Investigation Report

SCANDINAVIAN SUN Cruise Ship Fire
Port of Miami, Florida
August 20, 1984

Prepared by

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In Cooperation with

Federal Emergency Management Agency/
United States Fire Administration

and

National Bureau of Standards/
Center for Fire Research

Revised December 11, 1985

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The non-profit technical and educational organization: To promote the science and improve the methods of fire protection and prevention; to obtain and circulate information on these subjects and to secure the co-operation of its members and the public in establishing proper safeguards against loss of life and property by fire.
This investigation was conducted by the National Fire Protection Association (NFPA) under an agreement with the Federal Emergency Management Agency/United States Fire Administration (FEMA/USFA) and the National Bureau of Standards/Center for Fire Research (NBS/CFR). The investigation was jointly funded by these agencies and the NFPA.

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ABSTRACT

On August 20, 1984, a fire onboard the cruise ship M/V SCANDINAVIAN SUN, while docking at the Port of Miami, resulted in two fatalities and fifty-seven injuries among passengers, crew and City of Miami fire fighters. The rapidly spreading fire forced many of the passengers, who were in the process of disembarking, to remain onboard until the fire was extinguished. The fatalities, one passenger and one crew member, were eventually found in their cabins during the search of the ship.

The fire was discovered just after the ship had completed docking. The fire, which originated in the auxiliary engine room, was caused by the ignition of atomized lubricating oil leaking from a diesel engine driving one of the ship's generators.

Products of combustion were able to extend vertically six decks above the main engine and auxiliary machine rooms by way of a ladder accessway and through an open passageway and watertight doors. Doors leading to passageways on several of the upper decks were also open during the initial stages of the fire which allowed dense smoke and heat to extend horizontally into crew and passenger cabin areas.

The spread of fire and heavy smoke conditions were mainly confined to the port side of the ship, although starboard portions of the cruise ship were also affected.

The following are considered to be major factors contributing to the loss of life in this fire:

- The failure to extinguish the fire in its incipient stage by either automatic or manual means.
- The rapid and intense flash fire resulting from the ignition of a combustible lubricating oil.

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• The rapid horizontal and vertical spread of products of combustion throughout the ship caused mainly by open fire doors.

• The presence of combustible interior finish materials in passageways and in the stairtower.
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I. INTRODUCTION

The National Fire Protection Association (NFPA) investigated the M/V SCANDINAVIAN SUN cruise ship fire in order to document and analyze significant factors that resulted in the loss of life.

This study was conducted under a major fires investigation agreement among the Federal Emergency Management Agency/United States Fire Administration (FEMA/USFA), the National Bureau of Standards/Center for Fire Research (NBS/CFR) and the NFPA. The agreement, funded by FEMA/USFA, NBS/CFR and NFPA, provides for the investigation of technically significant fires by NFPA's Fire Investigations and Applied Research Division to document and analyze incident details and report lessons learned for fire prevention purposes.

The NFPA became aware of the fire on the day following the occurrence. James R. Bell, Fire Analysis Specialist, traveled to the Port of Miami to document the facts related to the fire. A two-day on-site study and subsequent analysis were the basis for this report. Entry to the fire scene and data collection activities were made possible through the cooperation of the Miami Fire Department, the U.S. Coast Guard and the National Transportation Safety Board (NTSB). This report presents the findings of the NFPA data collection and analysis effort. Much of the information contained in this report is based upon U.S. Coast Guard findings presented in the "Report of the Research and Development Center Survey of 20 August 1984 Fire on the SCANDINAVIAN SUN," prepared by the U.S. Coast Guard, Research and Development Center, Groton, Connecticut.

This report is another of NFPA's studies of fires having particular educational or technical interest. The information presented is based on the best data available during the on-site data collection phase and further data acquired through subsequent follow-up. It is not NFPA's intention that this
report pass judgement on, or fix liability for, the loss of life and property on the SCANDINAVIAN SUN.

The cooperation and assistance of Chief Kenneth McCullough; Assistant Chief Dan Fabyan; Lieutenant J. C. Gilbert; and Investigators C. Weintraub and F. Odierno of the Miami Fire Department are acknowledged. Also the assistance of Commander Rene Roussel, Commanding Officer, Marine Safety Office, U.S. Coast Guard (Miami); Mr. Samuel F. Powell, Technical Director, U.S. Coast Guard Research and Development Center, Mr. Donald Kerlin, Marine Technical and Hazardous Materials Division, U.S. Coast Guard (Washington, D.C.); Mr. Leon Z. Katcharian and Dr. Merrit Birkey of the National Transportation Safety Board are also acknowledged and greatly appreciated.
II. BACKGROUND

The M/V SCANDINAVIAN SUN fire was the second major fire to occur on a cruise ship at a U.S. port city with six months.\(^1\) Although there were no fatalities, the first fire heavily damaged the M/V SCANDINAVIAN SEA and took fire fighters 40 hours to suppress. The SCANDINAVIAN SUN fire was also a difficult fire to control, caused by the rapid horizontal and vertical spread of products of combustion throughout the ship.

The Ship

The SCANDINAVIAN SUN provided daily cruises between the Port of Miami and Freeport, The Commonwealth of the Bahamas. The SCANDINAVIAN SUN was owned and operated by Scandinavian World Cruises. The ship was built in 1968 and had been refurbished in 1982. The cruise ship had an overall length of 442 feet and registered tonnage of 9,902 gross tons. The SCANDINAVIAN SUN was capable of carrying 1,177 passengers and a crew of 223. On the one-day cruise on August 20th, there were 537 passengers onboard with a crew of 201.

The SCANDINAVIAN SUN's port of registry was Nassau in The Commonwealth of the Bahamas. The Bahamian government is a party to the International Convention for the Safety of Life at Sea (SOLAS) 1974, a treaty which establishes minimum safety standards for ships.

Foreign passenger vessels that trade in the United States are required by law to comply with the SOLAS treaty. The SOLAS details specific measures, design features, and life safety arrangements that passenger vessels must meet. The vessel's flag state, in this case The Commonwealth of the Bahamas, is required to ensure that the vessel is designed, built, and continually maintained to those standards. The U. S. Coast Guard as part of its

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responsibility, conducts what are referred to as "control verification examinations" on a periodic basis. The U. S. Coast Guard inspection program is conducted to ensure continued maintenance of the SOLAS standards. If the vessel is in compliance with the certificate issued by the flag state, the U. S. Coast Guard issues a control verification certificate. Inspections by the U. S. Coast Guard do not take the place of the required flag state inspections, but are designed to supplement them. The U. S. Coast Guard made a "control verification examination" of the SCANDINAVIAN SUN on March 23, 1984, and re-issued a control verification certificate valid until January 11, 1985.

To meet the the SOLAS standards, ships are usually provided with a series of active and passive fire protection systems. Examples of active fire protection systems onboard ships include: fire detection and alarm systems, standpipe systems, portable fire extinguishers, and fixed fire extinguishing systems protecting specific high hazard areas.

The passive fire protection systems include the structural assemblies that are built into the ship. The passive system makes use of thermally insulated structural steel assemblies (bulkheads and decks) which are designed to retard the spread of fire from compartment to compartment and deck to deck for the time interval required to isolate and extinguish a fire or to allow for safe abandonment of the vessel. Horizontal separation is provided by fire-rated bulkheads which divide the decks into main vertical zones referred to as MVZs. SOLAS standards require these fire-rated bulkheads be spaced so as to limit the maximum length of a MVZ to 131 feet.

Support of both the active and passive fire protection systems in a fire situation is provided by the crew. Selected crew members are trained in shipboard fire fighting techniques which include the use of fire fighting
equipment, self-contained breathing apparatus (SCBA), and an understanding of
the role of the passive fire protection systems in containing and
extinguishing a fire.

**Construction Details**

The SCANDINAVIAN SUN had nine deck levels designated in the following
manner (See Figure 1):

<table>
<thead>
<tr>
<th>Deck</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main engine and auxiliary machine room</td>
</tr>
<tr>
<td>2</td>
<td>Tween Deck</td>
</tr>
<tr>
<td>3</td>
<td>Bimini Deck</td>
</tr>
<tr>
<td>4</td>
<td>Andros Deck</td>
</tr>
<tr>
<td>5</td>
<td>Nassau Deck</td>
</tr>
<tr>
<td>6</td>
<td>Bahamas Deck</td>
</tr>
<tr>
<td>7</td>
<td>Exuma Deck</td>
</tr>
<tr>
<td>8</td>
<td>Bridge Deck</td>
</tr>
<tr>
<td>9</td>
<td>Sun and Sports Deck</td>
</tr>
</tbody>
</table>

Decks 3 through 7 were joined by interior stair towers on both the
starboard and port side. Passageway configurations, doorways, cabins, utility
or service areas, and common areas varied per deck.

The third and fourth deck levels which each contained an auto and truck
bay for the ferrying of vehicles, ran longitudinally the full length of the
ship. Vehicles could directly access the bay through the stern of the ship
over portable steel ramps extended from the pier.

Interior passageway partitions and bulkheads were constructed of a
plastic-laminated mineral composition board on a steel plate set in steel
frames. Passageway doors at MVZs also consisted of plastic-laminated mineral
board on a steel plate installed in steel frames. Stateroom doors were
comprised of composition board covered with a plastic laminate.

Passageway ceilings consisted of light metal slats with multiple pinhole
sized perforations on steel suspensions. Electrical cables and wiring and
some utilities were located in the space between the suspended aluminum ceiling
and the deck plate above.
Upper decks were constructed of steel with various leveling compounds on the surfaces. Passageways and common areas were covered with various floor coverings, mainly carpet.

The main engine room and the auxiliary machinery room were two decks in height. Access to the auxiliary machinery room was through two watertight doors at either side of the compartment at the lowest level and through two ladders from the third deck level to the second deck level known as the Tween Deck. The Tween Deck was constructed using steel grate catwalks that extended around the perimeter of the main engine room.

A bulkhead provided separation between the main engine room and the auxiliary machinery room at the first and second deck levels. A ladder and hatchway from the main engine room joined the ladder and hatchway from the auxiliary machinery room in a small enclosed space on the third deck level to form the fidley.* The bulkhead between the two rooms at the base of the fidley was limited to a 36-inch high knee wall. This area was separated from the third deck port side passageway by a watertight door and a passageway fire door that formed a foyer space approximately 3 feet in depth.

The port side passageway ran both forward and aft from the point at which the main engine room/auxiliary machinery room hatchway joined the passageway. Door no. 8 leading to the car deck (Bimini Deck), was located within 5 feet of this intersection. The aft portion of the passageway led to the crew's quarters and the forward portion joined a port side stairtower which ran from the third to the seventh decks.

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*Fidley. Spacious trunkway above and opening into the boiler-room through which fireroom ventilators, escape ladders and, usually, uptakes to smoke stack are led; generally has one or more landings or decks, in addition to its weather covering, composed of iron gratings.
Both the passageway to the crew's quarters and the stairtower were provided with fire doors. At the time of the fire, the doors were determined to be in the open position.

Fire doors, providing horizontal and vertical fire separation throughout the ship, were retained in the open position by electromagnetic release mechanisms. The doors were provided not only at openings to the stairtowers but were present at locations within the passage ways on each level. To isolate sections of the ship during fire emergencies, each of these fire doors could have been released by a manually operated push button or released simultaneously throughout the ship from the bridge.

There were six sets of watertight doors which could be remotely operated from the bridge. In this incident, the auxiliary machinery room's forward and aft watertight doors were closed from the bridge and then reopened to allow for fire fighting operations.

Fire Protection Systems

Fire Detection System

There was a mixture of fire detection and alarm systems installed in the ship. A zoned heat detector system was provided with detectors located throughout most areas of the ship. Alarm zones registered on a fire alarm annunciator panel located on the bridge of the ship. In response to an alarm signal, an officer on the bridge could take action and, for example, release fire doors within the zone. The heat detectors were fusible link-type detectors which activated at approximately 167°F. The heat detection systems did not automatically sound alarms within the zone or release the fire doors within that alarm zone.

A smoke detection system, with ionization-type detectors, was located in the machinery spaces. In addition, a smoke detector system was located in the lower trailer hold area that was designed to be used in combination with a
manually operated carbon dioxide system. This system was also arranged to provide notification directly to the bridge. Since there was no fire involvement in the lower trailer hold area, the detection system was not activated.

**Carbon Dioxide Extinguishment System**

There were carbon dioxide extinguishing systems which protected the stabilizer room, separator room, lower trailer hold, machinery spaces and emergency generator room. All systems, except the lower trailer hold, could be manually activated from panels located in locked boxes on the Exuma Deck.

The carbon dioxide systems could be individually activated by first unlocking a panel box and then pulling a lever. For the machinery spaces, unlocking and opening the box automatically shut down the ventilation fans for the machinery spaces. The keys for the activation boxes were kept on the bridge and by the chief engineer. The CO$_2$ system contained fifty-five, 100-pound bottles of carbon dioxide extinguishment agent.

On the night of the fire, the chief engineer mistakenly activated the carbon dioxide system protecting the stabilizer room instead of the system for the machinery spaces.

**Sprinkler System**

An automatic sprinkler system protected the car deck storage portion of the Bimini Deck and Andros Deck. Since this area was not involved in the fire, the system was not activated.

**Weather Conditions**

At the time of the fire, the weather was mild, approximately 70°F, with high humidity and a slight breeze.
Public Protection

The City of Miami Department of Fire, Rescue, and Inspection Services protects the 34-square mile city. The City operates 12 stations with a total of 661 career fire fighters and 167 nonuniformed personnel. The Protection District includes over 22 miles of waterfront.

The Port of Miami, operated by the Metro-Dade County Port Authority, is located on a man-made island in the Biscayne Bay. The Port facility contains seven piers. The City of Miami provides fire and rescue services to the Port of Miami on a contract basis.
III. THE INCIDENT

Ignition Sequence and Discovery

The SCANDINAVIAN SUN returned to the Port of Miami from a day cruise to Freeport, Bahamas, and completed docking at 2255 hours. Passengers and crew members were preparing to disembark. At approximately 2256 hours, the second engineer passed through the auxiliary engine room and noticed oil spraying from the lubricating oil line to auxiliary engine #1. The second engineer then attempted to shut down the generator but during this process, ignition occurred.

At approximately 2259, the second engineer went to the control room, located on the Tween Deck, and sounded the fire alarm to the bridge and the officers' quarters. Since the ship had docked, no one was located on the bridge, but many of the officers heard the fire alarm from the engineering control room.

The second engineer along with others of the engine room staff, prepared a hose line and from 2301 to approximately 2308 hours, they attempted to fight the fire in the auxiliary engine room.

On the bridge, the following actions took place:

<table>
<thead>
<tr>
<th>Time</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2305</td>
<td>The captain is the first officer to return to the bridge.</td>
</tr>
<tr>
<td>2310</td>
<td>The captain notices that the following fire detectors have been activated on the fire alarm panel:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Fire Detection Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>Tween Deck - auxiliary engine room</td>
</tr>
<tr>
<td>33</td>
<td>Bimini Deck port aft</td>
</tr>
<tr>
<td>27</td>
<td>Car Deck - one system and alarm for whole deck</td>
</tr>
<tr>
<td>25</td>
<td>Andros Deck port aft</td>
</tr>
<tr>
<td>23</td>
<td>Andros Deck port center</td>
</tr>
<tr>
<td>19</td>
<td>Nassau Deck starboard aft</td>
</tr>
<tr>
<td>18</td>
<td>Nassau Deck port aft</td>
</tr>
<tr>
<td>17</td>
<td>Nassau Deck - lobby area</td>
</tr>
<tr>
<td>12</td>
<td>Bahamas Deck - Lucaya West Dining Room aft</td>
</tr>
<tr>
<td>8</td>
<td>Bahamas Deck - casino starboard forward</td>
</tr>
</tbody>
</table>

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Emergency fans for air conditioning were stopped.

Magnetic door holders are released to close fire doors throughout the ship.

Crew fire alarm sounded.

Abandon ship signal (7 short - 1 long) given over ship's bells.

Chief engineer asked bridge to close watertight doors to auxiliary engine room.

Announcement made twice, "Keep clear of watertight doors."

Watertight door controls closed on the bridge.
Fire Growth and Development

The fire apparently started when a threaded plug in the cooling line to one of the ships' auxiliary generators, fell out of its fitting. The lubricating oil\(^2\) sprayed from the 1/2-inch threaded hole, and began to collect on other surfaces including the overhead area of the auxiliary machine space. The broken cooling line supplied the diesel engine that drove the ship's #1 generator (800 kw). The pressure in the line was estimated to be 70 psi.

The 185-gallon oil reservoir connected to the line was normally kept full. Approximately 148 gallons remained in the reservoir after the fire. Approximately 37 gallons of oil were sprayed from the orifice. It was determined by U. S. Coast Guard investigators that the oil was spraying for 1/2 to 1 1/2 minutes.

The most probable source of ignition was determined by the U. S. Coast Guard to be the exhaust manifold to the #1 auxiliary engine. Although the exhaust manifold was insulated, there were some exposed metal surfaces. The chief engineer for the ship reported that exhaust manifold temperatures were typically between 842\(^\circ\)F-932\(^\circ\)F. Other possible sources of ignition include: a set of electrical contacts located in cabinets on the Tween Deck of the auxiliary machinery room, or an undetermined open flame or sparks in the auxiliary machine room.

Once ignition occurred, the engine room staff attempted to fight the fire with hose lines for several minutes without success. The engine room staff was forced to retreat from the auxiliary machinery room because of the intense fire. Because of the severity and in an attempt to isolate the fire, the

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\(^2\) Flash point 400\(^\circ\)F; ignition temperature 700\(^\circ\)F.
chief engineer requested to the bridge that the watertight door between the auxiliary machinery room and the main engine room be closed.

Once the lubricating oil spray had been ignited, the fire spread to other fuel sources, many of which had been coated by the deflected oil spray. The flames were prevented from entering the main engine room by the strong forced ventilation supplied to the main engine room. However, the forced ventilation of the machinery spaces provided an abundant supply of oxygen to the fire, resulting in an intense fire. These strong ventilation currents also provided the mechanism for the rapid movement of the products of combustion to adjacent areas of the ship (See Figures 2-4).

From the room of origin, the products of combustion moved to the port side of the Tween Deck headed upward, and then emerged from a forward escape ladder. The fire was able to extend into the fidley, a common space to both the auxiliary and main engine rooms.

At this point the smoke, heat and flames extended in two directions. Products of combustion were able to travel straight up the open vertical spaces in the fidley. Through this means the flames caused minor surface damage, consuming the accumulated dust and grease on the Fidley surfaces. The flames exited to the top of the fidley stack (seven decks above) and impinged on an electrical cable. The cable was part of the ship's emergency generator system. The damage to the cable resulted in the failure of the emergency electrical system.

The second avenue of spread was into the aft passageway of the Bimini Deck (See Figure 5). But to reach the Bimini Deck, the flames had to pass through two open doors that gave access to the auxiliary and main engine room areas. The inner door was a 4-dog watertight door which required manual closing. The outer door opening was a fire door that was equipped with a self-closer.
Post-fire examination of the flame patterns indicated that both doors were in an open position during the fire. U. S. Coast Guard investigators determined that the doors were propped open to facilitate some equipment movement.

Once the fire reached the Bimini Deck, it traveled in two directions. The fire moved aft in the passageway to the crew's quarters and forward to the base of a stairtower on the port side of the ship.

The fire that went aft passed by door no. 8 (the sliding door leading to the Car Deck) which was not fully closed. Located in the passageway just beyond door no. 8 was a fire door through which access to the crew's quarters was gained. This fire door was determined to be latched in the open position. As a result, the fire was able to progress down the passageway and did considerable damage to the overhead and upper portion of the plastic laminate veneer on the bulkheads. However, the fire did not enter the staterooms located on the port side of the passageway. The fire that spread forward to the port side stairtower did considerable damage to the area. From the base of the stairtower, the fire extended up to the Andros Deck (See Figure 6). The fire was able to extend into the passageway on this level and moved forward in the ship. Fire movement aft, at this level appears to have been limited by a closed fire door. There was no flame damage in the staterooms on the port side of this passageway although heavy soot deposits indicated that smoke penetrated into the staterooms.

The fire continued to extend up the port side stairtower to the Nassau Deck (See Figure 7). The Nassau Deck marked the extent of the flame damage. The aft portion of the stairtower was severely damaged. In the forward portion of the stairtower damage was limited to the heat and smoke effects on the interior finish materials.
On the Nassau Deck, smoke moved into the lobby area through the open double-leaf fire doors. Although delayed, the closing of the double leaf fire doors in the corridor leading to the lobby by the crew limited damage outside of the port staitower.

Smoke and heat continued up the staitower to the Bahamas Deck (See Figure 8). Bulkheads at this level had blistered causing partial delamination of the wall finish material. The heat and smoke were stopped by a closed door at the aft end of the staitower on the Bahamas Deck.

Heat and smoke continued up the staitower to the Exuma Deck and then extended aft through a short passageway into the Hideaway Lounge (See Figure 9). Heat in the Lounge was sufficient to melt synthetic plants at its port and starboard entrances.

The smoke and heat continued to move forward from the starboard side of the Hideaway Lounge through open doors and then moved down an open staitower to the Bahamas Deck. The products of combustion then moved up two decks by way of a spiral staitower. When they reached the Bridge Deck above the spiral stair, there was sufficient heat to activate the 168°F heat detector located above the staitower.

As the captain had noted from the fire alarm zone indicators on the bridge fire alarm annunciator panel, the movement of the products of combustion was sufficient to activate detectors along the circuitous route noted above in 13 minutes.

Smoke Spread by the Ventilation System

Smoke was also able to spread throughout much of the upper portions of the ship by the heating, ventilation and air conditioning (HVAC) systems. Soot deposits were found throughout the ship on ventilator screens and on one of the ventilation exhaust louvers located port side aft on the Sun and Sports Deck. However, the extent of smoke through the HVAC was not determined.
Passenger Evacuation

After the ship had docked, passengers were gathering in the lobby on the Nassau Deck to take the gangway into the terminal. Passengers were already in the process of disembarking when products of combustion entered the lobby on the Nassau Deck through the open double-leaf doors leading to the port side passenger stairtower. Passengers not on the gangway reportedly started pushing and yelling for those on the gangway to move forward.

At the direction of the ship's purser, crew members manually closed the four sets of fire doors on the perimeter of the lobby. Since the lobby had filled with heavy smoke, the purser led the passengers remaining onboard to the forward deck.

Passengers gathered on the forward deck were reportedly apprehensive. As a result, evacuation of passengers was started over a fire department aerial ladder. Approximately 75 passengers were evacuated over the aerial ladder before conditions aboard the ship were thought safe enough for the ship's crew to lead passengers to safety through passageways and stairways at the stern of the ship.

Indicative of other passenger actions were the members of a church youth group and their chaperones who returned to their fourth deck (Andros Deck) stateroom to prepare to disembark. While in their stateroom, a wisp of dark smoke entered the room through the crack around the door. Once alerted to the fire, the group entered the passageway and turned toward the bow of the ship and started running down the corridor. During their evacuation, it was reported that the smoke appeared to fill the corridor in 5 to 10 seconds. Although conditions were quickly deteriorating, the group made it to the forward port stairtower and eventually to the deck above. They remained on the forward deck until guided off the ship several hours later.
It was not until they had been reunited with the other members of the group on the pier that it was realized that one of the chaperones who had been with them in the stateroom, was missing.

Fire Fighting and Rescue

Crew at Bimini Deck (Door No. 8)

The ship's crew noticed the fire at the partially closed door no. 8 leading to the car deck. The crew started to cool the door with water from a standpipe hose line. After a second hose line was pulled, the crew proceeded to attack the fire through door no. 8. The fire in the aft corridor was reported to have been extinguished quickly by the ship's fire crew. In an initial search of rooms in the area, the crew heard someone pounding on a cabin room door. A member of the crew was located in Room 236 and was removed from the area.

City of Miami Fire Department

The City of Miami Fire Department received a telephone call reporting a fire aboard the SCANDINAVIAN SUN at 2317 hours. The initial call was placed from a pay phone located in the customs building. The initial assignment included 4 engines, 2 aerials, a rescue vehicle and a district chief.

As the Miami Fire Department units on the first assignment arrived at the pier at 2321 hours, moderate to heavy smoke was seen coming from midship and from the stack and upper deck areas. The members of the first units also observed passengers gathering and being directed to the forward deck at the bow of the ship.

The ship's security personnel informed the district chief that passengers were being overcome by smoke on the Nassau Deck Lobby. The district chief directed that a ladder be raised to the gangway and hose lines advanced into the Nassau Deck lobby. A search of the Nassau Deck Lobby, however, found no passengers overcome from the smoke.
One aerial truck was positioned at the stern of the ship for fire fighting, if it became necessary. A second aerial was positioned near the bow of the ship with the aerial raised to the forward deck. Due to the unsafe angle of the ladder to the railing of the ship, only one aerial ladder was used. Seventy-five passengers were assisted down the ladder by fire fighters. As smoke began to clear in upper passageways, the remaining passengers were directed to the port side of the ship and taken to the ground.

The district chief set up a command post on the pier outside of the customs building. The captain of the ship came to the command post and assisted fire department personnel. Ship's officers and crew members were assigned to guide and assist the fire department personnel.

Fire Fighting by Fire Department Personnel

In order to attack the fire located midship, the engine company crew entered the ship through the starboard pilot door. They pulled two 1 3/4-inch hand lines, crossed the car deck and attacked the fire in the port aft passageway through door no. 8. The engine company crew reported that they reached the base of the stairtower but were driven back by the intensity of the fire.

The engine crew was then advised that the fire was located in the engine room. They pulled their line back and proceeded down the starboard ladder to the main engine room. With other engine company crew, they attacked the fire in the auxiliary engine room after first being delayed by the closed watertight door.

Upon entry into the auxiliary engine room, they reported that there was little residual fire evident. Fire fighting in this area was limited to the extinguishment of a small fire in combustible material located at the ceiling level.

Fire fighters then returned to the Bimini Deck and reattacked the fire in the port side passenger stairtower through door no. 8. This time they
advanced on the fire and reached the Andros Deck at the foot of the stairs leading to the Nassau Deck. As they made their attack, the low air alarm on the SCBA of one of the fire fighters sounded. According to operating procedures, if one fire fighter is forced to withdraw, the entire crew will withdraw together. They tied off a hose line to the stairtower railing with the fog nozzle in the open position, directing water vertically up the stairtower. The relief crew was able to extend the line to the Exuma Deck to complete extinguishment of the fire.

Fatalities

Shortly before 0200 hours, the Command Post was advised that a check of the passengers revealed that a female passenger had been reported missing. Repeated searches of the cabin area on the Andros Deck as well as other parts of the ship were conducted at 0200, 0220, and 0400 hours. Although room 440 had been searched by teams of ship's crew and fire department personnel, the body of the missing female passenger was not located until 1300 hours the next day. The configuration of the bathroom area, the passenger's small stature, heavy soot conditions, and darkness contributed to the difficulty of the search teams locating the victim.

Just minutes before her body was located, the body of a crew member, not previously reported missing, was found in his cabin located in a port side cabin on the Bimini Deck, four cabins aft of the cabin from which the crew member was rescued during the fire.

Fire Damage

Damage to the SCANDINAVIAN SUN was reported to be estimated at approximately 2.3 million dollars. The fire caused little damage on the lower levels of the auxiliary machinery room but caused considerably more damage on the Tween Deck level. Products of combustion moved throughout the remaining portions of the ship consuming the plastic laminate material mostly on the lower levels.
IV. ANALYSIS

Discussion

The fire originated in the auxiliary machine room adjoining the main engine room. The type and amount of the initial fuel contributed to an intense buildup of fire in the upper spaces of the auxiliary machinery room. The expulsion of the lubricating oil under pressure most likely contributed to the distribution, atomization, and splattering of the fuel throughout much of the port side of the auxiliary machinery room space, especially at the Tween Deck level.

The intensity of the lubricating oil-fed fire created thermal convection currents which rapidly extended the fire vertically into the base of the fidley and into the port side aft passageway. In addition, the strong convection currents, caused from the forced ventilation of the machinery spaces, added to the rapid vertical extension of the fire to adjoining areas of the ship.

Although the fire was seen by engineering staff at the ignition, efforts of the staff to control or extinguish the fire in the early moments of the fire were ineffective. Considering the intensity of the fire at this stage of its growth, an automatic fire suppression system such as automatic sprinklers, would likely have been the only effective means to control the fire.

Products of combustion were able to rapidly extend to the decks above the main engine and auxiliary machine rooms by way of escape ladder access hatches to the fidley, and through a passageway fire door and a watertight door that were blocked opened. The fire was also able to enter the third deck port side passageway and subsequently the port side passenger stairtower through fire doors held in the open position by electromagnetic door-release devices. Doors to passageways on the upper decks were similarly open during the initial stages of the fire which allowed smoke and heat to extend into the
passageways and common areas on the upper decks. In this incident, the manual activation of the master control for the fire door electromagnetic releases did not occur until 2312 hours, approximately 15 minutes after the beginning of the fire.

If fire doors were arranged to automatically close upon the activation of a detection device with a fire zone, (or other similar arrangement that would achieve isolation), the spread of fire would have been greatly limited. In this incident, their activation depended upon an action from the bridge. Response from the bridge most likely came after the products of combustion had moved into adjoining areas of the ship.

The fire alarm signal lights indicated zones where products of combustion were able to travel rapidly through the aft and central portions of the ship. By 2310 hours, 14 minutes into the fire, the light array on the bridge fire alarm annunciator panel indicated that products of combustion had traveled through the communicating stairtowers, passageways, and common areas.

Once the products of combustion from the fire in the auxiliary machine room entered the Bimini Deck aft passageway, the interior finish materials in the passageway began to burn. The intense fire caused the plastic laminate veneer to delaminate and burn. The subsequent burning of the plastic laminate panels was responsible for both the continued and rapid propagation of the fire and for the production of dense smoke which was distributed throughout most of the ship.

**Summary**

It is fortunate that this fire occurred upon arrival of the ship at the Port of Miami. Most passengers had left their staterooms and were already disembarking or on the Nassau Deck awaiting to disembark. Given the speed at which products of combustion were able to move through the central and aft portions of the ship, and the delay in compartmenting portions of the ship,
had this fire occurred when passengers were still in staterooms, the loss of
life could have been of much greater magnitude.

The ship's officers and crew, following shipboard emergency plans for fire
fighting, isolation, and search and rescue, were able to take action which
helped to mitigate the impact of the fire and the rapidly spreading smoke. In
particular, ship's officers and crew responded rapidly to move passengers to
the forward deck.

Although the crew members made concerted efforts to attack the fire, the
magnitude and location of the fire in the port side stairtower and
communicating passageways would have probably been beyond the best efforts of
the crew with limited protective equipment and breathing apparatus.

Without the availability of the City of Miami Fire Department to provide
the manpower, equipment, and resources to make an aggressive interior attack,
it is also likely that the vessel would have sustained substantially greater
fire damage.

The U. S. Coast Guard noted in their report of the incident that the Miami
Fire Department appeared to have done an excellent job in suppressing the
fire. The U. S. Coast Guard and the Miami Fire Department attribute the
success to fire department's personnel being familiar with a ship's
configuration, etc., through participation with the U. S. Coast Guard in
control verifications of many ships in the port.

The following are considered to be major factors contributing to the loss
of life in this fire:

- The failure to extinguish the fire in its incipient stage by either
  automatic or manual means.
- The rapid and intense flash fire resulting from the ignition of a
  combustible lubricating oil.
- The rapid horizontal and vertical spread of products of combustion
  throughout the ship caused mainly by open fire doors.
- The presence of combustible interior finish materials in passageways
  and in the stairtower.
APPENDICES
FIGURE 1: SCANDINAVIAN SUN
Section on Center Liner

Built 1968
L.O.A. 442 ft.
Gross Tonnage 9902 tons

<table>
<thead>
<tr>
<th>Area of Origin</th>
<th>Fire Spread</th>
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<table>
<thead>
<tr>
<th></th>
<th>Maximum</th>
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<tbody>
<tr>
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<td>223</td>
<td>201</td>
</tr>
<tr>
<td>Passengers</td>
<td>1177</td>
<td>537</td>
</tr>
</tbody>
</table>

20 Aug
FIGURE 2: SCANDINAVIAN SUN
Section on Center Liner

9. Sun and Sports Deck
8. Bridge Deck
7. Exuma Deck
6. Bahamas Deck
5. Nassau Deck
4. Andros Deck
3. Bimini Deck
2. Tween Deck

Aux. Mach. Room
Main Engine Room

X Area of Origin
Fire Spread
Smoke Spread
FIGURE 3: ENGINE SPACES
PHOTO 1: Lubricating oil was detected spraying from a cooling line to one of the ship's generators.
PHOTO 2: An open watertight door and fire door allowed products of combustion to extend into crew and passenger areas.
PHOTO 3: The fire spread vertically through stairtower openings.
PHOTO 4: Combustible wall finish material contributed to the spread of the fire throughout the chimney.