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Special passenger vessel issue

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Covers

(Front) - Queen Mary, the grand old transatlantic liner, was launched in 1934 and decommissioned in 1967. The ship is now a maritime museum and hotel complex in Long Beach, California.

(Rear inside) - Queen Mary arrives in New York in 1937.

Introduction

RADM Joel D. Sipes

Safety of life at sea is a traditional, longstanding, even sacred mission of the United States Coast Guard. The fulfillment of that mission takes many forms, the most important of which is prevention, and then, in the event of an accident, the preservation of life.

Historically, passenger vessel safety has been a matter of great concern to the United States, and to the Coast Guard in particular, since the time of the great luxury passenger liners.

Recently, there has evolved what I will characterize as a seagoing leisure trade. Cruise passenger ships operating from United States ports have brought with them a new set of problems with which to deal.

Most cruise ships are properly manned and maintained because of a positive and constructive attitude on the part of management. Even so, problems do occur.

Typical among them are a rebirth of older ships, some ill-managed and poorly maintained; crews not properly prepared to deal with life-threatening emergencies; insufficient safety briefings to passengers; and, all too often, a general commitment by management to economics before passenger safety.

This is not to say that United States passengers should avoid this form of recreation. Instead, it is to remind them that going to sea has inherent risks to begin with, and that such problems could raise that risk unacceptably.

The responsibility for continued passenger vessel safety is shared under international arrangements by ship owners and operators, the crews of ships, and the administrations of flag states and port states.

The United States is primarily a port state and a world leader in assuring the safety of cruise vessels. United States passengers make up the vast majority of persons worldwide who take advantage of this unparalled form of leisure activity.

RADM Joel D. Sipes

Passenger cruise vessels generally have a good safety record. They provide an unequaled opportunity for enjoyment. Also they allow individuals to gain a unique appreciation for the sea, its mystique and power.

There have been unfortunate casualties involving cruise passenger ships in the last decade, but always the safety of passengers has been the paramount consideration.

I thought it would be helpful to dedicate an entire issue of *Proceedings* to the topic of passenger cruise ships. My hope is that this issue will reinforce the attention to detail given to passenger safety. Also, I want to provide a special insight into how the international system works and the role of the United States Coast Guard in that system.

As a reader, you will see that cruise ship safety has come a long way over the years. Also, you will conclude that safety of life at sea is an evolutionary process and that more work can still be done to prevent casualties.

RADM Joel D. Sipes is Chief of the Coast Guard's Office of Marine Safety, Security and Environmental Protection.

Evolution of the modern cruise liner

S.M. Payne

This article has been excerpted from a technical paper of the Royal Institution of Naval Architects published in the Naval Architect Journal in May 1990.

History

The early years

The idea of passengers embarking on a sea trip for pleasure was first promoted by Arthur Anderson, one of the founders of the Peninsular and Oriental Steam Navigation Company in 1835. Formed in 1837, the P & O offered its first "cruises" to the Mediterranean in 1844.

These were not cruises in the modern sense, but normal commercial voyages of cargo and passengers with sightseeing arrangements provided for passengers booked as "cruisers" at ports of call. A complete cruise entailed travelling on several ships on different legs of a circumnavigation of the Mediterranean.

In 1889, the Orient Line, in association with the Pacific Steam Navigation Company, became the first regular line operator to offer a true cruising program. The vessels ***Chimborazo*** and ***Garonne*** were sent on seasonal cruises to the Norwegian Fjords. Four years later, nine summer Mediterranean cruise voyages were undertaken.

A third vessel, ***Lusitania,*** was detailed in 1895 to a 60-day luxury cruise to the West Indies, Madeira, Tenerife and Azores.

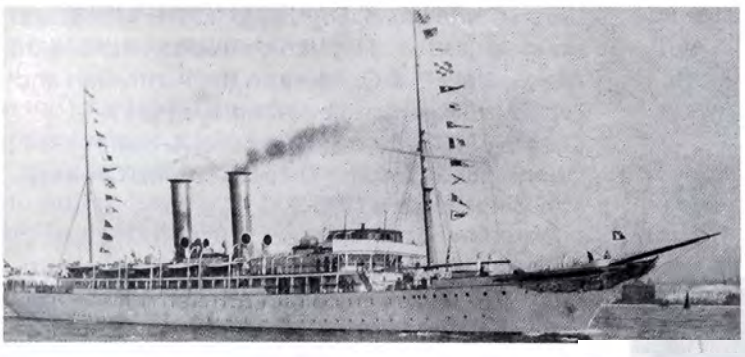
The three ships were roughly the same size at approximately 3,860 tons and 304 feet in length. Like all other vessels operating cruises at the time, these ships retained their ordinary line voyage accommodations without any added attractions, such as swimming pools, sports decks and posh lounges.

Of all the early companies engaged in cruise services, the Hamburg America Line offered the most exclusive voyages. In the winter of 1891, the 7,000-ton ***Augusta Victoria*** cruised the Mediterranean.

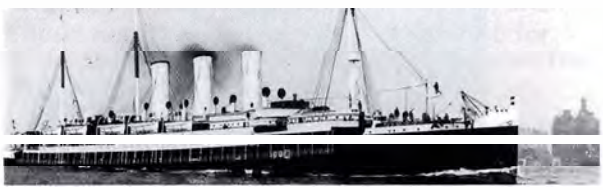
In January 1901, the Hamburg America Line commissioned the world's first liner built for cruise service, the two-funnelled luxury yacht *Prinzessin Victoria Luise*. Measuring 446 feet in length with a gross tonnage of 4,409, the ship had exclusive accommodations for 200 passengers and a private suite for the German Kaiser. Unfortunately, *Prinzessin Victoria Luise* was wrecked after being stranded on an uncharted reef off Jamaica in 1906.

In 1911, the magnificent four-funnelled, 16,700-ton steamer *Victoria Luise* emerged as the largest of the early cruise liners. Originally the ***Deutschland,*** the ship entered service in 1900 as an express liner on the Atlantic. Even though it once set a record for the fastest Atlantic crossing, its high operating costs convinced Hamburg America that the largest profits lay in ships of great size and modest speed.

Launched in 1871, Lusitania arrives in New York in 1907.



(left) Prinzessin Victoria Luise, the first steamer built for cruising and (below) Augusta Victoria outbound off New York around 1890.



Deutschland was withdrawn from the Atlantic and refurbished for continuous cruise service as *Victoria Luise*. The engine rooms were cut down and passsenger accommodations renovated to cater to 487 first-class passengers.

Victoria Luise survived World War I, but in poor condition. The ship spent its last years as an emigrant carrier and was scrapped in 1925.

The Thirties

There wasn't a great deal of cruising after World War I. The loss of many vessels and the high cost of replacements halted most cruise activities.

One exception was the Royal Mail's second *Arcadian,* which was converted from the war-damaged 12,002-ton *Asturias,* which entered service in 1908. The conversion included the installation of a tiled swimming pool, and a supply of hot and cold water to each cabin. *Arcadian* was in constant demand for charter work for 12 years, gaining a fine reputation as a British cruise liner.

The introduction of *Stella Polaris* in 1927 heralded the dawn of a new era in ultra-luxury cruising. Similar in concept to *Prinzessin Victoria Luise,* the 5,209-ton *Stella Polaris* was a large yacht accommodating 165 passengers. The ship had an ornate, scrolled clipper bow, twin masts, one buff funnel and a white hull. In the winter, it usually sailed around the world for more than 100 days, and, in the summer, cruised the fjords and Nordic countries.

Blue Star Line's *Arandora Star* was the most luxurious of the larger continuously operating cruise liners. Known as the "queen of cruising liners," *Arandora Star* started service with line voyages to South America in 1927.

Two years later, *Arandora Star* was redesigned for cruising with three former refrigerated cargo holds converted into passenger spaces. New public rooms including a ball room, garden lounge and gymnasium were added, and a swimming pool and sports deck were installed. All this cost the princely sum of 200,000 pounds.

In 1932, more than 100,000 Britons spent their holidays afloat, taking some 200 cruises on luxury liners from British ports. At this time, a two-week cruise would cost from 12 pounds for tourist rates and 21 pounds first class on an Orient Line ship to the Mediterranean.

The depression hit passenger ships hard in the 1930s, and many famous vessels were pressed into cruise service to keep them in operation.

For example, the Cunard Atlantic express fleet, *Mauretania* (1907), *Aquitania* (1914) and *Berengaria* (1912), normally remained tied up at New York for six days between voyages. However, the need to generate income was so acute that they were sent on "booze cruises" to the Caribbean between Atlantic crossings. These four-day excersions, which cost as low as $50, marked the beginning of popular cruising.

After World War II

As did the first World War, World War II severely disrupted passenger shipping. Several notable cruise liners, including the 42,348-ton *Empress of*

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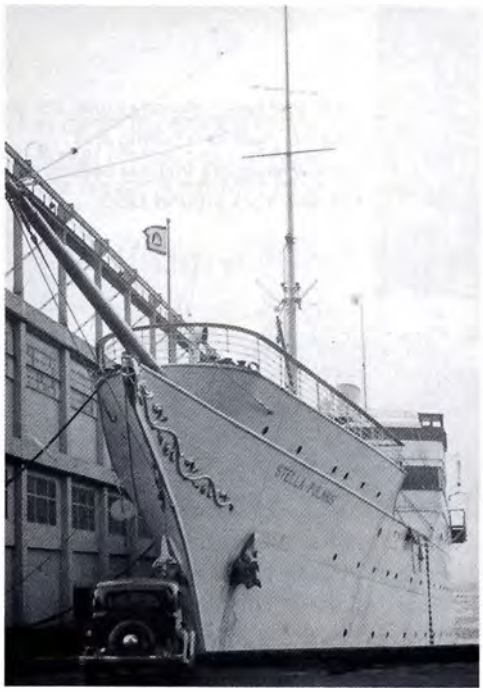

Stella Polaris (1927), one of the first luxury cruise ships, docks in New York.

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Britain, were lost during the conflict. And once again, the demands of liner shipping reduced the number of ships available for cruises.

In 1948, Cunard took delivery of the 34,172-ton *Caronia*, which was designed for luxury cruises, with full air conditioning, outdoor pool and private baths in every cabin. Distinctively painted in four shades of green, Cunard's first permanent cruise liner was dubbed the "green goddess." Crew members called the vessel, "God's waiting room," because of the many elderly passengers, some of whom were permanent residents.

Regarded as the epitome of postwar cruising luxury, *Caronia* initially operated at considerable profit. However, the ship's large size, low passenger density (600 maximum with 640 crew members), high fuel bills and escalating operating costs caused it to slip into the red in the early 1960s. *Caronia* was sold for scrap in 1974.

The majority of vessels built after World War II were for line voyage routes. Many new large ships entered service, including the 28,705-ton Union Castle liners, *Edinburgh Castle* (1948) and *Pretoria Castle* (1949), which traded with South Africa. New P. & O. liners on the Australian and Far East routes included *Himalaya* (1949), *Chusan* (1950), *Iberia* (1954) and *Arcadia* (1954). Orient line ships were *Orcades* (1948), *Oronsay* (1951) and *Orsova* (1954).

As ships that survived the war were retired in the late 1950s, larger vessels joined the liner fleets. Union Castle took on *Pendennis Castle* (1958 - 28,582 tons), *Windsor Castle* (1960 - 37,640 tons) and *Transvaal Castle* (1961 - 32,697 tons). P.& O. added *Canberra* (1961 - 45,773 tons) and the Orient Line, *Oriana* (1960 - 41,923 tons).

Significantly, all these ships depended on cargo as well as passengers for survival, each having considerable stowage space.

Despite the threat of increasing competition from the air, new flagships were pressed into service on the North Atlantic from 1952 through 1969. There were more nationalistic flagships than company flagships on this route with *United States, Rotterdam, Bremen, France, Michelangelo/Raffaello* and *Queen Elizabeth II.*

Entering service in May 1969, *Queen Elizabeth II* was proclaimed, "the last of the superliners," with the widespread expectation that nothing approaching its size would ever be built again.

The Sixties

The first winds of change occurred on the South Atlantic. The British flagships *Reina del Mar* (1956) and *Andes* (1939) were redeployed from their South American routes and adapted for cruising in the early 1960s. The mainstay of British luxury cruising in the decade, the two ships catered to 500 first class and 1,026 one class tourist passengers.

As air competition increased during the 1960s, many liners were dispatched on cruises. Well-known companies including French, Furness, Greek, Holland America and American Export lines featured mostly single-departure cruises.

However, the Eastern Steamship Company offered a choice of three-, four- and seven-day Bahamas and Caribbean cruises on *Bahama Star*

(1931) and *Ariadne* (1951). These excursions operated year-round from the port of Miami.

In the late 1950s, the postwar P. & O. and Orient liners were upgraded with full air conditioning, stabilizers and, in some cases, more private plumbing. Several ships were recast for one class tourist operation instead of the first and tourist classes by adding extra berths in first class cabins. It was hoped that these alterations would enable the ships to compete with air transportation on round-the-world routes.

Once begun, the decline of ocean travel was rapid. During the late 1960s and early 1970s, almost all line voyage routes ceased to be profitable. Many ships were sold for scrap, while a few turned to cruising.

The last continuous line voyage operation, Union Castle/Safmarine's Cape Mail Run, ended in 1977 with the sale of the *Windsor Castle* and *S.A. Vaal*.

Modern cruise ships

Home Line's *Oceanic* (1965) can be considered as the first "modern" cruise liner by default. Designed for line voyages between Cuxhaven and New York, the vessel instead entered service as a full-time cruise ship, sailing from New York to Bermuda and the Bahamas. An attraction of *Oceanic* was an extensive lido deck amidships with a Magrodome roof, which could be open or closed depending on the weather.

The first "new generation" cruise ship, however, was the Norwegian Caribbean Cruise Line's *Sunward* (1966). The ship started out as a car ferry/cruise vessel sailing from Southampton to Gibraltar for Klosters Sunward Ferries. This was not a successful undertaking.

About a year later, *Sunward* enjoyed nearly instant success running three- and four-day cruises from Miami to Nassau with accommodations for 554 passengers.

Three new ships were quickly built and put into service: *Starward* (1968), *Skyward* (1969) and *Southward* (1971). To satisfy the demand for cruise berths, the 70,000-ton *Norway* joined the Norwegian Caribbean Line fleet in 1980.

The Norwegians realized the great potential of cruising quickly, and, in the early 1970s, two new cruise lines were formed: Royal Caribbean and Royal Viking.

Royal Caribbean Cruise Line initially ordered three 18,500-ton ships from the Wartsila Helsinki shipyard. In the early 1970s, *Song of Norway*, *Nordic Prince* and *Sun Viking* were delivered and put in continuous service with the same itinerary throughout the year.

The popularity of these three ships brought about a demand for more berths. Consequently, in 1978 and 1980, *Song of Norway* and *Nordic Prince* were lengthened to accommodate a 40-percent increase in capacity.

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The deluxe liner, Empress of Britain (1931) was the largest allied liner lost during World War II (above right its elegant Mayfair Lounge).

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Catapulting demand necessitated a new larger ship rather than similarly jumboizing the remaining vessel. In 1982, 37,584-ton *Song of Norway* was delivered, followed by 74,000-ton *Sovereign of the Seas* in 1988.

While the Royal Caribbean Cruise Line catered to the upper end of the mass market, the Royal Viking Line appealed to the more exclusive upper market with three 21,800-ton ships delivered from Wartsila in 1972 and 1973. *Royal Viking Star, Royal Viking Sky* and *Royal Viking Sea* accommodated 536 as against 725 passengers on the Royal Caribbean ships.

Popularity again necessitated jumboizing all three ships to 28,220 tons in the early 1980s. In 1988, 40,000-ton *Royal Viking Sun emerged.*

Carnival Cruise Lines joined the Norwegian and Royal Caribbean lines in major mass market operations in 1972 with the former Canadian Pacific transatlantic liner *Empress of Canada* (1961), renamed *Mardi Gras.*

The Carnival ship prospered with a "non-union" crew, a "flag of convenience" registry and an oversize casino. It was joined in 1975 by an old running mate, *Empress of Britain* (1956). Renamed *Carnivale,* the vessel brought added prosperity to the line since shore costs could be spread over the running of two ships.

Festivale, the former *Transvaal Castle* (1961) joined the fleet in 1978, followed by five new vessels: *Tropicale* (1980), *Holiday* (1985), *Jubilee* (1986), *Celebration* (1987) and *Fantasy* (1989). Two more 70,000-ton ships are on order with Wartsila: *Ecstasy* and *Sensation.*

Innovations

Promenades

The traditional passenger ship arrangement of public rooms occupying longitudinal center-line positions on one deck required promenades for access. On multi-class ships, such an arrangement usually was reserved for first class spaces only. Other classes made do with public rooms scattered where they would fit without any need for promenades.

Promenades were fully enclosed with glazed windows, partially enclosed with and without windows, or open with either bulwark or railing. Initially, the choice depended on the route.

On the Atlantic ships, such as *Aquitania* and other Cunard Line ships, the promenades were either fully or partially enclosed to protect passengers from the elements. Warm-weather boats, on the other hand, such as those of Union Castle and P. & O., provided open promenades.

The long narrow spaces were also used for relaxation with rows of seats and deck chairs, providing vantage points for the perennial shipboard activity of watching the sea.

Although primarily a warm-weather cruise ship, Cunard's *Caronia* had enclosed port and starboard promenades to contain air conditioning, a practice followed by most cruise ships.

The idea of using promenades for more than just thoroughfares was extended with the introduction of Carnival Cruise Line's *Holiday* in 1985.

Rather than having two promenades of relatively narrow width, one double-width promenade was placed on the starboard side. This shifted the public rooms against the shell on the port side, allowing for windows to overlook the sea and provide natural daylight. Named "Broadway," the promenade had a snack/refreshment bar and a street side cafe.

A number of new ships, such as *Seaward,* have traditional promenades, but some vessels have dispensed with them altogether. For example, passage on *Crown Odyssey* is through the casino.

Public rooms

The elimination of multi-class accommodations did away with duplication of facilities. Traditional rooms such as smoking and drawing rooms became multi-purpose lounges.

One of the greatest changes has been the relocation of restaurants to the upper decks. Traditionally, restaurants on line voyage ships were located low down in the vessel with visable or screened portholes providing negligible natural light and no view. On new cruise liners, restaurants are high up on the ship's structure

with oversize windows providing full natural light and wonderful views of the sea.

Unfortunately, forward facing observation lounges are no longer a part of new cruise ships. (In its original form, *Queen Elizabeth II* had an observation lounge, but it was soon removed to make room for a galley extension.)

Many new ships are constructed with sharply angled bridge front superstructures, forming low head-room space which is difficult to use. Newer Carnival cruise liners use this prime lookout space for air conditioning equipment or as changing rooms for entertainers. Devoid of windows, the superstructure fronts have a slab-like appearance.

Royal Caribbean Cruise Line ships have unique observation lounges located half way up the funnel structure, providing an unparalled observation platform, a sales gimmick and an unmistakable corporate image. The first three Royal Caribbean ships had cantilevered lounges aft, with access limited to an exterior stairway. *Song of America* (1984) and *Sovereign of the Seas* (1988) each have wrap-around 360-degree lounges with lifts and internal stairways.

Some modern passenger ships have dispensed with traditional accommodation layouts of full length public rooms above cabin decks. They have adopted modern car ferry practice in grouping public rooms aft on top of each other.

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Public rooms
Yesterday -- Today

(left) First class Palladian Lounge of Aquitania (circa 1920s)
(below) Golden Odyssey's Rendezvous Foyer (circa 1990s)
(below left) Leeward Dining Room of S/S Norway (circa 1990s)
(bottom) Dining room of Normandie (circa 1930s)

The "atrium" of 1912, the grand stairway entrance of Olympic, a sister ship of Titanic.

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The reasoning behind this practice is to move passenger cabins away from potential noise and vibration sources, such as propellers and engines. Being predominately noisy areas themselves, public rooms don't need to be isolated.

The "stacked" public room arrangements cause some passenger inconvenience, and most of the newer ships follow the traditional longitudinal design.

The traditional ship's cinema survives on many new ships, although the provision of television in each cabin with a full range of films and information services precludes the need for this facility.

Entertainment on line voyage ships was invariably limited to dancing to the ship's band, bingo, fancy dress balls and the like. Recently, amusements have diversified, with some ships offering full compliments of entertainers.

Big show extravaganzas with full theater facilities are staged in multi-purpose show lounges. Many new ships are equipped with two deck multi-level lounges providing good sight lines to the stage from all corners. In addition, demonstrations, lectures, aerobics and computer lessons are offered.

Atriums

Sovereign of the Seas boasted the world's first marine atrium, the Centrum, in January 1988. This is not quite the case, because several of the great French Line transatlantic vessels, i.e., *France* (1912), *Paris* (1921) and *Ile de France* (1927), all had atrium entrance halls.

The atrium on *Sovereign of the Seas* rises up through five decks and provides a spectacular link to most of the vessel's 20 public rooms with staircases arranged between each deck level.

Despite the new-found popularity of atriums with operators, some authorities are less enthusiastic. The U.S. Coast Guard maintains that some atriums exhibit features which conflict with Safety of Life at Sea (SOLAS) regulations. For example:

a) Atriums, while not specifically prohibited by SOLAS, do not meet the intent. Atriums with staircases (such as on *Sovereign*) are particularly hazardous due to the natural desire of passengers to use open stairs instead of protected stairways as a means of escape in a fire emergency.

b) Spaces contained within atrium boundaries represented additional fire hazards (chemicals from a photo laboratory, cosmetics etc.), with such spaces having limited fire boundary protection.

c) Steps within main fire zones are required to be kept to a minimum. With normal maximum fire zone divisions fixed at 40 meters, the Coast Guard questioned the desirability of

Sovereign of the Seas' atrium rises up through five decks.

steps of up to 20 meters in some of *Sovereign's* horizontal divisions.

Although the flag administration of the vessel had accepted *Sovereign of the Seas*, the Coast Guard ultimately objected based on these points and forced Royal Caribbean Cruise Line to make considerable modifications to the vessel's atrium area (including the installation of sprinklers) while in service before an extended operating certificate was issued, allowing the vessel to sail from the United States with passengers.

Cabins

Traditionally, passenger cabins have been placed throughout the ships according to class. However, cabins on paddle steamships were all located in the aft section because the paddle machinery took up so much room amidships.

The advent of the screw propeller did not influence the location of accommodations right away, and passengers on early screw steamers had to put up with the noise and vibration of the propulsive device.

Beginning with *Oceanic* in 1871, the White Star Line took the bold step of moving the first class passenger cabins to midships away from the vibrations.

Future ship generations followed suit, placing first class accommodations amidships within the hull on the boat deck. Second class cabins were located aft of first class on lower decks. Third class or steerage occupied the extreme ends of the lowest decks.

The introduction of highly skewed propellers made it possible to use the aft quarter of the ship for accommodations. Modern one-class cruise liners usually place cabins over the middle three quarters of the ship.

Europa (1981) and *Royal Princess* (1984) have unconventional cabin arrangements. Cabins on *Europa* are placed on the forward two thirds of the ship, with public rooms stacked on top of each other aft. *Song of America* and *Soverign of the Seas* follow this practice to some degree.

Caronia (1948) set the pattern of having private facilities in each cabin, precluding the need for "visits down the hall," common on earlier line voyage ships. Minimal facilities consist of a combined toilet, washbasin and shower space. More expensive cabins have a full bath, and suites sport jacuzzis.

Most vessels provide a range of cabin sizes from standard to super deluxe suites and apartments.

Passenger ship architects try to maximize the number of outside cabins because of their premium rates. Swedish American Line's *Kungsholm* (1953) was the first major passenger ship with all outside cabins.

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Normandie, shown in New York in the late 1930s, had enough turbo-electric power to supply one-fourth of France with electricity.

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Machinery

Advances in marine propulsion are continuously being made to improve efficiency of operation.

It is interesting to note that after sea trials of the transatlantic liner, ***Normandie*** (80,000 tons), in 1935, the French Line stated that the ship's fuel consumption at 29 knots was the same as that of ***Ile de France*** (1927 - 44,356 tons) at only 23 knots.

The turbo-electric plant on *Normandie* was the fourth largest commercial thermal power station in the world, and the only one at sea.

For economical reasons, modern diesel cruise liners are invariably designed to have the main engines and the auxiliaries run on the same type fuel. And engines are being modified to cope with the combustion of poorer grades of fuel.

Power take-offs from main engine prime movers are also popular. This enables the generally more efficient prime mover to be used for electrical generation at sea, with the auxiliaries being used only in the harbors.

To run installed diesel plants at maximum efficiency, combinations of engines are sometimes installed in "father and son" arrangements with a clutch/gearbox linkage between the two to meet various power demands.

Since the re-engining of *Queen Elizabeth II,* diesel-electric power station-type installations have become increasingly popular. Resilient mounting of diesel engines has brought transmitted noise and vibration levels of diesels nearer to those of steam turbines.

Steam turbines

Although considered the Rolls Royce of engines, steam turbines are economically unattractive compared to the higher thermal efficiency of diesels. The last passenger ship to be fitted with steam turbine engines was *Fairsky* (1984).

Slow-speed diesels

Slow-speed diesel engines can be operated without gearboxes, considered by some technicians to produce too much noise and maintenance problems for a high-class liner.

However, direct-drive diesels have their own problems. One of which, torque limitation in harbor maneuvering, can be overcome with a controllable-pitch propeller installation.

Slow-speed diesels with power take-offs are installed in Carnival's *Tropicale, Jubilee, Celebration* and *Holiday*. The latter vessel built in 1985 has two uni-directional slow-speed seven-cylinder Sulzer RLB66 engines with integral thrust bearings. They produce a top speed of about 21 knots. Each engine is rated at 11,760 KW at 140 rpm.

Medium-speed diesels

A reduction gearbox is required for medium-speed diesels for optimum propeller performance at relatively low rpm. Installed on *Seaward* in 1988 are four 5,280 KW Sulzer 8ZAL40S medium-speed diesels, two connected to each screw shaft (CP propeller) via reduction gears and elastic couplings. Power take-offs are arranged. Top speed is 21.9 knots.

Father and son diesels

Different power demands can be optimally met by clutching in and out of various father and son diesels connected to a shaftline via a gearbox.

Built in 1988, *Crown Odyssey* has this arrangement. One MaK 8M601 and one MaK 6M35 are connected to each of the two shafts via sophisticated gearboxes. Power take-offs are provided. Different engine combinations can produce 21.3 MW, 16 MW and 5.3 MW for optimal economic propulsion.

Diesel-electric engines

Four eight-cylinder MAN B&W 58/64 diesel-electric engines rated at 9,720 KW are installed on Sitmar Cruise's *Fair Majesty/Star Princess* (1989).

These will drive alternators via elastic couplings at 400 rpm, producing 9,420 KW at 6.6 KV, 60 Hz. A 12-pulse synchro-converter control system will drive two frequency-controlled 12 MW propulsion motors at 145 rpm.

The contract requirement is for a speed of 19.5 knots to be produced with three engines running at 85 percent MCR. A fixed pitch propeller was chosen as it is possible to run this propulsion system at infinitely variable speeds from 0 to 145 rpm, in both forward and reverse direction.

Operational advances

Modern passenger ships have evolved from line voyagers with an ever increasing complexity of systems. Technical advances under the waterline since the 1930s cruise vessels ensure comfortable passage, safe and easy docking, slow-speed unaided harbor maneuvering and economical hydrodynamic propulsion.

Stabilizers

Modern cruise liners of ten or more decks are very concerned about stabilization of roll. Several systems have been used to reduce roll effectively, including partially filled tanks and fin stabilizers.

Active fin stabilizers were first developed in the 1930s, but not perfected until the early 1950s. The Cunard cargo-passenger ships *Media* and *Parthia* (1947/48 - 13,345 tons) were retro-fitted experimentally with fin stabilizers in 1952 to correct poor rolling characteristics. The success of these installations promped the *Queens* and other liners to be similarly fitted.

The largest fin stabilizers manufactured to date are those installed in the three new 70,000-ton Carnival cruise ships. Each ship will be provided with a Brown Brothers twin fin installation of 14.5 square meter fin area. (Brown Brothers' four-fin installation on the *Queen Elizabeth II* can reduce a 20-degree roll angle to three degrees.)

Unsuccessful attempts have been made to reduce pitching motions. In 1954, a hemi-spherical fin appendage designed by the Royal Netherlands Navy was fitted to the bow of Holland American Line's *Ryndam*. During sea trials with the appendage, *Ryndam's* stern began lurching and swinging furiously to such an extent that the ship had to divert from the intended course and put into Southampton to remove the fins.

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Crown Odyssey (1988), one of the newest cruise ships, has father and son diesels.

The largest passenger ship to date, Queen Elizabeth (1940 - 83,673 tons), carried 2,314 passengers in 1946 after serving as a troop carrier during World War II.

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Maneuvering devices

Thruster installations are fitted to most modern cruise liners to lessen dependence on tugs for berthing and unberthing operations.

Among the first passenger ships to be fitted with size thrusters were *Oriana* (1961) and *Canberra* (1962). *Oriana* was noteworthy in being fitted with both two bow and two stern thrusters, each unit being driven by a 500-hp. electric motor (410 KW). *Canberra* was constructed with a single bow thruster driven by an 800 hp. (600 KW) electric motor.

The "specific capacity" (total installed power divided by projected longitudinal air draught area) of individual installations varies widely.

The most powerful side thruster installation envisioned for a passenger ship to date is that provided for the three new Carnival Cruise Line ships, *Fantasy, Ecstasy* and *Sensation.* It consists of three bow thrusters and three stern thrusters, each of 1.5 MW.

In January 1988, *Sovereign of the Seas* became the first major passenger liner to have Becker flap-type rudders. Unlike the customary twin spade rudders normally fitted to cruise liners [total area between 2-3 percent of L(bp) times T(lwl)], twin Becker flap rudders can be orientated to provide side thrust aft (one propeller thrusting aft with active rudder, the other thrusting forward to balance with inactive rudder for parallel movement in association with bow thrusters), thus precluding the need for stern thrusters.

Another high-performance rudder, the Schilling rudder without flap, has yet to be installed on a major passenger ship.

Propellers

Propellers have always been a cause for concern among passenger ships. Vibrations from a badly designed propeller can cause misery and discomfort throughout the after section of a ship. Sometimes it is also felt forward with resonance of the hull girder. Cavitation and blade pulse influences are well known.

In order to maintain blue ribbon speed, the illustrious North Atlantic liners, *Mauretania* (1907) and *Normandie* (1935), suffered severely in view of the high powers being transmitted to their screws. Both vessels benefitted from redesigned propellers replacing their original installations.

This phenomenon is not confined to past generations of vessels. The new high skew propellers fitted to *Queen Elizabeth II* during its 1986/7 rebuilding in Germany had to be changed in July 1988 for basically the same reasons.

Song of Norway became the first passenger ship to be fitted with high skew controllable pitch propellers when its conventional propellers were replaced during jumboizing of its hull in 1978. (High skew propellers require a

controllable pitch system for astern thrust because their rotational direction is not reversible.)

Vibrations of high skew propellers have been reduced to about two thirds that of conventional propellers. Experienced blade frequency pressure amplitudes range from 1.5 to 3 KPa, whereas conventional propellers exhibited values from 5 to + 8 KPa. Corresponding vibration velocity levels have decreased from 4-7 to 1-3 mm/s.

A high skew installation can lead to greater propulsive efficiency by allowing a larger propeller diameter than would normally be considered prudent to be adopted, while, at the same time, minimize pulse vibrations.

Aesthetics

A common complaint among passengers is about how ugly the ships have become. The fine entry North Atlantic liner-type bow has given way to a much fuller equivalent on modern cruise ships. Forecastles are getting shorter. The counter stern survives on only two passenger ships (*Independence* and *Constitution* 1951), and the flat transom stern has largely replaced the cruiser-type as norm.

With length being the most expensive shipbuilding dimension, ships have become shorter and more squatty with higher, but beamier hulls. The cry, "Is it stable with so much out of the water?" is common and difficult to answer to a layman who is used to *Queen Mary*.

The length of the North Atlantic liners was fixed according to the space needed for accommodations, combined with the necessary length to breadth ratio desirable for propulsion, and the right combination of length, breadth and draft for good seakeeping, particularly under severe North Atlantic weather conditions. These constraints produced a "classically" proportioned vessel.

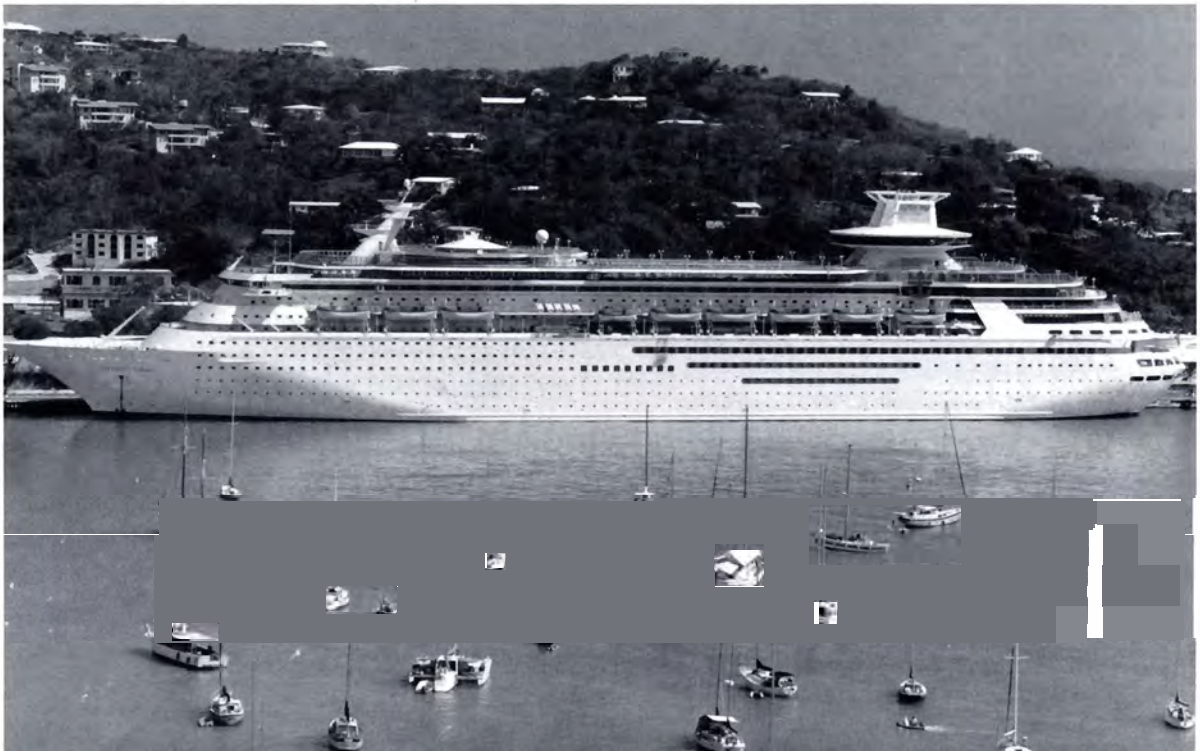
Cruise ships operating in calm warm- weather seas can afford to move away from traditionally-accepted form ratios toward a fuller bow form, creating more space and revenue.

Drafts are kept to a minimum, enabling modern cruise ships to enter shallower ports of call.

The length of a modern cruise ship is largely determined by what is required to accommodate the necessary number of lifeboats (according to strict regulations) for the vessel's intended passenger complement.

Continued on page 14

Sovereign of the Seas (1988 - 74,000 tons) is the largest cruise ship in service, with a capacity for 2,600 passengers.



Continued from page 13

Future ships

As of November 1988, the average age of the world's cruise fleet was about 21 years. The two oldest active cruise liners were Chandris Lines passenger vessels: *Britanis*. 56, and *The Victoria*, 52 years of age. Newcomers included Norwegian Cruise Line's *Seaward*, Royal Cruise Line's *Crown Odyssey* and Royal Viking Line's *Royal Viking Sun*.

With such a high average age and the cruise industry's continued growth, the demand for new ships will go on.

In recent years, several interesting and novel projects have been announced. One is *Windstar*, a sailcruiser that is already in service with two sister ships. These ships offer real sailing experiences with cruise liner comfort.

Other projects, still in the design stages, are more radical. Wartsila Marine Industries, a Finnish shipbuilding company, is exploring new cruise liner concepts, including a small waterplane twin hull (SWATH) vessel.

Two other recent projects have received attention because of their huge sizes. It must be remembered that the largest passenger ship to date was Cunard Line's *Queen Elizabeth* (1940 - 83,673 tons), and that the largest passenger ship in service now is Royal Caribbean Cruise Line's *Sovereign of the Seas* (1988 - 74,000 tons).

Phoenix World City

The design for *Phoenix World City* calls for a massive hull with aircraft carrier sponson decks and underslung lifeboats. The stern will contain a floodable dock for four high-speed 400-passenger tenders.

Three hotel blocks rising from the hull will contain passenger cabins. Public rooms and crew accommodations will be within the hull. At 250,000 tons, *Phoenix World City* is designed to carry 5,600 passengers and 1,800 crew.

Ultimate Dream

In many respects, the projected 345-meter 160,000-ton *Ultimate Dream* is a mini *Phoenix* with underslung lifeboats and a huge hull. However, the superstructure design differs in that it will be a continuous "S," and, therefore, will not be composed of blocks.

Cruise markets

During 1986, more than three million people spent their annual holiday afloat. This figure increased to 3.5 million per year by the end of 1987. Of this number, some 2.7 million passenger departures were from the Port of Miami, the "Cruise Capital of the World."

Each Saturday and Sunday at 4 pm, a fleet of liners provides a spectacle of immense proportion, edging away from their Miami berths and sailing in line down the exit channel to the open sea. For the most part, these ships represent the Miami "mass market."

The Caribbean islands, so perfectly scattered off the warm Florida coast, provide an idyllic destination for the cruise ships, being within leisurely (and hence, economically) steaming distance, and sufficient in number to provide several diverse ports of call within a weekly Miami to Miami circuit.

The United States domestic cruise industry has been growing at the rate of eight to 15 percent since the early 1980s. Fears from the Chernobyl and *Achille Lauro* incidents resulted in a strengthening of the domestic market as cruise passengers turned away from other cruising areas, notably North European and Mediterranean.

If the historical relationship between the growth in United States consumer income and cruise demand is maintained, then the cruise industry should have continued growth at least through to the year 2000.

However, growth for the period 1986 to 2000 is forecast at roughly only half that of 1978 to 1986, because of a lower forecast in inflation adjusted consumer income. A halving in United States population growth for the same period is also considered a significant factor.

It is anticipated that the supply of cruise berths will outstrip demand in the ratio of approximately 4:3 by 2000, and that demand will slump to 6.6 percent during the period from

Tomorrow's cruise liner . . .

A resort, conference and business center, Phoenix World City (250,000 tons), with three eight-deck hotel towers, will accommodate 5,600 passengers and 1,800 crew.

1986 to 1992 and fall again to 4.4 percent during the period from 1992 to 2000. Correspondingly, supply will fall from 9.3 percent to 3.9 percent over the same two periods.

In order to meet the challenge that such forecasts imply, the cruise lines are consolidating and merging to form more efficient operational groups. Several well known lines have recently been sold for merger. Sitmar Cruises and Home Lines are two such examples.

The United Kingdom and other North European cruise markets continue to be relatively depressed with very few companies operating successfully.

However, the intention of Cunard and P. & O. to double the United Kingdom domestic cruise market over the past few years has obviously met with some success with P. & O./Princess relocating the flagship *Royal Princess* to the European theater during 1989.

Conclusion

The cruise liner has evolved from the "line voyager" passenger ship being pressed into cruise service, usually for survival, to the "super liners" of today, dedicated from the outset to providing holidays afloat.

Technological advances have provided greater operating efficiency, and an enhanced shipboard environment with stabilization, air conditioning and the like.

Class distinctions have disappeared, with passenger facilities being provided for all.

Once threatened with total extinction, the passenger ship is now assured of a continued existence with ever increasing numbers of larger sizes being built to satisfy current demands.

S. M. Payne is a naval architect in technical marine planning in London, England.

Passenger ship safety

Dr. Robert L. Scheina

Relatively speaking, ships carrying passengers are a recent innovation in the history of sea-going vessels. A mere 150 years ago, people travelled by ship only when it was absolutely necessary. At that time, such travel was dangerous, unhealthy and monotonous.

The large number of immigrants who set sail for the United States starting around 1815 created the first demand for passenger-carrying ships.

By sail

Navigation dangers

In the 1830s, navigation was an art, not a science, with few aids to guide the mariner. Perhaps 50 lighthouses and 100 or so buoys were the only navigational guides available on the American coast when transatlantic passenger service began to take hold.

Powered by the wind on their sails, ships collided with land, ice, floating debris and each other. Most collisions involved ships striking land.

Ice was probably the second greatest danger during the early years of transatlantic passenger service. Every few years, a ship with passengers would simply disappear in the North Atlantic, the probable victim of an iceberg.

Fire

The ships themselves were not terribly safe. There weren't any laws regulating the ships or their sailors.

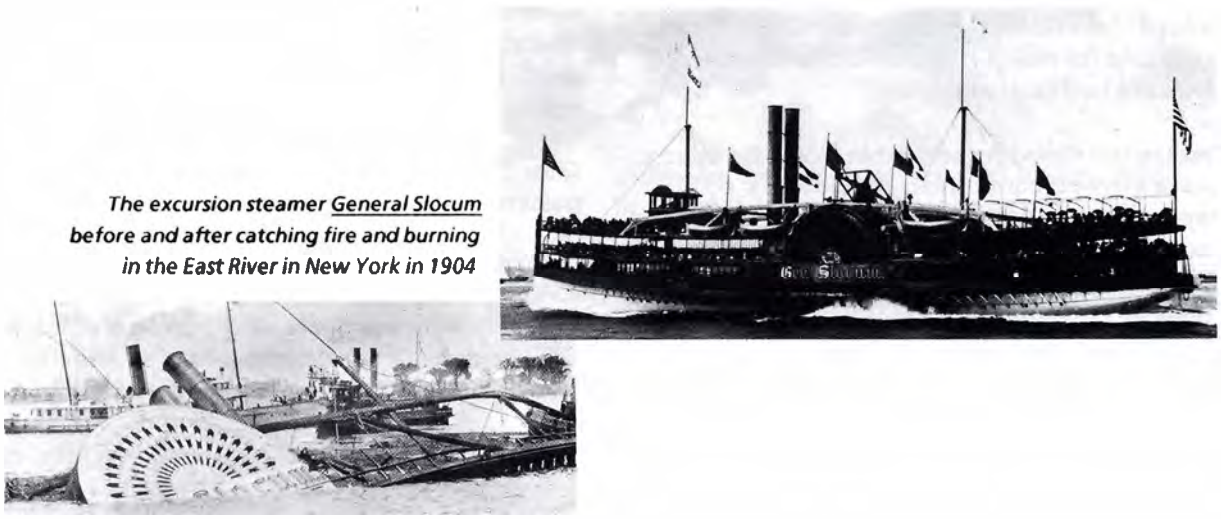
Fire was the sailor's worst enemy. Ships were constructed of wood and, to a large measure, covered with pitch to keep them from leaking. All that was needed was a spark to start an inferno.

Therefore, fire for cooking, heating (rarely provided) and smoking (only allowed in the galley) onboard ship was strictly controlled.

Disease

During the early decades of the 19th century, ships carrying passengers were extremely unhealthy. Hundreds of people were crowded into a poorly ventilated vessel, sometimes measuring less than 200 feet. Provisions competed with cargo for any space left over.

There was no refrigeration. The weather deck of a ship was frequently crowded with livestock, the only source of fresh meat. It wasn't unheard of for storms to wash the animals overboard before they could be served for dinner.



The excursion steamer General Slocum before and after catching fire and burning in the East River in New York in 1904

In any event, the livestock only lasted a few weeks into the trip. After that, meals often consisted of worm-infested salted meat, stale bread and putrid water. Such cuisine caused indigestion, often followed by scurvy and worse.

Sanitation

Water was in short supply and sanitation conditions were abominable. A ship would set sail with casks full of water for cooking and drinking. This was later supplemented by rain water, if the elements cooperated.

The toilet for all on board was the ship's head, which fortunately was washed by salt spray.

Monotony

Of course there were no swimming pools, deck games or entertainment of any kind, making passenger travel extremely monotonous.

A trip from Southhampton to Boston usually took up to six boring weeks, and it was eight-months from New York to San Francisco if Cape Horn was successfully rounded on the first try.

By steam

Sea travel became faster, more predictable and safer around the middle of the 19th century, increasing the number of passengers.

The steam engine freed ships from the vagaries of the wind, giving them greater flexibility to stay out of harm's way. Iron and later steel permitted the construction of larger, stronger ships, which were less susceptible to damage.

Between 1850 and 1900, passenger ships tripled in length and increased many times in tonnage.

Problems

The new technologies, however, created new problems. Early steam engines were driven by primitive boilers, which exploded too frequently, causing large losses of life.

In 1823 alone, 14 percent of all steam vessels in the United States were destroyed by explosions, resulting in more than 1,000 fatalities.

Legislation

In 1824, Congress authorized the Secretary of the Treasury to investigate the causes of the appalling number of disasters involving boiler explosions. However, no federal action was taken.

In 1838, Congress passed laws providing for the inspection of hulls and boilers, the installation of fire-fighting and life-saving equipment, and the creation of the Steamboat Inspection Service.

Continued on page 18

Titanic sailed from Southampton on its ill-fated maiden voyage on April 10, 1912, carrying 2,350 passengers and crew. The magnificent liner struck an iceberg off the coast of Newfoundland and perished on April 14, 1912.

The U.S. Coast Guard cutter Tampa tows Morro Castle after the passenger ship burned at sea in 1934.

Continued from page 17

However, neither centralized supervision nor professional inspections were provided. In spite of the legislation, ship disasters involving boiler explosions increased.

During the first eight months of 1852, seven disasters cost 700 lives. Later in the year, Congress mandated licensing of engineers and pilots on steam vessels carrying passengers, tightened many safety requirements, and reorganized the Steamboat Inspection Service.

Nevertheless, the disasters continued.

Sultana

On April 27, 1865, the worst maritime disaster in United States history took place. The Civil War was a very recent memory when the paddle-wheel steamer *Sultana* embarked with 2,000 Union veterans and 376 regular passengers from Memphis, Tennessee, up the Mississippi River to Cairo, Illinois.

About 2 a.m., a boiler exploded and the vessel caught fire. The entire ship was soon engulfed in flames and burned to the waterline. More than 1,450 people perished from suffocation, drowning or exposure on the banks of the river.

New laws

In 1871, Congress again reorganized the Steamboat Inspection Service, requiring masters and chief mates as well as engineers and pilots to be licensed. The avowed objective of the service was broadened from preventing the death of passengers to include the safety of the crew as well.

New calamities

While iron and steel hulls decreased the potential for fire on board ship, wood was still used extensively for superstructures. Also mechanical propulsion required ships to carry fuel, which became a major source of fire.

On June 15, 1904, the excursion steamer *General Slocum* caught fire and burned in the East River in New York. More than 950 people lost their lives. Many of them were children on a church outing.

Following this tragedy, Congress passed legislation further regulating fire-fighting equipment and life-saving gear to be carried on passenger ships.

Growth - new problems

A tremendous increase in the size of passenger ships created new problems. The new iron and later steel ships could carry thousands of people instead of hundreds. The chance of losing one of these ships through collision was greatly reduced, but should such a sinking occur, the loss of life would be high.

Titanic's impact

The sinking of *RMS Titanic* on April 12, 1912, with the loss of more than 1,500 lives had a significant impact upon safety at sea.

The International Ice Patrol was established, and since its inception, not a single ship has been lost to ice within the patrolled area.

International agreements regulated ship-board radios. Legislation was passed concerning life-saving devices to be carried on board ships. Also lifeboatmen were required to be examined and certified.

Finally,the United States adopted certain provisions of the International Convention of Safety of Life at Sea (SOLAS) of 1914.

New technologies

New technologies were also applied to navigational aids, directly benefiting passenger-carrying ships.

Introduced early in the 20th century, the submarine bell, a sonar-type sending and receiving device, was placed on large liners to pick-up sonar transmissions emitting from lightships and light stations off major ports. The system had a range of about eight miles.

Also, radio beacon navigation was introduced, which would be replaced by Loran after World War II.

Effects of new disasters

Two disasters in the mid-1930s brought about numerous changes in passenger-ship regulations.

On September 8, 1934, the motor vessel *Morro Castle* burned at sea, causing 124 fatalities. Nearly five months later on January 24, 1935, the passenger vessel *Mohawk* sank after colliding with the Norwegian motorship *Talisman,* and 45 people lost their lives.

Consequently, legislation was passed regulating the structure, equipment and materials for passenger ships. Other laws were enacted defining the officers and crew necessary to operate a vessel efficiently, and mandating supervision over the merchant marines.

Finally, the 1936-37 legislation produced the first requirement that marine casualties involving regulated vessels be reported and investigated to prevent recurrences.

Between world wars

Passenger-ship trade changed little between the world wars. True, the large number of immigrants slowed to a trickle, but ships were still the only means available to cross the Atlantic for all except the very wealthy. Also, coastal passenger ships had little competition, so the trade flourished.

After World War II

The United States emerged from the second world war with the world's largest merchant fleet, yet few of these ships entered the commercial passenger trade. Many had been given wartime exemptions from safety regulations, and would require expensive alterations to compete in this trade.

Sea-going passenger traffic declined as the airplane superceded the ocean liner for trans-continental travel. Also, with the construction of an inter-continental highway system, more Americans began to use the automobile for cross-country travel.

Cruise ships

During the 1970s, increasing numbers of Americans began to take deep-water cruises. As a result, a new type of passenger vessel evolved from the trans-oceanic liners to serve this new clientele - the cruise ship.

Dr. Robert L. Scheina is the historian of the U.S. Coast Guard.

Growth with safety

John T. Estes

In the late 1960s and early 1970s, a whole new type of travel began to emerge. A fascinating hybrid of transportation and hospitality, the cruise industry has since undergone phenomenal growth and evolution.

Growth

In 1970, it is estimated that some 500,000 people took cruises. For the most part, they set sail on 10-day to two week vacations from New York, or perhaps, the fledgling Port of Miami. They traveled from island to island in the Caribbean on vessels that had been converted from transatlantic or transpacific service, or that split their time between cruising and crossing.

In 1990, about four million North Americans are expected to take cruises from many ports in the continent. Their experience will be vastly different from that of the early cruisers.

Evolution

The range and pace of activities have greatly increased. Cruise ships are "round-the-clock" activity centers, offering guests multiple choices of things to do each hour or permitting them to do nothing at all.

Cruising used to be more of a "tour" vacation, with the vessel steaming from island to island so that passengers could sightsee and shop at as many destinations as there were days in the cruise.

Now the ship is the destination, a kind of floating resort offering all the amenities of its land-bound brethren. Even the lingo has changed -- voyages are more often than not called "cruise vacations," passengers are "guests" and many crew members are "hotel staff."

The cruise industry has made a complete transition from transportation to vacation/hospitality.

Building boom

In the 1980s, the cruise industry embarked on a building boom of vessels designed to deliver the best possible vacation. In the past 10 years, some 40 new or substantially refurbished vessels were introduced into the North American market.

The pace has quickened in the 1990s. It is estimated that some 50 new vessels are under construction or planned for the first three years alone. In 1990, 17 new or refurbished ships with a combined total of nearly 11,000 berths will be introduced, eclipsing the previous record of 8,000 new berths in 1988.

"Round-the-clock" activity centers, cruise ships offer their guests multiple choices of things to do or let them do nothing at all.

MS Noordam sails past Sitka on a "cruise vacation," touring the Inside Passage of Alaska.

More than 34,000 berths are contracted through 1994, thus ensuring double-digit growth for the industry for the next four to five years at the very least.

The new cruise ships range in size from intimate luxury vessels to 2,600-passenger "mega-liners." They cater to changing consumer lifestyles with high-tech fitness equipment, spacious theaters for Broadway productions or Las-Vegas-style reviews, tiered dining rooms, expanded pool and outdoor facilities, computer workshops, video game palaces and children's playrooms.

Safety

Much more dramatic than the recent lifestyle changes made in cruise ships are the advanced safety innovations.

Governed by the conventions and treaties of the International Maritime Organization (IMO), the cruise industry is closely monitored in the United States by the Coast Guard, which is recognized throughout the world as the leading authority on marine fire protection and other safety issues. Cruise industry representatives must work very closely with the Coast Guard.

ICCL

A trade association committed to safety, the International Council of Cruise Lines (ICCL), represents about 90 percent of the ocean-going overnight cruise line industry.

ICCL member companies employ skilled seamen as deck and engine crews. They are qualified under the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers. These professional crews undergo regular, frequent safety training, emphasizing evacuation, fire drills and other emergency situations.

International regulations cover the design and construction of passenger vessels and the type of materials used on board.

The cruise industry views safety as an ongoing process and is continually working to improve and enhance policies and procedures of its vessels. ICCL member companies are committed to the safe operation of all cruise ships in their fleets. In fact, safety is at the core of the operational policy of each member line.

Communications

Recognizing the human element in maritime safety, ICCL members believe that communication and training are also essential elements of the safety assurance process.

Effective communication within shore management, within the ship and between the two is essential for safe, reliable and economical ship operations -- and is vital with respect to emergency procedures.

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The ICCL member companies have identified three avenues of onboard communication that must remain open. They are:

* **With each individual** to ensure that he or she understands duties and required action when discovering or responding to an emergency.

* **Within each section of a ship's company** to ensure that it operates as a team in a crisis.

* **With the passengers** to ensure a safe and calm response should an emergency situation arise.

The lines recognize that staff and crew who come into contact with passengers must be able to communicate well with them. In addition, they must receive specific training to maximize their availability in an emergency.

Crew members who normally do not come into contact with passengers also must undergo a continuing program of training to maintain the industry reputation for safety.

Training

In addition to focusing on procedures in an emergncy, training must also emphasize on-the-job requirements and safety.

The industry believes that accidents and emergencies can be avoided by careful and correct working practices, and that good ongoing job training and meticulous supervision of work practices are the primary factors leading to a safe operation.

Cruise lines believe that all crew members should undergo minimum-level emergency training, including:

* Basic sea survival.
* What to do when faced with a potentially hazardous situation.
* How to communicate during a crisis.
* How to render "first aid" until help arrives.

Cruise lines also are designating special safety officers, and are engaging safety consultants to review and recommend procedures.

Passenger involvement

Finally, the cruise industry is getting the passenger into the act in very visible ways.

Until very recently, safety measures, except for the compulsory life boat drill, which was presented as a regulatory instead of a safety feature, were almost hidden from the passengers. It was assumed that they did not want serious considerations to intrude on their vacations.

The industry's evaluation of passenger reaction changed following the *Achille Lauro* security incident in 1985, when most lines established or increased airport-type security systems without incurring passenger dissatisfaction.

Now the passenger is becoming part of the safety process with increasing exposure to emergency instructions in their ticket-jackets and in-room booklets and videos.

Conclusion

Health, safety and security always have been the primary concerns of the cruise industry, which now must care for four million passengers and thousands of crew members.

We believe that current rules and regulations, diligently enforced, will continue to ensure the safety of all passengers and crews. We have encouraged free and open dialogue on the subject of safety, and are constantly strengthening safety standards.

John T. Estes is the president of ICCL, which represents Admiral, Bermuda Star, Carnival, Chandris, Commodore, Costa, Crystal, Cunard, Holland America, Norwegian, Premier, Princess, Royal Caribbean, Royal, Royal Viking and Windstar cruise lines.

International maritime procedures

CAPT Thomas E. Thompson

1987 - A cruise vessel visiting the Territory of Guam was determined by the U.S. Coast Guard not to be in compliance with the International Convention for the Safety of Life at Sea (SOLAS), because the fire fighting system was corroded and wouldn't work. More than 450 passengers were not permitted to embark on their vacation cruise. They and excess crew members were sent home on airline tickets purchased by the cruise operator. The ship left port empty.

1988 - During another cruise ship's routine drydock and SOLAS control verification examination, blue styrofoam insulation was found around all ventilation ducting in the overhead of each deck. (Styrofoam insulation is flammable and emits a toxic gas when it burns.) Before the vessel was permitted to carry any passengers from United States ports, the Coast Guard ordered the insulation removed and other discrepancies corrected.

One result of the Coast Guard's action in the second example was a significant delay in returning the vessel to service at substantial cost to the owner. Another result was the improvement of passenger safety.

What is this Safety of Life at Sea (SOLAS) convention and why does the Coast Guard use this international standard as a basis for vessel inspection?

More importantly, perhaps, is how we ensure that the SOLAS convention meets and maintains our safety expectations for foreign vessels with United States passengers aboard.

SOLAS

The SOLAS convention is the primary international treaty setting the standards for passenger and merchant vessel construction, lifesaving equipment and fire-extinguishing systems to assure a minimum level of safety.

The first international convention for SOLAS was adopted in 1914 as a result of the *Titanic* disaster. Due to the outbreak of World War I, however, it was not put into effect.

SOLAS conferences conducted in 1929, 1948, 1960 and 1974 all resulted in significant improvements in many aspects of vessel safety design and construction.

Continued on page 24

The Norwegian ship Royal Viking Sun (not one of the cases above) is subject to SOLAS requirements when embarking passengers in a United States port.

SOLAS REGULATIONS

ENACTED	EFFECTIVE
1948	November 19, 1952
1960	May 26, 1965
1974	May 25, 1980
1981 Amendments	September 1, 1984
1983 Amendments	July 1, 1986
1988 Amendments	October 22, 1989 & April 29, 1990
1989 Amendments	February 1, 1992

Continued from page 23

The most recent SOLAS Convention of 1974 has been adopted by more than 100 countries, controlling more than 95 percent of the world's merchant tonnage. This convention was amended in 1981, 1983, 1988 and 1989.

IMO evolution

In 1948, the United Nations Maritime Conference agreed to form a special U.N. agency, the Intergovernmental Maritime Consultative Organization (IMCO), to develop internationally acceptable standards to improve safety at sea and prevent pollution of the oceans.

Established in 1958, IMCO was renamed the International Maritime Organization (IMO) in 1982.

IMO organization

The IMO's governing body is the assembly, which meets every two years. It consists of representatives from 134 member countries and two associate members. Between assembly sessions, a council of 32 members elected by the assembly functions as the IMO governing body.

Five committees under the assembly and council deal with legal, technical cooperation, facilitation, marine environmental protection and maritime safety issues. These committees are in turn supported by a number of subcommittees. (See chart on page 26.)

Coast Guard participation

The Coast Guard participates at all levels of the IMO, although primarily through the committees and subcommittees, particularly the committee on maritime safety.

The Maritime Safety Committee is responsible for the development and maintenance of the technical and administrative provisions of the SOLAS convention, as well as other ship safety conventions. These include the load line convention, tonnage measurement convention, and the convention on standards of training certification and watchkeeping for seafarers. (The latter convention has not yet been ratified by the United States.)

The Coast Guard is represented on the Maritime Safety Committee by the chief of the Office of Marine Safety, Security and Environmental Protection.

Participation of the private sector in the development of United States positions on IMO issues is through the Shipping Coordinating Committee, a federal advisory committee formed by the Department of State in 1958.

The Coast Guard chairs three technical subcommittees and 12 domestic working groups of the Shipping Coordinating Committee, which addresses virtually every aspect of vessel safety as it relates to construction; inspection; fire protection, cargo carriage, subdivision, stability, navigational systems, communications,

(left) IMO headquarters building in London.
(below) IMO Maritime Safety Committee meets.

watchstanding, traffic separation schemes and personnel competency.

IMO procedures

Typically, public meetings are conducted to formulate United States positions on proposed IMO amendments. Announcements of these meetings are printed in the *Federal Register* before the working group meeting. Invitations to participate are sent directly to interested industries, labor groups, technical societies, government agencies and others. Private and commercial sector participation at these meetings is encouraged.

Recommendations of member countries for amendments of the SOLAS convention are forwarded to the Maritime Safety Committee. After necessary debate and refinements by subcommittees, the amendments may be accepted and returned to the Maritime Safety Committee for adoption.

Ratification

Ratification of an IMO convention by the United States with the advice and consent of the Senate, establishes that document as a treaty which becomes the "law of the land."

After the convention has been specifically adopted into United States law, the Coast Guard is able to write regulations affecting United States flag vessels. The Coast Guard can also apply the ratified convention to foreign flag vessels visiting United States ports.

Higher standards

Before the IMO, international treaties in force set minimum requirements for vessel safety which met with varying degrees of success.

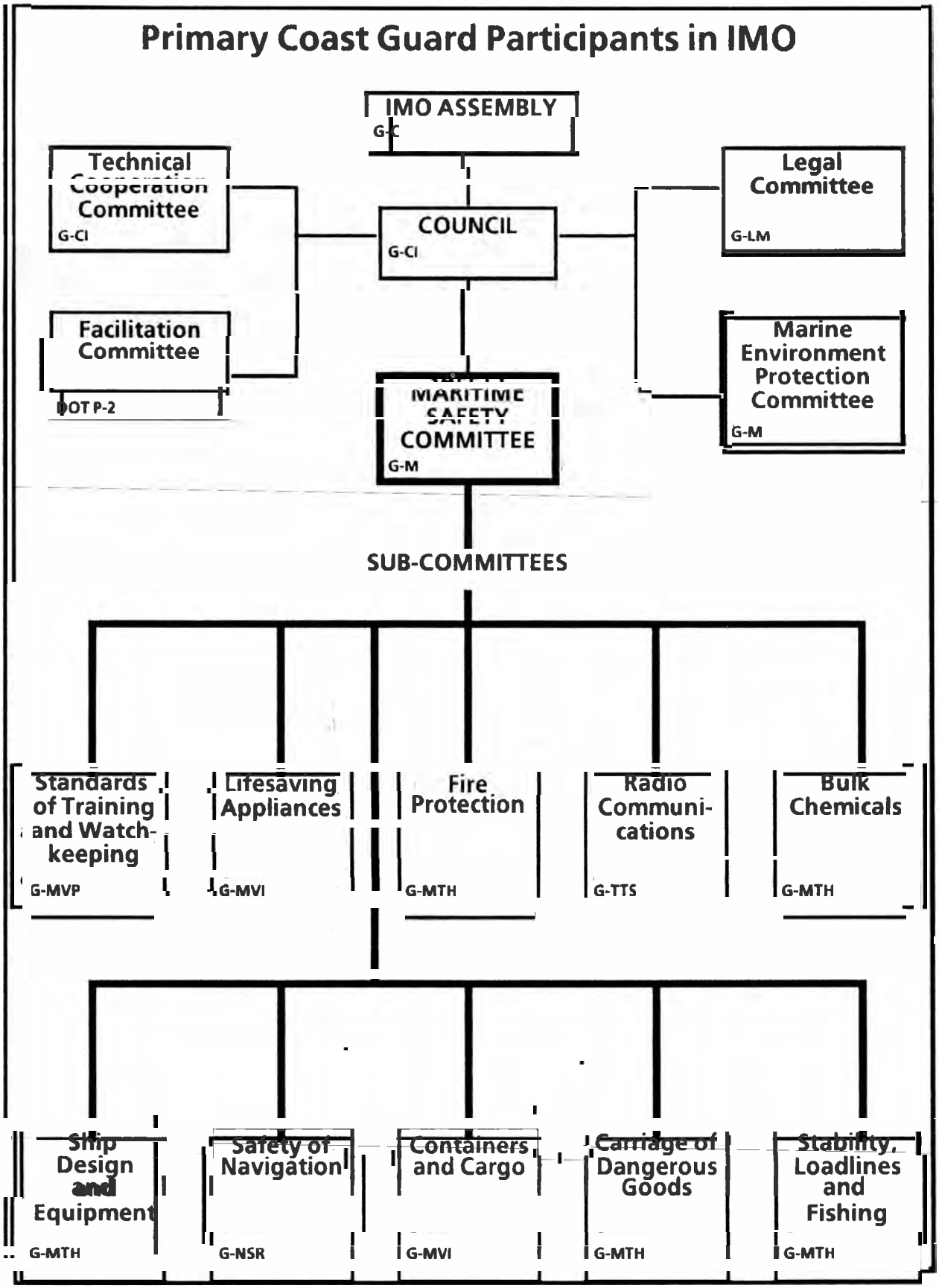
During the last two decades, the international community using the IMO forum has worked steadily to raise worldwide safety standards above a minimum level. This has been in response to serious maritime casualties, an evolving recognition of a linked world community and the revolutionary advancement of the shipping and passenger vessel industry.

International standards for new ship design and construction were significantly improved by the second set of amendments to SOLAS 1974, which were enforced in 1985. Since that time, the IMO has continued to make great strides to improve passenger vessel safety.

New requirements for stability after damage were established this year. The Subcommittee on Fire Protection has drafted proposed amendments, which, when adopted, will greatly improve the fire safety of all passenger ships.

Efforts of the Coast Guard and IMO are paying off in tangible improvements to the SOLAS convention and overall safety of life at sea.

Captain Thomas E. Thompson is the chief of the Marine Technical and Hazardous Materials Division of the Coast Guard's Office of Marine Safety, Security and Environmental Protection.


Primary Coast Guard Participants in IMO
IMO ASSEMBLY
G-C
Technical Cooperation Committee
G-CI
COUNCIL
G-CI
Legal Committee
G-LM
Facilitation Committee
DOT P-2
MARITIME SAFETY COMMITTEE
G-M
Marine Environment Protection Committee
G-M
SUB-COMMITTEES
Standards of Training and Watch-keeping
G-MVP
Lifesaving Appliances
G-MVI
Fire Protection
G-MTH
Radio Communi-cations
G-TTS
Bulk Chemicals
G-MTH
Ship Design and Equipment
G-MTH
Safety of Navigation
G-NSR
Containers and Cargo
G-MVI
Carriage of Dangerous Goods
G-MTH
Stability, Loadlines and Fishing
G-MTH

Recent IMO initiatives

Marjorie Murtagh

The United States gains as much, if not more, than it contributes by actively participating in the IMO. A wealth of international expertise on marine matters, particularly safety, is ours just for belonging.

Passenger ship safety, a constant consideration among IMO members, has been greatly enhanced through recent initiatives by the international community. New and revised regulations, Maritime Safety Committee (MSC) circulars and assembly resolutions have produced incremental safety improvements worth noting.

Following are some of the most recent IMO accomplishments and their ramifications.

SOLAS amendments

1988 and 1989 amendments to the SOLAS Convention will increase the stability of damaged passenger ships, provide supplementary emergency lighting for ro-ro ferries, improve the watertight integrity of passenger ship bulkheads and upgrade fire hoses on all ships.

Resolutions

Resolution A.653(16) recommends improved fire test procedures for surface bulkheads, ceiling and deck finish materials. Potential materials will be screened for use aboard ship, assuring an acceptable level of ignition, flame spread and heat release properties.

Resolution A.652(16) recommends fire test procedures for upholstered furniture. Originally proposed by the United Kingdom, these procedures will assure that upholstered furniture will not readily be ignited by a dropped cigarette or even a lit butane match.

Resolution A.654(16) recommends consistent graphic symbols for fire-control plans to assure that shore-based fire fighters can readily operate ships' systems to help fight in-port fires.

Resolution A.647(16) recommends guidelines for good ship management for safe operation and pollution prevention.

Regulation

Approved by the MSC in May 1990, a regulation for fire training and drills aboard passenger vessels assures that crews will receive regular shipboard as well as land-based training, and will routinely conduct fire-fighting drills on their ships.

Circular

MSC Circular 526 provides requirements for large multi-deck open spaces (atriums).

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Fire hoses will be upgraded on all ships and fire control plans should be readily available and understood, according to MSC resolutions.

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Vital topics

The MSC Subcommittee on Fire Protection covered a number of significant topics relating to cruise ship safety at its most recent session in July 1990.

Human element

"The role of the human element in maritime casualties," including on board communication problems, is on each technical subcommittee agenda. The Subcommittee on Fire Protection examined proposals put forth by Norway on the subject.

Norway expressed concern that poor management practices cause casualties and, thus, are the key weakness in the system, and proposed that Resolution A.647(16) be mandatory for passenger ships on international voyages.

The subcommittee agreed with Norway's concern and forwarded comments to the MSC for consideration.

Norway also suggested a revision to IMO Resolution A.466(XII), "Procedures for the control of ships." The subcommittee supported Norway's contention that the general level of passenger ship safety would improve if port states fully exercised their existing control procedures and conducted a more detailed review of passenger ships operating from their base ports where passengers board ship.

These comments were also relayed to the MSC.

Fire systems

An ad hoc working group on fire-protection systems for passenger ship safety recommended sprinklers, a fully integrated system to account for delays in crew response and the prohibition of dead-end corridors.

Smoke control

The results of smoke control research were analyzed. Ventilation systems and their effect on smoke movement have been a concern for a number of years, because most fire casualties are victims of smoke inhalation rather than burns.

Ventilation ducts are used to provide air to staterooms. Moreover, traditional shipboard designs use the corridors to return air to exhaust or recirculating fans.

Existing regulations deal with this by permitting openings only in the lower half of corridor bulkhead doors. The theory is that smoke will fill the room, enabling detection before passing into the passengers' escape route.

A number of countries have expressed concern about this untested theory and have undertaken studies of the mechanics involved.

Pipe materials

A working group is fast approaching a standard of acceptance on the use of materials other than steel for sprinkler and other piping systems in accommodation spaces.

The use of combustible materials in concealed spaces is not taken lightly. The group has carefully considered ways to prevent a system intended to save the ship from serving as a vehicle for spreading a fire.

A number of tests have been conducted on fire stops. Fire endurance and flame spread testing to establish criteria is close to conclusion. Acceptable smoke tests are still being developed. Toxicity criteria for all shipboard materials is much further away.

The long-term maintenance headaches of pipe replacements due to corrosion and the blockage of systems by rust may soon be things of the past.

Fire fighting

An ad hoc working group will convene at the next subcommittee session to deal with divergent opinions on the adequate sizing of fire mains and pumps for fighting shipboard fires.

Current requirements base the size of the fire pumps on the size of the bilge pumps, rather than vice versa. The working group will determine how much water is needed to fight a fire, making sure that the fire main and pumps can and will supply it in an emergency. Then the bilge pump requirements can be determined.

Visions of the majestic *Normandie* lying on its side in New York harbor because of flooding with an overabundance of fire-fighting water may have influenced the development of this requirement.

Galley ventilation

The subcommittee recently discussed galley ventilation systems, particularly those serving as exhaust ducts for ranges. Despite the addition of filters, grease accumulates in these "flues," making them likely candidates for fires.

The most famous ventilation fire was on *Angelino Lauro* in 1979. High heat generated by fire in the galley duct ultimately ignited other combustibles in the overhead spaces and spread the fire to accommodation spaces.

France proposed that applicable requirements be clarified to prevent such a condition in the future. This recommendation was supported.

Future galley range hood vents will have the necessary protection to be able to prevent and suppress such fires.

Upon Germany's suggestion, these arrangements will be extended to cargo as well as passenger ships.

Existing ships

More and more older passenger vessels are being revived to meet the demands of the expanding cruise market. This trend gives cause for concern because these ships were designed and built according to the technology of the 1940s and 1950s.

Lessons learned from recent casualties have highlighted safety risks in this technology, which have been dealt with through significant amendments to a new SOLAS convention. Requirements under SOLAS 1974 corrected major safety problems of existing ships.

It was anticipated that older vessels would be phased out in a reasonable time, and that the remaining ships would, in time, comply with SOLAS 1974 requirements for new ships. This did not happen.

Of the more than 100 large foreign flag passenger vessels currently operating from United States ports, 26 are more than 30 years old and another 23 are more than 20 years old. In total, 72 are more than 10 years old.

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The majestic Normandie lies on its side in New York harbor on February 9, 1942.

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The hulls, machinery and equipment of these ships have been subject to many years of ocean service. Lifetime maintenance is costly, and often an easy victim of fiscal belt tightening.

Passenger ships have arrived to operate for the first time in the United States with inadequate and leaky lifeboats, with crews who don't know how to launch them. The subjects of control verification investigations, these ships also have numerous fire safety violations, eroded structural elements, critical machinery in terrible condition and emergency equipment that doesn't work.

Modifications have been made to some older vessels to help them compete with new ships. Even though not considered "extensive," these changes can have a major impact on a vessel's safety.

For example, an influx of combustible materials, such as plastics, has been noted. This was not envisioned by drafters of earlier conventions.

Spaces have been redesignated in ways that increase fire risks without appropriate compensation. This would be prohibited by current SOLAS standards.

And there are some ships with so many modifications that neither the owner or flag can recall when they were made nor what SOLAS convention was applied.

There have been casualties. The most recent and tragic was the *Scandinavian Star* fire with more than 150 fatalities.

Concerns for new ships, such as smoke and combustible material control, means of escape, stair landing spaces, and main vertical zone lengths and steps, are even more vital on the older vessels.

Supported by the Subcommittee on Fire Protection, Norway suggested that existing ships be required to upgrade safety measures if they are to continue to operate beyond the year 2000. This issue will be deliberated in May 1991 by the MSC.

The importance of this issue lies in the fact that the industry that must abide by the requirements is actively participating in their development and adoption.

Helicopters

The United States and Australia has requested that the subcommittee look at provisions for helicopter facilities on passenger ships.

Helicopter transportation could be essential for emergencies in some remote exotic areas where cruise ships are beginning to operate. There are even some conceptual plans for incorporating helicopter facilities on future passenger vessels.

However, the risks involved with helicopters landing on top of accommodation spaces will have to be carefully taken into account. As yet, there are no requirements for this type of operation.

Conclusion

The purpose and intent of SOLAS regulations are founded on solid principles of naval architecture, marine engineering and safety. The benefits gained from the experience of the international marine experts participating in the IMO are without equal in any other forum.

Resolution of issues is ultimately achieved to the overall satisfaction of all IMO participants, thus to the enormous benefit of passenger ship safety worldwide.

Marjorie Murtagh serves as the United States representative to and vice-chairman of the IMO Subcommittee on Fire Protection.

Safety of Life at Sea standards

LCDR Marvin Pontiff and LT Randell Sharpe

The new luxury cruise liner Nordic Empress underwent Coast Guard inspection during its first United States port of call in Miami in June 1990.

Introduction

The passenger cruise market is one of the fastest growing of the United States travel industry. About four million people, 80 percent of the world market, are citizens of the United States.

New luxury cruise liners with tremendous passenger capacities are under construction. Older vessels are being modified and pressed into service to meet the increasing demand.

With this tremendous growth comes a higher potential for catastrophe, unless increased steps are taken to ensure that safety standards are sufficient and consistently enforced.

Coast Guard inspector examines a lounge in Nordic Empress in June 1990.

International compliance

The Coast Guard relies upon certificates issued by each foreign vessel's flag administration as the primary means of determining compliance with SOLAS standards.

Depending upon their size and number of passengers, passenger vessels registered with countries which have not ratified SOLAS or do not hold valid SOLAS certificates, are required to be inspected when they arrive at United States ports under our domestic regulations (46 C.F.R., subchapters H or T).

Recently, however, despite the presence of valid SOLAS certificates, some ships have been found not to be in compliance with international standards.

The main areas of concern involve the overall conditions of hulls and machinery, and the potential degradation of structural fire protection due to modifications and selective application of the regulations adopted by various SOLAS conventions.

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Coast Guard inspectors conduct an initial control verification exam on the bridge of Fantasy in Miami in February 1989.

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What is "reasonable and practicable" under SOLAS varies from country to country, and sometimes interpretations of SOLAS regulations differ between the United States and other countries which have adopted SOLAS standards.

Also, with increased market competition, new vessel construction involves innovative design concepts not addressed by SOLAS conventions. They include atriums and glass bulkheads. These are being assessed from a fire protection standpoint.

Control verification

The Coast Guard examines all foreign vessels sailing from U.S. ports with American citizens through its "control verification" program. Under this program, plans approved by flag administrations are first sent to the Coast Guard Marine Safety Center (MSC) for review.

In many cases, the flag administration does not review the plans until a few days before (or even after) the ship arrives at its first United States port. This causes unnecessary delays in a vessel's operating schedule.

Flag administration-approved plans should be submitted at least 45 days prior to the initial United States port call.

After reviewing the plans, the MSC sends comments to the vessel owner and the Coast Guard Officer in Charge, Marine Inspection, at the first port of call. Usually, the comments address areas in the plans that are in question, such as structural fire protection and means of escape.

The vessel's owner then schedules the control verification examination with the appropriate Officer in Charge, Marine Inspection, giving as much advance notice as possible. The initial exam may take several days as it is very comprehensive.

All certificates are examined for compliance with international treaties and conventions to which the United States is a party.

Upon completion of the exam, a certificate of compliance in the form of a letter for control verification is issued to expire no later than the vessel's SOLAS safety certificates. This letter is reissued every year.

Subsequently less detailed exams are conducted quarterly to ensure vessel safety systems are being maintained and to confirm that crew training requirements are being met.

Older ships

More than 70 percent of existing vessels were not built to comply with regulations for new ships in the latest (1974) SOLAS convention. (All vessels must comply with at least SOLAS 1948 standards.) In general, ships do not have to undergo the vast rehabilitations necessary to meet newer requirements.

However, if a ship underwent major modifications that substantially altered its dimensions, passenger-carrying capacity or service life, it is required to meet current standards to a reasonable extent.

Port state interventions

The lack of proper maintenance of structural fire protection elements on some vessels has resulted in port state interventions by the Coast Guard.

Under SOLAS, Chapter I, Regulation 19, a port state can prevent a vessel from embarking passengers when there are clear grounds for believing that the condition of the ship or its equipment is substantially below specifications set forth in its certificates, or that the ship and its equipment is not maintained to conform with SOLAS regulations. Domestic law provides similar authority.

Maintenance

Concerning maintenance on older vessels, the administration or classification society that issued the SOLAS certificates plays a significant role in ensuring that the owners fulfill their responsibilities. The certificates should not be reissued when a vessel's condition is allowed to degenerate.

A Coast Guard letter distributed in December 1989 alerted field inspection units to maintenance problems found on older vessels and ordered a hard-line approach to be taken when determining compliance with SOLAS regulations.

Modifications

In some instances, the certificate issuer did not know about modifications made to a vessel by present or past owners. This could have been due to ownership changes or the lack of up-to-date vessel plans.

In other instances, compliance was difficult to determine because standards from several SOLAS conventions were applied to one vessel over a period of years.

To determine vessel compliance with current SOLAS regulations as accurately as possible, the Coast Guard has increased its inspection efforts by adding headquarters policy development personnel to field inspection teams.

Long service lives

SOLAS 1974 standards contain grandfathering provisions for certain older vessels. However, SOLAS regulation drafters did not anticipate such a large number of passenger vessels would remain in service long after what was considered a normal service life.

In light of today's increased concerns over passenger vessel safety, the United States, as well as the Scandinavian countries, question the continued acceptance of wood construction permitted by SOLAS 1960 regulations.

Conclusion

United States unilateral actions are tempting as an easy fix for various problems uncovered by vessel inspections. The Coast Guard, however, continues to believe that international channels must be the principal route for improvement.

Domestic legislation may jeopardize trade with other countries and force passenger vessel operations out of United States jurisdiction.

The SOLAS process is an excellent framework through which to uphold high safety standards throughout the world. But the application and enforcement of SOLAS regulations must be consistent from country to country.

LCDR Marvin Pontiff and LT Randell Sharpe are project officers in the Merchant Vessel Inspection Division of the Coast Guard's Office of Marine Safety, Security and Environmental Protection.

Safety board's role

Ralph E. Johnson

NTSB

The National Transportation Safety Board (NTSB) is an independent federal agency that serves as the overseer of transportation safety in the United States. It is responsible for improving safety in marine, railroad, highway, pipeline and civil aviation transportation.

The NTSB conducts its mission primarily by determining the probable causes of accidents through direct investigations and public hearings, and secondarily through staff review and analysis of accident information, through evaluations of the effectiveness of other agencies, and through special studies, published recommendations and reports to Congress.

Authority

Created by the Transportation Act of 1966, the NTSB began operations in April 1967 as an autonomous agency under the Department of Transportation.

In 1974, Congress enacted the Independent Safety Board Act, establishing the NTSB as a totally independent agency of the federal government and broadening its investigative role in surface modes of transportation. The NTSB began operations under this act on April 1, 1975.

The NTSB board consists of five members appointed by the President and confirmed by the Senate. Their five-year terms are staggered so that only one term expires each year. The President designates the chairman and vice-chairman.

NTSB's Office of Surface Transportation Safety directs the investigation of all surface transportation accidents. Since there are no marine investigators in the regional offices, the eight investigators and three technical specialists in the Marine Division at NTSB headquarters in Washington, D.C., investigate marine accidents worldwide.

Regulations

On December 1, 1977, the NTSB and the Coast Guard issued joint regulations concerning marine accident investigations, which became effective January 3, 1978.

The NTSB regulations are contained in Part 850 of Title 49 of the Code of Federal Regulations, and the Coast Guard regulations are in Part 4 of Title 46 of the Code of Federal Regulations.

The regulations state:

- Under its rules of practice for surface transportation accidents, the NTSB may conduct an investigation of a major marine accident or request the Coast Guard to conduct an investigation under its administrative procedures.

- If the Coast Guard conducts the investigation, the NTSB may designate a person or persons to participate in every phase of the investigation.

- A major marine accident is a casualty that results in:

  (a) the loss of six or more lives;

  (b) the loss of a mechanically-propelled vessel of 100 or more gross tons;

  (c) property damage initially estimated as $500,000 or more; or

  (d) serious threat to life, property or the environment by hazardous materials.

These regulations apply to all United States passenger vessels anywhere in the world and foreign-flag passenger vessels operating in United States waters.

The NTSB investigated the collision of the passenger vessel Mississippi with the towboat Crimson Glory on the Mississippi River near Donaldsonville, Louisiana, on December 12, 1985

Investigations

After the Coast Guard has determined that a major marine accident has occurred, it notifies the NTSB duty officer. The NTSB then determines whether it will conduct an investigation.

It is not possible for the NTSB to investigate all major marine accidents due to its limited resources. It is one of the smallest agencies of the federal government with less than 400 authorized positions.

The NTSB conducts investigations using a technical party system under which all participants are involved in developing the facts of an accident. The parties are designated by the NTSB as necessary for each individual accident, and may include government agencies, private companies, associations and unions. The Coast Guard is always a party to NTSB marine accident investigations.

Party representatives serve as assigned by the NTSB's investigator-in-charge. They must be suitably qualified technical employees who do not occupy legal positions. Parties cannot be represented by any person who also represents claimants or insurers.

The NSTB's investigative teams normally possess a wide range of skills. A maritime investigation team could include a deck or engineering officer, a naval architect, a metallurgist, a meteorologist, a survival factors specialist and a human performance specialist.

During an on-scene investigation, wreckage parts and failed machinery components are identified and marked for further testing. Logbooks, course recorder tapes, bell logger tapes and other documentary evidence is collected. Sworn testimony may be taken, if necessary.

Except for proprietary and national security information, all facts accumulated during NTSB investigations are made public.

After each major investigation, the NTSB issues a report describing the facts, conditions and circumstances of the accident; determines its probable cause; and makes recommendations for safety improvements to help prevent similar accidents from occurring in the future.

The NTSB and the Coast Guard frequently hold joint factfinding investigations, saving the taxpayers the cost of two separate probes. However, after the factfinding phase of the joint investigation is completed, the NTSB prepares a report independent from the Coast Guard.

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Special studies and reports

Subsequent analysis of investigation findings provides the NTSB with the facts necessary to issue special studies, discussing in detail problems or weaknesses in specific areas of transportation safety.

Based on a recent study of passenger vessel safety, the NTSB has requested additional authority to investigate accidents on foreign-flag passenger ships carrying primarily United States passengers.

The NTSB is required to make an annual report to Congress, which includes a detailed appraisal of accident investigations and prevention activities of other government agencies.

In addition, every two years the NTSB conducts a biennial review, evaluating transportation safety nationwide and recommending needed legislation and administrative action to Congress.

Recommendations

Safety recommendations are the NTSB's most important product. Structured to correct safety problems identified in accidents, the recommendations are made to the government or private organization that can take the necessary corrective action.

The strength of these recommendations is based on their supporting facts and analysis, the openness of the followup process, and the agency's ability and willingness to take action.

Although the safety recommendations are not mandatory, the acceptance rate is high.

Agencies under the Department of Transportation must respond to the recommendations within 90 days. If an agency refuses to comply with a recommendation, the response must detail the reasons for such a refusal.

The NTSB requests that government agencies outside the Department of Transportation and private organizations also respond within 90 days.

When recommendations involve changes in federal regulations, the NTSB will monitor the rulemaking process to its completion. When a study must be conducted to determine the best course of action, the NTSB will monitor its progress to the point of a solution.

Because of these necessary followup activities, a recommendation file will typically remain open for a year or more.

Summary

The NTSB's role in passenger vessel safety is to investigate passenger vessel accidents, determine probable causes and issue safety recommendations. The NTSB does not have any regulatory authority over passenger vessels. The Coast Guard has the primary regulatory authority in the United States.

The 1974 Independent Safety Board Act prohibits the use of NTSB reports in civil litigation, and NTSB investigators cannot testify as expert witnesses.

To ensure the safety of all United States passengers aboard both United States and foreign vessels, the NTSB needs the full cooperation of passengers and crews, vessel owners and operators, and government and private regulatory agencies during accident investigations.

Ralph Johnson is the deputy director of the NTSB Office of Surface Transportation Safety.

Unique role of classification societies

Daniel F. Sheehan

Lloyd's Coffee House

Today's ship classification society is a unique institution in today's maritime world.

While it was established for purely economic reasons, the society is now necessary to the function of modern marine transportation and plays a vital role in assuring passenger vessel safety, as well as the safety of other types of vessels and marine structures.

Origins

Today's classification society originated in the 18th century, along with the maritime insurance industry, in a coffee house owned by Edward Lloyd in London.

Individuals serving as underwriters for shipments of goods to points around the world became increasingly concerned about continued losses they suffered because of poorly equipped and maintained ships.

The underwriters assembled a group of knowledgeable individuals with maritime backgrounds to judge the seaworthiness of merchant ships. This group set up an elemental rating system to serve as a basis for decisions on whether or not to extend insurance coverage to the ships and their cargos.

What they did was classify and register ships according to their fitness and intended service -- thus began the modern classification society.

Today's functions

In its purest sense, a classification society is designed to provide exactly the same service that the 18th century underwriters had in mind -- to establish a relative rating system for various ships as a standard for insurance provision.

Over the years, the role of the classification society has evolved into one with the following generally accepted functions.

Classification Functions

1. Establishing rules for the design and construction of commercial vessels.*
2. Verifying through periodic surveys that the ships are maintained according to their rules.
3. Affirming to sovereign governments by official documents that ships are built to the specific requirements in treaties ratified by the governments.
4. Serving as quality control agents for traditional maritime and non-maritime industries.
5. Serving as design agents, normally through subsidiaries, for traditional maritime structures and systems.
6. Advising delegations to the IMO on safety and pollution prevention issues.

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* The societies review and analyze the designs of new ships to determine their adherence to the rules. They also survey the building of ships to see that approved plans are followed and that good workmanship practices are used. This includes visits to fabrication plants and material manufacturers to witness testing.

It should be noted that not all classification societies perform all of these functions.

Crossover activities

Normally "not for profit" institutions, classification societies obtain most of their income from ship owners for services relating to vessel classification.

While inspecting for classification purposes, a society also often performs "regulatory" functions on behalf of a government. (This is for inspection and issuance of certificates in accordance with international maritime conventions.) Some flag states delegate their entire regulatory responsibility to one or more classification societies.

The classification process begins when a ship owner or builder selects a society. If the ship is still on the drawing board, naval architects submit their renditions and calculations for approval to the society under its requirements.

There are proscribed mechanisms for existing ships transferring from one society to another. Normally a committee examines a vessel's documentation and decides its classification.

With respect to passenger vessels, in most cases, a classification society acts as an agent for a government in determining compliance with international treaties, such as the SOLAS convention.

The treaties, however, often contain provisions which are subject to a variety of interpretations. There are some provisions that are left "to the satisfaction of the administration." This has caused no end of problems for both flag and port states.

Uniformity

A convention must be carried out and enforced in as uniform a manner as possible for it to have validity. If not, ship safety levels could be subject to wide variances.

Flag states have an obligation to ensure that their vessels comply with the requirements of international treaties which they have ratified. Ship owners have the same obligation.

Port states have the right and the obligation to assure that vessels visiting their ports comply with the treaties ratified by their flag administrations. This is normally carried out under a function called port state control, which can be conducted with varying degrees of intensity.

United States conduct

Port state control efforts by the United States are rigorous, particularly on passsenger vessels. When problems arise, the classification society is often scrutinized intensely.

If a problem involves poor maintenance or physical condition, the Coast Guard points a finger at the owner and then asks the society why it maintained the vessel's classification.

If a problem concerns the interpretation of a convention requirement, the owner may question the society's viewpoint and the flag state may or may not go along with the society. And, of course, the port state that discovered the problem in the first place, wants to know what will be done about it.

Regardless of any problems, the role of the classification society is an integral part of the partnership for safety between the owner, flag and port state in the United States and abroad.

Daniel F. Sheehan is the senior technical advisor in the Coast Guard's Office of Marine Safety, Security and Environmental Protection.

Research on FIRE

Allen Penn

New materials and technologies for passenger ship design, construction and outfitting are coming along so fast that it makes one's head swim. One wonders what tomorrow will bring.

The Coast Guard is going all out to make sure that the multitude of applications of the new techniques will not jeopardize the safety and well being of passengers and crews aboard today's miraculous megaboats.

Fire protection, stability and human factors are all subjects of special Coast Guard research and development projects for improving safety on cruise vessels. Fire protection is the topic of this article.

Continuing threat

As the number of cruise passengers increases, the maritime industry seeks to reduce costs with the new materials and technologies. While often improving safety levels, these innovations also present new combustion hazards.

Fire and explosion pose a continuing threat to life and property at sea, especially when smoke and toxic gases get out of control aboard ship.

Research essential

Extensive testing and evaluation of new technologies as they affect safety at sea is essential to support the position of the United States with the IMO, and to guide industry standards and regulations.

The Coast Guard's Marine Fire and Safety Research Program supports naval engineering and environmental response projects, along with commercial vessel safety. This multi-mission approach often results in positive, far-reaching effects on other Coast Guard programs as well as those of other federal agencies, commercial industries and international ruling bodies.

Goal

The goal of the Coast Guard's Marine Fire and Safety Research Program is to reduce the losses to life, vessels, cargo and property caused by fire and explosion. Ultimately, these projects will improve the domestic and international awareness of these hazards, and develop better standards to nurture a thriving safe maritime industry.

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Coast Guard technicians evaluate the potential flame spread of plastic piping at the Fire and Safety Test Detachment.

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FIRE RESEARCH

Completed projects

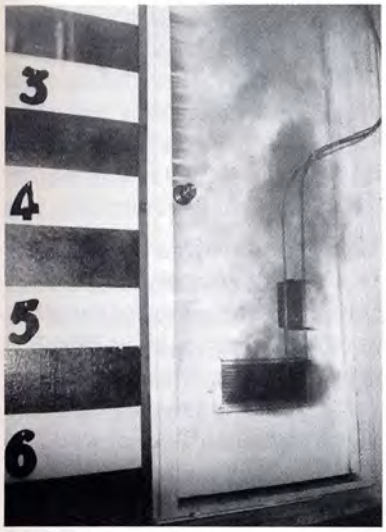
Ship's lounge burnout experiments (NTIS Report No. A116123)
Smoke-gas hazards of bulkhead finish materials (NTIS Report No. A147761)
Smoke-gas hazards of deck covering materials (NTIS Report No. A142266)
Smoke-gas hazards of furnishings (NTIS Report No. 147641)
Fire resistance testing of bulkhead and deck penetrations
Phase I - (NTIS Report No. A163315)
Fire resistance testing of bulkhead and deck penetrations
Phase II - (NTIS Report No. A211235)
Smoke-gas hazards - shipboard compartment fires (NTIS Report No. A167204)
Evaluating fire doors with hose ports (NTIS Report No. A182474)
An investigation of smoke produced by interior bulkhead finishes and secondary deck coverings (NTIS Report No. A208160)

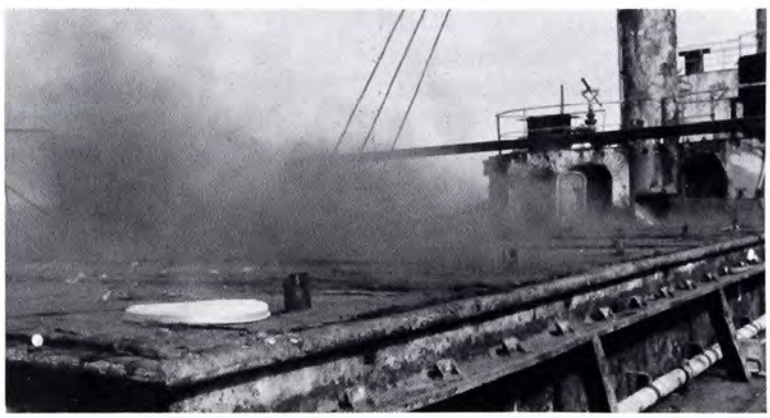
Current projects

Toxic fire products
Surface flammability of carpets
Smoke emission of wool carpets and primary deck coverings
Corridor and stairway width
Marine fire detection
Aluminum small passenger vessel fire endurance
Smoke control passenger vessels
Fiberous reinforced plastic hulls and superstructures

Future projects

Fire resistance of insulations
Audible signals for escape routes
US-IMO standards for flammability of upholstered furniture
Endurance of sprinkler protected glass
Flame spread of paint





(top left clockwise) Coast Guard tests smoke movement through door vents, combustibility of an insulated steel boundary with a penetration, smoke damage from burning cars on roll-on/roll off deck, and flammability of stateroom furnishings.

Support sources

The Marine Fire and Safety Research Program has five major sources of support. They are:

1. ***Marine Fire and Safety Research Division*** is staffed with fire-protection experts and is located at the Marine Safety Laboratories, Groton, Connecticut.

2. ***Fire and Safety Test Detachment*** is the only full-scale marine fire testing facility in the world. Located in Mobile, Alabama, the detachment conducts tests on surplus ships to simulate actual environments on merchant and naval vessels.

3. ***Marine Fire Research Laboratory*** conducts small-scale, preliminary and verification tests in Groton, Connecticut.

4. ***Industry*** offers substantial in-kind support in the form of suppression agents, fire fighting hardware, system design and test materials.

5. ***Contract awards*** are made for projects that are not suitable for testing at the Mobile detachment or the Groton laboratory. This permits large projects to be accomplished quickly in their entirety or in part.

Allen Penn is a project engineer with the Marine Technical and Hazardous Materials Division of the Coast Guard's Office of Marine Safety, Security and Environmental Protection.

Built not to burn

Klaus Wahle

SOLAS 74 requires that bulkheads, ceilings, linings and insulation in all passenger vessels be constructed of noncombustible materials. For aesthetic reasons, combustible veneers, moldings and facings are permitted in limited thicknesses.

Noncombustibility

One of the most misunderstood and misused terms in the fire-protection field, noncombustibility means different things to different people.

To some, it denotes materials such as brick, stone or steel, which do not burn under any conditions. To others, it includes materials which do not burn quickly or progressively when ignited.

The Coast Guard is constantly being presented with reports certifying that certain materials are not combustible because they have been subjected to various ignition or surface flame spread tests without burning up. These reports, however, are usually not valid.

Definition

SOLAS 74 defines a noncombustible material as, "a material which neither burns nor gives off flammable vapors in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined to the satisfaction of the administration by an established test procedure. Any other material is a combustible material."

The test procedure recommended by SOLAS 74 is described by IMO Resolution A.270(VIII), which has been superseded by IMO Resolution A.472(XII).

This resolution has been incorporated into the domestic marine regulations of many countries. In the United States, it is Coast Guard Regulation 46 CFR 164.009, published in 1976.

Test apparatus

The noncombustibility test uses a small, vertical, electrically-heated furnace with natural ventilation and small cylindrical material test samples.

The ceiling materials on this passenger ship lounge were tested for combustibility limits.

The furnace apparatus consists of a furnace tube, stabilizer, draft shield, furnace stand, temperature coil controls with a voltage stabilizer, specimen holder, specimen insertion device, and three thermocouples to measure the temperatures of the furnace, specimen surface and specimen center.

Test procedure

The furnace is heated and stabilized at 750°C (1382°F). A previously conditioned material sample is attached to the holder and inserted into the furnace.

Measurements of temperature rise of the furnace, sample surface and center are made. Any observed flaming of the specimen is recorded.

The test takes 20 minutes or until peak temperatures have been passed, whichever is longer.

Test requirements

An average of five test samples must meet the following requirements to be classified as noncombustible:

1. 50°C maximum furnace temperature rise.
2. 50°C sample surface temperature rise.
3. 10 seconds maximum duration of flaming.
4. 50-percent maximum weight loss.

Note: There is no pass/fail criterion for the temperature of the sample center, although it is recorded.

Criteria significance

The furnace temperature of 750°C was selected because it is believed to be representative of temperature levels known to exist in building fires. For many construction materials, complete burning of combustible elements will occur as readily at 750°C as at 900°C (1600°F) or at 1000°C (1800°F).

The 50° criteria have been established to account for temperature rises due to heat from the burning of small amounts of organic binders which are necessary to shape inorganic particles into usable insulation boards or blankets, as well as to account for the test apparatus properties.

The 50-percent maximum weight loss criteria was added after it was demonstrated that low-density organic forms could burn and be consumed so rapidly that the thermocouples could not respond quickly enough to register a significant temperature rise. On the other hand, the liberal value of 50-percent weight loss permits materials to contain a certain amount of water to be liberated during the test.

The intention of the test and pass/fail criteria is to limit acceptable materials to those that are primarily inorganic in nature. All materials now approved as noncombustible by the Coast Guard are believed to be inorganic, except for small amounts of organic binder (for example, about six percent or less by weight for fiberglass insulation).

Organic materials

Organic materials, including plastics, cannot be rendered noncombustible by any currently known treatment.

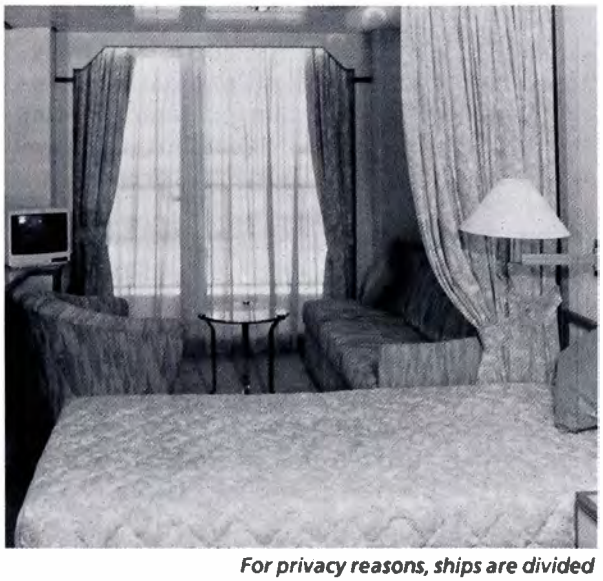
Often organic materials containing fire-retardant components or surface treatments are submitted for approval as noncombustible. Such methods may delay the ignition and reduce surface flame spread, but they neither reduce the amount of combustible elements nor prevent the decomposition of the material under severe heat exposure.

Ship characteristics

Ships have unique characteristics quite different from those of buildings, which make extensive use of noncombustible materials imperative. They include:

1. Ships are self-contained. They must provide their own routine services as well as emergency services, such as water and electricity. A fire can jeopardize essential services, placing the ship at the mercy of the sea.

Continued on page 44



For privacy reasons, ships are divided into discrete compartments.

Continued from page 43

2 Ships are often far removed from outside assistance and cannot rely on a fire department to respond within minutes. Ships must supply their own fire departments.

3 If one must leave a burning ship, it is to a lifeboat or the water, not dry land.

4 Means of escape on a ship are usually upward, the same direction that fire, heat and smoke spread most rapidly, rather than downward as in the case of a burning building.

5 Weight limitations on ships preclude the use of heavy, multi-hour fire barriers often found in buildings.

6 For privacy reasons, ships are divided into a number of discrete, usually small compartments, making containment possible.

These characteristics make it necessary to build ships with as little fuel as possible to feed a fire. Since most of the furnishings are usually combustible, and articles brought aboard by passengers and crew cannot be controlled, it is imperative that the vessel itself be constructed of noncombustible materials to the greatest possible extent.

Noncombustibility tests ensure that ship construction materials will not contribute to the intensity of a fire.

Combustible finishes

Ships' bulkheads and ceilings are usually covered with decorative surface finishes to make interior accommodation areas appealing. The vast majority of decorative finishes, veneers, moldings and other decorations are by their very nature combustible.

To keep fire hazards to a minumum, it is necessary to control the amount of these combustible materials used on board ship, confine them to certain locations, regulate their thickness and limit their total volume with respect to the area they cover.

In addition, such finishes in corridors, stairway enclosures and hidden spaces must have low flame-spread characteristics and limited heat-release values.

Conclusion

The mandatory use of noncombustible construction materials for passenger vessels has served the public well, even though it has not solved all fire protection problems nor prevented all fires.

There are no international efforts underway to reduce or modify this requirement, despite occasional complaints by vendors and vessel owners that it prevents the use of some cheaper or lighter or more attractive materials.

On the contrary, recent international efforts to improve passenger vessel fire protection have been aimed toward supplementing noncombustible construction regulations by addressing some areas not previously well defined. These areas include flammability and smoke development of interior finish, ignition of upholstered furniture, smoke toxicity and movement, and supplementary sprinkler systems.

The public can rest assured that every possible effort will be made to keep passenger vessels safe and free from fire.

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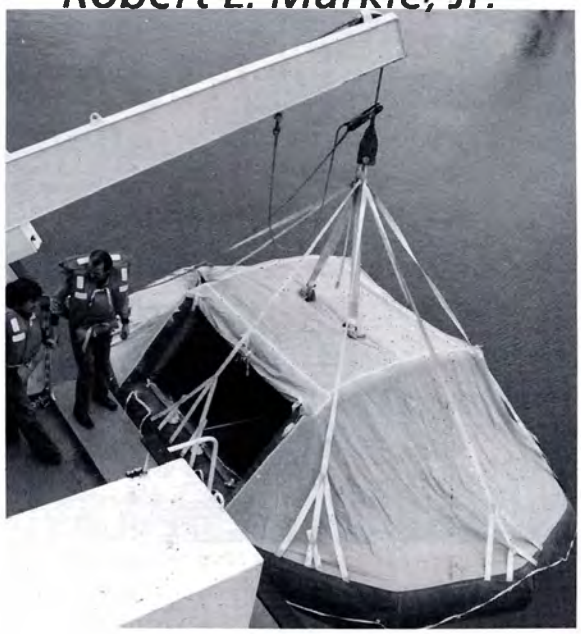
Lifesaving systems

Robert L. Markle, Jr.



Davit-launched liferaft is prepared for boarding.

It has been more than 75 years since ~~Titanic~~ sank after colliding with an iceberg in the North Atlantic. Since then, ship safety has improved in many ways.

However, when passengers on a modern cruise ship are summoned to their muster stations for the lifeboat drill, many of them have visions of ~~Titanic~~ sinking beneath the water.

Some count the lifeboats and add up the number of people on board to assure themselves that there will be enough space for everyone on board if the "abandon ship" order comes. Some passengers call or write the Coast Guard if the numbers don't add up.

The *Titanic* disaster may seem like ancient history, but its legacy is still with us in the international SOLAS treaty.

Early standards

Some of the basic standards agreed to in the SOLAS treaty drawn up in 1914 in response to *Titanic* are still part of the SOLAS convention today. They include the establishment of the International Ice Patrol and state-of-the-art radiocommunications, and the provision of lifeboats with sufficient capacity for everyone on board.

1983 amendments

The 1983 amendments to SOLAS completely revised the lifesaving chapter for new ships for the first time since 1948.

Unlike previous SOLAS lifesaving chapters, which included tables on the number of boats and davits required on ships of certain lengths in various services, the 1983 chapter is more performance-oriented. There are still minimum requirements, but new, innovative lifesaving systems are permitted, even encouraged.

Prinsendam

Are lifeboats still really needed on a modern passenger cruise ship? For more than 500 people on board *Prinsendam* in the fall of 1980, they were.

A fire interrupted the ship's cruise to Alaska and the Orient, and when fire-fighting efforts failed, all on board took to the lifeboats and liferafts. Everyone was saved.

Continued on page 46

Lifeboats saved 326 passengers and about 300 crew members after Klinsebodin caught fire in the fall of 1980. Here the burning cruise ship drifts in the Gulf of Alaska.

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Prinsendam was a relatively modern ship, only seven-years-old when it sank. Newer than many ships in the cruise trade today, *Prinsendam* met all of the relevant SOLAS structural requirements.

Maxim Gorky

In June 1989, ***Maxim Gorky***, a Russian cruise ship, struck an ice floe north of the Arctic Circle near Norway. With the hull starting to flood through two holes, the ship started to go down.

About 325 of the 900 persons on board had abandoned ship in lifeboats by the time a Norwegian Coast Guard vessel and helicopters arrived.

The accident was a reminder of the *Titanic* disaster for at least one passenger, who was quoted in ***Time Magazine***. However, this time, with modern communications and lifesaving equipment, rescue ships and helicopters arrived within four hours of the accident.

Some passengers were treated ashore for hypothermia and broken bones, but no lives were lost.

Today's standards

The SOLAS convention now requires a passenger ship to be capable of being completely abandoned within 30 minutes of the alarm.

This means that ship designers must give careful consideration to the layout of a ship, its escape routes, and where and how the passengers will be mustered and directed to their survival craft.

Design problems

Positioning lifesaving equipment on modern cruise ships can present problems for the designer. New ships tend to have more decks to increase passenger capacity.

On some ships, this means that even if lifeboats are stowed bow-to-stern on both sides, there still would not be enough lifeboat capacity for all on board.

Liferaft solution

This problem has been solved by using inflatable liferafts for part of the "survival craft" capacity. Stored uninflated in barrel-like containers, these rafts carry survival equipment that is comparable to that on lifeboats.

Seating is on the floor rather than on seats, but insulation keeps passengers tolerably warm. Double-layer canopies keep out wind and spray.

Since SOLAS 1960, inflatable liferafts have been permitted as part of the lifesaving equipment on passenger ships.

Under the 1983 SOLAS amendments, passenger ships built after July 1, 1986, on unlimited international service, can have liferafts for as many as 25 percent of the persons permitted on board. Ships that go only on trips of no more than 600 miles one-way nor 200 miles from port at any time (short international voyages), are allowed to use inflatable liferafts for up to 70 percent of their survival craft capacity.

Hypothermia

Hypothermia, or subnormal body temperatures, is the primary hazard in any abondon-ship situation.

There were enough lifejackets onboard *Titanic* for everyone, but those who had to use them in the cold North Atlantic water quickly perished. And *Prinsendam* had enough survival gear for everyone, but after 13 hours in the last lifeboat, the wet and cold passengers were suffering the first stages of hypothermia.

Since passengers may be any age and physical condition, hypothermia is a greater concern on cruise ships than on cargo and tank vessels.

The 1983 SOLAS amendments deal with hypothermia by requiring partially enclosed lifeboats on passenger ships. These lifeboats have rigid cabin tops over both the bow and stern sections, but are open in the middle to permit rapid boarding.

A flexible canopy stretches over the open section to keep out wind and waves. In fair weather, it can be left open for ventilation.

Launching liferafts

Passengers cannot be expected to jump from the deck to a liferaft in the water, and descending ladders is time-consuming and dangerous.

The conventional method is to launch several liferafts, using a small davit and winch. The raft is hauled from its container over the side, where it is inflated and secured to the side of the ship. Passengers walk to the edge of the deck right into the liferaft.

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Modern lifeboats have rigid cabin tops over both the bow and stern, with the middle section open for rapid boarding.

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When it is full, the liferaft is lowered to the water, released and towed away from the ship by a motor lifeboat. The launching crew on deck hauls the hook back and repeats the process with the next liferaft.

The largest davit-launched liferafts carry 35 persons, and the most liferafts that can be loaded and launched in the allotted 30 minutes is six. This means that up to 210 persons could be handled at one liferaft station. This is greater than the capacity of the largest lifeboat, and the liferaft launching station takes up only about one-third the deck space of one large lifeboat.

Inflatable slides

Designers are seeking ways to increase the number of persons who can be evacuated from a single embarkation station.

Inflatable slides, such as those used on airliners, have been used on ships with varying degrees of success for about 20 years.

Early prototypes had stability problems in high winds. When the slide got wet, it could be extremely slippery, leading to high speed descents. When a person hit the inflated platform at the bottom of the slide at high speed, he or she could be catapulted right into the water.

Modern slides have overcome these problems. They are stable in high winds and seas, and their surfaces are a non-slippery mesh material that drains the water.

There is an open inflatable platform at the bottom of the slide. The liferafts are dropped in the water near the platform, where crew members inflate and secure them for boarding.

Because these liferafts are not designed to be suspended from a hook with a full load of people on board, they are not as limited in size. Liferafts for 50 persons are available, and even larger sizes are possible. Using a double-track slide and large rafts, one manufacturer expects to be able to handle 500 people in 30 minutes.

Escape chutes

The escape chute is another device under consideration. This is a fabric tube which hangs vertically from the embarkation deck to the inflatable platform floating on the water. The launching and loading of liferafts are carried out the same way as with the slide.

The evacuees drop into the opening at the top of the chute, and folds of fabric inside the outer sleeve control the speed of descent through to the platform at the bottom.

The manufacturer of the escape chute maintains that it can handle one person every three seconds, or about 500 in 30 minutes, allowing for a five-minute deployment.

Lifejackets

SOLAS requires lifejackets for everyone on board, including children, plus some spares. The 1983 amendments include a new standard for lifejackets requiring more buoyancy and improved performance.

Lifejackets in use today all have lights attached to make it easier to find survivors in the water at night.

Lifebuoys

Passenger ships have many ring lifebuoys distributed around open deck areas in case somebody falls overboard. Half of them have lights that automatically turn on when the buoy is thrown in the water. Two buoys stowed near the bridge have 15-minute smoke signals to help with location during the day.

Satellite beacons

Starting in 1991, international passenger ships will start carrying satellite emergency position-indicating radiobeacons. By 1993, they all will have them.

These beacons automatically start broadcasting distress signals when they are thrown into the water or when they float free from a sinking vessel. Signals are picked up by United States and Soviet polar-orbiting satellites, and relayed to ground stations which can identify the ship and its location.

When help is close by, parachute flares carried on the bridge can alert potential rescuers to a ship in distress and help them to locate the ship more quickly, especially at night.

Emergency provisions

Lifeboats and rafts are equipped for several days at sea. Emergency food and water are carried, along with distress flares and smoke signals, fishing kits, first-aid kits, sea sickness medication and other provisions to help survivors for up to a week.

Thermal protective aids made of "space-blanket" material, which help ward off hypothermia by preserving body heat, will also be stowed on lifeboats and rafts. There will be enough of these devices for at least 10 percent of the capacity of the boat or raft. Ships with open lifeboats travelling in colder climates, however,will have to carry one thermal protective aid for each person on board.

Training

The best equipment can be useless if it's not used properly. The 1983 SOLAS amendments stress the need for crew training in the lifesaving system on board.

The only training required in the past was the fire and boat drill. Today, there must be training sessions in lifesaving equipment and survival at sea.

Crew training is required in the use of inflatable liferafts, treatment for hypothermia and handling lifesaving equipment in severe weather and seas.

Language can be a problem. Crew members, as well as passengers, may be of several different nationalities. A set of symbols has been developed to illustrate labels and instructions in a way that can be universally recognized, regardless of language. These symbols are recommended for use on cruise ships and should start appearing in the near future.

Conclusion

Cruise ship travel usually is calm and safe. SOLAS requirements are intended to protect ships from fire, loss of stability and hull damage.

Crew members on platform under inflatable slide prepare to bring liferaft into boarding position.

A lot of attention is paid to SOLAS lifesaving systems which everyone hopes will never have to be used. In the rare cases when ship safety systems fail, these systems should ensure that all on board can survive a disaster at sea.

Robert L. Markle, Jr., is the chief of the Survival Sytems Branch of the Coast Guard's Office of Marine Safety, Security and Environmental Protection.

Damage stability

LCDR Randall Gilbert and Patricia Carrigan

The *RMS Titanic* disaster in 1912 heightened the concern for ship vulnerability due to flooding accidents caused by collisions and groundings. The measure of the ability of a ship to survive such accidents is called damage stability, and has been a basic concern since Noah's ark.

This stability is attained by subdividing the inside of a ship's hull into compartments separated by watertight bulkheads spaced at appropriate intervals lengthwise and crosswise throughout the vessel. Flooding caused by hull penetration is therefore limited to a relatively small space enclosed by decks and bulkheads, leaving enough buoyancy in the rest of the ship to keep it afloat.

Calculations regarding subdivision size and location are based mostly on the size of a ship and number of passengers. This and other flood damage-control methods are based on lessons learned from actual ship casualties.

The extent of damage which a ship must withstand and survive is prescribed by United States regulations and international law.

Vital factors

There are two significant factors to take into account when assessing the damage stability of a ship.

First, a maximum extent of damage is assumed in the design calculations. However, almost any ship will sink if damaged extensively enough. There must be a realistic assessment of the amount and types of damage a ship should be able to withstand and reasonably expect to survive.

The second factor is the margin of safety remaining after the damage is done. Known as residual stability, this is a measure of the ability of a damaged ship to remain afloat and upright under additional forces, including wind, waves, passenger movement and survival craft launching.

Modern problems

The damage stability requirements contained in SOLAS 1974 regulations are essentially the same as those adopted in 1948.

Passenger vessel designs have undergone considerable change since 1948. The conventional deep draft fine hulls of the liner trade have been replaced by broad shallow hulls.

It was determined by Coast Guard review in the early 1980s that modern cruise ship designs were evolving in ways that weakened their residual stability.

It was demonstrated that if a modern passenger ship was damaged by collision to the extent designated by SOLAS standards as being within safe limits, it could capsize when lifeboats were launched and passengers shifted to the side for boarding, or if the weather was anything but flat calm.

The old liners inherently had adequate residual stability with their high watertight decks, full crosswise watertight bulkheads up to the weather deck, and a limited number of passenger decks.

Today's passenger cruise ships have broad midbodies, low watertight decks and many levels of passenger accommodations -- characteristics which lead to reduced residual stability.

Disaster

There was significant opposition to raising the level of residual stability requirements at the IMO until United Kingdom's *Herald of Free Enterprise capsized* after accidental flooding in March 1987.

Although *Herald of Free Enterprise* was a passenger ferry, its hull design was similar to most modern passenger ships. The disaster emphasized the need for stricter residual stability standards for all passenger ships.

New *and Old*
Song of America (1984) and Mauretania (1907) provide vivid contrasts in passenger vessel design.

Coast Guard response

In response to the *Herald of Free Enterprise* casualty, the Coast Guard established a stability survey program for all cruise ships operating out of United States ports.

The program demonstrated that foreign passenger ships uniformly complied with existing SOLAS regulations, but it also confirmed that many foreign cruise ships had minimum residual stability.

New ship standards

In 1989, IMO members agreed on tougher damage stability standards for new ships, and subsequently adopted them into the SOLAS 1990 amendments, which came into effect in April 1990.

Thus, new damage stability requirements for all new United States passenger vessels are being developed and should be enforced soon.

Existing ship proposal

Following the *Herald of Free Enterprise* tragedy, a United Kindom research study on the damage stability characteristics of passenger ships confirmed that the SOLAS 1990 residual stability standards were necessary for all passenger ships.

Based on these findings, the United Kingdom submitted a proposal to the IMO's Maritime Safety Comittee to retroactively apply the SOLAS 1990 amendments to existing passenger ferries.

The United Kingdom proposal has been forwarded by the committee to the technical Sub-committee on Stability and Load Lines and on Fishing Vessel Safety for discussion at their next meeting in early 1991.

United States objective

The United States will continue to work with the United Kingdom and other countries through the IMO and other international stability groups to ensure that all passenger ships -- new and old -- have sufficient stability after damage to withstand any reasonable natural forces.

LCDR Randall Gilbert directs the Stability and Subdivision Section, Naval Architecture Branch of the Coast Guard's Office of Marine Safety, Security and Environmental Protection. Patricia Carrigan is a naval architect in the Stability and Subdivision Section.

Passenger ship examinations

Allen Penn

Introduction

More than 100 large cruise ships with a combined capacity for more than 90,000 passengers operate out of United States ports. All but two, *Constitution* and *Independence*, are foreign-owned and operated.

It is estimated that at least ten more foreign cruise ships carrying another 10,000 passengers will be constructed in the next four years.

More than 70 of the existing ships are between 10 and 40 years of age. Many of the older ships adhere to international structural and safety standards established long ago.

There is concern that the safety of these vessels may not be adequate to ensure the survival of their passengers and crews.

Examination program

Established in 1968, the Coast Guard Passenger Vessel Examination Program ensures that ships with overnight accommodations for 50 or more individuals meet up-to-date SOLAS fire safety standards or United States passenger vessel requirements.

The program was evaluated in 1984 following fires aboard *Scandinavian Sea* and *Scandinavian Sun*. It was concluded that all foreign passenger vessels operating out of United States ports should continue to be examined periodically for adherence to safety standards.

Foreign vessels carrying passengers from United States ports are examined at their first United States port of call and, at least, annually thereafter. Ships operating out of several United States ports under the jurisdiction of more than one marine safety or inspection office are examined at least quarterly.

The structural fire protection, fire detection and extinction systems, and fire and abandon ship drills are carefully inspected for compliance with SOLAS and United States regulations.

EXAMINATION POINTS

Examining the structural fire protection, fire detection and extinguishing systems is primarily a material inspection and fairly objective.

The fire and abandon ship drill inspections are far more subjective, because these exercises rely on the training and experience of the crew.

STRUCTURAL

FIRE PROTECTION

1. Method of construction
2. Main vertical zone
3. Draft stops
4. Dead-end corridors
5. Fire doors
6. Stairwells
7. Ventilation systems
8. Use of combustible materials
9. Posting of fire control plans

FIRE DETECTION AND EXTINCTION

1. Location of fire detectors
2. Sprinkler system installation
3. Alarms for fire detectors and extinguishing systems
4. Fixed fire extinguishing systems:
   (a) Arrangement
   (b) Controls
   (c) Instructions
5. Fire main and pumps

DRILLS

1. Fire
   (a) Conducting the drill
   (b) Station bill and crew duties
   (c) Fire screen doors
   (d) Local fire department responsibilities
2. Abandon ship

Ship drills

It is up to the vessel operator to make sure that crew members who are responsible for passenger safety are skilled in the performance of their duties, particularly in cases of mixed nationalities where English isn't the first language.

Passengers and crew must be keenly aware of their stake in assuring their own survival, particularly in abandon ship drills which require passenger participation. The crew must convey the gravity of all ship drills to the passengers.

Fire drill

Following are minimum accepted standards used by the Coast Guard in evaluating officer and crew performance during fire drills on board large cruise ships.

General guidelines

1. Realism is advised. Where possible, minimize simulation and institute realistic situations, such as the charging of fire hoses. (Discharging of hoses in interior locations is not encouraged.)
2. Fire teams should be fully manned, equipped and ready with hoses connected to fire hydrants.
3. Flooding systems, i.e., Halon, CO2 or sprinkler, should be manned by experienced crew members.
4. Ventilation and electrical power should be turned off in the area where the drill is conducted.

Alert

1. Inform a crew member of a fire and subsequent drill.
2. Activate fire alarm and smoke detectors.

Initial action

1. Inform the bridge of a fire and, if known, its class and exact location.
2. Secure doors and hatches to the compartment where the fire is located.
3. Break out fire-fighting equipment.
4. Report to assigned emergency station.

Drill activities

1. Establish communication with the bridge, fire-fighting teams, engineering and fire-control stations.
2. The following information must be conveyed:
   a. General or fire alarm for all hands,
   b. Location and class of fire, if known,
   c. Status report of fire-fighting teams and stations, and
   d. Condition of fire pumps, sprinkler and fixed extinguishing systems.

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Cruise ship officer directs lifeboat drill.

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3. Secure fire screen doors, watertight doors and hatches.

4. Start all fire pumps.

5. Equip and direct fire-fighting teams.

6. Account for and gather all non-essential personnel and passengers in safe locations on the ship.

Coast Guard observations

Coast Guard inspectors observe and verify that the fire-fighting teams are properly manned and outfitted, and that information passes smoothly between the ship's captain, the fire-fighting teams, the bridge and the engineering department.

Questions asked by the Coast Guard reviewing a fire drill examine the crew's awareness of the following:

1. Fire emergency signal,

2. Pre-designated safe routes and alternate routes for inaccessible normal routes.

3. General location of fire,

4. The correct way to report a fire,

5. The bridge and emergency telephone numbers,

6. Emergency exits from machinery spaces, and

7. Location of extra fire-fighting equipment.

Lifeboats are lowered during fire and boat drills on SS Meridian.
(left) In stowed position
(below) On embarkation deck

Abandon ship drill

The abandon ship or lifeboat drill demonstrates the skill of the crew in the following:

1. Preparing lifeboats and liferafts for launching,
2. Lowering lifeboats and boarding passengers,
3. Lowering lifeboats to the water,
4. Releasing lifeboats and operating them free of the falls,
5. Hooking lifeboats up to the falls,
6. Raising lifeboats and disembarking passengers, and
7. Stowing lifeboats.

Questions asked of a ship's crew by the Coast Guard during an abandon ship drill examination include:

1. What is the emergency signal?
2. Where are the passengers gathered?
3. How do the passsengers learn of their abandon-ship stations?
4. What spaces are checked and evacuated to ensure that all passengers are accounted for?
5. What are the procedures for evacuating an injured person?
6. What are the procedures for contacting the bridge and what information is relayed?
7. How are passengers directed to their survival craft?
8. When are passengers allowed to return to their cabins?
9. Where are the lifeboats, liferafts, lifejackets and emergency provisions stowed?
10. What are the capacities of the lifeboats and liferafts?
11. Where and when do the passengers board the survival craft?
12. How are the liferafts launched?

Conclusion

Between Coast Guard examinations of passenger vessel safety, it is vital that a ship's structural fire protection integrity, and fire detection and extinction systems be maintained in prime condition; and that officers and crews practice fire and abandon ship drills with the passengers every week.

Every ounce of preparedness means a greater chance of passenger and crew survival in a crisis at sea.

Allen Penn is a project engineer in the Marine Technical and Hazardous Materials Division of the Coast Guard's Office of Marine Safety, Security and Environmental Protection.

Fire safety from the drawing board

Marjorie Murtagh

Safety must be designed into tomorrow's cruise ships on the drawing board.

Not long ago, a new, dramatically designed foreign cruise ship arrived at a United States port on its maiden voyage to pick up U.S. passengers. Travel magazines and newspapers heralded its breathtaking design.

At the same time, however, the Coast Guard's Marine Safety Center (MSC) was uncovering some design features with potential fire safety problems in conflict with international construction requirements.

The plan review indicated that there were potential problem areas in the ship's overall fire safety system. This ship presented situations which were not explicitly accounted for in existing regulations.

The designer and builder felt they had discussed their plans adequately with the flag administration before construction, and that they were in compliance with safety requirements. The flag administration changed sometime during the design and construction phase, and it was not clear what had been agreed upon. The new flag relied on others to review for compliance in the final stages.

The United States, the port administration, had not been consulted for interpretation, and the lack of safety features became an "existing" problem.

The owners felt that they were in the middle. They had contracted to have a new ship designed and built to the latest safety standards, and now there were questions.

There were more than a thousand vacationing passengers waiting to board with their tickets in hand. Nevertheless, the ship's owners would be faced with liability if they didn't comply and make time-consuming, costly modifications.

Frantic phone calls and hasty meetings with flag representatives took place. At the last minute, the ship was allowed to sail with temporary operational measures to assure passenger safety until the necessary modifications could be made.

This is not the story of a specific ship. Rather, it is a general account of events that have occurred with many ships several times in recent years. However, it is being repeated a lot less frequently these days.

Due to an aggressive Coast Guard program to assure public safety aboard foreign passenger vessels, changes have been made in the way ships are designed, constructed and presented for United States trade.

Background

Prior to 1974, Coast Guard review of foreign passenger vessels focused on as-built details of a ship, and control verification was done strictly by onboard field inspection, without any previous plan review.

The Officer in Charge, Marine Inspection, (OCMI) would board the vessel when it arrived and determine within approximately one day if it met SOLAS requirements.

The burden of making such a determination on a complex floating city in such a short time was enormous. However, it was expected that the bulk of the inspection and compliance review would already have been done by the flag administration's representative.

Then, in the early 1980s, a series of fires erupted aboard foreign passenger ships. Also, a number of violations of basic treaty requirements were discovered during control verification inspections.

There was a need for increased vigilance with regard to fire safety.

Pre-arrival review

In early 1985, the Coast Guard reinstituted pre-arrival plan reviews. NVIC 1-85, Fire Safety Standards for Foreign Passenger Vessels, provided for the plan review of foreign passenger ships to minimize delays for owners of vessels planning to set sail from a United States port for the first time.

Plans can be reviewed by trained professionals and forwarded with comments to the OCMI prior to the ship's initial arrival in port. This worked well until a ship with major design problems arrived in port at the same time that its plan review was completed.

Now, the plan review process begins much earlier.

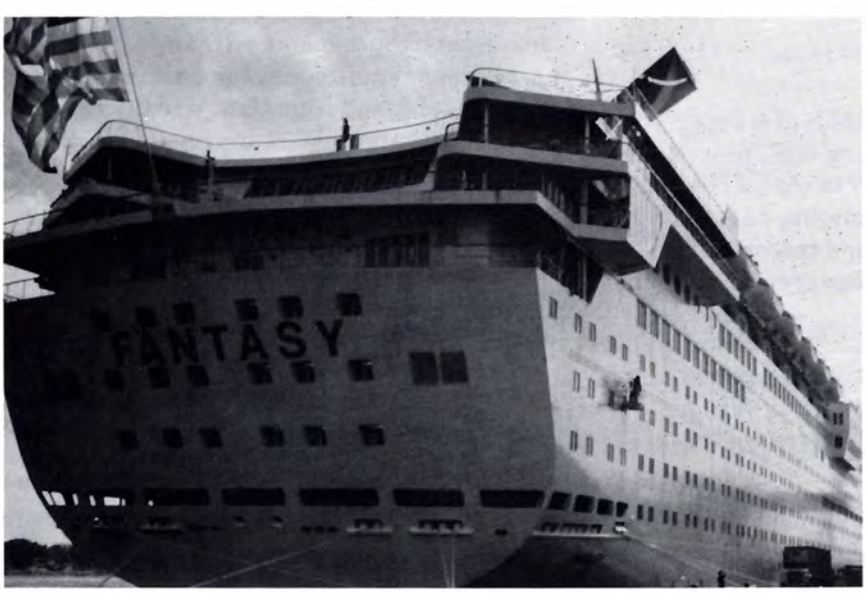
From the drawing board

Control verification for passenger ships intended to operate from United States ports currently begins with a review of concept drawings submitted early in the design process.

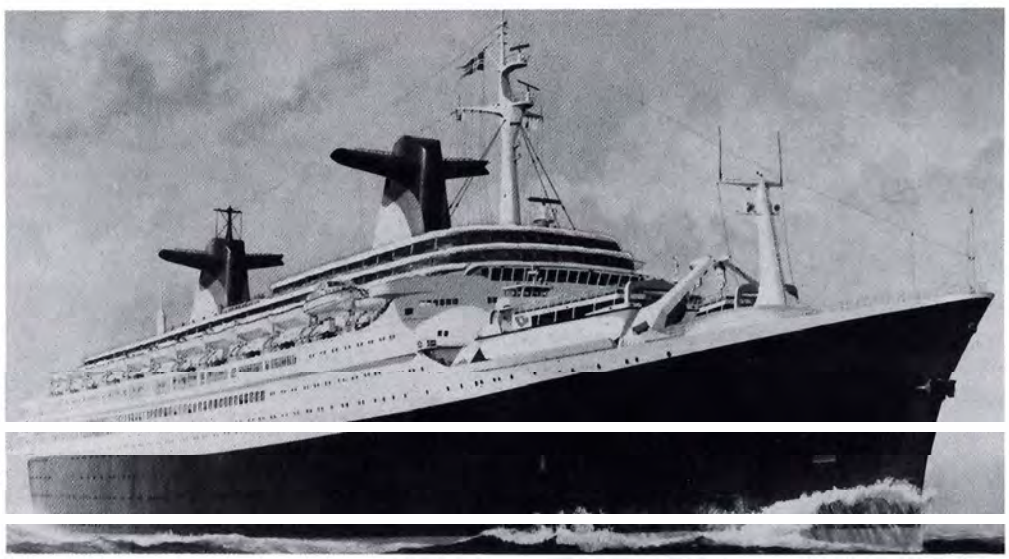
Meetings are called to discuss new concepts as well as potential problems of which the builder, owner or flag may be aware. The Coast Guard comments appropriately after reviewing the overall design.

Changes that can be agreed upon are made when the design is on paper, rather than in steel. The cost and time savings are immeasurable.

Continued on page 58



Fantasy (1989) is an excellent recent example of Coast Guard-designer-builder cooperation on built-in fire protection from the very beginning.



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The MSC still conducts a detailed plan review with summary comments for the OCMI prior to a ship's first arrival, and the OCMI still is responsible for verifying compliance. However, the technical support preceding the inspection helps to ease the burden.

In addition, the new Control Verification Augmentation Program provides on site technical support to the OCMI during the initial inspection.

Older ships

The growing demand for cruise ships is being met to some degree by updating older vessels. This can be as simple as replacing old carpet and furniture, or as complex as changing out the bottom plating, re-engining and tearing out accommodation spaces for renovation.

In some cases, modifications take place over a number of years and are done in accordance with standards that existed when the ship was built. Current rules permit this to some extent, but there is cause for concern.

The individual changes may not in themselves constitute a "modification of a major character" as defined by SOLAS standards, but the overall result can be major. That is, piece-meal changes can ultimately result in a "new" ship.

Therefore, the Coast Guard encourages ship owners to come in early to discuss plans for modifying existing ships.

Safety first

All ships do not have great problems. There are major areas of agreement on many international requirements, and the vast majority of ships go from design to operation without contention.

A high level of safety is achieved by enforcing the international requirements that now exist. It is imperative that daring new concepts or changes made to existing vessels do not affect the safety record.

Marjorie Murtagh is head of the Fire Protection Section, Ship Design Branch, Marine Technical and Hazardous Materials Division of the Coast Guard's Office of Marine Safety, Security and Environmental Protection.

Double check on safety

Ross Mowery

A recent incident . . .

On December 22, 1989, the Coast Guard's Marine Technical and Hazardous Materials Division (MTH) received a casualty report concerning a fire aboard a foreign-flagged passenger vessel in dry dock in Portland, Oregon.

The Panamanian vessel was having various public rooms refurbished, when sparks from a workman's cutting torch started the fire. It spread rapidly as it fed on a non-approved, combustible Styrofoam insulation in an overhead around the ventilation ductwork.

As the fire occurred in the shipyard, it was the responsibility of the City of Portland Fire Department to extinguish. It took Herculean efforts on the part of all on-duty city fire fighters, plus the ship's captain and his fire-fighting team to suppress the blaze.

The fire, which destroyed 22 cabins, was of special significance because it was, and still is, highly questionable if such a major fire-fighting commitment would have been possible if the incident had occurred at sea.

The combustible insulation had been installed throughout most of the vessel's hot and cold air ventilation ductwork. This extensive fitting of a material not in compliance with SOLAS regulations appeared to have taken place in the early 1960s, or perhaps during the vessel's construction in 1958.

After most of the fire damage had been repaired, the ship sailed to San Diego, California, and was subsequently detained for other significant deficiencies, including severely wasted propulsion boiler foundations, wastage in the engine room tank tops and deteriorated wiring circuits, some of which were essential to the ship's proper function.

Efforts were already underway before this incident to examine the foreign-flagged passenger vessel industry as a whole, along with the general safety level afforded passengers who were mostly from the United States.

A report on passenger vessel safety issued by the National Transportation Safety Board supported the Coast Guard's desire to expand existing inspections for older ships.

Heightened concern

The Coast Guard decided to examine the Panamanian ship after the fire for several reasons. The fire had caused extensive damage, a questionable insulation had been installed on the ventilation ductwork, and there was already heightened concern regarding safety levels on older passenger ships -- ships that transport more and more United States citizens.

The newest passenger ships entering the United States are constructed according to the latest SOLAS standards. Because of lessons learned from the past, these ships offer tremendous improvements in life safety, escape routes and structural fire protection

Most of the passenger ships currently in use are foreign-flagged and more than ten years old. Age plus the ever present threat of "FIRE" on board prompted further concern at Coast Guard headquarters that more thorough inspections were imperative.

Our ships first

When the Coast Guard examined the ship described in the recent incident under the "Old Vessel Inspection Program,"it became apparent that it was necessary to examine the fire protection and general safety of older passenger ships pressed into service with extensive modifications.

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SS Constitution (1951) is shown in dry dock being refurbished in 1990.

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The conclusion was reached to examine the two United States passenger vessels, *SS Constitution* and *SS Independence*, first to judge their general condition, especially with regard to fire protection and machinery.

Control verification

The Control Verification Augmentation Program was established by the Coast Guard in early 1990 to help fill these needs. Under this program, a highly specialized team of experts supplements the efforts of the current field inspection force with initial control verifications of new passenger ships and older ships with a history of SOLAS compliance problems.

Typically, the ships with significant problems are the older passenger vessels which do not have the tremendous fire protection and life-safety advances recommended by SOLAS 1974 standards as amended.

Teamwork

Control verification teams include individuals who are highly skilled in specific areas of concern, including safety, fire protection, naval architecture and even the control verification process itself.

Technicians with special expertise in older hull and machinery conditions serve on teams examining older passenger ships which could have problems in those areas. This knowledge is essential for a comprehensive evaluation of a vessel's overall general condition.

Team focus on the general condition of a vessel is an important objective of the program. A complete assessment of the machinery, hull, general structure, fire protection and means of escape is vital to ensure passenger safety.

Teams have significant responsibilities in helping Officers in Charge of Marine Inspection interpret SOLAS standards, especially in regard to older vessels which may have serious fire protection or life safety deficiencies.

Team members also review problem areas uncovered through plan reviews, alteration histories, actual complaints, or from previous inspections of sister ships or similar class vessels.

While on board passenger vessels because of a casualty, control verification teams have often discovered significant safety problems. For example, a recent investigation of an engine room fire on *Regent Star* also uncovered escape route problems, a major conversion of the propulsion system, missing fire doors and other serious deficiencies.

Ships examined

Since the control verification program began, ten ships have been examined -- eight foreign-flagged vessels, and *Constitution* and *Independence*. These ships represent a broad cross section of ages.

Five of the ships were constructed before 1960, two were built in the 1960s and the remaining three are of rather recent vintage. One was *Fantasy*, Carnival Cruise lines newest vessel.

Again,in most cases, it was the older vessels that had difficulty maintaining the SOLAS standards to which they were modified or constructed.

Goals

The improvement of international standards to ensure the safety of passenger vessels is the overall goal of the control verification teams.

Flag administrations and classification societies will continue to be held accountable for certifications of passenger vessels sailing with United States citizens aboard.

Interpretations of SOLAS requirements by flag administrations, classification societies and port state inspection authorities must be more consistent.

A unified international effort to identify SOLAS standards that need modifications will be supported.

Continued efforts within the IMO to clarify and improve the SOLAS convention will be a high priority particularly with regard to safety conditions on older passenger vessels.

The Control Verification Augmentation Program is a highly visible operation that is contributing greatly toward the improvement of safety levels for United States passengers enjoying the blossoming cruise market.

Ross Mowery is a fire protection engineer in the Marine Technical and Hazardous Materials Division in theCoast Guard's Office of Marine Safety, Security and Environmental Protection.

SS Independence (1951) was refurbished in 1989.

Casualty investigations

Doug Rabe

"From the standpoint of safety of life at sea, the construction and the inspection of ships are, perhaps, of more importance than any other subjects to be considered. This is true because the hazards of the sea often produce situations with which it is impossible for even the best of men to cope, unless they have under them vessels which are able to withstand and survive the hazards."

This statement introduced a 1937 Senate report on the results of investigations into the *Morro Castle* and *Mohawk* passenger vessel tragedies.

(*Morro Castle* was destroyed by fire in 1934, causing 124 fatalities. Early the following year, *Mohawk* sunk after a minor collision and 45 persons lost their lives.)

We are just as concerned with the construction and inspection of ships today. When a marine casualty occurs, an investigation follows. Only through investigations of safety system failures, can the level of safety of life at sea be improved.

Requirements

Title 46, U.S. Code, Chapter 63, requires the investigation of marine casualties to determine:

- the cause of a casualty, including the cause of any death;
- whether an act of misconduct, incompetence, negligence, unskillfulness or willful violation of law by any licensed, certificated or documented individual, or any other person, including an officer, employee or member of the Coast Guard, contributed to the cause of the casualty;
- whether there is evidence of a civil offense or criminal act;
- whether there is a need for new laws or regulations, or changes to existing laws or regulations, to prevent recurrence of the casualty.

This law applies to United States-flag vessels anywhere in the world and to foreign-flag vessels involved in casualties in United States waters.

Investigations

The Coast Guard investigates about 4,500 marine casualties per year. This includes about 1,000 investigations of personnel injuries and deaths not associated with a vessel casualty, i.e., someone falls overboard.

Passenger vessels of all types are associated with about 350 casualties a year, 30 of which involve large passenger ships in United States waters.

Generally, the cases are about evenly split between vessel and personnel casualties. Most importantly, the vast majority of them are minor.

Most marine casualty investigations are conducted by investigating officers assigned to marine safety and marine inspection offices.

In the event of a catastrophic casualty with numerous complex issues, the Coast Guard Commandant convenes a marine board of investigation, consisting of highly qualified experts who can be counted upon to provide a thorough investigation and viable recommendations.

The National Transportation Safety Board also is authorized to investigate major marine casualties and usually participates with the Coast Guard in Marine Boards of Investigation.

Case histories

The following two cruise ship fire casualties were investigated by Marine Boards of Investigation.

Angelina Lauro

In the afternoon of March 30, 1979, a fire erupted in an unattended skillet/fryer in the crew galley of the Italian passenger ship *Angelina Lauro*, which was moored in St. Thomas, United States Virgin Islands.

The fire was discovered by a cook and bakers in the adjacent dining room, where it had spread through the exhaust duct from the vent hood over the skillet/fryer.

Initial fire-fighting efforts were unsuccessful, and the 669 passengers and 380 crewmembers were evacuated.

The fire was finally extinguished on April 4. There were only two minor injuries. The vessel was a total loss.

The Marine Board of Investigation found that "the proximate cause of the casualty was that person(s) unknown turned on the skillet/fryer located in the crew's galley to its highest setting, position #3, and thence left it unattended. As a result, the oil in the skillet/fryer overheated and reached the point of auto-ignition."

The spread of the fire through the exhaust duct revealed a weakness in construction requirements for galley exhaust ducts.

Scandinavian Sea

The Bahamian *M/V Scandinavian Sea* was underway on its daily "cruise to nowhere" from Port Canaveral, Florida, on March 9, 1984, when the ship's plumber saw smoke curling around the edges of a closed door to Room 414.

He opened the door with his master key and discovered a circular fire on the carpet. He reported the fire to the bridge by telephone and then attempted unsuccessfuly to put it out with a water fire extinguisher.

The chief officer and other crew members also fought the fire, but it got out of control. The master had set course to return to Port Canaveral minutes after the fire was discovered. Upon arrival, the 744 passsengers debarked.

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Angelina Lauro burns while moored in St. Thomas, Virgin Islands (inset) A lounge area is completly gutted by the fire.

Scandinavian Sea

Shoreside fire fighters at Port Canaveral tackle fire in forward section of the cruise vessel.

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Despite intense efforts by many shoreside fire-fighting personnel, the blaze spread throughout the forward section of the vessel and was not extingished until March 11. There were no serious injuries or deaths, but again the vessel was a total loss.

The Marine Board of Investigation concluded that "...the physical evidence strongly suggests that the fire initially began and spread with the aid of an unknown flammable liquid..."

Fire safety improvements

Investigations of the *Angelina Lauro*, *Scandinavian Sea* and other ship fires have identified many areas for fire safety improvements.

Shortcomings in crew fire-fighting preparedness, including unfamiliarity with emergency equipment and safety procedures have been noted, along with a lack of guidance for shoreside fire fighters in the unique aspects of shipboard fire fighting.

Numerous changes in national and international rules for shipboard fire protection have been proposed and adopted. For example, the IMO recently adopted a change in SOLAS regulations to upgrade fire hoses used on ships.

Casualty investigations have highlighted other fire safety improvements, which are currently under discussion at IMO. They include:

- construction requirements for galley exhaust ducts,
- integrated fire protection systems, including automatic ventilation system shutdowns and automatic fire door releases,
- automatic sprinkler systems,
- hose ports in fire doors,
- low-power emergency floor lights to direct passengers to emergency exits.

Casualty investigations, including those involving *Angelina Lauro* and *Scandinavian Sea*, have demonstrated the need for contingency plans to deal with emergencies in our ports. Today, the Coast Guard coordinates the development of such plans for all United States ports.

It was also learned that shoreside fire fighters often lack knowledge of vessel construction and stability problems created by the accumulation of fire-fighting water.

In response to a Coast Guard request, the National Fire Protection Association developed a standard entitled, "Recommended Practice for Land-based Fire Fighters Who Fight Marine Vessel Fires."

In addition, the Coast Guard's Navigation and Vessel Inspection Circular 1-85, "Fire Safety Standards for Foreign Passenger Vessels," is being updated.

Other improvements

Casualty investigations have provided the impetus for many non-fire related improvements in ship construction and operation.

Engineering requirements for boilers have been tightened to prevent explosions. Compartmentation standards have been improved to avert another *Mohawk* disaster.

Lifeboats, lifejackets, exposure suits, qualification standards, equipment requirements - and the list goes on -- have been improved as a result of the findings of casualty investigations.

International cooperation

The governments of maritime nations have long recognized the value of marine casualty investigations. However, the investigation systems of various nations have not all been compatible, and some of the data provided to the IMO has not been detailed enough for proper analysis.

Several years ago, the governments of Liberia and the United States launched an IMO effort to improve intergovernmental cooperation and coordination in casualty investigations.

Consequently, on October 19, 1989, the IMO adopted Resolution A.637(16), "Cooperation in Maritime Casualty Investigations," which established guidelines for all IMO member nations.

The resolution calls for early intergovernmental consultation to determine which nation or nations will conduct the investigation when more than one nation has an interest in a casualty.

Under the resolution, participation by appropriate parties and coordination of investigative activities are planned.

The Coast Guard believes that this resolution will improve the quality of marine casualty investigations worldwide.

Mega Borg

Acting under the new IMO resolution, the Coast Guard cooperated with the Norwegian government in the investigation of the explosion and fire that erupted on board the Norwegian tanker *Mega Borg* on June 8, 1990 in the Gulf of Mexico. (See *Proceedings* July-August 1990 issue.)

Requested by the government of Norway, Coast Guard investigators conducted preliminary interviews with the vessel's crew while Norwegian personnel were travelling to Galveston to begin their investigation. Coast Guard personnel then helped develop the facts of the case and question witnesses under oath at the Norwegian hearing.

Although this case concerned a tankship accident, the same type of investigation might follow an accident involving a foreign flag passenger vessel near United States waters.

Outlook

Through continued thorough marine casualty investigations, comprehensive reporting of results and international cooperative efforts under the new IMO resolution, the level of safety at sea throughout the world should be improved in the years to come.

Doug Rabe is the deputy chief of the Marine Investigation Division of the Coast Guard's Office of Marine Safety, Security and Environmental Protection.

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Safety recommendations for 1990s

Norman W. Lemley

Background

Innovative developments in passenger vessel design as well as a marked increase in the number of older vessels entering the United States cruise trade resulted in numerous questions regarding SOLAS treaty requirements.

In some cases, new design innovations were not envisioned by SOLAS requirements, and in other cases, the problem was with the wording of the regulations.

The Subcommittee on Fire Protection of the IMO Maritime Safety Committee (MSC) was assigned to study the situation and recommend improvements. Thus, a working group on fire protection systems for passenger ship safety was formed in early 1989.

The group consisted of delegates from Canada, China, Denmark, Finland, General Republic of Germany, Greece, Hong Kong, Italy, Japan, Liberia, Norway, Poland, Sweden, United Kingdom, United States and USSR. Observers from the International Chamber of Shipping and the Commission of the European Communities were also included.

First session

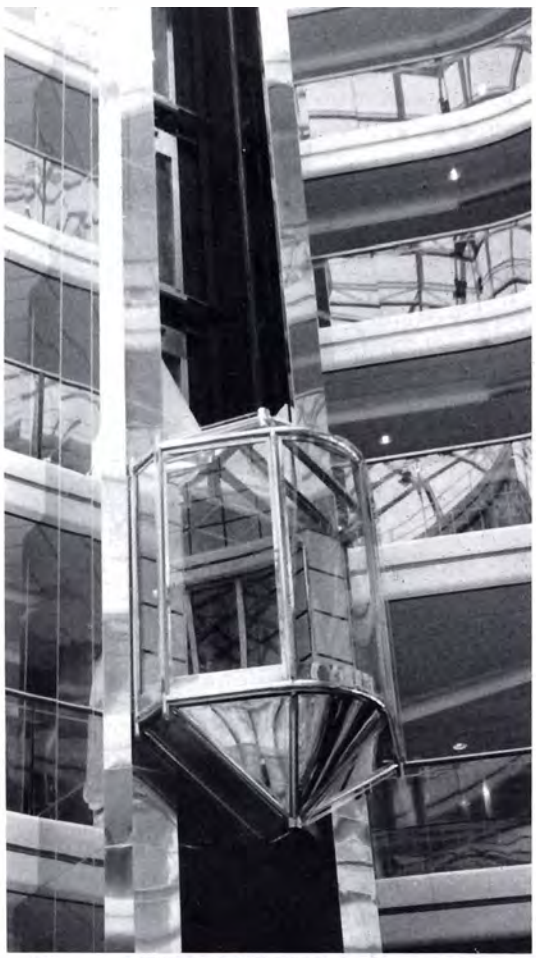
Recognizing the urgent need for internationally-agreed standards for atriums, the working group rapidly produced a comprehensive set of draft SOLAS regulations, along with a circular urging administrations and owners to follow the new requirements pending their adoption.

The MSC adopted the regulations at its very next session, illustrating the group's ability and willingness to act promptly in the interests of passenger vessel safety.

The following special standards apply to large open spaces spanning three or more decks with enclosed spaces for ships, offices and restaurants containing combustible furnishings.

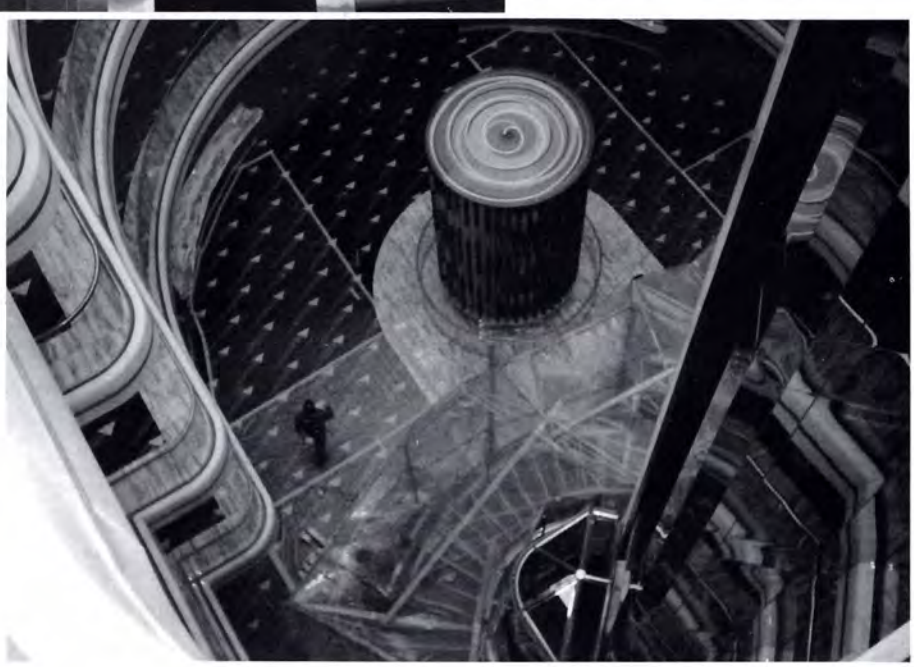
Atrium Standards

1. *The entire main vertical zone containing the space shall be protected throughout with a smoke detection system in compliance with regulation II-2/13, with the exception of 13.1.9.*
2. *The space shall be provided with a smoke extraction system capable of exhausting the entire volume of the space within ten minutes. This system shall be activated by the smoke detection system and capable of manual control.*
3. *Each level within the spaces shall have two means of escape, one of which should be an enclosed vertical passsageway, as defined in regulation II-2/28.1.5.*
4. *The entire main vertical zone containing the space shall be protected with an automatic sprinkler system, according to regulation II-2/12.*



Atriums

(left and far below) Fantasy atrium elevator and view from upper deck. (right below) Nordic Empress atrium.



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Second session

At the second session, the group developed a comprehensive draft of proposed revisions to requirements contained in Chapter II-2 of the 1974 SOLAS convention, as amended. They will be considered at the next IMO meeting in 1991.

1. **Spaces opening on to stairway enclosures**

   A revision of regulation II-2/29.2 deletes the term, "as far as practicable," and restricts the use of stairway enclosures for the purpose intended except to allow open information counters within their perimeters.

   Furniture must be kept to a minimum, according to regulation II-2/34.6, but should have restricted fire risk as described in regulation II-2/3.23.

   Access to stairway enclosures would only be allowed for public spaces, corridors and public toilets. Access from other spaces, especially dead-end corridors, is not permitted by the revised regulation.

2. **Fire integrity of stairway enclosures**

   Enclosed stairways should be the primary means of escape, and stairway enclosures must be provided giving access from both below and above. T he enclosures must have escape lighting, skid free deck surfaces and fire integrity of boundaries facing external stairways.

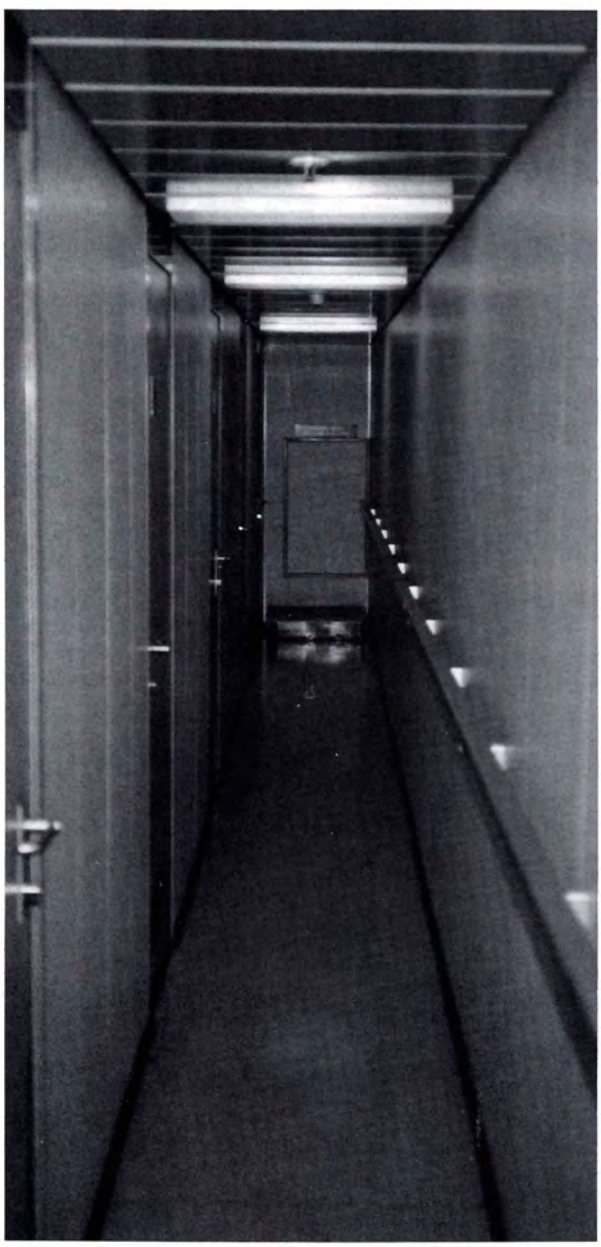
   Minimum width of stairways and corridors is defined and provisions made for determining the width of stairways servicing several decks.

   Requirements for the maximum angle of stairway incline and the provision of landings and their minimum areas are also specified.

3. **Dead-end corridors**

   A revision of regulations II-2/28.1.4 prohibits dead-end corridors of any substantial length.

Dead end corridors of substantial length are prohibited.



Ventilation fans and ducting in stairway enclosures

A revision of regulation II-2/32.1.5 provides for ventilation fans and associated ducting servicing stairway enclosures.

Ventilation of galley ranges

Revised requirements call for ventilation of galley ranges, including grease traps, fire dampers and their control, fire extinguishing arrangements for galley range ventilation ducts, exhaust fans, and remote operating arrangements for exhaust fans and dampers.

Fire doors in main vertical zone bulkheads

Revised requirements call for fire doors in main vertical zone bulkheads.

New parameters establish times of operation, maximum angles, remote control arrangements, alarms, remote release and local arrangements for operating fire doors.

7. **Hose ports**

New regulation II-2/30.7 requires hose ports in "A" class doors located in stairways, public spaces and main vertical zone bulkheads.

8. **Fixed fire detection, fire alarm systems and automatic sprinklers**

Revised regulation II-2/36 requires automatic sprinklers, fire detection and fire alarm systems, and fixed smoke detection systems in control stations, service spaces and accommodation spaces, including corridors and stairways on ships carrying more than 36 passengers.

Regulation II-2/36 also permits fixed fire extinguishing systems as an alternative in control stations where water may damage essential equipment.

Sprinkler systems are not required in voids, public toilets and similar spaces with little or no fire risk.

9. **Ventilation openings in "B" class doors and bulkheads**

A major effort to control smoke in escape routes is essential, and the removal of ventilation openings in "B" class corridor bulkheads and doors adjoining escape corridors and exits would minimize smoke movement into such spaces.

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Survival craft is stowed correctly on Fantasy's embarkation deck.

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Suitable ventilation systems can be designed for new ships to control smoke in corridors, reducing the need for corridor openings.

10. Integrated fire protection-detection systems

The use of integrated fire protection-detection systems is warranted, particularly in cases where manpower is needed for essential fire protection activities.

11. Survival craft stowage height

The maximum stowage height for survival craft is 15 meters, although it is necessary to account for safe escape for lower embarkation stations.

12. Fire protection for boundaries adjacent to survival craft

Fire integrity of bulkheads in the way of embarkation areas shall be A-60 (fire resistance in minutes).

Windows and sidescuttles on such bulkheads shall provide A-60 fire integrity, or A-0 fire integrity when water effectively cools them.

Embarkation and muster area decks shall be A-60, unless over an open space.

The fire integrity of shipsides, including windows and sidescuttles, below lifeboat and liferaft embarkation areas should be A-30.

13. Escape route lighting

New regulation II-2/18.9 requires photoluminescent signs and fire equipment markings as an alternative to electric lighting for recognizing escape routes and fire equipment locations.

14. Main vertical zone length

The correct maximum length of main vertical zones is 40 meters, as set out in regulation 3(9). However, a certain flexibility is needed to place main vertical zone bulkheads in line with watertight subdivisions, and to accommodate large public spaces which often extend the entire length of the 40° zone. (New stability regulations may require watertight subdivisions above the bulkhead deck.)

The width of main vertical zones should agree with the length requirements. The larger breadths of newer ships may necessitate longitudinal main vertical zones.

A revised regulation 24 establishes that the 40-meter main vertical zone may be extended to 48 meters under special circumstances. It also prohibits steps and aligns main lengths in the main vertical zones with subdivision bulkheads, and includes widths as well as lengths in main vertical zone considerations.

Queen Elizabeth II (1969) and all other existing passenger ships must comply with SOLAS 1974 regulations as amended in 1981.

Older ship improvements

The working group also prepared a list of various actions that might be taken to improve fire safety of existing passenger ships which do not meet the requirements of SOLAS 1974 as amended in 1981. (Other options are possible.)

1. Amend Regulation One relating to existing ships to ensure that all major repairs, alterations and modifications meet SOLAS 1974 standards.

2. Not permit ships carrying more than 36 passengers that cannot comply with the fire safety requirements for new ships in SOLAS 1974, as amended, to operate as passenger ships as of January 1, 2010.

3. By January 1, 2000, require such ships to:

   -- have a centralized, fully integrated fire protection-detection system installed which automatically operates the fire doors and fire alarm system, and is capable of detecting fires in concealed spaces;

   -- be fully sprinklered; and

   -- have a fixed gas fire protection system in the machinery spaces.

4. Same option as Number 3, except that actions must be completed by 1998, and the ships are only permitted to continue operation until 2010.

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5. Ships carrying more than 36 passengers must comply with the following requirements:

A) All fire doors which are not normally closed shall be capable of being released from the bridge. If necessary, the speed of closure shall be controlled.

B) Ventilation ducts (with a cross sectional area of 200 square centimeters and above), which pass main vertical fire zones shall have failsafe automatic closing fire dampers, which can also be manually closed from each side of the division.

C) Exhaust ducts from galley ranges shall be constructed of "A" class divisions where they pass through accommodation spaces or spaces containing combustible materials. Each exhaust duct shall be fitted with:

-- a grease trap easily removed for cleaning;

-- a fire damper in the lower end;

-- mechanisms for shutting off exhaust fans from within the galley; and

-- a fixed means for extinguishing a fire.

D) Fire alarms shall sound effectively all over the ship, including in passenger cabins.

E) An efficient loud-speaker system shall be installed.

F) A radiocommunicaton system shall maintain contact between bridge personnel and fire-fighting leaders.

G) Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces.

H) Two fire-fighting ensembles and two sets of personal equipment will be stowed on each deck with passenger spaces, in addition to the equipment already required (except for the deck covered by SOLAS regulation 17.3.1.1).

I) One self-contained compressed air-breathing apparatus with ten minutes' service capability for escape purposes shall be available for every two fire-fighting ensembles.

J) Three times the number of air cylinders required along with a special air compressor to charge them shall be stowed in an accessible place on the uppermost deck. The capacity of the compressor need not be more than 25,000 liters per hour.

-- The compressor shall be self-contained or powered by the emergency generator.

-- The air cylinders shall be useable immediately after charging.

K) Low-level lighting or photoluminescent marking should be applied in appropriate areas.

The requirements presented in this article affect all personnel occupied in passenger vessel design and operation. They merit close reading. Comments on their value and impact are invited.

Norman W. Lemley is the assistant chief of the Marine Technical and Hazardous Materials Divison of the Coast Guard's Office of Marine Safety, Security and Environmental Protection. He is the chairman of the Passenger Vessel Safety Working Group.


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