. They also state that drills are to be conducted as if an actual emergency exists, with the breaking out and using of emergency equipment. Further, they state that fire drills should be held in different parts of the vessel.

An ALASKA SPIRIT deckhand stated that the drills on that vessel consisted of mustering on the bridge deck when the general alarm bell sounded. The drills were held whenever the vessel entered port and the crew changed. (This took place about every 7-10 days.) Fire drills were conducted without laying out or charging the fire hose lines from the hydrants, donning SCBAs, or putting on firefighting equipment. During abandon ship drills, the crew did not don survival suits.

According to the chief engineer, each time the ALASKA SPIRIT deployed for a fishing trip, the ship's officers held a meeting, primarily to familiarize the new personnel (such as the fish processors) with topics such as: routine rules and practices; general company and ship rules regarding smoking, running, riding conveyor belts, fighting, etc.; training and drill procedures for fire, abandon ship, man overboard, and flooding drills; and the general alarm warning sound.

They also used the meetings to conduct safety equipment familiarization sessions, such as demonstrating survival suit-wearing procedures and liferaft use; to identify muster station locations; and to allot emergency squad assignments and responsibilities during firefighting and chemical responses. According to the engineroom log, the last fire drill on the ALASKA SPIRIT had been held on May 5, 1995.

Tests and Research

Possible Ignition Sources -- The Safety Board investigated various possible ignition sources for this fire. The sources considered included portable electric space heaters found in crewrooms, a boot warmer found outside the port forward 02 deck crewroom, (lighted) smoking materials, battery chargers, and the cook pot found in the assistant fish master's room.

The space heaters on the vessel were rated at 5,000 watts at 220 volts. None was found plugged into an outlet.

Investigators examined the remains of a boot warmer found outside the four-person crewroom on the forward port side on the 02 deck. No evidence of electric arcing was noted. The bottom of the boot warmer was found on the deck and unburned, while the top of the appliance had been burned or melted away.

According to crewmembers, smoking had been permitted in the vessel's accommodation spaces. The four-person crewroom forward on the port side of the 02 deck was considered a likely area for fire origin, because a deckhand had seen the deck near this room on fire shortly after the fire alarm sounded. The room had been occupied by smokers on the night of the fire.

Battery Charger Examination -- Investigators found that Nippon Denchi was the manufacturer of the chargers removed for examination from the ALASKA SPIRIT's sister vessel, the ALASKA VICTORY. These chargers appeared to be identical to the heavily fire-damaged chargers found on the ALASKA SPIRIT. Electrical diagrams for the chargers were not available. The chief engineer testified that the chargers, which he called "converters," had been used to convert 105 volts AC to either 12 or 24 volts DC for wheelhouse radios. According to the chief engineer, the chargers were permanently mounted. During the fire investigation, it appeared that the chargers on the ALASKA SPIRIT had been hard-wired or permanently wired to the radios in the wheelhouse. On August 29, 1995, the fire-damaged battery chargers were examined (see appendix C), photographed, and disassembled. No evidence of electrical arcing was found.

Cook Pot Examination -- An inventory of the contents of the assistant fish master's room provided to the Safety Board listed an object described as a "boiler." This appliance was a round cylindrical object found sitting on the deck in this room; it was essentially a cook pot that had been used to heat water. The cook pot was constructed of two concentric metal cans approximately 9 inches tall and 7 inches in diameter. When asked if crewmembers had cooked food in their rooms, the cook said he had not been aware of anyone doing so.

The cook pot was found next to the built-in bunk bed. A darkened burn pattern around it trailed over to the corner of the left battery charger. A power cord extended from the bottom of the cook pot forward to the center of the forward bulkhead. The insulation on the exposed cord and plug had been destroyed. Because of the damage to the room, investigators could not determine whether the plug had been connected to an electrical receptacle.

Investigators removed the cook pot, along with a piece of carpeting to which it was attached. The cook pot and the remains of a small can next to it (stuck to the same piece of carpeting) were sent to the Safety Board for further analysis. Investigators found many small tube-type fuses made of glass and screws stuck together on the can bottom. The can appeared to have been a receptacle for these spare parts.

The carpeting under the cook pot was intact and gave some evidence of heating but none of burning. A broken glass tube ran up the side of the cook pot between the two concentric cans. The tube appeared to have been used as a sight glass to determine the water level in the cook pot.

The power cord to the cook pot was about 5 feet long. Part of the power cord (about 12 inches) was coiled beneath the cook pot. This portion of the cord was still intact and evidenced no fire or heat damage. The rest of the cord consisted of two bare wires. All the electrical insulation on this part of the cord was missing. The plug that held the prongs was completely destroyed, and the prongs held the electrical leads attached with screws. No evidence of electrical arcing was noted on the power cord.

The bottom of the cook pot was covered by a metal plate attached with three screws. This plate appeared to have been a heat reflector. About ½ inch of a powdery material that easily crumbled away was found on top of this plate. Above this material were electrical wiring and support hardware (consistent with Bakelite[22]) for attaching the electrical leads to a heating element in the bottom of the innermost can. The insulation on these wires was fiberglass and it appeared to be undamaged. The wire attachment hardware, however, was soft and powdery. A small switch was fastened to a recessed hole in the center of the inner can. This switch came apart during the disassembly, and investigators could not determine whether it had been functional before the fire. It appeared to have been an over-temperature switch, but this could not be verified, since the cook pot manufacturer could not be identified.

Heat Detector Testing -- The detectors on the ALASKA SPIRIT were automatic restorable detectors[23] and were not required equipment for this vessel. Following the accident, a heat detector from the ALASKA SPIRIT's galley was removed and tested by an independent laboratory (see appendix D for results).

[22]Trademark for any group of thermosetting plastics having high chemical and electrical resistance used in a variety of manufactured articles.

[23]A device of which the sensing element is not ordinarily destroyed by the process of detecting a fire. Restoration of the device to a detection mode may be manual or automatic.

The detector was found in acceptable operating order.

The detector was set to be activated at about 70 °C (158 °F) and to reset at about 60 °C (140 °F). Coast Guard regulations for heat detectors (see 46 CFR 76.27) allow a range setting from "135 °F (57.2 °C) to 165 °F (73.8 °C)" for activating heat detectors. International regulations (Safety of Life at Sea, Chapter II-2, Part A, Regulation 13, Paragraph 3.3) allow a range from 54 °C (129.2 °F) to 78 °C (172.4 °F).

Other Information

Coast Guard Regulations -- The requirements for uninspected commercial fishing industry vessels are at 46 CFR Subchapter C (Uninspected Vessels), which includes Part 28, "Requirements for Commercial Fishing Industry Vessels."[24] Subpart 28.100 requires that each commercial fishing industry vessel meet the requirements of Parts 24 (General Provisions), 25 (Equipment Requirements - Life Preservers, Fire Extinguishers, and EPIRBs) and 26 (Operations) of Subchapter C, in addition to the requirements of Part 28.

Fish processing vessels "of not more than 5,000 gross tons" are exempt from Coast Guard inspection by law.[25] The ALASKA SPIRIT was 1,418 gross tons and was, therefore, exempt from inspection.

Section 28.710(a) also requires that, every 2 years, fish processing vessels not subject to inspection be examined for compliance with Subchapter C. Compliance must be certified in writing by the ABS, a similarly qualified organization such as the DNV, or a surveyor of an accepted organization.[26] A DNV surveyor examined the ALASKA SPIRIT on January 16, 1994, and found it to be in compliance with the appropriate regulations. The surveyor issued the vessel a Certificate of Compliance (valid until January 16, 1996) that certified that the vessel complied:

> With the applicable requirements of U.S. Regulations 46 CFR Chapter C Uninspected Vessels Part 28 as required by 46 CFR 28.710 (Lifesaving, Firefighting, Navigation, and Other Safety Equipment).

Coast Guard regulations require that those vessels built or converted on or after September 15, 1991 (the effective date of the regulations for commercial fishing industry vessels), "must be constructed so as to minimize fire hazards insofar as is reasonable and practical." Insulation must be noncombustible except when used for certain engineering applications, in cargo holds, and in refrigerated spaces.

[24]The regulations went into effect on September 15, 1991, and were the result of The Commercial Fishing Industry Vessel Safety Act of 1988, Public Law 100-424 (Title 46 USC Chapter 45).

[25]Title 46 USC 3302(c)(1).

[26]An organization that meets the requirements of 46 CFR 28.73 and is designated by the Coast Guard for the purpose of examining commercial fishing industry vessels.

Further, on vessels operating with more than 49 persons, the regulations at 46 CFR Part 28, Subpart D, require that superstructures and deckhouses be constructed of noncombustible materials. Because the ALASKA SPIRIT was converted in 1990 and carried fewer than 49 persons, it was not required to meet any of these fire safety requirements. However, the vessel's superstructure, deckhouse, and assistant fish master's room were constructed of steel (which is noncombustible).

Regulations require that vessels carrying 16 or more persons have an independent modular smoke detector or a smoke-actuated fire detecting unit in each accommodation space. The ALASKA SPIRIT was not required to have smoke detectors because it was converted before September 15, 1991, the effective date of the regulations.

The regulations do not require commercial fishing industry vessels to have sprinkler systems in their accommodation areas.

Regulations for existing fishing industry vessels (those built or converted prior to the effective date of the regulations - September 15, 1991) do not require a fire pump or that the pump be connected to fixed piping (fire main).[27] Only those vessels built or converted on or after September 15, 1991, that are 36 feet or more in length and carry more than 16 persons must be so equipped. The ALASKA SPIRIT, although not required to have a fire pump or fire main piping/hydrants installed, had this equipment.

On April 29, 1980, the Coast Guard issued Navigation and Vessel Inspection Circular (NVIC)[28] 8-80 (Fire Hazard of Polyurethane and Other Organic Foams) "to alert vessel inspectors, designers, builders, and operators of the potential fire hazard of polyurethane and other organic foam materials" because of "serious fires" on "several ships." These guidelines are intended to apply to all vessels. The NVIC states:

> When organic foams (including those described as self-extinguishing, non-burning, fire resistant, flame resistant, and similar terms) are exposed to fire or heat, they may ignite and burn with rapid flame spread, high temperatures, toxic gases, and voluminous quantities of smoke.

The NVIC further states that:

> Whenever polyurethane or other organic foam materials are installed in cargo holds or other spaces, it is recommended that a covering of 22 United States Standard Gauge (USSG) steel (about 0.03 inches or about 1/32-inch thick) or other suitable noncombustible material, with at least a 15-minute fire rating, be installed over the foam insulation.

[27]Regulations require that vessels with a power-driven fire pump have a fire main system, including fire main, hydrants, hose, and hose nozzles.

[28]Published by Coast Guard Headquarters to disseminate recommended policy, requirements, procedures, or guidance for Coast Guard marine safety personnel and the marine industry.

The ALASKA SPIRIT had RPU foam insulation on the steel hull in the crew accommodation areas on the 01 and 02 decks. It was not covered with a noncombustible material, nor was it required to be. Polystyrene blocks and fiberglass insulation were also used between the wooden framing and bulkhead covering, and (apparently randomly) in the overheads of the accommodation spaces.

On August 18, 1986, the Coast Guard issued NVIC 5-86 (Voluntary Standards for U.S. Uninspected Commercial Fishing Vessels) "In response to the poor safety record of uninspected commercial fishing vessels...". NVIC 5-86 (page 3-9) refers to NVIC 8-80 for further information on foam insulation in refrigerated compartments and fishholds. NVIC 5-86 (page 3-2) recommends that: (a) noncombustible materials should be used for bulkheads, decks, and other structures, in accommodations, service areas, and control spaces; (b) smoke or fire detection systems should be installed to indicate the presence and location of fire or smoke in galleys, other high risk spaces, and accommodations, further stating that an Underwriters Laboratory-approved house-type smoke detector is usually adequate for accommodations and galleys (page 3-5); and (c) combustible materials be limited to reduce the amount of fuel available for a fire. The NVIC also states that insulating foams and plastics produce extremely toxic products when burning and "should not be used or at least be reduced in quantity wherever possible" (page 3-3), and that "insulating materials in accommodations, service areas, control spaces, and machinery spaces should be noncombustible (Mineral wool, etc.)" (page 3-11).

Three Worcester Polytechnic Institute students, with the U.S. Coast Guard Headquarters Marine Technical and Hazardous Materials Division, prepared a report[29] for the Coast Guard which examined safety factors on fish processing vessels. Among other findings, the report concluded that polyurethane foam "has been shown to consistently contribute to fires aboard fish processing vessels." The report recommended that a substitute be found for polyurethane foam insulation.

Standards Applicable to Industrial Vessels -- Coast Guard structural fire protection regulations for Cargo and Miscellaneous Vessels are found at 46 CFR 92.07 and apply to industrial vessels[30] of 300 and over gross tons but less than 4,000 gross tons contracted for on or before July 1, 1968, which carry in excess of 12 "industrial persons."[31] The

[29] *Unclassed Fish Processing Vessel Study*, October 12, 1990.

[30] A vessel which, by reason of its special outfit, purpose, design, or function, engages in certain industrial ventures. Included are such vessels as drill rigs, missile range ships, dredges, cable layers, derrick barges, pipe laying barges, and construction and wrecking barges. Excluded are vessels that carry freight for hire or are engaged in oceanography, limnology, or the fishing industry. (46 CFR 90.10-16)

[31] Any person carried on board an industrial vessel for the sole purpose of carrying out the industrial business or functions of the vessel. Examples are laborers, such as wreckers and mechanics, technicians, drilling persons, and divers. Industrial persons and fish processing persons are similar in training and experience with respect to responding to emergencies aboard vessels.

regulations in part require that, within accommodation and service areas, corridor bulkheads shall be of "A"[32] or "B"[33] class construction; all other bulkheads shall be of "A," "B," or "C"[34] class construction. Trunks[35] shall be of "A" class construction; ceilings, linings, and all insulation shall be noncombustible. An approved interior finish may be used in corridors. An approved interior finish, as defined by the Coast Guard, is one that is subjected to American Society for Testing Materials (ASTM) E84[36] and develops a flame spread of less than 20 and has smoke development of less than 10.

These requirements were in the regulations when the structural fire regulations were being developed for commercial fishing industry vessels, but they could not, by law, be incorporated into the regulations for existing fishing vessels. (See section on ***Coast Guard Oversight of Fish Processing Vessels***.) They were only partially incorporated for fishing vessels that operate with more than 49 persons and were built or converted after September 15, 1991.

Building Codes -- See appendix E for building codes for shoreside structures.

Life Safety Code -- The National Fire Prevention Association (NFPA)[37] developed and published NFPA 101 "Code for Safety to Life from Fire in Buildings and Structures," known as the Life Safety Code (LSC).[38] The purpose of the LSC, stated in Section 1.2, is:

> To provide minimum requirements, with due regard to function, for the design, operation, and maintenance of buildings and structures for safety to life from fire and similar emergencies.

[32]"A" class bulkheads or decks shall be composed of steel or equivalent metal construction. In a standard fire test, they would be capable of preventing the passage of flame and smoke for 1 hour. A standard fire test is one which develops in the test furnace a series of time to temperature relationships as follows: 5 minutes—1,000 ^{o}F; 10 minutes—1,300 ^{o}F; 30 minutes—1,550 ^{o}F; and 60 minutes—1,700 ^{o}F.

[33]"B" class bulkheads shall be constructed with approved noncombustible materials. In a standard fire test, they would be capable of preventing the passage of flame for ½ hour.

[34]"C" class bulkheads must be constructed of approved noncombustible materials but are not required to meet requirements for the passage of flame.

[35]A passage extending through one or more decks to provide access or ventilation to a space.

[36]E84 is a standard test method developed by the ASTM. The method exposes a 24-foot by 20-inch specimen to fire and measures the rates of flame spread and smoke development. The material rating (flame spread index) and smoke number are obtained from a comparison with the flame spread rate and smoke development of red oak. The flame spread rates for shredded wood fiberboard (treated with flame retardant), gypsum board (with paper surface on both sides), and red oak (untreated) are -20 to 25, -10 to 25, and -100, respectively.

[37]The nonprofit NFPA advances the development and dispersion of fire safety standards, many of which are adopted into Federal, State, and municipal fire codes. Association volunteers are in such professions as fire service, health care, business, insurance, government, education, and industry.

[38]*NFPA Life Safety Code,* Chapter 6: "Existing Hotels and Dormitories," Section 6-5, Interior Finishes. National Fire Protection Association, Quincy, Massachusetts, 1994.

The LSC mainly addresses safe egress from shoreside buildings. It also establishes certain flammability requirements for building structure and interior design. For example, the LSC requires that smoke detectors be placed in sleeping quarters for hotels (with more than 16 sleeping accommodations) and dormitories (for more than 16 persons). In addition, the LSC limits the flammability of the interior finishes on walls and overheads of exit enclosures to Class A or Class B materials.[39]

Plywood of ¼-inch thickness has a flame spread rating of 120-196, depending on the exact type of plywood and finish.[40] The flame spread rating of the ¼-inch plywood used as interior finish on the 02 and 01 decks on the ALASKA SPIRIT was not available or determined by testing. It is, however, likely that the rating was greater than 120, based on the flame spread ratings for plywood of ¼-inch thickness.

If an approved automatic sprinkler system is in place in a location, the LSC states that Class C interior wall and overhead finish materials shall be permitted wherever Class B materials would normally be required. Class B interior wall and overhead finish materials shall be permitted anywhere Class A would normally be required.

U.S. Fishing Fleet -- The U.S. fishing fleet numbers approximately 130,000 vessels, of which about 250 are fish processors or combination fishing-fish processor-type vessels. Approximately 50 fish processing and 76 combination fishing-fish processing vessels are more than 79 feet long.[41] Only one U.S. fish processing vessel, the 17,845-gross ton OCEAN PHOENIX (635.5 feet long), is required, because of its size, to be inspected by the Coast Guard.

Approximately 1,400 U.S. fishing industry vessels are over 79 feet long. Crew size varies greatly for vessels over 79 feet, "from 4 to 5 for fishing vessels, to 20 to 30 for large catcher-processors, to well over 100 for the largest floating processor."[42] The Coast Guard does not maintain records of crew size for uninspected vessels, so it does not know how many vessels are more than 79 feet long and carry more than 16 (or 49) persons. Between January 1992 and December 1995, a total of 1,167 fishing industry vessels were newly registered with the Coast Guard. Of these, 1,105 were less than 79 feet long, 60 were between 79 and 100 feet long, 1 was 112.8 feet long, and 1 was 201.2 feet long. The last vessel is similar in size to the ALASKA SPIRIT.

[39]The LSC defines three classes of finish materials, dependent on flame spread and smoke development, as follows:

Class A — Flame spread of 0-25 and smoke development of 0-450,

Class B — Flame spread of 26-75 and smoke development of 0-450, and

Class C — Flame spread of 76-200 and smoke development of 0-450.

[40]*Flame Spread Performance of Wood Products*, National Forest Products Association, Washington, D.C., 1992.

[41]*Fishing Vessels of the United States 79' and Over*, Nautilus Publishing Co., Seattle, Washington, 1994.

[42]*Fishing Vessel Safety*, National Research Council, National Academy Press, Washington, D.C., 1991, p. 41.

Accident Statistics -- According to Coast Guard records, from January 1, 1992, through March 15, 1994, a total of 2,214 fishing vessel accidents[43] were reported and investigated. Of these, 228 (10.3 percent) involved fires, of which 105 either were classed as uncontrollable or burned themselves out. The dollar loss of $24.8 million caused by the fires was 29.5 percent of the total for fishing vessel accident losses ($84.2 million) during this period.

For the period March 16, 1994, through 1995, records are incomplete because of open investigations and computer file loading in progress. One fire on a fish processing vessel that was not included in the statistics was the fire on board the fish processing vessel ALL ALASKAN in July 1994.[44] The Safety Board investigated this fire, in which one person died and the 379.5-foot-long vessel sustained damage in the range of $24.3-30 million.

Coast Guard Oversight of Fish Processing Vessels -- Uninspected vessels that must be examined by a qualified organization (ABS, DNV, etc.) for compliance with regulations are not normally examined by Coast Guard personnel. The ALASKA SPIRIT was in this category and was required to be examined by the DNV biannually. If, however, the Coast Guard had boarded the vessel at sea, an examination could have been carried out. The Coast Guard's at-sea program of boarding fishing industry vessels operates in conjunction with search and rescue, fisheries management, and law enforcement boarding. The Coast Guard does not conduct planned patrols for the sole purpose of safety equipment enforcement.

Title 46 United States Code (USC) Chapter 45 is the codified law affecting uninspected commercial fishing industry vessels. In prescribing regulations under this chapter, the Secretary (of Transportation) "may not require the alteration of a vessel or associated equipment that was constructed or manufactured before the effective date of the regulation."[45] Thus, vessels are exempt from new regulations and the owner or operator cannot be required to upgrade equipment or meet construction requirements for vessels built or converted before the regulation's effective date. Fire and electrical regulations or requirements (at 46 CFR Part 28, Subpart D), and stability requirements (at 46 CFR Part 28, Subpart E) are effective only for new vessels or vessels that complete a major

[43]Coast Guard regulations at 46 CFR 4.05 define accidents/casualty as: a grounding; loss of main propulsion or primary steering or any associated component or control system; an occurrence that adversely affects the vessel such as fire, flooding, failure of fixed fire extinguishing systems, life saving equipment, auxiliary generating equipment, or bilge pumping systems; loss of life; injury which requires professional medical treatment beyond first aid, or a person is unfit to perform routine vessel duties, an occurrence not meeting the above that results in damage to property in excess of $25,000. (Note: Over the years, the damage amount has been gradually increased to its present amount.)

[44]Marine Accident Report -- *Fire On Board the U.S. Fish Processing Vessel ALL ALASKAN, Near Unimak Island, Alaska, Bering Sea, July 24, 1994* (NTSB/MAR-95/02).

[45]Title 46 USC 4502(e)(2).

conversion[46] on or after September 15, 1991. (See table 1 on pages 36-37 for fire regulation summary and comparison information.)

Survival Factors

Fire Control Efforts -- Conditions reported by the SVFD fire chief that affected the ALASKA SPIRIT firefighting efforts appear in appendix F.

Notification Procedures -- Seward's emergency operators normally receive 6 weeks on-the-job training under a supervisor. During the program, they are instructed in gathering basic information from callers on the nature and location of the complaint. Seward's emergency operators are also trained to question callers to determine if fire or hazardous chemicals are involved in the complaint. Additionally, the city of Seward has prepared a Vessel in Distress Procedure Manual (revised March 1995) that identifies information that emergency operators should gather to address a general emergency involving a vessel at sea (i.e., the name of the vessel, its radio type, coordinates, survival equipment, the number of people involved, etc.).

Among the resources available to local planners is the Western Alaska Marine Firefighting Contingency Plan (see Local Contingency Planning section below). The plan provides the following checklist for information gathering:

- What is the name and telephone number of the person reporting?
- What is the nature of the emergency and extent of fire?
- What is the location of the incident?
- What is the exact location of the fire, by compartment and deck?
- Is anyone trapped or injured?
- What is burning? (Details regarding class of fire)
- Is any hazardous cargo in or near the fire?
- What, if any, firefighting efforts are in progress?
- What is the vessel's capability to maneuver?
- What is the amount and type of "bunker" (fuel for ship's engines)?

While the Seward emergency operators were not specifically familiar with the plan, they were trained to obtain basic information on the nature and location of the fire from the initial caller.

Local Contingency Planning

City of Seward -- The Alaska Division of Emergency Services approved the Kenai Borough Emergency Plan, which addresses natural disasters and hazardous materials releases. The plan establishes an emergency operations center and command levels for operations and support personnel. It also

[46]Defined at Title 46 USC 2101 (14a) as "a conversion of a vessel that: (A) substantially changes the dimensions or carrying capacity of the vessel; (B) changes the type of the vessel; (C) substantially prolongs the life of the vessel; or (D) otherwise so changes the vessel that it is essentially a new vessel, as decided by the Secretary [of Transportation - U.S. Coast Guard]."

lists other support agencies and resources in the State.

The last training drill or "table-top exercise" conducted by the Kenai Peninsula Borough prior to the accident took place on December 8, 1994. The scenario addressed was the involvement of an above-ground propane storage tank in a fire. The last previous marine firefighting training session for the SVFD occurred on May 21, 1995. Between 1984 and June 1995, the SVFD responded to 25 marine incidents that took place on vessels ranging in length from 14 to 218 feet.

In summer, Seward-Anchorage is the terminus for many of the world's largest cruise ships, which visit western Alaska from the West Coast of the United States and Canada, making approximately 185 port calls (about 125 in Seward). SVFD personnel board all cruise ships visiting Seward to conduct a familiarization tour of each vessel. This is not part of the Kenai Borough Emergency Plan. Other than the borough emergency plan, the SVFD does not have a local contingency plan for dealing with shipboard fires.

Western Alaska Marine Firefighting Contingency Plan -- According to the Coast Guard's Marine Safety Manual,[47] each COTP must maintain a marine firefighting contingency plan for dealing with shipboard and waterfront fires within their geographic area of responsibility. Marine Safety Office Anchorage's area is western Alaska. The Western Alaska Marine Firefighting Contingency Plan (dated September 18, 1987) was distributed to the harbor masters and fire departments within the Western Alaska Zone, namely Anchorage, Homer, Whittier, Seward, Kodiak, and Dutch Harbor.

The plan recommends that local fire chiefs take charge of firefighting operations within their jurisdictions and that vessel masters or senior officers serve as liaisons between the fire chief and the vessel crew. It lists key steps that should be taken before firefighters arrive. The steps include sounding the crew alarm, making an announcement on the public address system, and notifying the local fire department with specific information (such as location by deck and compartment, firefighting efforts in progress, and personnel involved).

Under a Section 20, Fire Department Contingency Plan recommendation:

> Each fire department which is responsible for the fighting of shipboard fires should establish a training program within their unit, dealing with shipboard fires. Fire departments should establish local contingency plans to cover such emergencies. A copy of this plan is to be submitted to the COTP.

While Seward has not specifically developed a firefighting contingency plan to deal with shipboard fires, many of the key steps in its firefighting strategies and assigned individual responsibilities are identical to those in the Coast Guard's Western Alaska Marine Firefighting Contingency Plan.

[47]The manual presents the authority, background, policy, and rationale for various programs associated with marine safety for the information, use, and guidance of Coast Guard personnel assigned to carry out marine safety duties.

Table 1 – Comparison of fire safety regulations and guidelines (all information has been revised and condensed for table inclusion)

	Commercial Fishing Industry Vessels Built or Converted Before September 15, 1991 46 CFR Part 28, Subparts C&D			**Commercial Fishing Industry Vessels Built or Converted On or After September 15, 1991** 46 CFR Part 28, Subparts C&D			**Industrial Vessels 300 Gross Tons (GT) and Less than 4,000 GT** 46 CFR Subparts 92, 95, & 97	**U.S. Coast Guard Voluntary Standards NVIC 5-86** Chapter 3 - Fire Safety
Persons on Board	16 or fewer	More than 16	More than 49	16 or fewer	More than 16	More than 49	In excess of 12 industrial persons	Any number
Fire Detection Systems	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	Each accommodation space must be equipped with an independent modular smoke detector or a smoke-actuated fire detecting unit.		Not required, except that each compartment containing explosives or enclosed spaces suited for vehicles shall be provided with a smoke-detecting or other suitable type of fire-detecting system. However, if a smoke-detecting system is installed, it shall meet the requirements of 46 CFR 76.33.	An approved house-type smoke detector is usually adequate for accommodations and galleys. Machinery spaces should have fire or smoke detectors with an audible and visual alarm in the pilothouse and on deck. Detectors should indicate the presence and location of fire or smoke in high risk areas.
Fire Suppression Equipment	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	A fixed gas (i.e. CO_2) fire extinguishing system is required for all vessels 79' long or over in a space containing an internal combustion engine of more than 50 horsepower (HP), an oil-fired boiler, or a gasoline storage tank.		Required in cargo compartments and tanks for combustible cargoes, paint lockers, engine spaces on vessels of 1,000 GT and over containing oil-fired boilers, or their fuel oil units, and with engine power of 1,000 BHP or greater. When a cargo compartment is to be working or living quarters, a water sprinkling system may be required.	Machinery spaces containing oil-fired boilers, fuel oil units, or internal combustion engines should have a fixed fire extinguishing system.
Fire Hose	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	Hoses must be connected to hydrants whenever the vessel is operating.		Fire hose shall be connected to the outlets at all times. However, on the open decks where no protection is afforded to the hose in heavy weather, or where the hose may be damaged from the handling of cargo, the hose may be temporarily removed from the hydrant and stowed in an accessible nearby location.	

Fire Main	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	Vessels 36’ or more in length must have a fire pump connected to fixed piping (fire main).	One to two fire pumps, depending on the GT of the vessel, piping and pumping requirements delineated.	Fire pumps and hydrants should be provided for all vessels in accordance with 46 CFR 95.10-5 to 15.
Structural Fire Protection	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	NOT REQUIRED	Each vessel must be constructed so as to minimize the fire hazards as far as it is reasonable and practical. Insulation must be noncombustible, except for machinery space pipe and machinery lagging and cargo holds. In addition, for more than 49 persons, the vessel’s hull, structural bulkheads, columns and stanchions must be made of steel. Deckhouse must be constructed of noncombustible material.	Ceilings, linings, and insulation, including pipe and duct coverings, shall be of incombustible materials. Any sheathing, furring, or holding pieces for securing any bulkhead (BH), ceiling, lining, or insulation shall be of incombustible materials. BHs, linings, and ceilings may have a combustible veneer within a room not to exceed 1/14” in thickness. Combustible veneer shall not be used in corridors. Corridors and BHs in accommodations shall be of “A” or “B” class construction. Stairtowers shall be of “A” class construction. The hull, superstructure, structural BHs, decks, and deckhouses shall be constructed of steel.	Noncombustible materials should be used for BHs, decks, and other structures and furniture in accommodations. Combustible materials and insulating foams should not be used or should be reduced in quantity wherever possible. For foam insulation use, consult NVIC 8-80. Insulating materials in accommodations should be noncombustible.
Fire Drills	Not required unless vessel operates beyond the Boundary lines.	Required once a month. Hold in different locations on the vessel. Drills to be conducted as if an actual emergency exists. All on board must participate, using emergency equipment.		Same as vessels built or converted before September 15, 1991.		Drills at least once every week and conducted as if an actual emergency exists. Fire pumps started and a sufficient number of outlets used to determine that the system is in proper working order.	Fire drills should be realistic and deal with an assumed outbreak of fire in some specified part of the vessel. Hoses should be laid out and tested. Drills should be held at intervals of not more than one month.

ANALYSIS

General

The weather conditions at the time of the accident were good and did not hamper the detection of the fire or the firefighting efforts. The engineroom equipment functioned properly before and during the fire. The Safety Board therefore concludes that the weather conditions and the vessel mechanical systems were not factors in this accident.

Source of Ignition

Early eyewitnesses reported almost simultaneous observations of fire in the wheelhouse and on the 02 deck. If the fire had started in the wheelhouse, it would have taken some time for it to progress downward to the 02 deck, so witnesses could not have seen fire simultaneously in the wheelhouse and the 02 deck in the early stages of the accident. In other words, had the fire begun in wheelhouse, the wheelhouse should have been seen to have greater fire involvement than the 02 deck, which is not what witnesses reported. On this basis, investigation for an ignition source was directed to the 02 deck.

On the 02 deck, the cook observed heavy smoke and fire in the port corridor 2 to 3 feet down from the overhead, and he could see only 10 to 15 feet into the port corridor. He observed only light smoke for the length of the starboard corridor. If the fire had started in the forward port corridor or the forward port crewroom, the fire spread by smoke or heat down the corridor should have occurred in the athwartships (cross) corridor and the starboard corridor, as well as down the port corridor. Fire damage on the 02 deck was more extensive on the port than on the starboard side. This pattern was most evident in the port and starboard corridors and living spaces along the outer perimeters of these two corridors. The final burn pattern was much deeper in the port corridor and cross corridor.

Although firefighting efforts were initiated at the 02 deck port aft door, the intensity of the fire forced firefighters to retreat. At this time, the port aft corridor was already fully involved in fire. Consequently, firefighters entered the starboard aft door to fight the fire. Early in the firefighting efforts, firefighters noted that the starboard bulkhead in the assistant fish master's room glowed red as viewed from the starboard corridor.

Since crewmembers had been socializing in the port forward four-person crewroom on the 02 deck on the evening prior to the fire, investigators considered the possibility that discarded smoking materials in this location might have ignited the fire. The duration and intensity of the fire would have ensured that any remaining residue from discarded smoking material was destroyed. However, discarded smoking materials do not appear to have caused ignition, given the ultimate burn pattern and eyewitness accounts of the fire.

Investigation revealed numerous other possible ignition sources on the 02 deck. They included: a boot warmer found outside the port forward crewroom, space heaters in crewrooms, battery chargers found in the assistant fish master's room, and a cook pot found in the assistant fish master's room. The location of the ignition source must be consistent with the following factors: (1) the pattern of fire damage on the 02 deck, (2) the early and almost simultaneous appearance of fire in the wheelhouse and 02 deck, and (3) the observation of fire in the 02 deck port corridor, but smoke only in the starboard corridor, early in the fire progression.

The deckhand who had been awakened by the fire alarm stated that he went about halfway up the stairwell to the 02 deck before the firefighters arrived and saw fire in the overhead and on the deck of the forward port corridor. He believed that he saw burning boots on the deck. Investigation of a boot warmer found outside the port forward crewroom uncovered no problems with the wiring that led over the door's metal threshold. Further, the boot warmer appeared to have melted or burned from the top down, with no indication of ignition from the lower part of the warmer.

These observations are consistent with radiant heat from the fire in the overhead having caused the boot warmer's melting. The investigation could not confirm what materials the deckhand might have seen burning on the deck.

Each accommodation space on the ALASKA SPIRIT appeared to have contained an electric space heater, since no other heat was available in the rooms. None of the heaters located by investigators was powered or plugged into an electrical source.

A fire starting in the assistant fish master's room could easily have spread (via the chase in the overhead above the bed) into the wheelhouse early in the course of the fire. Because the chase would have acted as a chimney going directly into the wheelhouse, fire-spread into the wheelhouse could have occurred before the smoke and hot gases escaped into the corridor via the room's light wooden door and vent fan opening. RPU foam lined the inside of the chase on the ALASKA SPIRIT's sister vessel and remnants of RPU foam were found in the chase on the ALASKA SPIRIT after the fire. Such a flammable lining would have increased the rapidity with which the fire would have spread into the wheelhouse by this route.

A fire initiating in the assistant fish master's room also could have spread to the wheelhouse by a second route. The burn pattern in the 02 deck corridor is consistent with fire exiting from this room into the port corridor. Smoke, hot gases, and fire would have exited into the port corridor via the fan vent opening and the light, hollow-core wooden door of the assistant fish master's room. The wooden, non-fire-rated door at the top of the stairway to the wheelhouse was destroyed and, according to testimony, was probably open at the time of the fire. This testimony is consistent with damaged conditions found after the fire. The wooden stair treads and wooden paneling in the stairwell between the 02 deck and the wheelhouse were

extensively damaged by the fire. Consequently, both the chase and the stairwell were major means by which the heat, smoke, and fire could have traveled from the 02 deck into the wheelhouse.

The assistant fish master's room was of fire-resistive construction, as it had steel bulkheads. However, the steel bulkheads were covered, interior and exterior, with light wooden construction materials. The extensive destruction of the materials in the assistant fish master's room indicates there was an intense fire in this room. The red glow that firefighters observed in the starboard corridor on the steel bulkhead of the assistant fish master's room is consistent with the burning of a high fuel load[48] (bedding, clothing, wood construction and framing material along this bulkhead). Based on the foregoing evidence, the Safety Board concludes that the fire originated in the assistant fish master's room.

The burn pattern under and beside the left battery charger found in the assistant fish master's room indicates that this damage occurred early in the course of the fire. That is, the fire burned the wooden shelf that supported the chargers before the materials (debris) fell onto and buried this charger. Further, the differential heat and fire damage noted in the left battery charger, as compared to the right charger adjacent to it, shows that the left charger was considerably hotter both inside and outside the charger case. The aluminum diode (rectifier) heat sink plates of the left charger were melted, and some of the molten aluminum was found under the shelf. The insulation on the transformer wires was completely burned away, but no electrical faults or arcing could be found in this charger. In addition, the charger contained little fuel that could have produced heat sufficient to melt aluminum heat sink plates.

Another possible ignition source in the assistant fish master's room was the cook pot found sitting on the deck next to the bunk-type bed and just forward of the battery chargers. Heat damage to the wire tie-downs and the internal potting material is consistent with excessively high temperatures inside the appliance due to overheating. Fire starting exterior to the cook pot and then spreading to it would have first destroyed the carpet and power cord that was coiled beneath the cook pot before causing internal heat damage to the cook pot. The fact that the carpet and power cord beneath the pot were unburned supports the conclusion that the fire did not start exterior to the cook pot.

The location of this cook pot next to the bed also made it a prime candidate as the ignition source. In this location, overheating of this appliance could have ignited bedding materials. The room had not been occupied for about 6 days. The room contained a heat detector but no smoke detector. Ignition of the bedding could have occurred sometime during the 6 days that the room had been vacant, and a smoldering combustion might have gone undetected for some time. The presence of water in the cook pot would have delayed overheating until the water evaporated.

[48]Pounds of combustibles per square foot of deck area.

From this ignition source, the fire could have spread to the wheelhouse via two routes. First, the cook pot was in close proximity to the bed. Once flames erupted, the high fuel load in the assistant fish master's room would have facilitated rapid fire growth and spread into the chase directly above the bed. The fire would have spread through the chase into the wheelhouse.

Second, the combustible gases and smoke that normally accumulate in the ceiling area of a room of origin would have quickly burned through the light wooden door of the assistant fish master's room, creating another path by which fire might have spread. Once the top of this door was burned, the smoke, heat, and combustible gases would have rapidly spread into the corridor and up the open stairwell to the wheelhouse. This scenario fits the report of the first eyewitness (the cook) that he saw flames in the wheelhouse and 02 deck port door.

Since the door to the assistant fish master's room and the fan vent opening are almost opposite the door to the master's room and the hospital room, this fire propagation scenario is consistent with the master being unable to escape the fire. He appears to have been overcome by the products of combustion (principally carbon monoxide) that would have moved directly across the narrow corridor to the doorways of these two rooms. Based on the foregoing evidence, the Safety Board concludes that the most likely ignition source was the cook pot in the assistant fish master's room.

When crewmembers leave their vessel after a voyage, they often do not check their accommodation rooms to verify that all electrical items have been turned off and secured, and that smoking materials have been removed. After occupants vacate a room, if it is likely to be vacant for a period of time, the room should be checked for fire hazards. Good marine practice calls for a responsible measure of "good housekeeping" on board vessels to lessen the danger of fire or other hazards occurring unexpectedly. Regular checking of rooms for fire hazards is one of the best possible safeguards against fire ignition. While such routine checks cannot guarantee vessel safety, they can increase the likelihood that accidents will be prevented.

The Safety Board therefore concludes that, had the FCA provided written guidance to vessel masters to check on the fire safety condition of vacant crewrooms and had such a review procedure been implemented, the fire might have been avoided. Consequently, the Safety Board believes that the FCA should develop written guidance for its vessel masters to use to review the fire safety condition of all crewrooms when the occupants disembark from the vessel and the room will be vacant, and should implement a procedure whereby the conduct of such reviews may be documented.

Fire Safety Standards

Construction -- The extensive use of combustible wood construction materials, the use of unprotected, highly flammable RPU and polystyrene insulations, and the high concentration of combustible bedding and furnishings on the ALASKA SPIRIT contributed to

a very rapidly spreading fire that was difficult to extinguish until much of the combustible fuel had been consumed. The fuel load was very high on the 02 deck because of the wood construction and the volume of bedding, clothing, and wood furniture in the small rooms.

All of the partition bulkheads were constructed of wood with a vinyl veneer that had a Class C flame spread rating. The assistant fish master's room had steel bulkheads, but they were covered with highly combustible wooden structures. Further, all of the interior hull and deck surfaces, the exteriors of which were exposed to the elements, were covered with RPU foam insulation. In some areas, sheets of polystyrene insulation were installed behind the wooden bulkheads and overhead. These combustible materials all contributed to fuel a rapidly spreading fire.

Because of the extensive use of ¼-inch plywood over light wooden supports in the escape corridors, the ALASKA SPIRIT would not have met the requirements of the Coast Guard structural fire protection regulations for cargo and miscellaneous vessels or the NFPA shoreside LSC. The Safety Board therefore concludes that the rapid fire growth and spread were due to the high fuel load and lack of noncombustible construction.

The Coast Guard had established cargo and miscellaneous vessel structural fire regulations and later developed the guidelines for fishing industry vessels in the NVIC 5-86 (which refer to the cargo and miscellaneous vessel regulations (46 CFR Subchapter I) for structural fire protection). Most of these regulations and guidelines were not incorporated into commercial fishing industry vessel regulations.

Had structural fire protection guidelines been adopted into the regulations for fishing industry vessels, the FCA would still not have been required to implement them. The ALASKA SPIRIT was exempted from the regulations because: (1) it carried 49 or fewer persons, and (2) it had been operating as a fishing industry vessel before the effective date of the regulations. The previous owner of the ALASKA SPIRIT apparently did not use the information in the NVIC's voluntary guidelines for fire protection when converting it into a fishing industry vessel.

Current Coast Guard regulations for new vessels carrying more than 16 persons require that vessels "minimize fire hazards insofar as is reasonable and practicable" and that "insulation be noncombustible." Except for NVIC 5-86, there is no other national standard for fishing industry vessels. This accident highlights the need to establish structural fire protection regulations for fishing industry vessels that carry more than 16 persons (the same figure is used in the LSC for shoreside buildings when more than 16 sleeping accommodations are available in the structure). NFPA does not have a life safety code for vessels, but it is working with the Coast Guard to develop such a document.

Following its 1994 investigation of the fire in the cargo spaces on the fish

processing vessel ALL ALASKAN,[49] the Safety Board recommended that the Coast Guard:

M-95-16

Establish, in cooperation with the National Fire Protection Association, a national marine safety standard on the safe use of rigid polyurethane foam and other organic combustible material insulations on vessels.

The Coast Guard replied to this recommendation that it is working with the NFPA to develop such a standard. The Safety Board classified this recommendation "Open -- Acceptable Response" on February 6, 1996. After the same accident, the Board recommended that the NFPA:

M-95-25

Establish, in cooperation with the U.S. Coast Guard, a national marine safety standard on the safe use of rigid polyurethane foam and other organic combustible material insulations on vessels.

The NFPA replied that it is working with the Coast Guard to develop such a standard to address fire protection and life safety aboard merchant vessels. The new standard will be designated NFPA 301. Pending the publication of NFPA 301, the Safety Board classified the recommendation "Open -- Acceptable Response" on October 26, 1995.

[49]Marine Accident Report -- NTSB/MAR-95/02.

Seeking changes to regulations takes time. In the interests of safety, the Coast Guard could, in the interim, develop a national marine fire safety standard with the NFPA. A national marine fire safety standard for commercial fishing industry vessels, containing structural fire protection standards, would improve the level of fire safety on commercial fishing industry vessels by reducing the amount of highly combustible materials in vessel living spaces and corridors.

Fire Detection Equipment -- While the ALASKA SPIRIT's previous owner had installed the fire protection equipment used on the vessel, the responsibility for reviewing the adequacy of that equipment to ensure the fire safety of the vessel and the crew lay with the current owner, the FCA. Such a review would have revealed the need for smoke rather than heat detectors in the vessel's living quarters. When the fire ignited on the ALASKA SPIRIT, by the time that the (properly operating) heat detectors activated, the fire had advanced to a point that the master could not escape and shoreside firefighters could only contain it to the 02 deck and wheelhouse. The Safety Board therefore concludes that, because heat rather than smoke detectors were used on the ALASKA SPIRIT, the crew was not provided with sufficient early warning of the fire, which led to the death of the master and allowed the fire to go out of control.

An operating smoke detector in the rooms, and especially in the room of origin, would have given warning of the fire while it was still in the smoldering stage. Smoldering fires can produce smoke without significantly increasing

room temperature. Openings (wire chase, wooden door with ventilation opening, and the opening in the bulkhead for a fan) in the room of fire origin allowed smoke and combustible and poisonous gases to spread quickly into other spaces in the vessel.

Smoke-actuated fire-detecting units or independent modular smoke detectors, however, are only required in the accommodation spaces of those commercial fishing industry vessels built or converted after September 15, 1991, that carry more than 16 persons. The minimal cost of these household-type battery-operated smoke detectors, and their ease of installation, strongly suggests the use of this safety device on existing vessels. The Safety Board recognizes that the FCA has installed a smoke detection system on the repaired ALASKA SPIRIT and believes that the FCA should install smoke detectors in accommodation spaces on all its vessels, regardless of whether heat detectors are installed.

Fire Suppression Equipment -- By the time the fire was discovered, it was well established and beyond the crew's capability to contain it. The crew and shoreside firefighters prevented the fire from burning back down the port inside stairwell to the 01 deck, and shoreside firefighters put enough water on the 02 deck to prevent heat and flames from propagating down to the 01 deck. Using shoreside equipment, firefighters working in narrow corridors and high heat virtually controlled the fire until it burned itself out.

The regulations for new fishing industry vessels that are 36 feet and over in length that carry more than 16 persons require a power-driven fire pump and fire main system, but no fire suppression system in the accommodation area. The ALASKA SPIRIT had a power-driven pump and fire main system, which were not required by the regulations for this existing fishing vessel, but did not have a sprinkler system. Although automatic fire-extinguishing sprinkler systems are not required in accommodation spaces, the management of the vessel is responsible for ensuring that fire suppression equipment is adequate to safeguard the crew and the vessel in case of fire. To provide effective fire protection to the crew and the vessel, fire suppression equipment should be part of the power-driven fire pump and fire main system.

The Coast Guard should consider requiring automatic fire-extinguishing sprinkler systems on fish processing vessels with accommodations that are not of noncombustible construction. Such vessels often carry large numbers of people not trained as firefighters. They also operate in areas remote from professional firefighting assistance, in weather and sea conditions that could prevent help from being rendered even if available. Sprinklers also reduce the dependency on vessel personnel for responding to and extinguishing a fire, which is especially important when a reduced crew is staffing the vessel.

The Safety Board therefore concludes that an installed sprinkler (suppression) system would probably have extinguished the fire in its early stages of development, impeded the spread of fire in the accommodation spaces, and possibly prevented the loss of life.

Therefore, in view of the fire danger posed by the combustible materials used in the construction of the ALASKA SPIRIT and ALASKA VICTORY, the Safety Board believes that the FCA should install automatic fire suppression systems in all its vessel accommodation spaces that are constructed of combustible materials.

Existing Standards -- The ALASKA SPIRIT investigation has shown that fire safety standards for commercial fishing industry vessels are inadequate. In particular, it highlighted deficiencies in the areas of structural fire protection, fire detection systems, and fire suppression systems. The Safety Board therefore concludes that the development and use of a national marine fire safety standard for commercial fishing industry vessels that includes structural fire protection standards and fire detection and suppression systems would improve the level of fire safety on board these vessels. Thus, the Safety Board believes that the Coast Guard should develop, in cooperation with the NFPA, a national marine fire safety standard for commercial fishing industry vessels, which should include structural fire protection standards and fire detection and suppression systems in accommodation areas, and adopt it into the regulations.

The Coast Guard reports that, since January 1992, a total of 62 new fishing vessels over 79 feet long have entered the industry. Only two of these vessels were over 100 feet long, and only one of the two was over 200 feet long.

It is probable that only these 2 vessels, out of the 62 entering the industry, will carry more than 16 persons and so be required to meet some of the new fire safety regulations. Even the larger vessel will likely not carry more than 49 persons and so will not be required to meet the structural fire regulations at 46 CFR 28.385.

A combination of reduced fishing quotas, over-capitalization, and owners' wishes to avoid costly implementation of the safety features required by regulations on new vessels perpetuates the use of older, less fire-protected vessels. These older vessels continue to operate without safety improvements, such as smoke detectors and the reduced use of combustible construction materials. By exempting these older vessels from safety regulations, two widely differing standards of safety for the fishing industry are effectively sanctioned. But all fishermen and fish processors are exposed to the same rigors on their jobs and should be afforded the same level of workplace safety.

As the result of Safety Board recommendations, passenger vessel safety has been improved internationally in recent years, with the phasing in of higher fire protection levels on vessels built before the introduction of more stringent fire safety regulations. The older, less fire-protected passenger vessels are no longer permanently excused from meeting the higher fire prevention standards for new vessels. The same procedure could be used to improve the fire safety of fishing vessels.

Under current law, existing fishing industry vessels built before the effective date of the regulations are permanently

exempted from meeting the new regulations. Because of the prevalence of fires that occur on fishing vessels and their great human and economic costs, the Coast Guard should seek legislation that would require the phasing in of fire safety regulations for all fishing vessels, regardless of age. Owners of existing fishing vessels could gradually upgrade their vessels, in a planned cost procedure, or defer upgrading until their vessel is no longer permitted to operate and then replace it with a new vessel that would meet the higher regulatory standards. Such action would remove from operation those vessels currently exempted from the safety regulations and set a single safety standard for the fishing industry.

The Safety Board therefore concludes that a procedure is needed to improve fire safety on existing fishing industry vessels by phasing in the fire safety regulations currently applicable only to new vessels to all vessels, regardless of age. Consequently, the Safety Board believes that the Coast Guard should promptly seek to change the law to require the phasing in of fire safety regulations to apply to all existing fishing industry vessels that carry more than 16 persons. The process of making the same regulations applicable to all such vessels should be completed by the year 2010.

Fire Hose -- Because some Armtex hoses were used on the ALASKA SPIRIT, a special adapter was required to connect the vessel's hydrant outlets with the nonstandard fitting of this hose. The Safety Board therefore concludes that because the ALASKA SPIRIT had some fire hoses that were incompatible with its hydrants, the crew was initially delayed in its firefighting efforts. (Given their limited resources and the rapidity of the fire growth, however, it is doubtful whether the ALASKA SPIRIT's crew could have saved the master even had the hoses been attached to the hydrants.)

The Safety Board is deeply concerned about the operation of a vessel with fire hose equipment that was not only incompatible but which had critical components (i.e. adapter coupling) stowed far away from the hydrants. It seems evident that if adapters are necessary, they should be installed. The responsibility for ensuring the adequacy of vessel fire hose systems and their practical hookup lies with the vessel's management, in this case the FCA. The Safety Board believes, therefore, that the FCA should direct the masters of all its vessels to check all fire stations on their vessels to ensure that fire hose thread couplers are compatible with vessel fire hydrants and to replace incompatible equipment as appropriate.

Coast Guard regulation 46 CFR 28.315(b)(2), requires that fire hoses be connected to each hydrant at all times that the vessel is operating. This regulation, however, applies only to commercial fishing industry vessels that had their keels laid or were converted after September 15, 1991, and that operate with more than 16 individuals on board. Coast Guard regulation 46 CFR 95.10-10, which applies to cargo and miscellaneous vessels, was also not applicable to the ALASKA SPIRIT. This regulation requires that all fire station hydrants have fire hose coupling threads of 1 ½-inch and 2 ½-inch sizes. NVIC 5-

86 refers to the above regulation as a voluntary standard for uninspected commercial fishing vessels.

As part of the regulatory efforts of the Coast Guard to ensure that fish processing vessels meet the regulations, every 2 years qualified organizations must examine and certify that vessels meet the requirements of 46 CFR Subchapter C. To improve the level of fire safety on board uninspected commercial fishing industry vessels, examiners should ensure that firefighting hoses are attached to and fit fire hydrants at fire stations.

Survival Factors

Reporting of Fire -- After the fire erupted, reports of it were quickly communicated to the SECC, via the 911 telephone number. Despite being alone, the emergency operator performed her duties well, not only in handling the incoming calls but also in dispatching police, fire, and medical units.

Nevertheless, more efficient communication might have been beneficial. Had the watchman identified himself, the 911 operator could have questioned him for additional details. The watchman might have been a source of specific information, such as the exact location of the fire on the vessel and whether individuals might have been trapped or injured. The FCA did not train night watch personnel in procedures for notifying response centers of an emergency.

The Safety Board therefore concludes that security night watch personnel on FCA vessels should have a checklist of initial notification procedures to ensure that requisite information is provided to emergency response communicators. At a minimum, the initial notification procedures should address: the emergency's nature, location, and extent; details as to personnel trapped or injured; and efforts in process to minimize the damage.

Drills -- The ALASKA SPIRIT's master last conducted a fire drill on the previous fishing trip when the vessel was at Dutch Harbor. However, the fire drill was conducted without the crew's laying out or charging the ship's fire hose lines from any of the hydrants or donning the SCBAs or firefighting gear. As a result, the firefighting system was not tested and the crew was not completely familiar with the equipment. This accident demonstrates the importance of holding realistic fire training drills, designed to improve the crew's familiarity with the equipment and to test the equipment's effectiveness. The Safety Board therefore concludes that the lack of realistic fire drills compromised the vessel's firefighting system.

Coast Guard regulation at 46 CFR 28.270, applicable to the ALASKA SPIRIT and all documented fishing vessels with more than 16 individuals on board,[50] requires that drills be carried out as if:

[50]On documented vessels with 16 or fewer persons, the rule applies if the vessel operates beyond the Boundary lines as listed in 46 CFR Part 7. Generally, the lines are seaward of the shorelines and cross entrances to small bays, inlets, and rivers.

> There were an actual emergency and must include participation by all individuals on board, breaking out and using emergency equipment, testing of all alarm and detection systems, donning protective clothing... .

Therefore, given the evidence that drills on board the ALASKA SPIRIT were not conducted as if an actual emergency existed, the Safety Board believes that the FCA should develop fire contingency plans that improve the readiness of its vessel personnel and equipment to respond to a fire emergency, and include provisions concerning the duties of security watch personnel and the training of crew in firefighting techniques by the implementation of realistic fire drill procedures. To be realistic, the drills should require that each crewmember know where all fire and lifesaving equipment is stowed and how to use it.

Significance of the ALASKA SPIRIT Investigation

The issues raised by the investigation of the fire on board the ALASKA SPIRIT are applicable to the entire fishing industry. Thus, to ensure that all of the recommendations developed as a result of the ALASKA SPIRIT investigation receive wide dissemination within the industry, the Safety Board believes that the Commercial Fishing Industry Vessel Safety Advisory Committee (CFIVSAC)[51] should inform fishing industry vessel owners of this accident and advise them to: install on their vessels smoke detectors in accommodation spaces; install automatic fire suppression systems in accommodation spaces that are constructed of combustible materials; develop written guidance for vessel masters to review the fire safety condition of all crewrooms when the occupants disembark from the vessel and the room will be vacant; direct vessel masters to check fire stations to ensure that fire hose couplers are compatible with vessel fire hydrants; and develop fire contingency plans that improve the readiness of vessel personnel and equipment, including provisions addressing the duties of security watch personnel and procedures for realistic fire drills.

Toxicological Test Results

The CHT tested the master's blood sample for the presence of drugs and found phenethylamine as a decomposition product but detected no other common drugs. The Safety Board therefore concludes that drug use was not a factor in this accident. Independent toxicological tests conducted by the Alaska State Medical Examiner's Office and the CHT both found high levels of COHb and alcohol in the sample.

[51]Established under the authority of Title 46 USC 4508, the 17-member CFIVSAC advises the Coast Guard Commandant, the Secretary of Transportation, and Congress on safety issues related to commercial fishing industry vessels. Committee members include crewmembers or processors on uninspected fish processing vessels, naval architects or marine surveyors, manufacturers of industry equipment, industry educators or trainers, insurance underwriters for fishing vessels, and the general public.

Carboxyhemoglobin (COHb) -- The Alaska State Medical Examiner's Office found that the master's death was caused by smoke inhalation. The results of the CHT test for cyanide, a toxicant sometimes found in smoke, were negative. Another toxicant, carbon monoxide (CO), was a component of the smoke, as evidenced by the high levels of COHb found in the master's blood sample. The Alaska Medical Examiner's Office and the CHT reported COHb saturation levels of 90.6 percent and 84 percent, respectively.

According to Hill,[52] the master would have become incapacitated and lost consciousness at 40-50 percent COHb saturation, before succumbing at the reported level of 84-90.6 percent COHb saturation.

The site where the master's body was found—inside the hospital room door—indicates that he had been awakened by the fire alarm. By the time the alarm sounded, air containing CO had probably already circulated through the common ventilation system and the louvered doors on the 02 deck.

Although the concentrations of CO in the master's room and hospital room when the alarm sounded cannot be determined with certainty, at 1-2 percent concentration of CO in the air, an exposed person would have had about 120 seconds before becoming incapacitated at the level of 40-50 percent COHb saturation; at 5-10 percent concentration in the air, incapacitation would take about 30 seconds. In either case, the master would have had perilously little time for escape. (See appendix G for more information concerning the toxic effects of COHb saturation.)

Alcohol -- The blood alcohol concentration (BAC) of the master's blood sample was reported as 0.353 gm/dL by the Alaska Medical Examiner's Office and as 0.360 gm/dL by the CHT. While this is a high BAC, the Safety Board found that the preponderance of evidence, both with regard to the master's lifestyle and the circumstances of his death, indicates that the high BAC was caused by postmortem generation rather than ingestion. (See appendix H for additional information regarding the master's BAC.) The Safety Board thus concludes that the high alcohol content in the master's blood sample was likely due to postmortem generation rather than ingestion.

[52]Hill, I.R., *Aviation, Space, and Environmental Medicine*, "An Analysis of Factors Impeding Passenger Escape from Aircraft Fires," March 1990, pp. 261-265.

CONCLUSIONS

1. The weather conditions and the vessel mechanical systems were not factors in this accident.

2. The fire originated in the assistant fish master's room.

3. The most likely ignition source was the cook pot in the assistant fish master's room.

4. Had the FCA provided written guidance to vessel masters to check on the fire safety condition of vacant crewrooms and had such a review procedure been implemented, the fire might have been avoided.

5. The rapid fire growth and spread were due to the high fuel load and lack of noncombustible construction.

6. Because heat rather than smoke detectors were used on the ALASKA SPIRIT, the crew was not provided with sufficient early warning of the fire, which led to the death of the master and allowed the fire to go out of control.

7. An installed sprinkler (suppression) system would probably have extinguished the fire in its early stages of development, impeded the spread of fire in the accommodation spaces, and possibly prevented the loss of life.

8. The development and use of a national marine fire safety standard for commercial fishing industry vessels that includes structural fire protection standards and fire detection and suppression systems would improve the level of fire safety on board these vessels.

9. A procedure is needed to improve fire safety on existing fishing industry vessels by phasing in the fire safety regulations currently applicable only to new vessels to all vessels, regardless of age.

10. Because the ALASKA SPIRIT had some fire hoses that were incompatible with its hydrants, the crew was initially delayed in its firefighting efforts.

11. Security night watch personnel on FCA vessels should have a checklist of initial notification procedures to ensure that requisite information is provided to emergency response communicators.

12. The lack of realistic fire drills compromised the vessel's firefighting system.

13. Drug use was not a factor in this accident.

14. The high alcohol content in the master's blood sample was likely due to postmortem generation rather than ingestion.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the fire aboard the ALASKA SPIRIT was the failure of The Fishing Company of Alaska, Incorporated, to address the inadequate fire safety conditions and practices on the vessel. Contributing to the severity of the damage and the loss of life was the lack of fire safety standards for commercial fishing industry vessels.

RECOMMENDATIONS

-- to the U.S. Coast Guard:

Develop, in cooperation with the National Fire Protection Association, a national marine fire safety standard for commercial fishing industry vessels, which should include structural fire protection standards and fire detection and suppression systems in accommodation areas, and adopt it into the regulations. (Class II, Priority Action) (M-96-1)

Promptly seek to change the law to require the phasing in of fire safety regulations to apply to all existing fishing industry vessels that carry more than 16 persons. (Class II, Priority Action) (M-96-2)

Publicize the circumstances of this fire to the fishing industry. (Class II, Priority Action) (M-96-3)

-- to The Fishing Company of Alaska, Incorporated:

Develop written guidance for your vessel masters to use to review the fire safety condition of all crewrooms when the occupants disembark from the vessel and the room will be vacant, and implement a procedure whereby the conduct of such reviews may be documented. (Class II, Priority Action) (M-96-4)

Install smoke detectors in accommodation spaces on all your vessels, regardless of whether heat detectors are installed. (Class II, Priority Action) (M-96-5)

Install automatic fire suppression systems in all your vessel accommodation spaces that are constructed of combustible materials. (Class II, Priority Action) (M-96-6)

Direct the masters of all your vessels to check all fire stations on their vessels to ensure that fire hose thread couplers are compatible with vessel fire hydrants and to replace incompatible equipment as appropriate. (Class II, Priority Action) (M-96-7)

Develop fire contingency plans that improve the readiness of your vessel personnel and equipment to respond to a fire emergency, and include provisions concerning the duties of security watch personnel and the training of crew in firefighting techniques by the implementation of realistic fire drill procedures. (Class II, Priority Action) (M-96-8)

-- to the Commercial Fishing Industry Vessel Safety Advisory Committee:

Inform fishing industry vessel owners of this accident and advise them to: install on their vessels smoke detectors in accommodation spaces; install automatic fire suppression systems in accommodation spaces that are constructed of combustible materials; develop written guidance for vessel masters to review the fire safety condition of all crewrooms when the occupants disembark from the vessel and the room will be vacant; direct vessel masters to check fire stations to ensure that fire hose couplers are compatible with vessel fire hydrants; and develop fire contingency plans that improve the readiness of vessel personnel and equipment, including provisions addressing the duties of security watch personnel and procedures for realistic fire drills. (Class II, Priority Action) (M-96-9)

-- to the National Fire Protection Association:

> Develop, in cooperation with the U.S. Coast Guard, a national marine fire safety standard for commercial fishing industry vessels, which should include structural fire protection standards and fire detection and suppression systems in accommodation areas. (Class II, Priority Action) (M-96-10)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

ROBERT T. FRANCIS II
Vice Chairman

JOHN A. HAMMERSCHMIDT
Member

JOHN J. GOGLIA
Member

GEORGE W. BLACK, JR.
Member

June 11, 1996

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APPENDIXES

APPENDIX A

Safety Board Investigation

Investigation

The U.S. Coast Guard notified the National Transportation Safety Board of this accident on May 30, 1995. Four investigators from the Safety Board's Washington, D.C., headquarters were dispatched immediately to Seward, Alaska. They began investigation of the accident on June 1, 1995. The Safety Board invited the National Fire Protection Association (NFPA) to assist in the investigation, and the NFPA sent one investigator to Seward.

The Safety Board investigated this accident independently, under the authority of Section 304(a)(1)(F) of the Independent Safety Board Act of 1974.

The report is based on the factual information developed as a result of the investigation and additional analyses made by the Safety Board. The Safety Board considered all facts in the investigative record that are pertinent to its statutory responsibility to determine the cause or probable cause of the accident and to make recommendations.

The Fishing Company of Alaska, Inc., the U.S. Coast Guard, and the Seward Volunteer Fire Department participated as parties to the investigation.

Hearing and Deposition

Sworn testimony regarding this accident was taken on June 2, 1995, in Seward, Alaska, and on June 5, 1995, in Seattle, Washington. On August 28-29, 1995, two Safety Board investigators went to San Francisco, California, to witness the testing of a heat detector that had been removed from the ALASKA SPIRIT and to examine the battery chargers removed from the ALASKA SPIRIT. On October 29, 1995, two investigators went to Seattle, Washington, to visit the ALASKA SPIRIT's sister vessel, the ALASKA VICTORY, and to examine undamaged battery chargers taken from that vessel.

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APPENDIX B

Crew Licensing Information

Master

ALASKA SPIRIT Master Todd M. Eggers received the original issue of his master's license on April 3, 1989, as Master of Near Coastal Uninspected Fishing Industry Vessels of not more than 1600 gross tons; also, Master of Near Coastal Steam or Motor Vessels of not more than 200 gross tons. On November 19, 1990, his license was amended to include Master of Ocean Uninspected Fishing Industry Vessels of not more than 2,000 gross tons. He renewed the license on February 23, 1994. The license included an endorsement as a Radar Observer (Unlimited) and had an expiration date of January 6, 1998.

Chief Engineer

Richard D. Lewis, Sr., was on his third issue of a license to serve as Chief Engineer of Limited Oceans Motor Vessels of not more than 5,000 horsepower. The license was issued on October 19, 1994, by the U.S. Coast Guard Officer-in-Charge of Marine Inspection (OCMI), New Orleans, Louisiana.

Assistant Engineer

Frank P. Lemacks, Jr., held a license to serve as Chief Engineer of Limited Oceans Motor Vessels of any horsepower, as well as Second Assistant Engineer of Motor Vessels of any horsepower. His license was issued for the fourth time on February 23, 1995, by the OCMI, New Orleans, Louisiana.

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APPENDIX C

Battery Charger Examination

On August 29, 1995, the two battery chargers found on the ALASKA SPIRIT were examined, photographed, and disassembled at Fire Cause and Analysis,[1] in Berkeley, California. (The charger found on the left side in the assistant fish master's room corresponded to model SP_1-35-20B; the charger from the right side corresponded to model SP_1-35-30B.)

The less damaged battery charger, which had been found on the right side in the assistant fish master's room, was examined first. Aside from the burned and melted condition of its meters, circuit breaker switches, and other plastic-type electrical devices, the battery charger did not show significant signs of damage. This charger had no melted metal parts. The two aluminum heat sink plates for the rectifiers (diodes) on this charger were intact, and the diodes were attached. The electrical insulation on the transformers in the charger was intact, although the transformers had experienced extensive fire damage.

The investigators next examined the other (left) battery charger taken from the assistant fish master's room. The plastic-type electrical devices on this charger were burned more extensively than the right charger's devices. The investigators separately removed the two transformers of the left charger from the chassis, took them apart (removed laminated plates from the transformer coils), and examined them. All electrical insulation had been burned from the transformers. There was no apparent arcing between primary and secondary coils on either of the two transformers in this charger. Two aluminum heat sink plates, on which the diodes had been mounted, had melted.

The exterior meter, switches, and connectors on the left charger were completely destroyed by the fire. Interior fire damage was extensive. All electrical insulation on the transformers in the left charger was destroyed. Investigators found no evidence of electrical arcing on the transformers.

[1]An independent company hired by the FCA to perform the analysis.

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APPENDIX D

Global Fire and Safety, Inc., Heat Detector Test Report

DATE: August 28, 1995

TO: USCG MSO Anchorage (ANCMS)
USCG MSO San Francisco (SFCMS)

FROM: Larry Ackerman

SUBJECT: M.V. Alaska Spirit

Evaluation Report

Received one Detector, Thermal type, for testing and evaluation of function. Unit was manufactured in Japan and designed to function as Thermal Detector established at 70° C / 158° F normally open contact Bi-metallic type. Unit was set-up above a fixed heat source, monitored contacts and temperature, Unit was tested three separate times, results are as follows:

	Start Temp C°	Function Temp C°	Reset Temp C°
1)	21.9	71.5	61.5
2)	35.0	69.0	61.1
3)	35.0	70.4	59.6

Results of the tests proved acceptable operation of device for rated function. In addition to tests, device was installed to a UL Fire Detection Panel and proved ability to initiate circuit fire condition.

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APPENDIX D

Upon completion of tests and evaluation, the Detector was found capable of initiating fire condition, providing the following conditions exist:

1. The unit is wired to a Detection Cabinet.

2. The wiring loop is complete and intact.

3. The Detection Cabinet is compatible with Detector application.

4. The Detection Cabinet is powered and tested with frequency to establish proper function and response.

Enclosed are excerpts from NFPA 72E standard on Automatic Fire Detectors for reference on frequency of testing and maintenance.

LGA/la
AlaskaSp.mem

APPENDIX D

NFPA 72E

Standard on

Automatic Fire Detectors

1990 Edition

NOTICE: An asterisk(*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 10 and Appendix D.

Chapter 1 Introduction

1-1 Purpose.

1-1.1 The purpose of this standard is to provide basic minimum requirements for the performance of automatic fire detectors to ensure timely warning for the purposes of life safety and property protection.

1-1.2 This standard is intended for use by persons knowledgeable in the application of fire detection as part of fire protection systems.

1-2 Scope.

1-2.1 This standard covers minimum performance, location, mounting, testing, and maintenance requirements of automatic fire detectors for protection of the occupant, building, space, structure, area, or object to be protected in accordance with the stated purpose.

1-2.2 This standard is intended to be used with other NFPA standards that deal specifically with fire alarm, extinguishment, or control. Automatic fire detectors add to fire protection by initiating emergency action, but only where used in conjunction with other equipment.

1-2.3 The interconnection of detectors, the control configurations, the power supply, or the output systems responding to automatic fire detector actuation are detailed in NFPA 71, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service*, NFPA 72, *Standard for the Installation, Maintenance and Use of Protective Signaling Systems*, NFPA 74, *Standard for the Installation, Maintenance, and Use of Household Fire Warning Equipment*, and others.

1-2.4 Nothing in this standard is intended to prevent the use of new methods or devices provided sufficient technical data are submitted to the authority having jurisdiction to demonstrate that the new method or device is equivalent in quality, effectiveness, durability, and safety to that prescribed by this standard.

Chapter 2 Common Requirements

2-1 General. Fire is a phenomenon that occurs when a substance reaches a critical temperature and reacts chemically with oxygen (for example) to produce heat, flame, light, smoke, water vapor, carbon monoxide, carbon dioxide, or other products and effects.

An automatic fire detector is a device designed to detect the presence of fire and initiate action.

2-1.1 Definitions.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

Ceiling. The upper surface of a space, regardless of height. Areas with a suspended ceiling would have two ceilings, one visible from the floor and one above the suspended ceiling.

Ceiling Height. The height from the continuous floor of the room to the continuous ceiling of a room or space.

Combination Detector. A device that either responds to more than one of the fire phenomena classified in 2-2.1.1 through 2-2.1.5, or employs more than one operating principle to sense one of these phenomena. Typical examples are a combination of heat detector with smoke detector or a combination rate-of-rise and fixed temperature heat detector.

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Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Spacing. A horizontally measured linear dimension relating to the allowable coverage of fire detectors.

2-2 Classification of Fire Detectors.

2-2.1 For the purpose of this standard, automatic fire detectors are classified as listed below.

2-2.1.1 Heat Detector. A device that detects abnormally high temperature or rate-of-temperature rise.

2-2.1.2 Smoke Detector. A device that detects the visible or invisible particles of combustion.

2-2.1.3 Radiant Energy Sensing Fire Detector. A device that detects radiant energy (ultraviolet, visible, or infrared radiation) that is emitted as a product of combustion reaction and obeys the laws of optics.

2-2.1.3.1 Flame Detector. See 5-2.1.4.

2-2.1.3.2 Spark/Ember Detector. See 5-2.1.7.

2-2.1.4 Fire-Gas Detector. A device that detects gases produced by a fire.

2-2.1.5 Other Fire Detectors. Devices that detect a phenomenon other than heat, smoke, flame, or gases produced by a fire.

2-2.2 Types of Detectors.

2-2.2.1 Line-type Detector. A device in which detection is continuous along a path. Typical examples are rate-of-rise pneumatic tubing detectors, projected beam smoke detectors, and heat-sensitive cable.

2-2.2.2 Spot-type Detector. A device whose detecting element is concentrated at a particular location. Typical examples are bimetallic detectors, fusible alloy detectors, certain pneumatic rate-of-rise detectors, certain smoke detectors, and thermoelectric detectors.

2-2.2.3 Air Sampling-type Detector. A sampling-type detector consists of piping or tubing distribution from the detector unit to the area(s) to be protected. An air pump draws air from the protected area back to the detector through the air sampling ports and piping or tubing. At the detector, the air is analyzed for fire products.

2-2.3 Operating Modes.

2-2.3.1 Nonrestorable Detector. A device whose sensing element is designed to be destroyed by the process of detecting a fire.

2-2.3.2 Restorable Detector. A device whose sensing element is not ordinarily destroyed by the process of detecting a fire. Restoration may be manual or automatic.

2-3 Shapes of Ceilings.

2-3.1 The shapes of ceilings are classified as follows.

2-3.1.1 Level Ceilings. Those that are actually level or have a slope of 1½ in. (40 mm) or less per ft (0.3 m).

2-3.1.2 Sloping Ceilings. Those having a slope of more than 1½ in. (40 mm) per ft (0.3 m). Sloping ceilings are further classified as follows:

(a) *Sloping-Peaked Type.* Those in which the ceiling slopes in two directions from the highest point. Curved or domed ceilings may be considered peaked with the slope figured as the slope of the chord from highest to lowest point. (*See Figure A-3-5.4.1.*)

(b) *Sloping-Shed Type.* Those in which the high point is at one side with the slope extending toward the opposite side. (*See Figure A-3-5.4.2.*)

2-4 Ceiling Surfaces.

2-4.1 Ceiling surfaces referred to in conjunction with the locations of fire detectors are:

2-4.1.1 Beam Construction. Ceilings having solid structural or solid nonstructural members projecting down from the ceiling surface more than 4 in. (100 mm) and spaced more than 3 ft (0.9 m), center to center.

2-4.1.2 Girders. Girders support beams or joists and run at right angles to the beams or joists. Where girders are within 4 in. (100 mm) of the ceiling, they are a factor in determining the number of detectors and are to be considered as beams. Where the top of the girder is more than 4 in. (100 mm) from the ceiling, it is not a factor in detector location.

2-4.1.3 Solid Joist Construction. Ceilings having solid structural or solid nonstructural members projecting down

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from the ceiling surface a distance of more than 4 in. (100 mm) and spaced at intervals 3 ft (0.9 m) or less, center to center.

2-4.1.4 Smooth Ceiling. A surface uninterrupted by continuous projections, such as solid joists, beams, or ducts, extending more than 4 in. (100 mm) below the ceiling surface.

NOTE: Open truss constructions are not considered to impede the flow of fire products unless the upper member in continuous contact with the ceiling projects below the ceiling more than 4 in. (100 mm).

| 2-5 Approval.

| **2-5.1** All fire detection devices shall be listed or approved for the purpose for which they are intended and shall be installed in conformity with this standard.

| **2-5.1.1*** All fire detection devices that receive their power from the initiating circuit of a fire alarm control unit shall be listed for use with the control unit. Where acceptable to the authority having jurisdiction, the manufacturer may provide information on the compatibility of the detection device with the control unit to satisfy this requirement.

| **2-5.1.2** Where required by the authority having jurisdiction, complete information regarding the fire detectors, including specifications and floor plans showing the location of the detectors, shall be submitted for approval prior to installation of the detectors.

| **2-5.1.3** Before requesting approval of the installation by the authority having jurisdiction, the installing contractor shall furnish a written statement to the effect that the detectors have been installed in accordance with approved plans and tested in accordance with Chapter 8 of this standard. Manufacturers' installation and service manuals shall also be furnished.

| 2-6 Acceptance Test. Upon completion of the installation, a satisfactory test of the fire detectors in accordance with Chapter 8 of this standard shall be made in the presence of a representative of the authority having jurisdiction.

| 2-7 Installation.

| **2-7.1** Where subject to mechanical damage, detectors shall be protected.

| **2-7.2** Detectors shall be supported, in all cases, independently of their attachment to the circuit conductors.

| **2-7.3** Detectors shall not be recessed in any way into the mounting surface unless they have been tested and listed for such recessed mounting.

| **2-7.4** Detectors shall be installed in all areas where required by the appropriate NFPA standard or the authority having jurisdiction. Each installed detector shall be accessible for periodic maintenance and testing. Where total coverage is required, this shall include all rooms, halls, storage areas, basements, attics, lofts, spaces above suspended ceilings, and other subdivisions and accessible spaces, and inside all closets, elevator shafts, enclosed stairways, dumbwaiter shafts, and chutes. Inaccessible areas that contain combustible material shall be made accessible and protected by detector(s).

Exception No. 1: Detectors may be omitted from combustible blind spaces where any of the following conditions prevail.

(a) Where the ceiling is attached directly to the underside of the supporting beams of a combustible roof or floor deck.

(b) Where the concealed space is entirely filled with a noncombustible insulation. In solid joist construction, the insulation need fill only the space from the ceiling to the bottom edge of the joist of the roof or floor deck.

(c) Where there are small concealed spaces over rooms provided any space in question does not exceed 50 sq ft (4. 6m^2) in area.

(d) In spaces formed by sets of facing studs or solid joists in walls, floors, or ceilings where the distance between the facing studs or solid joists is less than 6 in. (150 mm).

Exception No. 2: Detectors may be omitted from below open grid ceilings where all of the following conditions prevail.

(a) The openings of the grid are 1/4 in. (6.4 mm) or larger in the least dimension.

(b) The thickness of the material does not exceed the least dimension.

(c) The openings constitute at least 70 percent of the area of the ceiling material.

| **2-7.5*** Detectors shall also be required underneath open loading docks or platforms and their covers, and for accessible underfloor spaces of buildings without basements.

Exception: By permission of the authority having jurisdiction, detectors may be omitted when all of the following conditions prevail.

(a) The space is not accessible for storage purposes or entrance of unauthorized persons and is protected against accumulation of windborne debris.

(b) The space contains no equipment such as steam pipes, electric wiring, shafting, or conveyors.

(c) The floor over the space is tight.

(d) No flammable liquids are processed, handled, or stored on the floor above.

| **2-7.6** Where codes, standards, laws, or authorities having jurisdiction require the protection of selected areas only, the specified areas shall be protected in accordance with this standard.

| **2-7.7*** Duplicate terminals or leads, or equivalent, shall be provided on each automatic fire detector for the express purpose of connecting into the fire alarm system to provide supervision of the connections. Such terminals or leads are necessary to ensure that the wire run is broken and that the individual connections are made to the incoming and outgoing leads or other terminals for signaling and power.

Exception: Detectors that provide the equivalent supervision.

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Chapter 3 Heat Sensing Fire Detectors

3-1 Heat is added energy that causes substances to rise in temperature as well as the energy produced by a burning substance.

3-1.1 **General.**

3-1.1.1 The purpose and scope of this chapter are to provide standards for location and spacing of fire detectors that sense heat produced by burning substances. The detectors are usually referred to as heat detectors.

3-1.1.2 Heat detectors shall be installed in all areas where required either by the appropriate NFPA standard or the authority having jurisdiction.

3-2 **Operating Principles.**

3-2.1 **Fixed Temperature Detector.**

3-2.1.1 A fixed temperature detector is a device that will respond when its operating element becomes heated to a predetermined level.

3-2.1.2 **Thermal Lag.** When a fixed temperature device operates, the temperature of the surrounding air will always be higher than the operating temperature of the device itself. This difference between the operating temperature of the device and the actual air temperature is commonly spoken of as thermal lag, and is proportional to the rate at which the temperature is rising.

3-2.1.3 Typical examples of fixed temperature sensing elements are:

(a) *Bimetallic.* A sensing element comprised of two metals having different coefficients of thermal expansion arranged so that the effect will be deflection in one direction when heated and in the opposite direction when cooled.

(b) *Electrical Conductivity.* A line-type or spot-type sensing element whose resistance varies as a function of temperature.

(c) *Fusible Alloy.* A sensing element of a special composition (eutectic) metal, which melts rapidly at the rated temperature.

(d) *Heat-Sensitive Cable.* A line-type device whose sensing element comprises, in one type, two current-carrying wires held separated by a heat-sensitive insulation that softens at the rated temperature, thus allowing the wires to make electrical contact. In another type, a single wire is centered in a metallic tube and the intervening space is filled with a substance that, at a critical temperature, becomes conductive, thus establishing electrical contact between the tube and the wire.

(e) *Liquid Expansion.* A sensing element comprising a liquid capable of marked expansion in volume in response to temperature increase.

3-2.2 **Rate Compensation Detector.**

3-2.2.1 A rate compensation detector is a device that will respond when the temperature of the air surrounding the device reaches a predetermined level, regardless of the rate of temperature rise.

3-2.2.2 A typical example is a spot-type detector with a tubular casing of a metal that tends to expand lengthwise as it is heated and an associated contact mechanism that will close at a certain point in the elongation. A second metallic element inside the tube exerts an opposing force on the contacts, tending to hold them open. The forces are balanced in such a way that, on a slow rate of temperature rise, there is more time for heat to penetrate to the inner element, which inhibits contact closure until the total device has been heated to its rated temperature level. However, on a fast rate of temperature rise, there is not as much time for heat to penetrate to the inner element, which exerts less of an inhibiting effect so that contact closure is obtained when the total device has been heated to a lower level. This, in effect, compensates for thermal lag.

3-2.3 **Rate-of-Rise Detector.**

3-2.3.1 A rate-of-rise detector is a device that will respond when the temperature rises at a rate exceeding a predetermined amount.

3-2.3.2 Typical examples are:

(a) *Pneumatic Rate-of-Rise Tubing.* A line-type detector comprising small diameter tubing, usually copper, which is installed on the ceiling or high on the walls throughout the detected area. The tubing is terminated in a detector unit containing diaphragms and associated contacts set to actuate at a predetermined pressure. The system is sealed except for calibrated vents that compensate for normal changes in temperature.

(b) *Spot-type Pneumatic Rate-of-Rise Detector.* A device consisting of an air chamber, diaphragm, contacts, and compensating vent in a single enclosure. The principle of operation is the same as that described in 3-2.3.2(a).

(c) *Thermoelectric Effect Detector.* A device whose sensing element comprises a thermocouple or thermopile unit that produces an increase in electric potential in response to an increase in temperature. This potential is monitored by associated control equipment, and an alarm is initiated when the potential increases at an abnormal rate.

(d) *Electrical Conductivity Rate-of-Change Detector.* A line-type sensing element whose resistance changes due to a change in temperature. The rate of change of resistance is monitored by associated control equipment, and an alarm is initiated when the rate of increase exceeds a preset value.

3-3 **Temperature Classification.**

3-3.1 Heat detectors of the fixed-temperature or rate-compensated spot-pattern type shall be classified as to the temperature of operation and marked with the appropriate color code. (*See Table 3-3.1.*)

3-3.1.1 Where the overall color of a detector is the same as the color code marking required for that detector, either one of the following arrangements, applied in a contrasting color and visible after installation, shall be employed:

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be installed to prevent false operation or nonoperation after installation. Some of the considerations are as follows.

6-5.1.1 Fire-gas detectors may alarm in nonfire situations due to certain human activities. The use of some aerosol sprays and hydrocarbon solvents are examples. Accordingly, considerable care shall be employed when installing fire-gas detectors. They shall not be installed where, under normal conditions, concentrations of detectable gases may be present. A garage is not a place to use fire-gas detectors for fire alarm purposes because the concentration of carbon monoxide may be high enough to trigger an alarm.

6-5.1.2 Fire-gas detectors having a fixed temperature element as part of the unit shall be selected in accordance with Table 3-3.1 for the maximum ceiling temperature that can be expected in service.

6-5.1.3* The installation of fire-gas detectors shall take into consideration the environmental condition of the area(s). (*See Figure A-4-6.1.1.*) Fire-gas detectors are intended for installation in areas where the normal ambient conditions are not likely to:

(a) Exceed 100°F (38°C) or fall below 32°F (0°C); or

(b) Have relative humidity outside the range of 10 to 93 percent; or

(c) Exceed air velocity of 300 fpm (1.5 mps).

Exception: Detectors specifically designed for use in ambients exceeding the above limits and listed for the temperature, humidity, and air velocity conditions expected.

Chapter 7 Other Fire Detectors

7-1 Detectors in the classification of "Other Fire Detectors" are those that operate on principles differing from those described in Chapters 3, 4, 5, and 6.

7-1.1 General.

7-1.1.1 Detectors in the classification of "Other Fire Detectors" shall be installed in all areas where they are required either by the appropriate NFPA standard or by the authority having jurisdiction.

7-1.1.2 Facilities for testing or metering or instrumentation to ensure adequate initial sensitivity and adequate retention thereof, relative to the protected hazard, shall be provided. These facilities shall be employed at regular intervals.

7-2 Fire Characteristics.

7-2.1 These detectors shall operate when subjected to the abnormal concentration of combustion effects that occur during a fire, such as water vapor, ionized molecules, or other phenomena for which they are designed. Detection is dependent upon the size and intensity of fire to provide the necessary amount of required products and related thermal lift, circulation, or diffusion for adequate operation.

7-2.2 Room sizes and contours, airflow patterns, obstructions, and other characteristics of the protected hazard shall be taken into account.

7-3 Location and Spacing.

7-3.1 The location and spacing of detectors shall be based on the principle of operation and an engineering survey of the conditions anticipated in service. The manufacturer's technical bulletin shall be consulted for recommended detector uses and locations.

7-3.2 Detectors shall not be spaced beyond their listed or approved maximums. Closer spacing shall be utilized where the structural or other characteristics of the protected hazard warrant.

7-3.3 Consideration shall be given to all factors with bearing on the location and sensitivity of the detectors, including structural features such as sizes and shapes of rooms and bays, their occupancies and uses, ceiling heights, ceiling and other obstructions, airflow patterns, stockpiles, files, and fire hazard locations.

7-3.4 The overall situation shall be reviewed frequently to assure that changes in structural or usage conditions that could interfere with fire detection are remedied.

7-4 Special Considerations. Conditions that could foster false operation or nonoperation of detectors shall be considered when installation of detectors in this group is being planned.

Chapter 8 Inspections, Tests, and Maintenance

8-1 General.

8-1.1 Each detector shall be in reliable operating condition. Inspections, tests, and maintenance shall be performed.

8-1.2 Inspections, tests, and maintenance programs shall satisfy the requirements of this standard supplemented by the manufacturer's instructions.

Exception: Detectors installed to conform with the requirements of NFPA 74, Standard for the Installation, Maintenance, and Use of Household Fire Warning Equipment.

8-1.3 The owner or designated representative shall be responsible for inspections, tests, and maintenance. Delegation of authority shall be in writing.

8-1.3.1 The owner or designated representative shall be responsible for system alterations and additions.

8-1.3.2* Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire detection devices.

8-1.4 Before testing, people at all points where the alarm signals or reports shall be notified to prevent unnecessary response. At the conclusion of testing, those previously

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notified (and others necessary) shall be further notified that testing has been concluded.

8-1.5 Any method or device used for testing in an atmosphere or process classified as hazardous by Article 500 of NFPA 70, *National Electrical Code*,[3] shall be suitable for such use.

8-1.6 Records of all inspections, tests, and maintenance shall be kept on the premises for at least five years for review by the authority having jurisdiction.

8-2* Initial Installation Inspection and Tests.

8-2.1 After installation, a visual inspection of all detectors shall be made to be sure that they are properly located.

8-2.2 After installation, each detector shall be inspected to ensure that it is properly mounted and connected in accordance with the manufacturer's recommendations.

8-2.3 Heat Detectors.

8-2.3.1* A restorable heat detector and the restorable element of a combination detector shall be tested by exposing the detector to a heat source, such as a hairdryer or a shielded heat lamp, until it responds. After each heat test, the detector shall reset. Precaution shall be taken to avoid damage to the nonrestorable fixed temperature element of a combination rate-of-rise/fixed temperature detector.

Exception: A pneumatic tube line-type detector shall be tested either with a heat source (if a test chamber is in the circuit) or tested pneumatically with a pressure pump. The manufacturer's instructions shall be followed.

8-2.3.2 Line- or spot-type nonrestorable fixed temperature heat detectors shall not be heat tested, but shall be tested mechanically or electrically to verify alarm function.

8-2.3.2.1 Detectors with a replaceable fusible alloy element shall be tested by first removing the fusible element to determine that the detector contacts operate properly and then reinstalling the fusible element.

8-2.3.3 Where required for proper performance, the loop resistance of line-type detectors shall be measured to determine if it is within acceptable limits for the equipment being used. The loop resistance shall be recorded for future reference. Other tests shall be performed as required by the manufacturers.

8-2.4 Smoke Detectors.

8-2.4.1 To assure that each smoke detector is operative and produces the intended response, it shall be caused to initiate an alarm at its installed location. Before testing, each smoke detector shall be inspected to verify that any protection added during the construction phase to guard against contamination by construction dust and dirt has been removed and that smoke entry has not been impeded.

8-2.4.1.1* For spot-type or sampling-type detectors, the detectors shall be tested in place to ensure smoke entry into the sensing chamber and an alarm response. Testing with smoke or other aerosol acceptable to the detector manufacturer shall be permitted as one acceptable test method.

8-2.4.1.2 For projected beam-type smoke detectors, the detector shall be tested by introducing smoke, other aerosol, or an optical filter into the beam path.

8-2.5 Radiant Energy-Sensing Fire Detectors. Flame detectors and spark/ember detectors shall be tested in place in accordance with the manufacturer's instructions to determine that each detector is operative.

8-2.6 Fire-Gas and Other Fire Detectors. Fire-gas detectors and other fire detectors shall be tested for operation in accordance with instructions supplied by the manufacturer or other test methods acceptable to the authority having jurisdiction.

8-3 Periodic Inspection and Tests.

8-3.1* Detectors shall be tested as described in the following paragraphs. The method of test shall be as outlined in Section 8-2. The authority having jurisdiction may require testing at a greater frequency or may accept testing at a lesser frequency.

8-3.2 A visual inspection shall be made at least semiannually to ensure that each detector remains in good physical condition and that there are no changes that would affect detector performance, such as building modifications, occupancy hazards, and environmental effects.

8-3.3 Heat Detectors.

8-3.3.1 For nonrestorable spot-type detectors, after the fifteenth year, at least two detectors out of every hundred, or fraction thereof, shall be removed every five years and sent to a testing laboratory. The detectors that have been removed shall be replaced with new detectors. If a failure occurs on any of the detectors removed, additional detectors shall be removed and tested as a further check on the installation until there is proven to exist either a general problem involving faulty detectors or a localized problem involving one or two defective detectors.

8-3.3.2 For restorable heat detectors (except pneumatic line-type), one or more detectors on each signal-initiating circuit shall be tested at least semiannually and different detectors shall be selected for each test. Within five years, each detector shall have been tested.

8-3.3.3 All pneumatic line-type detectors shall be tested for leaks and proper operation at least semiannually.

8-3.3.4 Nonrestorable line-type fixed temperature detectors shall be tested for alarm function at least semiannually. The loop resistance shall be measured, recorded, and compared with that previously recorded. Any change in loop resistance shall be investigated.

APPENDIX E

Building Codes

The three major groups — the International Conference of Building Officials (ICBO), the Southern Building Code Congress International, Inc. (SBCCI), and the Building Officials and Code Administrators International (BOCA) — have developed national model building codes. The BOCA, the SBCCI, and the ICBO publish the National Building Code (NBC), the Standard Building Code (SBC), and the Uniform Building Code (UBC), respectively. Each code group is a consensus of building officials with a degree of uniformity among their model codes, although different regional and geographic needs are met by the different code groups.

Because of the high flammability of plastic foam insulation, the U.S. model building codes (shoreside) were modified in 1976 to limit the use of cellular plastic materials. The NBC, SBC, and UBC require that foam plastic insulation have a flame spread index of not more than 75 and a smoke development rating of not more than 450, when tested in accordance with ASTM E84. In addition, when used on room side surfaces, they either must be protected (covered) by a thermal barrier equal in fire resistance to ½-inch gypsum board, or they may be used only in buildings that have sprinkler systems.[1] Both requirements apply to foam more than 4 inches thick. The high flame spread rate of RPU foam is attributed to its relatively low decomposition temperature (about 325 ^{o}F) and high smoke emission rate (combustible gases).

In the 1960s and early 1970s, spray-on RPUs were advertised as self-extinguishing and nonflammable and were used extensively as thermal insulation in shoreside structures. In some instances, RPU foams were involved in fires during the construction phase.[2] RPU foam flammability and its associated hazards are best demonstrated by the full-scale room studies conducted by various investigators.

In a 1973 report by W.F. Marconi,[3] a room was completely lined with 1 ½-inch-thick RPU foam with a flame spread index of 200, when tested in accordance with ASTM E84. The wall and overhead lining were ignited from a source in the corner. The fire spread rates in this experiment exceeded the response capability of the automatic

[1]Model code provisions pertaining to foam plastics insulation. The Society of Plastics Industry, Inc., 1990.

[2]Paul, George H., Clougherty, Edward V., and Lathrop, James K., *Fire Journal*, "Federal Reserve Bank - Fire in Exposed Urethane Insulation in Building Under Construction," Boston, Massachusetts, July 1977, pp. 33-55.

[3]Marconi, W.F., *Fire Journal*, "Large-Scale Fire Tests of Rigid Cellular Plastic Wall and Roof Insulation," Boston, Massachusetts, November 1973, pp. 24-26.

sprinkler system. In a 1986 Swedish study,[4] a room was covered with various materials, including RPU foam, and ignition was initiated in the corner. The flash over[5] delay was measured, and the process took 6 seconds when the room was lined with RPU foam, compared with 157 seconds when lined with wood particle board.

[4]Sundstrom, B., *Full-Scale Fire Testing of Surface Materials*, Technical Report SP-RAPP 1986:45, Swedish National Testing Institute, Boras, 1986.

[5]Transition from a small fire to full-room involvement.

APPENDIX F

Conditions Reported by the SVFD Fire Chief that Affected ALASKA SPIRIT Firefighting

Absence of Forward Access Doors on the 02 Deck

The absence of such doors to accommodation areas limited the firefighters' ability to approach one side of the fire. Deeply seated fires in the master's room and the forward part of the 02 deck were not accessible during most of the incident due to intense heat.

Lack of Natural Ventilation in Accommodation Areas

In response to the high heat levels and volume of smoke, firefighters used blowers to exhaust heat and smoke from the 02 deck. Also, due to the limited firefighting access to the 02 deck, firefighters used power saws and sledge hammers to make holes in the steel bridge deck and forward bulkhead of the 02 deck. These openings immediately began releasing heat and smoke, which allowed the firefighters to introduce water down onto the fire from the bridge deck and permitted firefighter entry into the confined space.

Necessity of Frequent Firefighter Rotation

The fire chief rotated his crews to provide them respite from the intense heat and allow them to change SCBA bottles. Due to the narrowness of the corridor, the fire chief felt it was too hazardous to have two crews of firefighters in the accommodations area simultaneously. During the firefighting lull while crews rotated, the fire would advance down the corridor to the point of entry. Consequently, each crew had to rebattle the fire back to the point where the other had left it.

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APPENDIX G

Toxic Effects of Carboxyhemoglobin Saturation

The blood component hemoglobin normally carries oxygen from the lungs to the tissues. Hemoglobin, however, has a much greater affinity for carbon monoxide (CO) than for oxygen. When a person inhales air containing CO, the compound carboxyhemoglobin (COHb) is formed in the blood as CO occupies the positions on the hemoglobin molecule normally filled by oxygen. As indicated in table 1 (below), as the level of COHb saturation increases, the toxic effects become increasingly severe.

Table 1 — Toxic effects of Carboxyhemoglobin saturation

%COHb Saturation	Effect
10	Psychomotor and judgment inefficiencies
10-20	Exertional dyspnoea (shortness of breath)
20-30	Headaches
30-40	Nausea, dizziness, and muscular weakness
40-50	Syncope (loss of consciousness, fainting)
50-60	Convulsions
60-70	Coma
80	Rapid death

The time required for an exposed person to reach an incapacitating level of COHb saturation depends on the concentration of CO in the air. Fire-produced concentrations of CO in the air can range as high as 10 percent. Lower concentrations generally occur in well-ventilated fires. Higher concentrations occur in poorly ventilated fires, such as was the case during the early stages of the smoldering combustion in the assistant fish master's room.

Hill's report[1] tabulated COHb levels as functions of CO concentration in the air and exposure time. The length of time it would have taken for the master to reach an incapacitating level of COHb saturation cannot be precisely calculated, but a range can be derived (see table 2).

[1]Hill, I.R., *Aviation, Space, and Environmental Medicine*, "An Analysis of Factors Impeding Passenger Escape from Aircraft Fires," March 1990, pp. 261-265.

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Table 2 — Carboxyhemoglobin saturation as a function of exposure time and percentage of carbon monoxide in the air

% of CO in the air	% COHb Saturation			
	10 SECONDS	30 SECONDS	60 SECONDS	120 SECONDS
0.1	0.2	0.6	1.3	2.5
1	2.5	7.5	15.0	30.0
2	5.0	15.0	30.0	60.0
5	12.5	38.0	75.0	—
10	25.0	75.0	—	—

APPENDIX H

Master's Blood Alcohol Level

The blood alcohol concentration (BAC) of the master's blood sample was reported as 0.353 gm/dL by the Alaska Medical Examiner's Office and 0.360 gm/dL by the Center for Human Toxicology (CHT). The average can be expressed equivalently as 0.36 percent of alcohol by weight/volume. If the BAC was caused by ingested alcohol, the physiological effects in an individual who had not developed a tolerance for alcohol would have been "stupor, marked incoordination, and possibly coma."[1]

Upon receipt of the master's blood sample, the CHT staff observed that it did not appear to be whole blood and that the sample had hemolyzed due to decomposition. The CHT test found the sample's blood hemoglobin concentration to be 6.8 gm/dL, which is about 42 percent of that normally found in whole blood.

Literature on blood alcohol, forensic tests, and Government regulations on BAC levels all refer to concentrations in whole blood. Specimens from live individuals present no problem, but postmortem samples may have undergone extensive clotting. When some blood solids are absent because of clotting and sedimentation, the remaining fluid blood specimen will have a higher-than-normal water content.

Since testing detects alcohol in proportion to water content, the amount of alcohol found is also greater than it would be in a sample of whole blood. Such was likely the case with the master's blood sample, since the deputy fire marshal attending the autopsy noted difficulties in obtaining a fluid sample due to coagulation. Scientific literature[2] indicates that, in these circumstances, a whole blood sample's BAC might have been 10-20 percent lower than in the hemolyzed specimen.

Nevertheless, even if the master's whole blood BAC had been 10-20 percent lower than the detected value, the physiological effects of that level of ingested alcohol would still have been incapacitating. Consequently, the key question to consider is the origin of the alcohol. Was it ingested or was it a consequence of postmortem generation? Investigators found no evidence that the master had ingested alcohol on the day or evening before the fire, although that possibility cannot be conclusively discounted.

Investigators also considered the likelihood of postmortem alcohol generation — that is, alcohol generated by microbial action within the body after death. Confirmed

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[1]Freimuth, H.C., *Medicolegal Investigation of Death, 3rd ed*., W.U. Spitz (Ed.), "Forensic Aspects of Alcohol," Springfield, Illinois, 1993, pp. 767-775.

[2]Garriott, J., (Ed.), *Medicolegal Aspects of Alcohol Determination*, PSG Publishing, Littleton, Massachusetts, 1988.

postmortem alcohol levels in excess of 0.30 percent have been reported[3] and the condition can best be inferred by a positive finding of alcohol in blood, coupled with the absence of alcohol in urine and/or vitreous humor. Neither urine nor vitreous humor was available from the master's autopsy for cross-validation of the blood sample.

Postmortem generation of alcohol is likely to occur when a body has been exposed to elevated temperatures and time elapses between death and the collection of a test specimen. Such conditions were present in this case. Before being removed from the vessel, the deceased had been exposed to heightened temperatures (because of the fire) for more than 10 hours. Further, the hemolyzed condition of the blood sample noted by the CHT and the autopsy report's description of the body are both indicative of decomposition. In summary, the conditions were highly favorable for postmortem generation of alcohol.

[3]Canfield, D.V., Kupiec, T., and Huffine, E., *Journal of Forensic Sciences*, 38(4),"Postmortem Alcohol Production in Fatal Aircraft Accidents," 1993, pp. 914-917.