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On the Cover

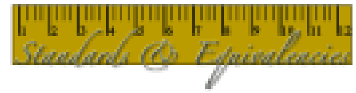
The tension leg platform Magnolia, shown during construction, is CococoPhillips' latest addition to the deepwater oil production fleet in the Gulf of Mexico. With first oil expected sometime in the fourth quarter of 2004, the Magnolia will be capable of producing 50,000 barrels of oil and 150 million standard cubic feet of natural gas per day from a total of eight wells. Marine Safety Center engineers have engaged in technical plan review of the Magnolia with the American Bureau of Shipping (ABS) Americas since December 2002. Cover is a USCG illustration.

History and People

SERT and Investigations

Plan Reviews

Standards/Equivalencies



Resources/Interaction/Guidance Available

New Technologies, Trends, Industries

Special to this Issue

On Deck

Back cover credit: The Coast Guard's Marine Safety Center and its staff in Washington, D.C. Joseph Kohler, U.S. Department of Transportation.

CORRECTION: The last issue of *Proceedings*, *Proceedings* at 60; Spring 2004; Vol. 61, No. 1; p. 15: the sentence regarding the *Marine Electric* should read: "Similarly, in February 1983, the *Marine Electric*, carrying coal, capsized and sank in a gale off the coast of Virginia with the loss of all but three men."

Icon Credits:
All are USCG illustrations.
History and People: Capt. Francis Saltus Van Boskerck, composer of the lyrics and music of Semper Paratus, shown here is his white dress uniform after his appointment to first lieutenant in 1902.

SERT and Investigations: The site of a marine collision involving a 520-foot commercial freighter and a tug-and-barge combination. Public Affairs Officer Krystyna Johnson, USCG.

Plan Reviews: stack of books copyright © 2003 USCG and its licensors.

Resources/Interaction/Guidance: laptop copyright © 2003 USCG and its licensors.

Assistant Commandant's Perspective

by Rear Adm. Thomas H. Gilmour
Assistant Commandant for Marine Safety, Security & Environmental Protection

As I consider this issue of *Proceedings*, I recall my role in the development of the Marine Safety Center (MSC) in the mid-1980s. Then a commander, I worked with then-Capt. Paul Pluta developing a plan to centralize what had been our five Merchant Marine Technical Branches into the MSC.

Throughout its 18-year history, the MSC has become vital to the Coast Guard, both in its primary prevention role, as well as its role in supporting Coast Guard field commanders' response operations. This unit has adapted to service the needs of its commercial customers, Coast Guard field operators, and the evolving missions of the Marine Safety, Security and Environmental Protection Program.

Most recently, MSC was charged with reviewing vessel security plans for U.S. vessels. In a very short period, thousands of vessel security plans were submitted, reviewed, and ultimately approved. Despite the challenges—stringent deadlines and the inclusion of many new vessels and vessel owners who had not previously been regulated—MSC staff stayed focused on the mission and quality service to its customers, providing excellent results during a critical surge operation.

With the construction of new U.S. flag cruise ships, the first in many decades, MSC will contribute to passenger vessel safety through plan review and third party oversight. MSC personnel are reviewing the largest casino vessels, some integrated with shore facilities, using performance-based techniques to augment traditional regulations.

Growth in deepwater floating production platforms has demanded that MSC keep pace with technology and practices, from review of the performance of materials, to novel ballast tank designs and mooring systems utilizing giant synthetic mooring lines to tether installations to the ocean floor. The Salvage and Engineering Response Team has provided technical assistance during marine casualty response operations, often in difficult situations. MSC engineers have also supported numerous major casualty investigations, from the I-40 bridge allision to the F/V *Arctic Rose* sinking, each having nationwide implications. Their discoveries and recommendations often shape the trends in vessel design and regulations for years to come.

To accomplish this sophisticated work, the marine safety program supports post-graduate training to develop these highly skilled, technical officers. They often return to Headquarters and MSC technical billets after field assignments, re-energizing the technical policy and standards-making arena with current operations, fresh ideas and experience. There are many success stories for both career progression and mission accomplishment associated with the marine safety technical career track. We will continue recruiting marine safety "technical types" to benefit from their leadership and technical solutions that enhance our prevention and response programs.

The future for our technical programs and work accomplished by the MSC is as bright, challenging, and exciting as ever.

T. H. Gilmour

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Champion's Point of View

by Capt. Roy A. Nash
Commanding Officer, U.S. Coast Guard Marine Safety Center

This issue of *Proceedings* focuses on the Marine Safety Center (MSC), how the unit is organized, stories of challenges and accomplishments, and its role in maritime safety.

MSC personnel bring a wealth of knowledge, expertise and innovation to the Coast Guard's Marine Safety program, primarily through the evaluation and approval of commercial vessel designs meeting Coast Guard safety, security and environmental protection requirements. Commercial designs and systems typically reviewed include freight, passenger and tank vessels, high-speed craft and floating offshore production facilities. But the technical services provided by the MSC have broadened considerably over the years, and the methods and management arrangements in which plans are approved have also evolved.

The MSC's staff is made up of a diverse group of engineers, naval architects and technical specialists. Most have advanced degrees in a major engineering discipline related to the maritime and offshore industries. These include marine, mechanical, electrical, chemical, civil, ocean and petroleum engineering. Some have more specialized graduate degrees, such as naval architecture, fire protection, human factors and even business administration. In addition, many MSC personnel are registered professional engineers or hold Merchant Mariner licenses.

There is a broad spectrum of backgrounds and work experience among MSC personnel. Many members of the civilian staff come from the private industry and other government agencies where they may have been responsible for multimillion-dollar engineering projects using the latest materials and ship design technologies—from state-of-the-art warships to commercial vessel construction at shipyards around the world. Likewise, our military personnel have different experience backgrounds from throughout the Coast Guard, including tours onboard cutters, the Coast Guard Yard, strike teams, Research and Development Center, as well as marine inspectors serving at various ports throughout the U.S. and overseas. Contractors and reservists have brought wide-ranging expertise, fresh enthusiasm and genuine commitment in achieving the task at hand.

The current active duty staff will eventually move on to other field or staff assignments and apply and share the technical expertise they have gained at the MSC. The permanent civilian staff keeps the MSC on track, providing core expertise, continuity and "corporate knowledge" to the unit and its customers, and brings newly assigned personnel up-to-speed.

This *Proceedings* issue includes examples of the many challenging projects pursued by the MSC's terrific personnel. As the unit approaches its 18th anniversary, we continue to provide expert technical services to field offices and maritime customers, and remain steadfast towards the prevention of accidents and incidents through review and approval of safe designs.

History of the Marine Safety Center

by Adm. J. William Kime
U.S. Coast Guard (Ret.)

A critical component of the U.S. Coast Guard's Marine Safety, Security and Environmental Protection Program has always been a technical staff to review and approve plans, specifications and procedures for new shipbuildings and alterations and to approve certain components and equipment to be installed in these ships. The Marine Safety Center, located in Washington, D.C., has performed these functions since its establishment in 1986. Prior to that, the functions were performed by other Coast Guard organizational units.

When the Coast Guard assumed responsibility for marine safety functions from the Bureau of Marine Inspection and Navigation (BMIN) in 1942, a merchant marine technical (MMT) staff was established at Coast Guard Headquarters in Washington, D.C. It was composed of prior members of the BMIN, some of whom were given Coast Guard commissions, and later included regularly commissioned officers and new civilian employees with engineering and naval architecture expertise, most of whom held degrees from the Massachusetts Institute of Technology, the University of Michigan or the Webb Institute. At the same time, the Coast Guard also created the position of technical advisor to the Commandant, who served as the marine safety program director.

This organizational structure functioned very well in the environment that existed at the time it was created; however, the environment began to change in the mid-1970s.

From 1942 until the early 1960s, this organizational structure functioned very well. There was a very active shipbuilding program in the United States, with shipyards located on all coasts producing what we might now call conventional, or traditional, vessels. In the late 1950s, shipbuilding began to take on a regional flavor, beginning with the emergence of a major building effort to support the oil exploration and production industry developing on the Gulf Coast, such as drill rigs, production platforms and offshore supply boats. The shipbuilding industry felt strongly that it wanted a Coast Guard technical staff that was both close-by and very conversant with the particular type of vessel or unit being constructed. This feeling spread and, by the early 1970s, the Coast Guard had established regional technical offices in New Orleans, New York, San Francisco, Cleveland and Hampton Roads. The MMT staff remained at Coast Guard Headquarters to develop regulations, ensure consistency among the field offices, represent the United States in international treaty development at what is now the International Maritime Organization (IMO), handle type approvals, admeasurement, the Letter of Compliance (LOC) program for the emerging foreign chemical carrier and gas ship fleet, act on appeals from field office determinations, and oversee many more policy, budget and program issues.

This organizational structure functioned very well in the commercial and governmental environment that existed at the time it was created; however, the environment began to change in the mid-1970s. Shipbuilding was experiencing a downturn in the United States, with new U.S.-flag ships being built in Europe and the Far East. Monitoring field office activity for consistency became increasingly more difficult with the same types of specialty vessels being built on several coasts. For example, oil industry vessels were being built on the East, Gulf, and West Coasts, while liquefied natural gas (LNG) tankers were being built on the East and Gulf Coasts. The Coast Guard, which had been given significant new responsibilities in the area of marine environmental protection that required a technical staff, considered combining the marine safety and marine environmental protection programs at both the field and headquarters levels. The overall Coast Guard budget was under increasing pressure from both the Congress and the administration, with emphasis being placed on streamlining and efficiency. Air travel was becoming more accessible, and the use of facsimile was developing. All of these factors pointed to the fact that a reexamination of the technical staff organization of the Coast Guard was necessary.

In the early 1980s, the Coast Guard commissioned a study to review this technical organization. Key participants in the study were Rear Adm. Paul J. Pluta (U.S. Coast Guard, Ret.), former Assistant Commandant for Marine Safety, Security & Environmental Protection, and current chief, Rear Adm. Thomas H. Gilmour. Recognizing a variety of factors—including the state of the marine industry, the pressures on the Coast Guard budget and available personnel, the need for consistency, the ease of travel, and the advent of electronic communications—the study recommended that there be one field office and one technical staff located at headquarters. The field office was not to be located in Coast Guard Headquarters, but with reasonable access to it. Further, the field office needed to be accessible to other governmental agencies, the public, and the industry by plane, train and local transportation. Considering all these factors, the group recommended the Washington, D.C. area for what is now the Marine Safety Center (MSC).

Today, a Coast Guard Headquarters technical staff retains oversight of the MSC, develops regulations, represents the United States at IMO, and considers appeals, etc., while the MSC, which is staffed by military and civilian engineering and naval architect professionals, has a broad scope of responsibilities, including:

Adm. William Kime was the 19th Commandant of the Coast Guard from May 31, 1990, through May 31, 1994. He was the principal visionary of the Marine Safety Center, and he oversaw its establishment in 1986 when he served as Chief of the Marine Safety, Security and Environmental Protection program.

- plan review;
- specification review;
- admeasurement policy determination and review;
- alternate compliance or equivalency review;
- equipment type approvals under Subchapter Q of the Code of Federal Regulations;
- oversight of organizations such as the American Bureau of Shipping that have been delegated authority to determine compliance with Coast Guard regulations;
- determination of ship modifications that constitute a "major conversion" under U.S. regulations and policy and international agreements; and
- approval of the reflagging of ships from foreign to U.S. flag.

These two sets of responsibilities will be under continuous review as the environment in the United States evolves. Relocating the MSC as a result of the transfer of the Coast Guard to the Department of Homeland Security may also be considered. However it is structured, what will remain constant is the ability of the technical staffs of the Coast Guard Marine Safety, Security and Environmental Protection program to serve the needs of the public, the industry, the administration and the Congress in a professional, timely, cost-effective and efficient way.

Marine Safety Center

Organization

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Commanding Officer
Capt. Roy A. Nash

Executive Officer
Cmdr. Alan M. Marsilio

The Marine Safety Center (MSC) provides technical expertise to the Commandant of the U.S. Coast Guard in support of the Coast Guard's Marine Safety, Security and Environmental Protection program. MSC staff works directly with the marine industry, the Commandant and Coast Guard field units to evaluate and approve commercial vessel and system designs, develop safety standards and policies, respond to maritime casualties, and oversee delegated third parties to ensure they comply with Coast Guard regulations.

Plan review and technical support staff are divided into five divisions: Vessel Security, Hull, Tank Vessel and Offshore, Engineering, and Tonnage.

Hull Division, (202) 366-6481
Cmdr. Tim Cherry, Chief
The Hull Division reviews stability, construction and arrangements (structures, structural fire protection, means of escape and ventilation) for U.S. flag commercial vessel designs, and Control Verification Examinations (CVEs) for foreign passenger vessels.

Small Vessel Branch (Hull Division)
Lt. Cmdr. Dan Venne, Chief (2004)
The Small Vessel Branch reviews small passenger vessels (Subchapter T), tug and tow boats, oceanographic research vessels (ORVs), freight vessels (<100m) and passenger submarines.

Major Vessel Branch (Hull Division)
Lt. Cmdr. Wilford "Buddy" Reams, Chief
The Major Vessel Branch reviews small passenger vessels (Subchapter K), large passenger vessels, freight vessels (>100m) and fish processing vessels and foreign passenger vessels for CVEs.

Tank Vessel and Offshore Division, (202) 366-6441
Lt. Cmdr. John Nadeau, Chief (2004)
The Tank Vessel and Offshore Division reviews structural fire protection, stability, vapor control systems, cargo piping, procedures and arrangements manuals, bulk liquid cargo authority and structures for U.S. Coast Guard certificated tank-

ships, tank barges, deck cargo barges, oil spill recovery vessels, oil field waste barges, offshore supply vessels (OSVs), mobile offshore drilling units (MODUs) and liftboats. For foreign vessels they review IMO Certificates of Fitness and prepare Subchapter O Endorsements issued with Letters of Compliance.

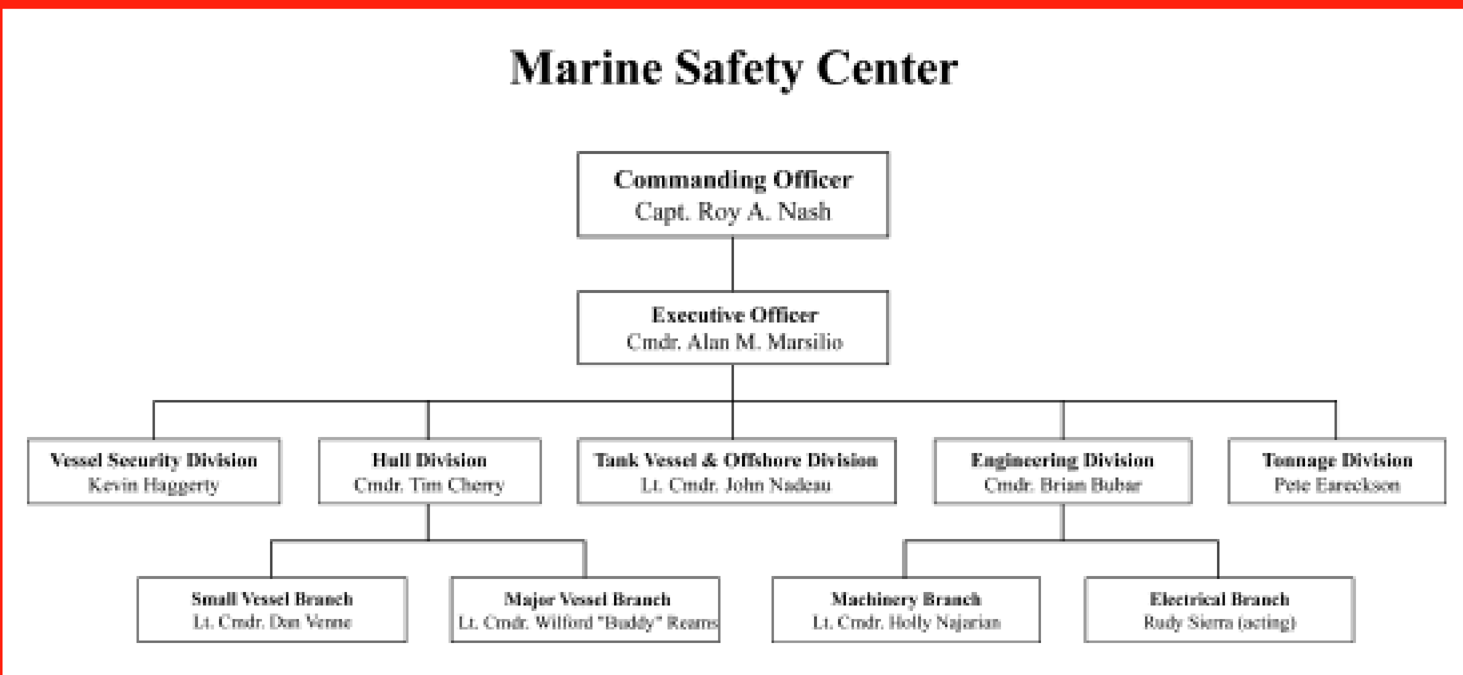
Engineering Division, (202) 366-6440
Cmdr. Brian Bubar, Chief
The Engineering Division reviews machinery and electrical plans to Title 46 of the Code of Federal Regulation (CFR) Subchapters F (Machinery and Piping) and J (Electrical) for the construction and alteration of U.S. flag commercial vessels. The Division responds to submittals from commercial vessel operators and engineering design firms concerning automated vital machinery and steering systems, pressure vessels, electrical distribution, boilers and other vessel systems.

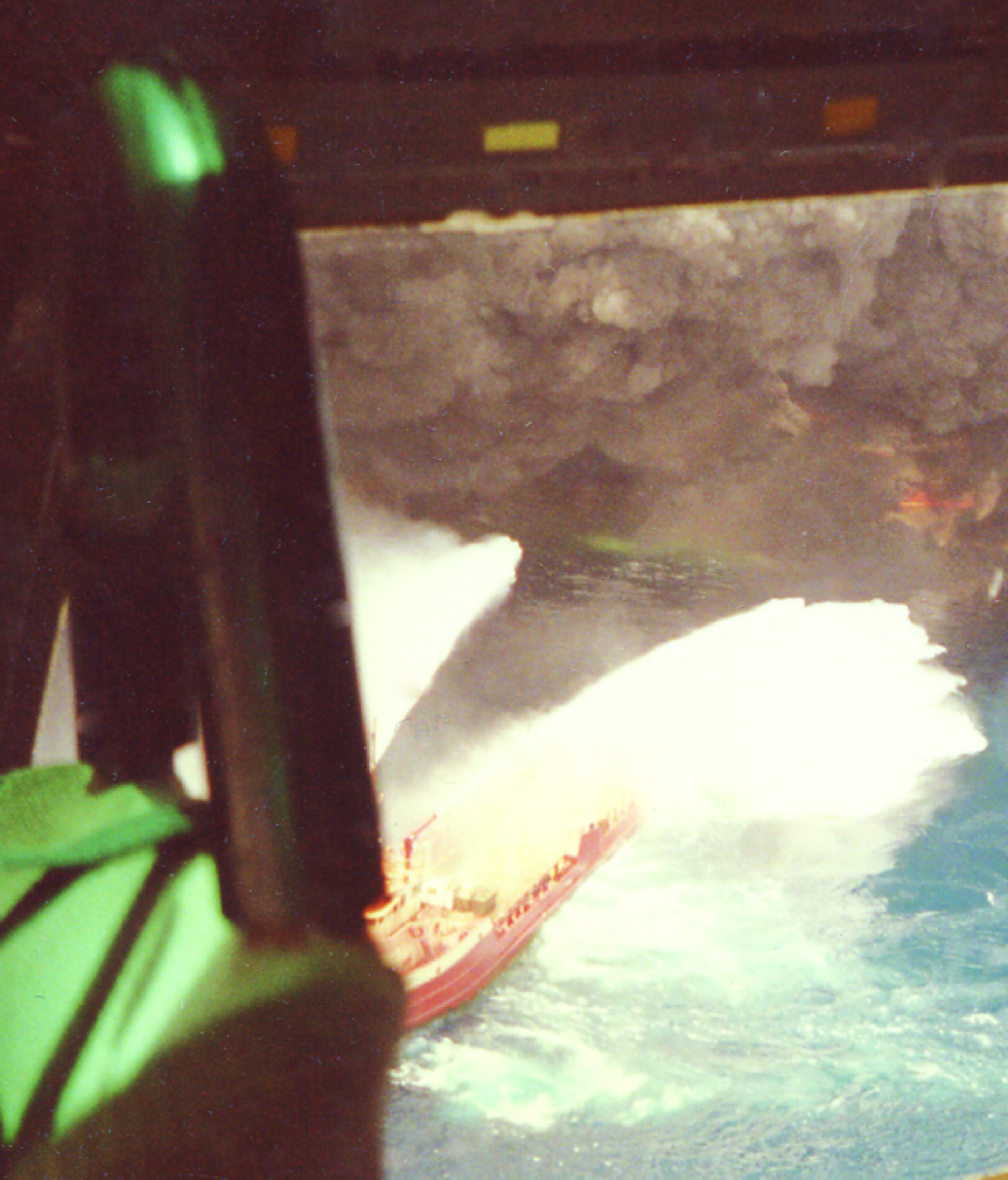
Machinery Branch (Engineering Division)
Lt. Cmdr. Holly Najarian, Chief (2004)
The Machinery Branch performs technical engineering evaluations primarily to 46 CFR Subchapter F (Machinery and Piping) for the construction and alteration of commercial vessels' machinery and piping systems. The Branch reviews specifications and calculations for vital machinery, steering systems, pressure vessels, boilers and other complex designs for compliance with applicable Federal laws, regulations, international treaties and conventions such as the International Convention for the Safety of Life at Sea (SOLAS), American Bureau of Shipping (ABS) Rules, technical standards and Coast Guard policies.

Electrical Branch (Engineering Division)
Rudy Sierra (Acting)
The Electrical Branch is responsible for conducting plan review of electrical systems on all vessel types. The types of systems include electrical power generation and distribution systems, automated control and monitoring systems (including witnessing Design Verification Tests), steering control systems, electrical systems for installation in hazardous locations and fire detection systems.

Vessel Security Division, (202) 366-3879
Kevin Hagerty, Chief
The Vessel Security Division reviews and approves security plans mandated by the Maritime Transportation Security Act for domestic vessels regulated by the Act.

Tonnage Division, (202) 366-6481
Peter Eareckson, Chief
The Tonnage Division provides services for all domestic commercial, recreational and public vessels, in many cases via oversight of third party organizations, and provides official tonnage guidance to the field and industry.





A Coast Guardsman peers out a helicopter window at the Norwegian tanker *Mega Borg* burning near Galveston, Texas, in June 1990. An explosion and subsequent fire caused 100,000 gallons of crude oil to be spilled into the Gulf of Mexico. The *Mega Borg* casualty was one of three that drove the Coast Guard to develop an in-house team of salvage response personnel. That team, known today as SERT, was formed five months after the fire seen in this image.


EXIT

SERT

Highlights of 2003 and Plans for the Future

by Lt. Derek T. Schade
Marine Safety Center

by Lt. Brad J. Rosello
Marine Safety Center

Team Inception

The U.S. Coast Guard Salvage Engineering Response Team (SERT) was officially founded in November 1990 after three major vessel casualties: *Exxon Valdez*, which ran aground on Bligh Reef spilling 11 million gallons of heavy crude oil; *Mega Borg*, which spilled 100,000 gallons of light crude oil in the Gulf of Mexico; and *Jupiter*, which had an explosion resulting in a devastating fire while moored on the Saginaw River in Bay City, Mich. Driven by these three incidents, the Coast Guard developed an in-house team of salvage response personnel that could provide immediate salvage engineering support to Federal On-Scene Coordinators (FOSCs) and U.S. Coast Guard Captains of the Port (COTPs) during responses to maritime casualties. Due to the technical, structural and stability expertise available at the Marine Safety Center (MSC), it was the logical place to establish this team of experts.

Currently, SERT maintains a team of eight to 10 staff engineers who respond remotely or on-scene to maritime casualties when requested by the FOSC or COTP. When engaged, SERT will provide guidance to response personnel concerning initial casualty assessment procedures, recommend methods to mitigate potential oil outflow or reduce the severity of a vessel grounding, and ascertain the technical feasibility of proposed salvage operations.

2003 Operational Highlights

SERT's 2003 operations highlight the importance of technical salvage assistance when responding to maritime casualties. During 2003, SERT responded to more than 40 requests for salvage assistance from 22 separate Marine Safety Offices (MSOs). These requests not only encompassed common grounding and lightering evolutions, but also included hazardous marine casualties, which posed a significant risk to the ship's crew, responding salvage companies and the surrounding environment. Upon activation, SERT duty officers provided immediate guidance and technical support to FOSCs and COTPs regarding the feasibility of proposed salvage plans. Among the more prominent casualties SERT responded to were the pollution abatement of the derelict SS *Sea Witch*, the grounding of the freight vessel *Kent Reliant* and the capsizing and grounding of the heavy lift vessel *Stellamare*.

Marine Casualties

Activities Baltimore activated SERT in August 2003 to assist with the pollution abatement and possible wreck removal of the derelict portion of the SS *C.V. Sea Witch*, which at the time appeared to be in use as a makeshift Oily Water Separator (OWS). Since no construction plans were readily available, SERT deployed on-scene and conducted a site survey of the vessel's grounded condition, tankage and structural integrity. Using this information, SERT prepared a computer model of the vessel and evaluat-

The *Kent Reliant* hard aground at the entrance of San Juan Harbor, 100 yards from Isla de Cabras. Courtesy Titan Maritime, LLC.

ed all probable lightering plans, including the removal of oily water, restoring buoyancy and relocating the vessel. During the evaluation process, the longitudinal strength, potential oil outflow and stability of the grounded vessel were examined to ensure salvaging efforts would not exacerbate the situation. To verify the validity of the assessment, SERT collaborated with the Navy's Supervisor of Salvage (NAVSUPSALV) representative, who was on-scene at the request of the COTP. Through technical analysis, SERT provided the Unified Command (UC) at Activities Baltimore with an accurate appraisal of the vessel's condition and risk-based assessment of potential salvaging proposals. Armed with this knowledge, the course of action identified by the UC was pollution abatement operations, in lieu of any heavy lift, buoyancy restoration or lightering operations, to reduce the possibility of future oil release, and to best focus on the risks at hand.

In September 2003, the 522-foot freight vessel *Kent Reliant* ran hard aground at the entrance of the San Juan Harbor, 100 yards from Isla de Cabras, suffering extensive structural damage to the double bottom. In addition to being near a historic site, El Morro Castle, the vessel grounded in a marine estuary inhabited by endangered marine life. The SERT duty officer was activated and, from his office in Washington, D.C., remotely integrated into MSO San Juan's Unified Command. Initially, SERT provided guidance regarding the collection of critical vessel casualty information—such as dive reports, soundings, pre-/post-casualty draft readings, and hull structure data—that would be needed to assess the feasibility of any future salvage operations. Using this information, and the construction plans obtained from the responsible party's professional salvor, Titan, the duty officer evaluated and approved the proposed lightering plan and methods for recovering buoyancy. After approving the proposed lightering plan, SERT continually analyzed and monitored the stability and longitudinal strength of the vessel during the offload of 5,600 tons of cargo and 52,000 gallons of fuel oil. As a result, the vessel was safely refloated, thereby mitigating the potentially devastating environmental damage.

Activities New York requested SERT assistance in December 2003 regarding the capsized heavy lift vessel *Stellamare*. While loading the second of three 300 metric ton turbine generators, the vessel experienced a sudden heel to port, allowing water to enter the vessel's cargo hold, ultimately capsizing the vessel. Upon arriving on-scene, the SERT duty officer ascertained the condition of the vessel—by examining the vessel's loading condition at the time of the capsizing and from the on-site dive reports—and worked concurrently with the response organization Donjon-SMIT to formulate a safe, effective salvage response. During the salvage plan review process, SERT analyzed the feasibility of heavy lift operations to right the capsized vessel. In order to ensure a controlled righting of the vessel, this analysis had to account for the turbine generator still attached to the vessel's onboard cranes, the water contained in the vessel's cargo hold and the vessel's ground reaction. By evaluating the technical feasibility of the salvage evolution, the SERT duty officer addressed many of the FOSC's concerns regarding the safety of response personnel, efforts to minimize oil pollution and how the salvage efforts would impact reopening the navigational channel.

Mission/Objectives

These three cases epitomize SERT's mission "to provide immediate salvage engineering support to U.S. Coast Guard Units in response to vessel casualties; which includes independent technical evaluation of the situation and helping to formulate practical and

The M/V *Stellamare* capsized and grounded at Federal Marine Terminal, pier no. 2 in Albany, N.Y.

effective solutions." While it is possible for SERT to evaluate the technical feasibility of salvage operations, SERT can also provide guidance to response personnel concerning initial casualty assessment procedures, methods to mitigate potential oil outflow, and means to mitigate the effects of a vessel grounding. SERT provides assistance, for instance, by maintaining the capability to analyze the technical aspects of situations that commonly arise during vessel marine casualties, such as:

- Evaluation of the ground reaction of a grounded or stranded vessel;
- Determination of the tractive forces needed to free a grounded vessel;
- Analysis of a vessel's hull stresses and longitudinal strength—during grounding, lightering, tidal cycles, etc.;
- Evaluation of a vessel's intact and damaged stability;
- Oil/hazardous chemical outflow;
- Evaluation of lightering plans;
- Determination of tidal effects on salvage evolutions; and
- Safe transit recommendations—weather, sea state, swell height, transit speed, etc.

Through these technical analyses, SERT can aid the COTP or FOSC to:

- Ensure the safety of personnel;
- Limit environmental damage;
- Restore the waterway; and
- Address any additional salvage concerns.

Team Composition

Throughout the past several years, as SERT has improved its visibility in the maritime community, and as the number of technical salvage assistance requests has increased, the team has evolved from a voluntary collateral duty into a more primary service provided by the MSC. Currently SERT is composed of seven staff engineers who, along with full-time plan review duties, also maintain a 24/7 duty rotation in the event salvage assistance is requested. The majority of the active duty members have earned master's degrees through the Coast Guard's marine engineering program, and have expertise in commercial vessel structures and stability. While members with this background generally make up SERT, officers with undergraduate degrees have had the opportunity to join, and have qualified as duty engineers, as well.

In May 2002, the tug *Robert Y. Love*, pushing two barges, struck the I-40 bridge over Arkansas River in Oklahoma. SERT provided assistance with salvage of the barges and removal of damaged bridge sections.

Training

During 2002, SERT identified a critical shortfall within its team composition. Due to an abnormal number of duty officers, more postgraduate (PG) trained officer transfers were departing the team than reporting aboard. These personnel shortages directly affect SERT's ability to maintain adequate response levels. As a result, many of these billets were backfilled with non-PG candidates. In order to bridge the training gap between the PG and non-PG officers, SERT developed an annual performance-based qualification program, which covered all of the basic and advanced salvage engineering competencies. These competencies include, but are not limited to:

- Basic Naval Architecture (BNA);
- Vessel framing systems/structures;
- Strength of materials/stress and strain analysis;
- Rules of thumb for grounded and stranded vessels;
- Salvage software (GHS, HECSALV);
- Incident Command System (ICS); and
- Salvage equipment and evolutions.

Currently, qualified salvage engineers at the MSC provide the majority of this training. However, SERT does partner with salvage companies that are members of the American Salvage Association (ASA) in order to obtain increased levels of practical salvage experience. Some of SERT's past training programs included ASA members such as: Resolve Marine Group (RMG), Titan Maritime, Donjon Marine, Crowley Marine Services and Jamestown Maritime Services (JMS).

Due to the environmental protection work that SERT performs, SERT also receives Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) funding to minimally support training and response capabilities. These funds allow SERT to maintain cell phones, response computers, and personal protective equipment, so that the team can assist the Coast Guard anywhere and anytime a marine casualty occurs. This support is critical to SERT's readiness.

Future Direction

State and federal governments have begun implementing increased preventive measures against terrorist attacks, including potential targets in the marine transportation system. The three cases discussed in this article briefly touch on the importance of maintaining salvage response capabilities

In February 2002, the *Swift* collided with a bulk cargo vessel. SERT provided on-scene support and approved the salvage plan consisting of lifting, righting and dewatering the vessel. Courtesy SERT.

and proficiencies in the event of maritime casualties, whether or not they are the result of terrorism.

The importance of salvage response capabilities was further stressed at a recent Marine Transportation Research Board (MTRB). During the discussion sessions many commercial salvors expressed deep concern regarding the federal government's lack of institutionalized salvage knowledge. Specifically, commercial salvors requested that:

- The National Response Plan (NRP) address salvage response;
- The FOSCs and COTPs maintain a salvage representative that is familiar with salvage resources and can identify with and rapidly communicate the concerns of the commercial salvors to the FOSC/COTP or UC/ICS commander;
- The federal government reduce the turnover of personnel at government agencies, such as the MSC SERT and the NAVSUPSALV since salvage is an experience-based profession; and
- The FOSC/COTP and the commercial salvors improve the transfer of information between the two teams.

Based on these concerns, SERT has established a long-term plan to ensure the level of salvage proficiency within the Coast Guard continually increases and to maintain a core salvage response element, which has become critical to the successful outcome of maritime casualties.

First, in an attempt to document the proficiency of its personnel and improve the salvage proficiency of Coast Guard members, SERT recently tailored its annual training program into the required format for acceptance by the Marine Safety Training Coordinating Committee (MSTCC) as a recognized Marine Safety Qualification. The proposed "Salvage Engineer" Personnel Qualification Standard (PQS) will serve to enhance the Coast Guard's capabilities during maritime casualties by providing a standardized level of knowledge expected by commercial salvors, COTPs and FOSCs.

Second, in addition to the development and desired acceptance of the PQS, the MSC recently proposed that the Coast Guard establish two permanent billets at the MSC, solely designated for salvage engineering response and readiness management. Two persons fully devoted to salvage-related matters, supported by a voluntary staff of duty engineers, would allow SERT to peruse the development of marine casualty training scenarios, 3-D modeling software for marine casualties, and training for MSC staff and MSO command cadre through the On-Scene Coordinator's Crisis Management Course. Additionally, they could refine training programs and augment the Coast Guard's collaborative efforts with marine industry personnel on Spill of National Significance (SONS) and Preparedness for Response Exercise Program (PREP) drills. As outlined in the MTRB's report on marine salvage capabilities, it would be a natural fit for the position of Coast Guard liaison to NAVSUPSALV, and could assist in the development of an inventory of nationally available marine salvage and firefighting assets, aid in the incorporation of salvage response into the National Response Plan, and support the Coast Guard's effort to promulgate new rules for salvage and marine firefighting in Vessel Response Plans.

Regardless of how the future may unfold, SERT will stand ready to assist the FOSC and COTP during maritime casualties nationwide. For more information about SERT, please visit the program's Web site **www.uscg.mil/hq/msc/salvage.htm**. You can also contact the duty salvor at (202) 327-3985 or through FLAGPOT at (800) DAD-SAFE.

SERT

A Valuable Resource Tool for Marine Safety Field Units

by Lt. Cmdr. Kyle McAvoy
Marine Safety Center

by Lt. Patrick Hilbert
Coast Guard Activities New York

Suppose you are the Command Duty Officer at a Marine Safety Office (MSO) or Sector Command and your watchstander wakes you up in the middle of the night to report that a marine casualty has just occurred within your area of response. Further suppose that the casualty involves a grounded oil tanker that is leaking cargo oil and creating a sheen immediately adjacent to an environmentally sensitive area. Or, instead of the grounded tanker scenario, suppose two freight ships have just collided and one may be in danger of capsizing. As you wipe the sleep from your eyes and realize you do not have a prepared scenario checklist for this type of casualty, and the rest of your watch is already juggling the daunting task of data collection, interpretation and chain of command briefs, your first thought might be, "where can I find help?" Well, if the situation you are about to deal with involves "salvage" or technical engineering decisions, and it probably will, the Marine Safety Center's (MSC) Salvage Engineering Response Team (SERT) is on standby to assist 24/7.

As discussed in the "SERT Highlights of 2003" article on page 12 of this issue, the SERT team at the MSC can help a Captain of the Port (COTP) or a Federal On-Scene Coordinator (FOSC) decipher, review or approve many technical salvage issues associated with a marine casualty response. The SERT team is composed of approximately 10 staff engineers stationed at the MSC who have developed the salvage engineering skills needed to integrate into a COTP or FOSC unified command and address these technical salvage issues. SERT was initially developed in the early 1990s; however, the demand by field units for the team's skills ultimately led it being incorporated into the MSC's Business Plan as a core mission in 2001. The MSC is trying to formalize the SERT mission even further and has requested that two new positions be created at the MSC that will be fully dedicated to SERT duties.

Two recent marine incidents in which SERT provided technical support exhibit the benefits of calling SERT for assistance. The first incident was a response to a pollution case near historic Fort McHenry in Baltimore, Md., where a remnant part of a scrapped former freight ship named *Sea Witch* was being used as an illegal, makeshift oil-water separator that was leaking oil into Baltimore's harbor. A harsh winter with heavier than normal precipitation was the last straw to years of neglect for this illegal operation and the dilapidated hull finally sank and grounded at its berth. It settled to the bottom in a listed condition and began to release much of the oil stored within its tanks. The amount

In August 2003, Coast Guard pollution response personnel worked on containing oil spilled from the scrapped freight ship *Sea Witch* in Baltimore Harbor.

of oil in those tanks was estimated to potentially be as much as 20,000 gallons.

A second incident in which SERT offered much-needed technical assistance was in the response to a tragic capsizing of a 289-foot heavy lift ship named the *Stellamare*, in the Port of Albany, N.Y. Sadly, three mariners from the crew of the vessel lost their lives in this maritime accident. The *Stellamare*, a Dutch Antilles-registered heavy lift ship, capsized on Dec. 9, 2003, while loading immense generators that weighed in excess of 308 metric tons (approximately 680,000 pounds). As the crew secured a 308 metric ton generator in the cargo hold, the vessel's master, using two ship's cranes, craned a second generator weighing 240 metric tons over the starboard gunnel. Suddenly, the vessel started listing to port causing the generator on the cranes to swing to port. The heeling moment created from these events was too much for the vessel and it continued to roll. In a matter of seconds, the *Stellamare* rolled to an 85-degree port list and settled hard aground on the river bottom. As a result of the list, and the fact that the cargo hatch was open, the hold filled with the frigid waters of the Hudson River and left the vessel crew scrambling for their lives. Tragically, three crewmembers failed to escape from the hold and made the ultimate sacrifice.

So, how specifically did SERT help the field units in these cases? In the *Sea Witch* case, there was no identifiable responsible party to count on to clean up the mess. In cases such as these, the COTP, acting as the FOSC, becomes the default responsible party and takes steps to eliminate the pollution risk on behalf of the American public. Activities Baltimore, in one of these steps, called upon SERT for help with this daunting and complicated endeavor.

The *Sea Witch* was actually what was left over from a freight ship that had been involved in a famous maritime collision with the *Esso Brussels* in New York in 1973. After the collision and resulting fire, the ship was cut in two sections and the cargo sec-

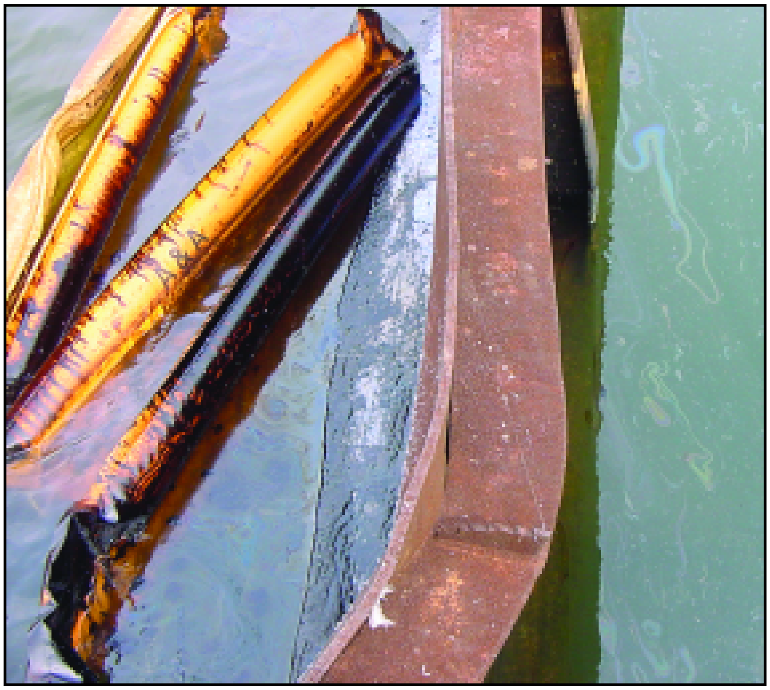
The Dutch ship *Stellamare* rolled to its port side in Albany, N.Y., as crewmembers attempted to secure two generators aboard the vessel. Three crewmembers died in this accident.

tion was towed and scrapped in Baltimore Harbor. Apparently, during the scrapping the main deck of these cargo holds was removed and holes were cut in the tank bulkheads at progressive levels to permit the settling and pumping of water from one compartment to the next. In this configuration, the tanks were usable as an ad hoc, albeit illegal, oil-water separator. After years of neglect and abuse from non-environmentalists who illegally dumped oily waste mixtures into this scrapped tanker, Mother Nature delivered the final blow in the form of copious amounts of snow and rainwater during the harsh winter of 2003. The excess water caused the vessel to trim down by the bow and led to uncontrolled down flooding of the oily mess within the tanks. The down flooding eventually caused the vessel to ground at its berth and contributed to the oily water mixtures onboard spilling out into the harbor.

Since there were many unanswered engineering questions surrounding this case, SERT assessed several salvage alternatives to obviate further pollution risk. They also recommended that the FOSC contact the Navy Supervisor of Salvage (NAVSUPSALV) for their salvage expertise and additional resources, such as divers and cranes. To get into the nuts and bolts of assessing which pollution elimination option was the best, the on-scene team had to delve deeper into some of the incident unknowns. The Coast Guard had to verify the source of the dirty oil leaking out into the harbor and ascertain the integrity of the hull structure, questionable at best, as it would affect the response options available to the FOSC. SERT created a computerized model to use as a tool for an in-depth engineering analysis. The analysis examined options such as raising the bow of the vessel just enough to patch the holes suspected of releasing the oil, trying to raise the vessel enough to completely remove it from the harbor, or the more probable combination of both of these options. To create the model and do the analysis, SERT surveyed and analyzed the structural adequacy of the vessel. The model was a helpful tool to determine if the vessel could withstand the estimated stresses associated with physically moving it. An outcome to be avoided was physically moving the hull, causing the tank bulkheads' fracture to exacerbate the environmental damage. SERT

The *Sea Witch* releasing oil into Baltimore Harbor. Courtesy SERT.

SERT explored three methods to eliminate the source of pollution from the hull of the *Sea Witch*.

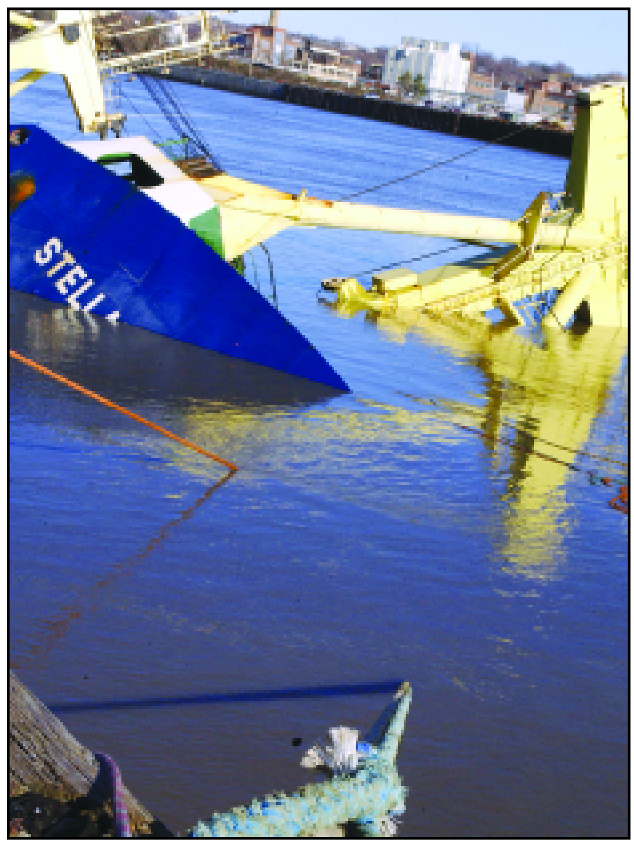


Already deflected bulkheads on the *Sea Witch* had to be preserved. Courtesy SERT.

worked closely with the NAVSUPSALV and the Coast Guard Atlantic Strike Team personnel, who were also on-scene, to explore all of these alternatives. SERT was then able to convert all of these technical salvage engineering proposals into more user-friendly concepts and fully brief the Activities Baltimore Command with their findings and recommendations. Eventually, commercial salvors were also brought in to help with the salvage recommendations, and the FOSC relied upon SERT to team up with their resources and help consolidate the salvage efforts into one collective "salvage voice" for the FOSC. In the end, the vessel was cleaned in place. The internal tanks of the vessel were scrubbed and the oil that was retrievable and recoverable was collected; the situation will be monitored to see if there is a recurring pollution problem. SERT's presence as a technical advisor to the Unified Command and FOSC in this case expedited a resolution to a complex and environmentally difficult situation.

In the *Stellamare* case in Albany, N.Y., the FOSC faced a very complex situation where a vessel had unexpectedly capsized. The FOSC for this case, Coast Guard Activities New York, requested SERT assistance due to the complexity of forces and myriad issues that had to be addressed by both the Coast Guard investigation and the salvage effort needed to re-open the commercial shipping channel. SERT was able to assist with both missions. Recall that the *Stellamare* was moored with its starboard side to the pier and was loading a 240 metric ton electric generator into its hold when it unexpectedly rolled to port. To load these generators, the *Stellamare* used two ship's cranes simultaneously, one crane attached to each end of the cargo load. Each of the *Stellamare*'s two cranes was certified to handle 180 metric tons of weight. Working in conjunction, and generally using "dry land engineering principles," these two cranes were capable of handling a 360 metric ton (approximately 794,000 pounds) load. On a ship, however, these calculations are much more complex.

In this incident, unlike in the *Sea Witch* case, representatives of the vessel and its operating company were available to assume clean-up and salvage responsibilities. However, due to the severity of the overall response necessary for this tragic event, the command representatives from Activities New York needed to assemble a large team to address many intense, and sometimes competing, demands. Questions regarding pollution clean-up, search and



Divers had to enter the water during clean-up of the *Stellamare* and traverse underwater obstacles, such as wire ropes and mooring lines.

rescue operations, navigable shipping channel closures, recovery of lost crewmembers, and salvaging the vessel and cargo all had to be addressed. Therefore, the Activities New York FOSC brought in players from the state of New York, the city of Albany, the *Stellamare*'s shipping company (Jumbo Shipping), oil spill clean-up contractors, commercial maritime salvors, the MSC's SERT, the Coast Guard Atlantic Strike Team and numerous members of the Activities New York Command to tackle this situation head on.

Cmdr. John Cameron conducts a press conference with many of the parties standing by that were involved in the salvage evolution of the *Stellamare*.

SERT took on both a short-term and a more long-term role in this case. Again, as in the *Sea Witch* case, the first order of business was to develop a computer model to work with and analyze key developments and outcomes. Using the model, SERT successfully predicted the ship's response to plans aimed at removing the vessel and its heavy cargoone generator overboard but still attached to the vessel, and the other in the cargo hold. This in turn gave the FOSC an added level of comfort that the salvage operation would be conducted in the safest manner possible. With regard to pollution clean-up efforts, SERT analyzed proposals from the clean-up contractors with two thoughts in mind: to ensure the safety of personnel working around the capsized vessel; and to direct the clean-up personnel to where pockets of oil on the ship resided. Using their model, SERT predicted which tanks may have already drained their oil content through tank vents and which ones had not. That determination was based on information such as how the ship rolled, its final static condition, and a bit of knowledge on which tanks were initially full before the vessel capsized. That way, divers could secure those vents that had the potential to leak more oil. But first, commercial divers along with city and state divers worked within the submerged cargo hold of the vessel to search for the missing crewmembers. Knowing whether or not the vessel may continue to move was crucial to these divers in order to minimize the potential of getting caught on a line under water.

SERT also helped Coast Guard investigators interview the ship's crew, and through its computer modeling, enabled the Coast Guard investigators to hypothesize as to the physics that contributed to the vessel's capsizing. This in turn helped explain the effects of weight distributions in ballast tanks and how they interplayed with the dynamic forces involved with heavy lift cargo ships. Over the long-term salvage operation, SERT was a critical resource that the FOSC leaned heavily upon to provide technical salvage expertise and to test proposed salvage plans. Finally, on Jan. 2, 2004, more than three weeks after the initial incident, two derrick barges staged at both ends of the *Stellamare* restored it to its normal operating position and dewatered its hold. The owners of the vessel then made arrangements to have it transported out of the Port of Albany, N.Y.

In summary, if you are facing some tough marine salvage engineering questions, you may wish to call upon SERT at the Marine Safety Center. SERT's ability to act as a technical liaison to the FOSC for incidents ranging from routine groundings to a complex salvage operation, such as the *Sea Witch* or the *Stellamare*, may help.

MSC Investigators

Clued in to Marine Casualties

by Lt. George Borlase
Marine Safety Center

On the hit television show "CSI: Crime Scene Investigation," police investigators call in specialized experts to collect information, analyze clues using a wide array of forensic and engineering techniques, and provide findings on what caused the accident or crime. Investigators use the information provided by the CSI analysts to determine what happened, why it happened and how to prevent future accidents or crimes.

The Coast Guard Marine Safety Center (MSC) often fills a vital role similar to "CSI" for Coast Guard field units investigating marine casualties. Called on by investigators, the MSC provides a wide range of casualty analyses, including stability evaluations, structural assessments, fire recreation and computer animation modeling. Armed with these analyses, investigators and industry better understand the causes of marine casualties and develop strategies for preventing future accidents.

Commercial fishing consistently ranks among the most dangerous professions in the United States and when a fishing vessel disappears without a mayday call, Coast Guard investigators often call on the MSC to identify what may have caused the vessel to sink. On April 2, 2001, the *Arctic Rose* sank in the Bering Sea, killing all 15 crewmen aboard. The Formal Marine Board of Investigation asked the MSC to identify the possible causes of the accident. Partnering with Dr. Bruce Johnson, professor emeritus at the U.S. Naval Academy and chairman of the Society of Naval Architects and Marine Engineers (SNAME) Ad-Hoc Panel on Fishing Vessel Operations and Safety, and Dr. Armin Troesch, chair of the University of Michigan Department of Naval Architecture and Marine Engineering, Lt. George Borlase developed 19 possible sinking scenarios. Using a wide range of static and dynamic stability tools, MSC evaluated the likelihood of each scenario and found progressive flooding topside from the aft deck into interior spaces most likely caused the accident. "[MSC's] networking with experts outside of the Coast Guard was beneficial in obtaining expert testimony on improvements to stability booklets," remarked Capt. Ronald Morris, head of the Formal Marine Board of Investigation. "The time that was dedicated to the marine casualty investigation was very important, though, and helped to craft a thorough analysis of the casualty."

Even when survivors are available and the vessel is recovered after sinking, Coast Guard investigators call on MSC to answer specific stability questions related to the sinking. On May 1, 1999, the amphibious vessel *Miss Majestic* sank in Hot Springs, Ark., killing 13 passengers. Investigators asked MSC to evaluate the stability of the vessel at the time of the accident and to determine if it met the current Coast Guard stability requirements. MSC visited a local amphibious passenger vessel with the same hull as the *Miss Majestic*, developed a computer model based on measurements pulled off the locally found vessel and then performed an inclining experiment on the vessel. With information on the local vessel, Lt. Cmdr. DeWane Ray was able to determine that the vessel's intact stability was fine and that flooding was the probable reason for the vessel's sinking.

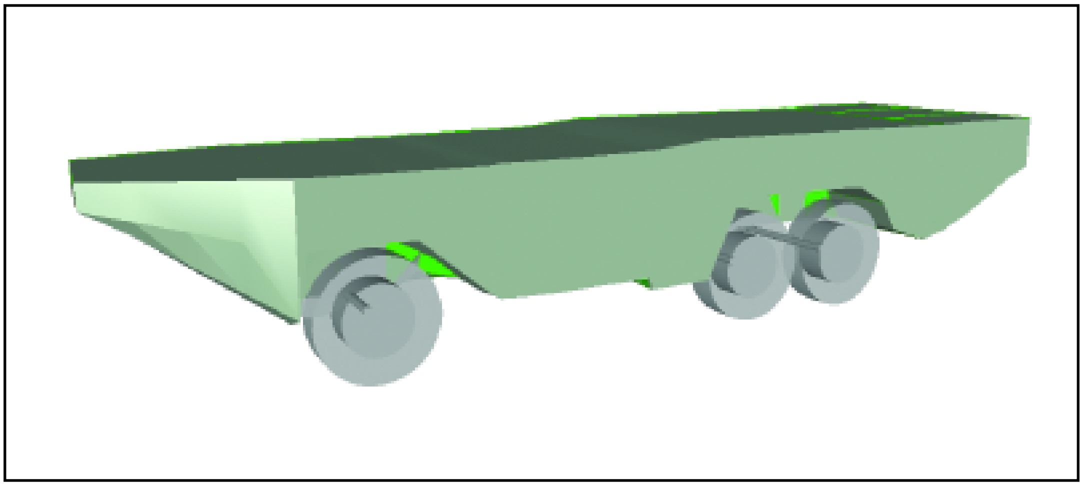


Figure 1. A DUKW computer model developed by MSC during the *Miss Majestic* casualty analysis, used to perform an inclining experiment to determine stability.

The fishing vessel *Adriatic* before its January 1999 sinking. Investigators conducted extensive stability analysis on a sister ship to the *Adriatic* to evaluate the vessel owner's claims that the ship was safe prior to the incident. Courtesy Debbie Clause, *Porthole II*.

Immediately following the July 2001 fire of the *Edward A. Carter*, above, investigators needed to determine at what speed the fuel oil was leaking, as well as how quickly CO_2 was escaping through open doors.

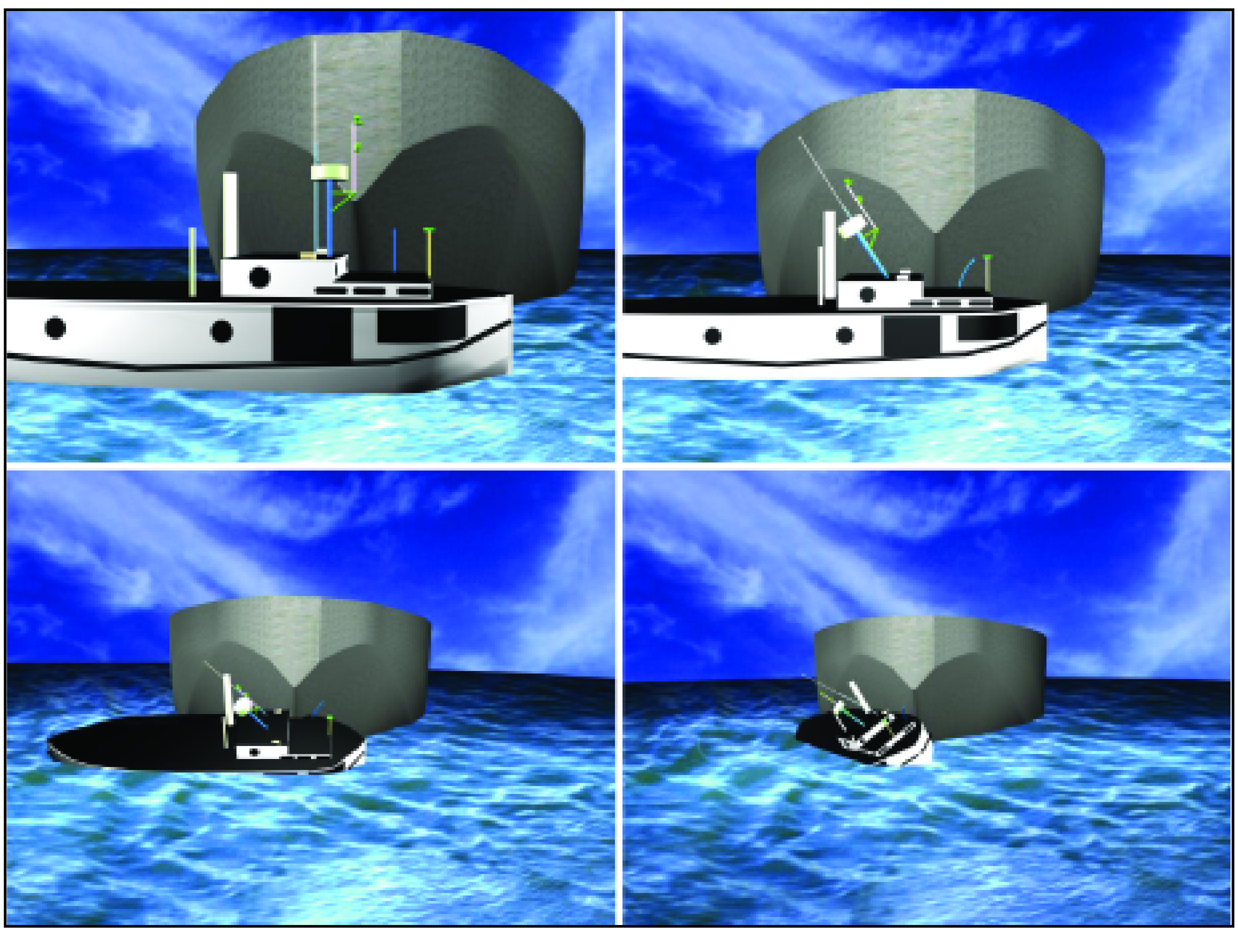
Just as "CSI" investigates different crimes, MSC does more than just provide stability analysis. When the fishing vessel *Adriatic* sank off the New Jersey coast on Jan. 18, 1999, subsequent dive surveys found a large intake pipe dislodged on the vessel. The Coast Guard investigator, Capt. Mary Landry, called on MSC to determine whether the pipe came loose at the surface or broke free when the vessel hit the bottom of the sea 120 feet below. Using structural simulation software, Lt. Steve Magee and Lt. Cmdr. Ray determined that the pipe did not come loose until after the vessel sank, refuting the vessel owner's allegations. "With only dive video available from the sunken vessel and no formal stability work that could be produced from the owners or insurers, Lt. Ray and Lt. Magee found a sister vessel to the *Adriatic*, and conducted extensive stability analysis," Capt. Landry reported afterwards. "Without their work, I could not have completed the casualty investigation and offered recommendations."

After the SSG *Edward A. Carter* caught fire at Sunny Point, N.C. on July 14, 2001, resulting in the death of two crewmembers, the Coast Guard investigators were left with a burnt vessel and a need to determine how quickly the heavy fuel oil was feeding the vessel's inferno, and how quickly the CO_2 dumped into the engine room escaped through open doors. Once again, MSC was called to determine fuel flow rates, based on the ship's piping schematics and the locations of all the pumps. Using complex flow calculations, John Sedlak and Lt. Holly Najarian were able to provide estimates of flow rates for two different fluids in different systems, enabling the investigators to quantify problems in the ship's fuel oil and firefighting systems.

All these engineering tools are not useful if MSC cannot effectively communicate the results, and MSC uses computer animation to visually demonstrate complex vessel motions. The fishing vessel *Linda E* disappeared on Lake Michigan on Dec. 14, 1998, and was later found by the U.S. Navy, with damage that appeared to be caused by a collision. The most likely vessel involved in the collision was a tug pushing an integrated barge, and MSC was asked to correlate the damage on the *Linda E* with the bow of the barge to determine whether these vessels were involved in a collision. Using plans of the barge and video of the *Linda E*'s damage taken by a Navy remotely operable vehicle (ROV), Lt. Cmdr. Ray showed that the bow of the barge ran over the *Linda E*, and then developed computer animation to show the relative sizes of the vessel and how the collision developed. Cmdr. Brian Emond, lead investigator for the *Linda E*, explained the impact of Lt. Cmdr. Ray's work. "Without this technical analysis, we would have had a sunken boat with damage that may have come from a vessel that was in the area. With the support provided by MSC, we had some very powerful images that enabled us to prove that a certain vessel had collided with the *Linda E*, and how the casualty transpired."

Just as "CSI" cannot provide exact solutions without all the forensic clues, MSC cannot perform exact calculations without all the casualty information. However, Coast Guard investigators don't have to be faced with major marine casualties or have complete information in order to contact MSC for assistance. Often, broad estimates in our casualty analyses can be very effective in validating an investigator's hunch. Additionally, knowing what could not have caused a marine casualty is often as important as knowing what did cause the marine casualty.

Working with Coast Guard field units, industry and professional organizations, such as the SNAME Panel on Marine Forensics, the MSC remains committed to assisting investigators in determining marine casualty causes and preventing similar accidents from occurring in the future.



Computer animation frames, created by MSC, show the relative sizes of the vessels involved in the *Linda E* collision and sinking. These frames also show how the collision most likely occurred. Courtesy MSC.

Buffalo Marine Barges Continue to Impact the Inland Tank Barge Fleet

by Lt. Cmdr. John Nadeau
Marine Safety Center

by Lt. Zach Malinoski
Marine Safety Center

Two marine casualties in the first half of 1996 focused the public eye on the safety of the bunkering industry. Structural failures on two tank barges in the Houston/Galveston area released nearly 5,000 barrels of fuel oil, raising questions as to the adequacy of structural design standards and of bunkering practices in general. Supported by the Towing Safety Advisory Committee (TSAC), the American Waterways Operators (AWO), the Ship Structures Committee and the Coast Guard's Office of Marine Safety, Security and Environmental Protection, the Marine Safety Center (MSC) spearheaded a technical analysis into the potential cause of failure. The results of MSC's analysis led to a number of regulatory and industry-developed solutions for preventing similar structural failures. Though the implementation of these preventive measures has curtailed serious structural failures within the inland barge fleet, regulatory provisions for the structural evaluation of 30-year-old barges threatens to force a large number of the older inland barge fleet out of tank vessel service.

In March of 1996, the deck of the tank barge *Buffalo 292* collapsed, creating a transverse crease and a 30-degree bend amidships and resulting in the loss of nearly 4,200 barrels of intermediate fuel oil (IFO). Approximately two months later, the tank barge *Buffalo 286* experienced a similar failure when the deck buckled near amidships, spilling 500 gallons of oil into Galveston Bay. Both barges were built by the same shipyard and were operated by the same company. Each barge was similarly constructed as a flush deck, single skin tank vessel with six port and starboard cargo tanks and bow and stern voids.

During each incident, the *Buffalo 292* and *Buffalo 286* were loaded in a sagging condition. Imagine walking across a skinny piece of wood, such as an eight-foot long two-by-four, that serves as a bridge across a stream; when you are half-way across, the wood sags under your weight. Similarly, although it is supported along its entire length by water, a barge that has its cargo concentrated near its middle, or midsection, will also sag. Physically, a sagging load condition causes the bottom plating and stiffeners of the barge to be in tension, or stretched, and the deck structure to be in compression, or squeezed. Though the specific tank loadings causing the sagging condition varied slightly between each barge, in both cases tank pairs 1 and 6, the foremost and aftmost tanks, were empty, leaving the cargo load concentrated in tanks 2, 3, 4 and 5, the tanks located nearest amidships. The only condition significantly different between the two failures was the weather. *Buffalo 292*'s failure occurred with a two- to three-

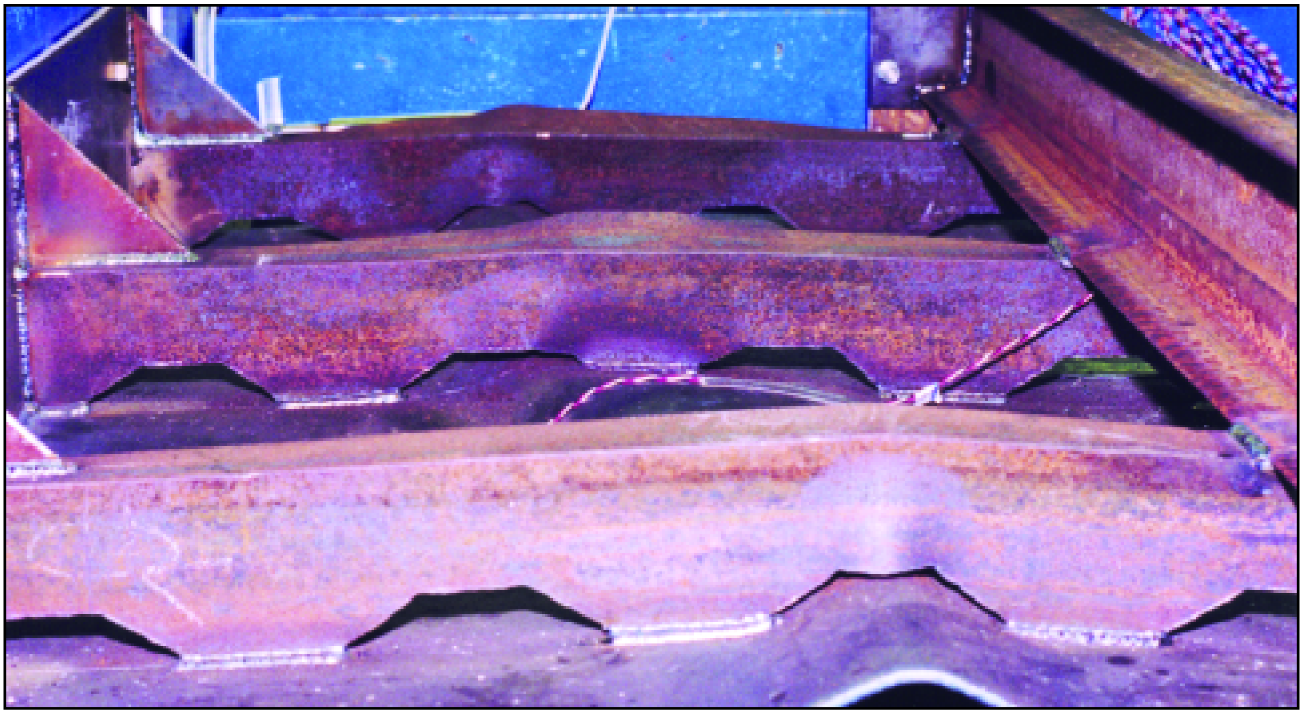
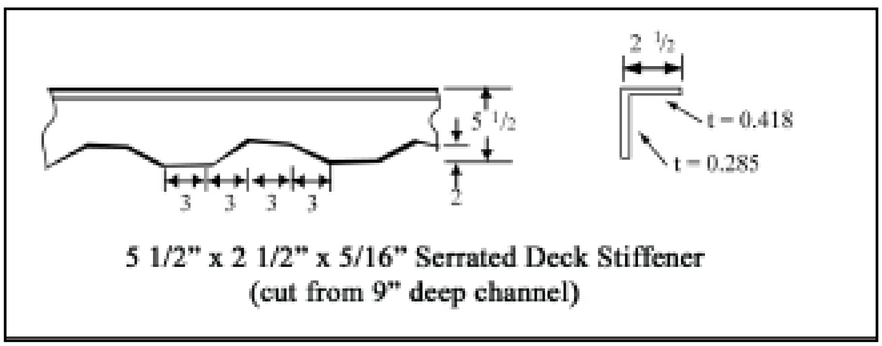


Figure 1, above: Test of plating supported with serrated stiffeners. Figure 2, below: Illustration showing a typical serrated stiffener. The tank tops, or decks, of many inland tank barges are supported with serrated stiffeners cut from channel beams.



foot chop, whereas the water was calm for *Buffalo 286*.

Given the extraordinary and frightening similarities of the barges and the short timeframe between incidents, investigators needed to determine if the casualties resulted from operational issues isolated to these two barges or from a structural deficiency common to the entire fleet of tank barges. To this end, the MSC undertook an in-depth engineering analysis of each barge in hopes of determining the following: 1) whether or not each barge was built and maintained in accordance with the design and construction standards in existence at the time they were built; 2) the stress applied to the bottom, side and deck structures by the barge's tank loadings; and 3) whether or not current design and construction standards adequately address buckling concerns of vessel structures under compression.

MSC initiated this analysis with data collection, sending staff engineers to the *Buffalo 286* to take measurements of its structural elements and to document the damage. Using these findings and the original construction drawings, MSC engineers quickly determined that the vessel was in fact built in accordance with the applicable structural standards, the "American Bureau of the Shipping (ABS) Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways, 1965" (Inland Rules, 1965). Analyzing *Buffalo 286*'s tank loads, MSC engineers determined the deck structure experienced compressive stresses between 15.9 and 16.6 thousand pounds per square inch (ksi). Since these barges were less than 30 years old, there were no regulatory limits for compressive stress. Even for tank barges more than 30 years old, the U.S. Code of Federal Regulations (CFR) permitted compressive stresses as high as 18.5 ksi. If the stresses were below the maximum compressive stress allowed by regulation, then why did these casualties occur?

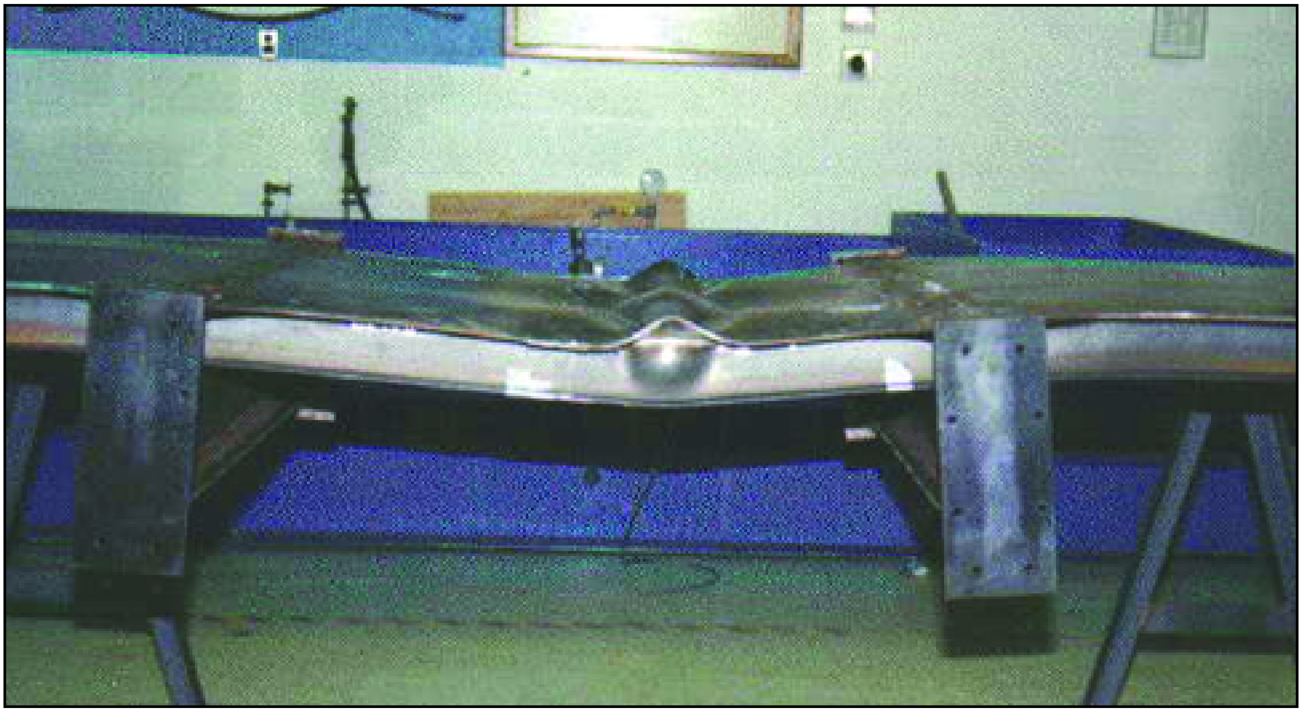


Figure 3. Test of plating supported with continuously welded conventional stiffeners. Courtesy MSC.

Imagine a yardstick with one end on the ground and the other end held firmly in your hand. If you press straight down on the yardstick, it will remain vertical until the pressure becomes so great that the yardstick finally bows out, or buckles. If you compare how hard you have to press to make it buckle to how hard you have to pull to separate the ends, you'll find it takes much less force to buckle the yardstick than to pull it apart. The same behavior occurs in the structural components of a barge's deck. As the vessel sags, the combination of deck plate and stiffeners are compressed to the point where they permanently bend or buckle out of shape. The stress that causes this type of buckling can be loosely termed the structure's ultimate strength. With actual deck stresses of the Buffalo barges less than the maximum allowed, MSC staff engineers believed some factor or factors defining buckling behavior and ultimate strength were not adequately accounted for by the 18.5 ksi compressive stress limit of the CFR, or ABS class rules.

To come to grips with the true buckling behavior of steel vessel structures, MSC made extensive use of not only its own engineering expertise but also the expertise of Washington, D.C., area research facilities. MSC directed Coast Guard and Ship Structure Committee funding to the Naval Surface Warfare Center, Carderock Division (NSWCCD) and the U.S. Naval Academy to conduct their own detailed analysis of the buckling problem.

The NSWCCD modeled each vessel using MAESTRO™ and ULSTR programs for more in-depth numerical analysis. Though these programs were adept at evaluating and confirming expectations defined by the current ultimate strength theories, they were limited in their ability to model the affects of some very common design and construction practices. The tank tops or decks of many inland tank barges are supported with serrated stiffeners cut from channel beams. Unlike conventional angle stiffeners, which are in contact with the deck plate along their entire length, serrated stiffeners only contact the plating for three inches out of every 12. This permits only intermittent welding and creates nine inches of unsupported plating for every three inches of direct support and contact.

In order to evaluate the potential degradation of ultimate strength caused by the use of serrated stiffeners, a team directed by professor Gregory White of the Naval Academy constructed scale models of typical deck structures for physical load testing in a lab. The models were grouped into three major categories based upon the type of stiffener and how it was attached to the plating: standard stiffeners continuously welded, standard stiffeners intermittently welded and serrated stiffeners intermittently welded.

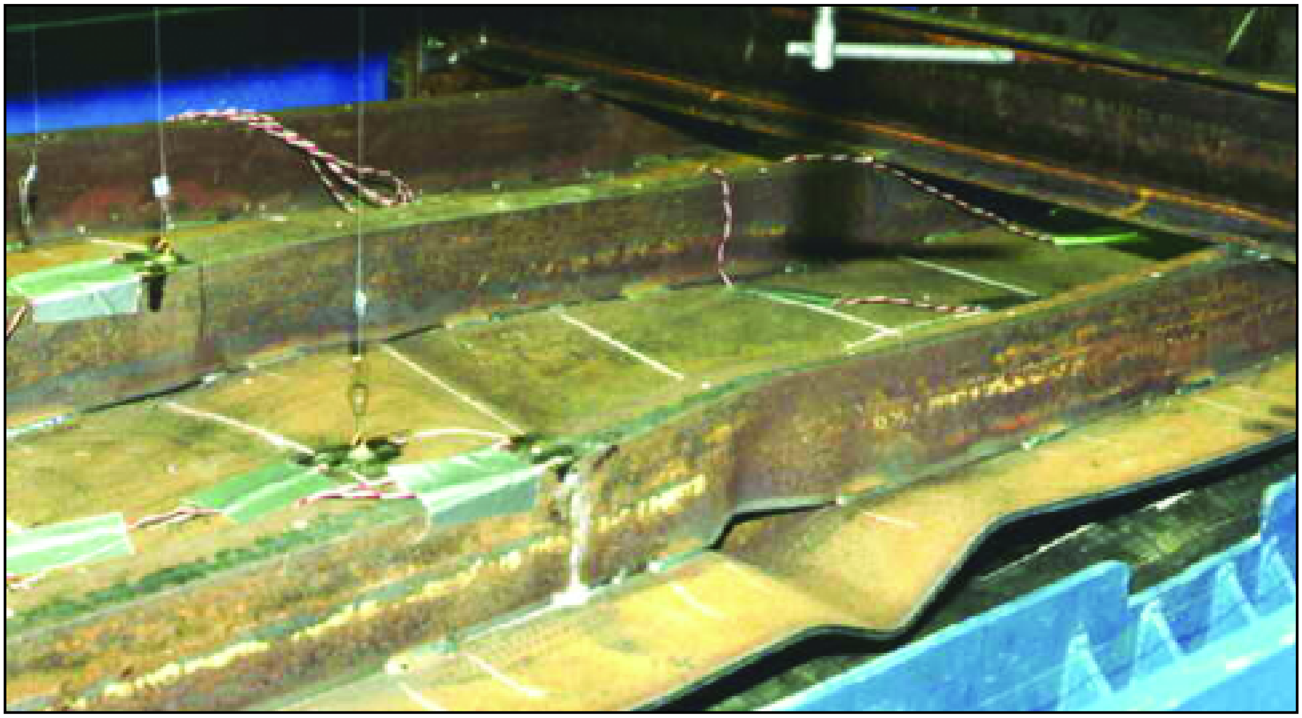


Figure 4. Test of plating supported with intermittently welded conventional stiffeners. Courtesy MSC.

The cumulative results of the research conducted by the MSC, NSWCCD and the Naval Academy confirmed that tank loading must be orchestrated to prevent the buckling of a barge's structure. At the time of their respective failures, the research indicated that the deck stresses for the *Buffalo 292* exceeded the deck's ultimate compressive strength by 6 percent. The stresses in the *Buffalo 286* at the time of the casualty were approximately 93 percent of its ultimate strength. Unlike the *Buffalo 292*, the deck stress of *Buffalo 286* did not exceed the estimated ultimate strength. Both MSC and NSWCCD attribute *Buffalo 286*'s failure then to a combination of pre-existing damage and set-ins in the deck that further reduced its strength.

To prevent additional casualties, MSC worked with the Coast Guard Office of Compliance (G-MOC) to develop Navigation and Vessel Inspection Circular (NVIC) 1-98. NVIC 1-98 published guidelines for calculating the ultimate strength of a tank barge's deck structure with the same formulas MSC used in its analysis. These guidelines were intended for use by naval architects and professional engineers to ensure all desired loading conditions maintained compressive stresses below the ultimate strength limit. Though NVIC 1-98 was published as voluntary guidance, it stressed that operators desiring to carry split loads should apply these rules to develop a safe loading plan.

In September 2000, ABS took a step in addressing buckling strength for inland tank vessels by issuing Rule Change Notice (RCN) 4 to the Inland Rules, 1997. With an effective date of Jan. 1, 2001, RCN 4 required all inland service tank barges to be designed in a manner that meets their new permissible buckling stresses. ABS took structural buckling safety one step further by also requiring bending moment calculations for all tank barges carrying split, or uneven, loads.

In addition to NVIC 1-98 and RCN 4, TSAC, AWO and other industry stakeholders developed a regional quality steering committee and published a bunkering "best practices" report. To date, the combination of industry best practices, RCN 4 and NVIC 1-98 have successfully prevented compressive failures like those experienced on the *Buffalo 292* and *Buffalo 286*.

However, since ABS' incorporation of RCN 4, structural designs and requirements for the prevention of buckling have slowly become a concern for industry again. Why? When a tank barge becomes 30 years old, 46 CFR 31.10-21a requires that it be gauged in order to determine wastage of the plating and stiffeners. Per 46 CFR 32.59, the gaugings are also used to determine if the midship section modulus, plating and stiffeners meet the requirements

Top: Structural damage at the deck knuckle of *Buffalo 292* following compressive failure of the tank top. Bottom: Compressive loads in the *Buffalo 292* tank top resulted in global structural failure, evidenced by a sharp crease and several tears along the breadth of the barge. Both courtesy MSU Galveston.

of the most current ABS rules. As these older barges come due for their structural reviews, it is becoming readily apparent that much of the older fleet cannot meet the permissible stress requirements of the newer rules without extensive and costly modifications. Consequently, many 30-year-old tank barges now face early retirement from tank vessel service.

The issue brings us back to the initial question regarding the Buffalo barge incidents: Were these 1996 structural failures due to operational and/or loading errors or were they due to an inadequate design with an unacceptable ultimate strength?

In truth, it is a combination of both. MSC's analysis, as well as industry's independent conclusions, clearly pointed out deficiencies in U.S. regulations where high stresses resulting from split loads were not addressed or prevented. In order to maintain some of these 30-year old barges in service, many operators and technical specialists have asked the MSC to examine equivalencies or requested application of alternative buckling criteria. These requests aim to minimize the amount of structural modifications without compromising the high degree of safety intended by the ultimate strength and permissible buckling stress of NVIC 1-98 and RCN 4, respectively.

To this end, MSC is currently involved in an ongoing study with a number of engineers in the inland barge industry to examine a number of alternatives. Though one policy or set of guidelines for the entire aging fleet would be preferable, initial evaluations indicate that the widely differing needs of operators and the design of tank barges require a more individual barge or barge class approach. MSC invites the comments or participation of any technical specialists or inland barge stakeholders.

For more information, please contact MSC at (202) 366-6441, or by e-mail at **zmalinoski@msc.uscg.mil**

Where Can I Find Vessel/Facility Security Plan Information?

by Cmdr. THADDEUS G. SLIWINSKI
Marine Safety Center

Background of the Security Regulations

Aftermath of September 11

In the aftermath of the tragic terrorist attacks on Sept. 11, 2001, the international community established a set of security-oriented regulations relating to vessel and port facilities. These regulations are referred to as the International Ship and Port Facility Security Code or the "ISPS Code." On the U.S. domestic front, President George W. Bush signed into effect the Maritime Transportation Security Act (MTSA) on Nov. 25, 2002, which authorized domestic security-oriented regulations similar to the ISPS Code. The MTSA is a landmark piece of legislation that is designed to protect the nation's ports and waterways from a terrorist attack.

Publication of U.S. Security Regulations

On July 1, 2003, the U.S. Coast Guard published a series of six interim rules in the *Federal Register* promulgating the maritime security requirements mandated by the MTSA of 2002. The final rules were published on Oct. 22, 2003, and took effect on Nov. 21, 2003. These six rulemakings include Implementation of National Maritime Security Initiatives (Title 33 of the Code of Federal Regulations (CFR) Parts 101–102), Area Maritime Security (33 CFR Part 103), Vessel Security (33 CFR Part 104), Facility Security (33 CFR Part 105), Outer Continental Shelf Facility Security (33 CFR Part 106) and Automatic Identification System (AIS) (33 CFR Parts 26, 161, 164 and 165).

A Wealth of Security Information is Available at Your Fingertips

Following the publication of the security regulations, the Coast Guard embarked upon an unprecedented effort to develop guidance and a support organization to assist owners and operators of vessels and marine facilities and others with interests in our nation's maritime transportation system to comply with the new security regulations. A wealth of Coast Guard-provided information is available at the touch of a button on your phone or a click of the "mouse" on your computer via e-mail and the Internet.

Homeland Security

U.S. COAST GUARD

MTSA-ISPS
Regulation
Implementation
Compliance
HELP DESK

MTSA-ISPS Help Desk
The MTSA-ISPS Help Desk provides a "one-stop shop" for up-to-date information on implementation of the MTSA.

Information Available
The Help Desk can provide assistance with general maritime security information, as well as regulation policy guidance regarding 33 CFR Parts 101–106, 26, 161, 164 and 165, Vessel Carriage Requirements and Automatic Identification Systems.

How to Contact
The MTSA-ISPS Help Desk may be accessed via the Internet on the U.S. Coast Guard Office of Port Security Web site: **www.uscg.mil/hq/g-m/mp/mtsa.shtml**, by e-mail at **uscgregs@comdt.uscg.mil** or by phone (877) 687-2243 (toll-free) or (202) 366-9991.

Vessel Security Plan (VSP) Information Desk
Information Available
This is the source for information regarding Vessel Security Plan (VSP) or Alternative Security Plan (ASP) submittal to the Coast Guard Marine Safety Center (MSC), including VSP and ASP status.

How to Contact
The Vessel Security Plan Information Desk can be contacted by phone (202) 366-3879, fax (202) 366-3817 or e-mail **securityplaninfo@msc.uscg.mil**.

Facility Security Plan (FSP) Help Desk
The FSP Help Desk is operated by Black & Veatch Special Projects Corporation and is a source for information regarding your FSP submittal to the National FSP Review Center.

Information Available
This is a source of information for FSP status information.

How to Contact
The FSP Help Desk can be contacted by phone at (866) 377-8724 [(866) FSP-USCG] or by fax at (913) 458-4700.

United States Coast Guard
Maritime Information eXchange
Security Plan Review

FREEDOM OF INFORMATION ACT

Coast Guard Maritime Information eXchange System (CGMIX)

What is CGMIX?

CGMIX is a Coast Guard online resource for the sharing of information. It can be accessed via the following link: **cgmix.uscg.mil/**. Clicking on the *Security Plan Review* tab enables vessel and facility operators to check the review status of their security plans submitted to the Coast Guard. A tracking number is required.

Marine Information for Safety and Law Enforcement (MISLE) Tracking Number

This is a seven-digit number assigned by the Coast Guard to the vessel/facility owner/operator that is used to access their VSP or FSP status via CGMIX. The MISLE Tracking Number will be communicated in a letter to the submitter after receipt of a VSP or FSP by the MSC or National FSP Review Center, respectively.

Coast Guard Office of Port Security

The Coast Guard Office of Port Security maintains a comprehensive Web site that can be accessed via the following link: **www.uscg.mil/hq/g-m/mp/index.shtml**.

Information Available

Information found on this Web site includes, but is not limited to, the following:

- Law, Regulations;
- Navigation and Vessel Inspection Circulars (NVICs);
- Policy Advisory Committee (PAC) Decisions;
- Articles, Publications;
- Presentations;
- Compliance Phase (July–December '04);
- FAQs; and
- Training.

Coast Guard Captain of the Port (COTP) Locator

www.uscg.mil/vrp/maps/msomap.shtml

This link will enable you to locate the local Coast Guard COTP who will be visiting your vessel/facility to verify compliance with the MTSA. Many of the COTPs have Web sites with additional valuable information.

Coast Guard Marine Safety Center (MSC)

www.uscg.mil/hq/msc/

The MSC Web site contains useful links and advice for submitting VSPs and FSPs. Guidance for creating/improving a VSP is also on this Web site. It contains guidelines and other aids intended to assist commercial vessel owners to comply with the commercial vessel safety regulations.

Transportation Security Administration (TSA) Vulnerability Self-Assessment Tool

www.tsa.gov/public/interapp/editorial/editorial_0826.xml

This link provides access to a valuable resource developed by the TSA to help in conducting vulnerability self-assessments.

Navigating the Maze of Vessel Standards and Alternate Compliance Options

by Cmdr. TIMOTHY CHERRY
Marine Safety Center

by MARK WOLF
Marine Safety Center

Introduction
The process of certifying inspected commercial vessels has become increasingly complex over the past decade or so. Prior to the 1990s, answers to questions like "What standard does my vessel have to meet?" and "Who approves and certifies that a vessel meets a standard?" were fairly simple. Now answers to those types of questions are not so straightforward. In the past, the U.S. Coast Guard mainly did the technical plan review, approval, and field inspection and compliance. Now there is a plethora of options available to vessel owners and operators to design, construct, outfit and certify their vessels for commercial service. This article will focus on the Marine Safety Center's (MSC's) role in the technical plan review process and present the Whys, Whats, and Whos pieces of the puzzle.

Over the past decade or so, Authorized Classification Societies (ACS) and other third parties have been admitted into the plan approval and inspection process. Additionally, various international standards with flag and port state interpretations have created an overlapping web of vessel design and certification requirements based on the vessel type, previous flag and classification society rules. What once was a clear process has become a maze of standards, equivalencies, and interpretations which more than doubles the available options for review and approval. Understanding key elements of what is the standard and who is conducting the approvals for the overall regulatory scheme makes navigating the maze a little less daunting.

Why
The Coast Guard is called on to review and approve vessel designs for a variety of reasons. Most often, it is in anticipation of a new vessel's construction. It may also be an existing vessel undergoing an initial inspection or major modification, a foreign vessel being re-flagged to U.S. service, or a foreign cruise ship.

What
It is very important to know what standard a vessel is designed, constructed, and outfitted to meet. Depending on the type of vessel or the service provided, owners and operators have several choices to pick from. The various standards are summarized below.

Code of Federal Regulations (CFR)
Domestic regulatory standards for inspection and certification, construction and arrangement, lifesaving and fire protection equipment, machinery and electrical installations, and vessel control and operations. Titles 33 (Navigation and Navigable Waters) and 46 (Shipping).

CFR and International Conventions
International vessel standards for safety and pollution prevention. Created by the International Maritime Organization (IMO), and including the International Convention for the Safety of Life at Sea (SOLAS), the International Convention for the Prevention of Pollution from Ships (MARPOL), Tonnage, and Load Line conventions. A U.S. vessel may have to meet both U.S. and international standards in order to sail in foreign waters.

Maritime Security Program (MSP)
This program allows militarily useful U.S. commercial vessels to be designated for emergency service to carry military cargo in time of war, national emergency, or military contingency. If re-flagged to the U.S., the standard is the recognized classification society rules and international convention with the interpretation of the previous flag.

Alternate Compliance Program (ACP)
This voluntary program allows authorized classification societies to review U.S. vessels for compliance with Coast Guard design and inspection regulations. The standard is the classification society and international convention rules, supplemented by U.S. flag interpretation and select parts of the CFR.

IMO High Speed Craft Code (HSC)
This code, also created by the IMO, acknowledges the conceptual changes in designing and building high-speed vessels.

Who
The MSC process for vessel plan review is divided up into two categories, depending on whether the Coast Guard plays an approval or oversight role. Navigation and Vessel Inspection Circulars (NVICs) are policy documents created by the Coast Guard to help guide industry and classification societies. Several of these documents have been created to provide guidance about the enforcement or compliance with marine safety regulations and Coast Guard marine safety programs.

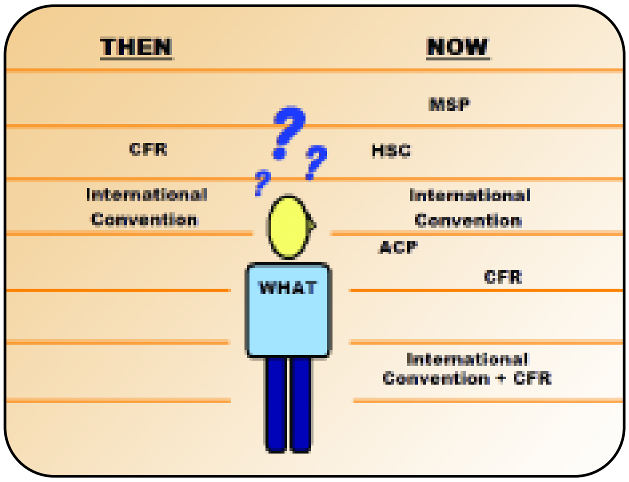
Boatswain's Mate Matt Neder crews the Coast Guard escort for the Carnival cruise ship *Ecstacy*. The Coast Guard routinely escorts cruise ships, as do Port Police, following September 11. Chief Warrant Officer Lance Jones, USCG.

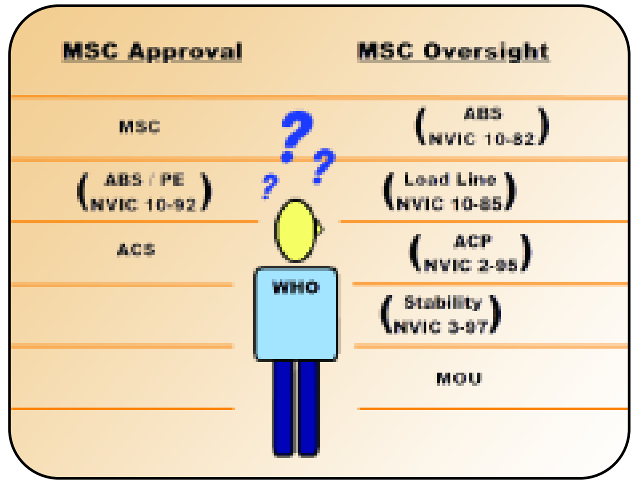
MSC Approval
Many vessel plans are still reviewed independently by the MSC, including construction, arrangement, lifesaving, fire protection equipment, and equipment installations drawings. MSC applies CFRs, SOLAS rules, or the HSC Code in their review as appropriate. However, in order to give industry options to streamline procedures and to take credit for work already done by classification societies, the Coast Guard has authorized several alternative methods for review and approval.

NVIC 10-92 was created to authorize Professional Engineers (PEs) or the American Bureau of Shipping (ABS) to certify certain vessel plans. When applying NVIC 10-92, all Coast Guard regulations, interpretations, and policies must be adhered to, and MSC still reviews and stamps plans for approval.

MSC Oversight
The Coast Guard has continued to create more ways in which plan review can be accomplished by others, allowing faster and more detailed analyses to take place. Guidance for oversight generally has been issued through the creation of NVICs. However, unlike the MSC approval method above, NVICs still maintain oversight authority for the review and approval of vessel plans by a third party.

One of the first circulars created to allow third party





plan review was NVIC 10-82. This circular permitted ABS to review and inspect certain parts of an ABS classed vessel being constructed or undergoing major modifications.

Soon after, NVIC 10-85 was developed authorizing vessel load line reviews to recognized classification societies. The delegated responsibilities are carried out in accordance with established standards and procedures, while the Coast Guard maintains technical and administrative oversight through periodic visits to spot check records and files. Fifteen years later, NVIC 3-97 was established to extend to ABS the authority to perform stability related reviews for compliance with Coast Guard rules and regulations. The ABS had been recognized as an authorized load line assigning authority of the Coast Guard for U.S. vessels since 1929.

In 1995, the Alternate Compliance Program (ACP) was created, with guidance located in NVIC 2-95. This program is both a set of standards to follow, and a definition of who shall execute the review. Currently, ABS, Det Norske Veritas (DNV), and Lloyd's Register (LR) are ACP authorized to conduct reviews for U.S. flag vessels.

In addition, the Coast Guard has established Memorandum of Understanding (MOU) with various public vessel owners, including Military Sealift Command and the Army Corps of Engineers. These vessels may be ACP authorized, but are inspected and certified using a Statement Of Voluntarily Compliance (SOVC).

Currently, in order to engage in third party assessment over vessel plans, the ACS is required to track all plan submittals and notify the MSC with a copy of all plan approval correspondence. After receiving each notification, the MSC has two weeks in which to select the associated materials for oversight. Even after two weeks, the MSC reserves the right to request a plan for oversight. If the MSC observes that the ACS failed to detect a non-conformity on the part of the plan submitter, it will notify the ACS and subsequently engage the ACS in a dialog in order to resolve the failure to detect the error. The MSC is in the process of modifying its oversight tracking procedures to develop more useful and robust methods for selection, assessment, and feedback of third party work.

As a practical example of the alternatives now offered in vessel plan review, consider a new vessel construction. In the past, vessel plans would be reviewed and approved by the MSC to CFR standards. Today with the ACP, an owner can select any ACP approved classification society for the review. Using ACP, the vessel standard is the classification society's rules, international convention, and approved U.S. supplement. An ACP authorized society may then approve the plans on behalf of the MSC, with the MSC providing oversight. This process provides owners increased flexibility when designing and scheduling new or modified vessels, and helps to distribute workloads previously dedicated solely to the MSC.

Conclusion

What once was a simple process of applying domestic or international regulations to ship designs has become a strikingly more complicated process. In an effort to maintain a thorough and timely review process, alternative avenues for plan review have been employed. It is more important now than ever for all involved in the plan review process to clearly understand what standards will be applied, who is responsible for approval, and if the MSC is conducting oversight.

Tonnage Measurement

Old and New

by Peter Eareckson
Marine Safety Center

Managing the tonnage measurement program offers the Marine Safety Center (MSC) some unique challenges and opportunities. Tonnage measurement is the process of assigning gross and net tonnages and registered dimensions to vessels of all sizes, and its impact is far reaching. Though tonnage measurement today has much in common with what "admeasurers" have done for centuries, the "tools of the trade" and complexity of measurement rules and systems have undergone many changes, especially in the last 40 years. This article examines where we have been and where we are today with the tonnage measurement program.

Gross and net tonnages are measures of carrying capacity. The words "ton" and "tonnage" are derived from the old English word "tun," meaning "barrel,” and in the middle ages, taxes were assessed on wine barrels carried in trade between France and England. By the late 1700s, systems were in place in Europe to assign tonnages to reflect vessel carrying capacity in "tons" of roughly 100 cubic feet each (related to the size of a standardized barrel). These early systems derived tonnage using a product of the vessel's principal dimensions. The First Congress of the United States adopted a variant of the British system in use at the time and established a network of Customs surveyors and collectors to measure vessels and collect tonnage taxes.

In 1854, the British started using a more sophisticated method of determining tonnage (referred to as

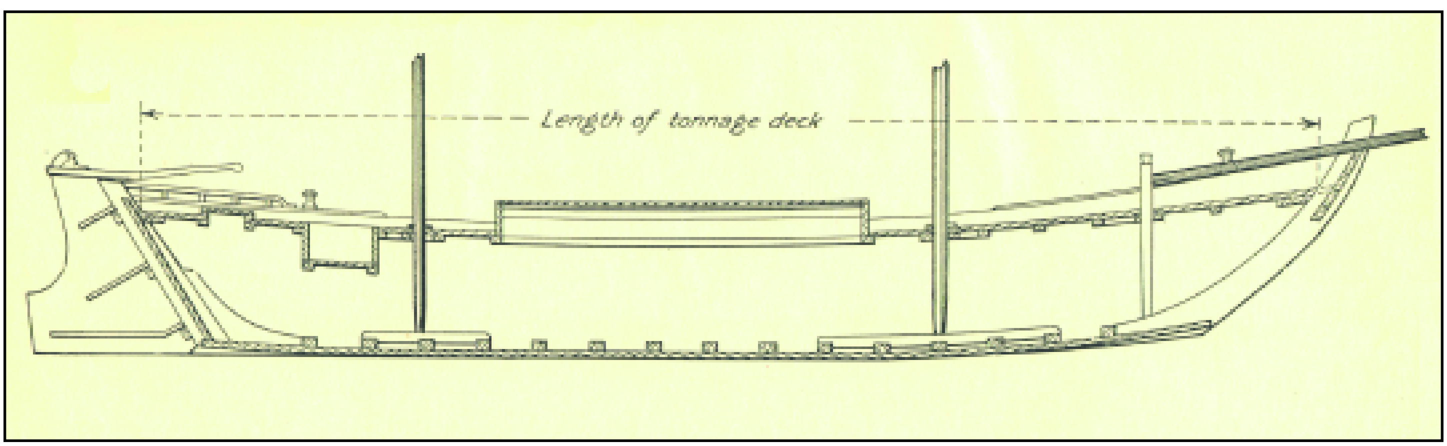


Figure from tonnage regulations of 1895 illustrating how the “tonnage length” is measured for a small sailing vessel. Establishing the tonnage length is one of the first steps in calculating the “under-deck tonnage” using the Moorsom measurement system.

Tonnage certificates issued by the MSC are needed for Suez Canal transits of warships, such as the guided missile destroyer USS *Oscar Austin* (DDG 79). Courtesy U.S. Navy.

self-propelled vessels of all sizes. Finally, in 1983, the United States ratified the International Tonnage Convention of 1969, which introduced an accurate and more consistent method to arrive at gross and net tonnage based on naval architectural principals. This new convention measurement system was applied to certain vessels domestically in 1986.

In addition to the many changes in the tonnage rules since 1965, there have also been major changes in the way the tonnage measurement program operates. In 1967, the 35 Customs surveyors at ports around the country were transferred to the Coast Guard when it became part of the new Department of Transportation. Twenty years later, tonnage measurement under the standard, dual and convention

the "Moorsom" system for the naval architect who devised it). This system relied on modern calculus to derive volumes based on a series of internal measurements. The United States followed suit in 1864 with its own Moorsom system. It is still in use today as an option for measurement of any U.S. flag vessel and is now known as the standard measurement system.

In former years, the tools of the trade were tape measures, specialized measuring devices and preprinted forms for recording measurements and helping with the lengthy hand calculations involved. The MSC is in possession of a set of "lift rods," formerly used to suspend a measuring tape overhead in the upper reaches of a vessel's hold. MSC files contain a number of the original calculations from the early 1900s, many done in ink with exquisite care, which serve as a testament to the craftsmanship of our predecessors in the business.

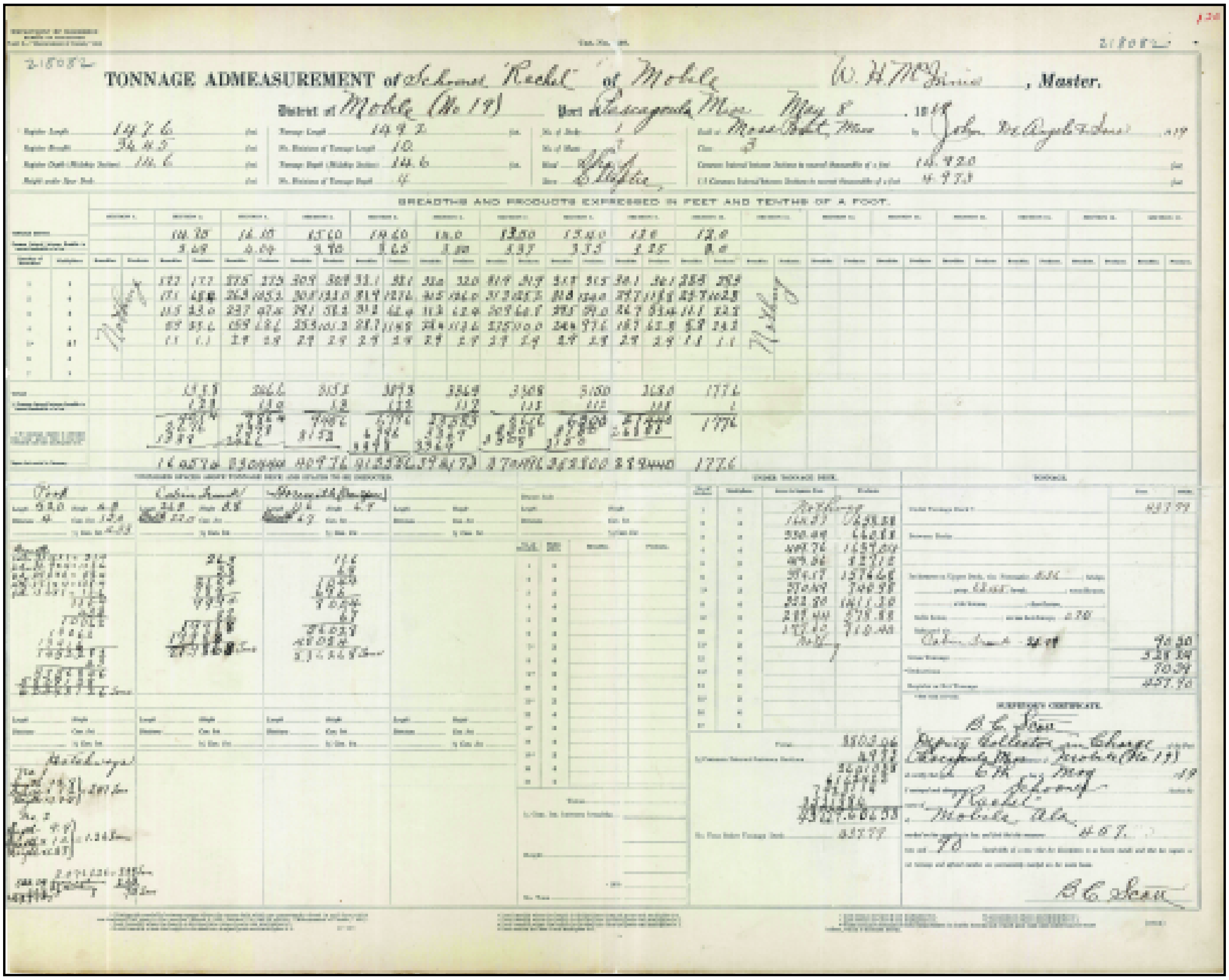
Our standard measurement continued as the only measurement system of the United States for just more than a century, although it underwent many changes (more about this later). Then, in 1965, standard measurement was joined by a new international variant on the Moorsom system (called the dual measurement system) aimed at making shelter deck vessels safer. One year later, a formula-based simplified measurement system was adopted for recreational vessels and this system was extended in 1982 to smaller commercial vessels and to non-

Tonnage Openings in Wartime

In 1941, President Roosevelt made it possible for compliance with navigation and inspection laws to be waived for war purposes.

With this authority, the sealing of tonnage openings was allowed for the duration of the war, to prevent downflooding on damaged merchant ships.

In 1965, the dual measurement system provided safer alternatives to placing unsealed tonnage openings in and below the weather decks.



TONNAGE ADMEASUREMENT of Schooner Rachel of Mobile , Master.

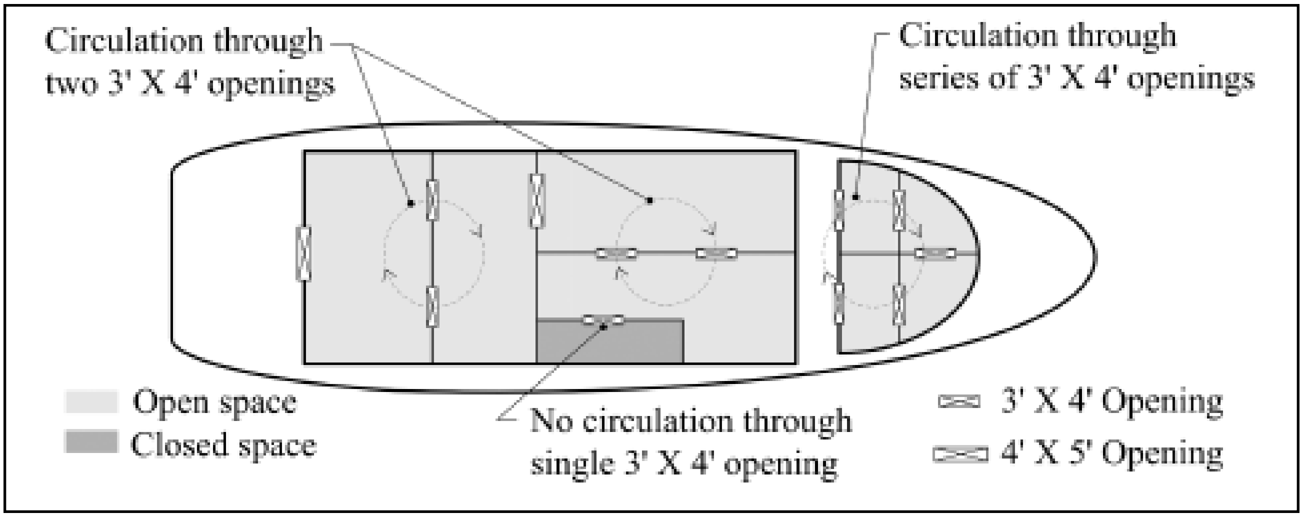
BREADTHS AND PRODUCTS EXPRESSED IN FEET AND TENTHS OF A FOOT.

SURVEYOR'S CERTIFICATE.

Excerpted portion of a 1924 tonnage calculation sheet for the schooner *Rachel* (O/N 218012) from MSC files. Note the "long hand" arithmatic needed before the advent of mechanical and electronic computational tools.

systems was turned over to authorized classification societies for all vessels except warships and Coast Guard cutters, with Coast Guard Headquarters maintaining responsibility for overall management of the tonnage measurement program. In 1995, this function was transferred to the MSC. Since then, MSC has increasingly engaged in partnership and oversight activities with the classification societies, of which five now measure vessels on behalf of the United States.

The world of tonnage measurement has become decidedly more complex. MSC is grateful for the arsenal of modern tools at its disposal to improve efficiency, reduce error rates and focus resources on broader program issues. For example, MSC uses computer models and other electronic tools (some developed in-house) to establish tonnages under all the measurement systems. MSC maintains a number of different databases, including one for policy, which contains over 4,000 records that span 150 years of tonnage measurement decision making. MSC utilizes modern desktop publishing tools to produce and update a variety of graphics-intensive documents available on its Web site, most notably MSC Technical Note (MTN) 01-99, Tonnage Technical Policy. A Web-based tool MSC created allows members of the public to calculate tonnages of vessels measured under the simplified measurement system. MSC easily communicates through the Internet with Coast Guard field personnel, Customs and Border Patrol inspectors and its coun-



An illustration taken from MTN 01-99 depicting the circulation of open space within a superstructure. A change notification subscription service for this MTN is available through the MSC's Web site: www.uscg.mil/hq/msc.

terparts in foreign governments around the world. In these respects, what MSC does today is very different from what its predecessors did in 1789.

But with these advancements have come challenges. One of the biggest is sorting out when tonnages assigned under the various measurement systems can be used. For example, U.S. law and international treaties provide for certain vessels to be regulated according to their tonnages assigned under the older measurement systems in some cases, but not in others. MSC produced Navigation and Vessel Inspection Circular (NVIC) 11-93 that addresses this matter for U.S. flag vessels and is working to expand and improve guidance of this nature. With more than 1,000 requirements under U.S. law and international conventions that are based on tonnage, the task is sometimes daunting.

Another major challenge is in applying 19th century measurement systems to 21st century vessel designs. Many of the tonnage rules have been altered over the years to favor certain industry segments or achieve other objectives that are not related to determining a vessel's size (like providing better living conditions through crew space deductions). The result is that modern day "admeasurers" must apply tonnage measurement rules that are far more complex than in former times.

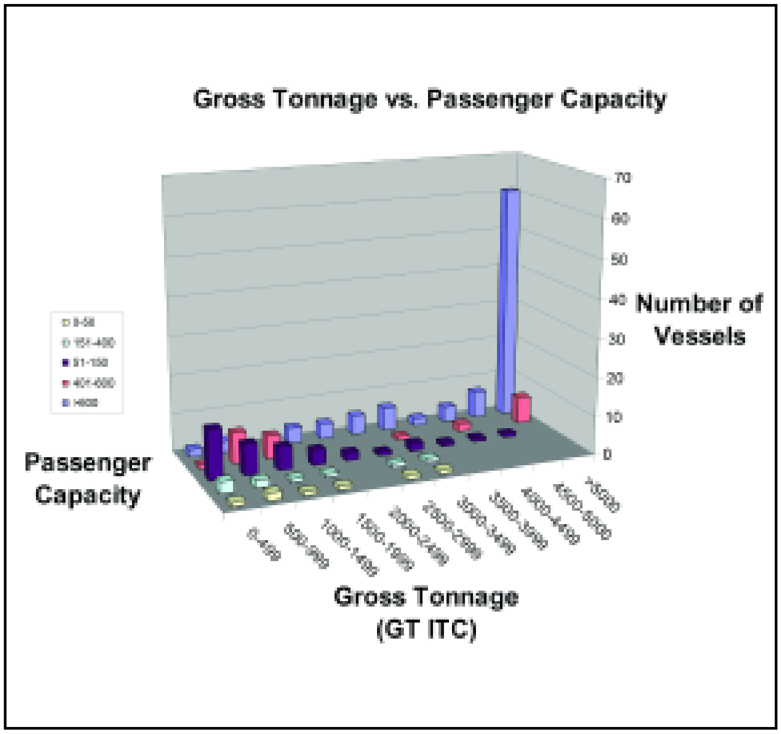
Gross and Net Tonnage vs. Weight

Gross and net tonnages are volume measures and were formerly expressed exclusively in units of "tons" of 100 cubic feet each.

Gross ton = measure of overall size

Net ton = measure of carrying capacity

Displacement ton = measure of weight, not volume



In addition to measuring vessels, the MSC performs data analysis to support regulation projects involving tonnage. The graph above is for Subchapter H passenger vessels.

And yet some aspects of the business would be quite recognizable to our predecessors of centuries ago. Perhaps the single greatest constant in the history of tonnage measurement has been the resourcefulness of vessel owners and designers in using tonnage measurement systems to their advantage. To illustrate:

- In the medieval wine trade between France and England, royal agents assessed taxes on wine by physically appropriating barrels of wine ("tuns") from the cargo and reimbursing the owners for less than the market value. The number of tuns collected depended on the number of tuns carried. When taxes were assessed based on every 10 tuns or 20 tuns carried, vessels came to be correspondingly sized to minimize the amount of taxes paid.

- The Moorsom systems came about in response to the manipulation of vessel dimensions to "beat" the formulas previously in effect. Under these formulas, tonnage was calculated using a product of the hull length and the square of its breadth (breadth divided by two was substituted for the depth because of the difficulty of measuring depth in laden vessels). This led to long, narrow and deep vessels that were subject to capsizing. In fact, the long, over-hanging bows of some clipper ship designs has been attributed to "cheating" the length measurement in this formula.

- Since most tonnage measurement systems account in some way for the total volume of all enclosed spaces, there is great incentive to design vessels with semi-enclosed spaces that can be considered "open to the weather," and therefore not in tonnage. A ruling by the British House of Lords in 1875 on large openings in a spar deck has led to today's practice under the standard measurement system of using "tonnage openings" covered by non-sealing plates to exempt space as open space.

- The passenger space exemption of the measurement system was introduced in 1865 to minimize the economic impact of the transition to the new Moorsom system from

Naval architect Frank Perrini of the MSC's Tonnage Division uses a computer model for volume measurements.

The cruise ship *Sovereign of the Seas* measures 73,192 gross tonnage, but displaces only 34,300 long tons in a fully loaded condition. Courtesy Royal Caribbean International.

the old formula method. The formula ignored volumes of structures on or above the main deck. Since steamboats of the era had large superstructures consisting of passenger space elevated above an open maindeck area, their tonnages went up drastically under the Moorsom system. In response to industry complaints, Congress allowed the exemption from tonnage of all such passenger spaces elevated above the maindeck. This has led to no end of creative methods to qualify additional passenger spaces for exemption by inserting false decks or lowering the main or "uppermost complete" deck to allow for more passenger space decks.

For better or for worse, the time-honored tradition of designing vessels to meet certain tonnage objectives continues. A large part of our business still involves wrestling with the specifics of how tonnage measurement rules are applied to vessels that may not quite look like what the designers of the rules had in mind. It would have been difficult for anyone in George Moorsom's time to have imagined modern cruise ships or offshore supply vessels, let alone wing-in-ground craft that resemble airplanes more than boats.

Tonnage measurement at the MSC represents the continuation of a very important governmental function and a long and proud tradition. It involves a unique blend of "old" and "new" and has as much relevance today as it did in the early days of our nation. Challenges abound, and at times appear overwhelming, but they certainly keep the job interesting. To learn about the tonnage measurement program, please feel free to contact MSC at (202) 366-6502 or visit the Tonnage Page of its Web site at **www.uscg.mil/hq/msc**.

Regulating Safety Through Engineering Standards

by Lt. Michael Ciaglo
Marine Safety Center

Introduction
A vessel, whether a large, cutting-edge offshore supply vessel employing Z-drive propulsion, or a 35-foot sport fishing Subchapter T boat, is made up of numerous mechanical integrated systems. These systems provide everything from the propulsion of the boat to the sanitary services onboard. However complex, these various piping and electrical systems must comply with the applicable standards as required in Title 46 of the Code of Federal Regulations (CFR).

The current engineering regulations, both Subchapter F (Marine Engineering) and Subchapter J (Electrical Engineering), provide requirements directly and by incorporation by reference. The latter is a method by which the Coast Guard adopts existing industry standards and makes them U.S. Coast Guard regulations. This was not always the case, as the original regulations, first published in 1935, had the Coast Guard establishing minimum requirements for each shipboard system. It was not until later that industry standards were used in the regulation of commercial vessels.

The complex machine that is a commercial vessel is a conglomeration of many systems resulting in a single unit that provides some service, whether moving cargo, carrying passengers or some other maritime function. Each individual shipboard system plays a role in the operation of the vessel, and each system also has a varying degree of importance to the safety of the vessel. Therefore, each mechanical, piping or electrical system has its own set of requirements, very often a combination of organic regulations and industry standard-driven requirements.

With the continued advances in technology, and the speed with which they have developed, the Coast Guard had a large responsibility to recognize and develop appropriate standards for vessels. Each time a new technology or concept appeared and required Coast Guard regulation, research and development was needed and the CFR had to be changed to reflect the advancement. This is a time-intensive process, and industry was not being allowed to reap the benefits of new technologies. Thus, the process to adopt outside standards was pushed to the forefront.

By accepting industry standards, the Coast Guard no longer had to internally evolve with the advancing technology; rather, the burden fell on the industries that were developing the new technologies to create their own set of requirements. The Coast Guard's responsibility then became oversight, ensuring the applied standards were robust enough to maintain the desired level of safety required in the marine industry. This allowed Coast Guard resources and funds to be focused on other issues instead of trying constantly to keep up with the advances. It also permitted the marine industry to meet a standard already recognized within their field instead of entirely different Coast Guard regulations. This did not release the Coast Guard from maintaining familiarity with new, novel concepts, but the level of required knowledge was reduced. As such, the Coast Guard maintains the right to limit, modify or replace adopted standards, with less time and resources for the Coast Guard.

While many standards are updated regularly by the associations who publish them, the CFR is very specific to which version is the recognized revision. This is a very important issue in plan review, as many designers incorrectly use the most recent update of a standard.

One of the most obvious of the adopted standards in Subchapter F is the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. As the title indicates, this code provides guidance on the design, manufacture and installation of boilers and pressure vessels. All pressure vessels and boilers installed on inspected vessels must comply with the requirements of this code as modified by the applicable sections in Subchapter F. Consequently, the Coast Guard is able to set very stringent design and construction standards for specialized equipment without having to develop its own requirements.

Current Standards

The latest revision of the CFR includes many standards incorporated by reference. This helps make the regulations much smaller while still requiring a high level of safety for all regulated systems. While many standards are updated regularly by the associations who publish them, the CFR is very specific to which version is the recognized revision. This is a very important issue in plan review, as many designers incorrectly use the most recent update of a standard. This is one spot in which the Coast Guard is still limited by the CFR change process, although every effort is made to ensure the regulations reflect the current industry practices.

MSC staff engineers begin with the Code of Federal Regulations (CFR) when reviewing all plans, including this electrical one-line diagram. The CFRs are augmented by various policy documents, such as Navigation and Vessel Inspection Circulars (NVICs), Marine Technical Notes, the *Marine Safety Manual*, and regulations promulgated under various international treaties like SOLAS and MARPOL. Lt. Errol Glenn, MSC.

Material specifications developed by the American Society for Testing and Materials (ASTM) are the requirements used for all piping systems reviewed under the purview of Subchapter F. Specifically, the ASTM material specifications adopted by ASME Code Sections I, III and VIII are accepted under the regulations. This demonstrates that industry standards are not all-inclusive and use other resources to provide guidance.

Subchapter J adopts several standards used in the electrical field. The Institute of Electrical and Electronics Engineers

(IEEE), National Electrical Manufacturers Association (NEMA) and International Electrotechnical Commission (IEC) standards adopted by the CFR provide guidance for shipboard electrical and control systems. Most electrical or electronic equipment installed on inspected vessels must comply with these standards or those of the National Electrical Code (NEC) or Underwriters Laboratories (UL). It is important to note that the CFR is very specific as to which revisions of the IEEE, NEMA, IEC and NEC apply.

A ship's service turbo-generator is loaded onboard. MSC staff engineers review and approve all aspects of machinery systems, from the type of wire to the location of major machinery, all of which are governed by strict regulatory standards. Courtesy U.S. Department of Transportation, Maritime Administration.

UL specifications are widely used on the mechanical side of shipboard systems. Some equipment installed must have the UL stamp in order for the Coast Guard to accept it, similar to pressure vessels having the ASME "U" stamp. Another organization to bridge the gap between the electrical and mechanical requirements is the National Fire Protection Association (NFPA), which publishes the NEC. NFPA has several standards adopted for piping systems, most notably NFPA 13, Installation of Sprinkler Systems.

The Coast Guard does not adopt domestic standards exclusively. The IEC and International Maritime Organization (IMO) standards are internationally adopted regulations that the Coast Guard has accepted. The IMO regulations for pollution prevention equipment (PPE), marine sanitation devices (MSDs) and plastic pipe are adopted within the appropriate parts of the CFR. Domestic compliance with changes to these standards typically falls in line with the timeline established by the IMO.

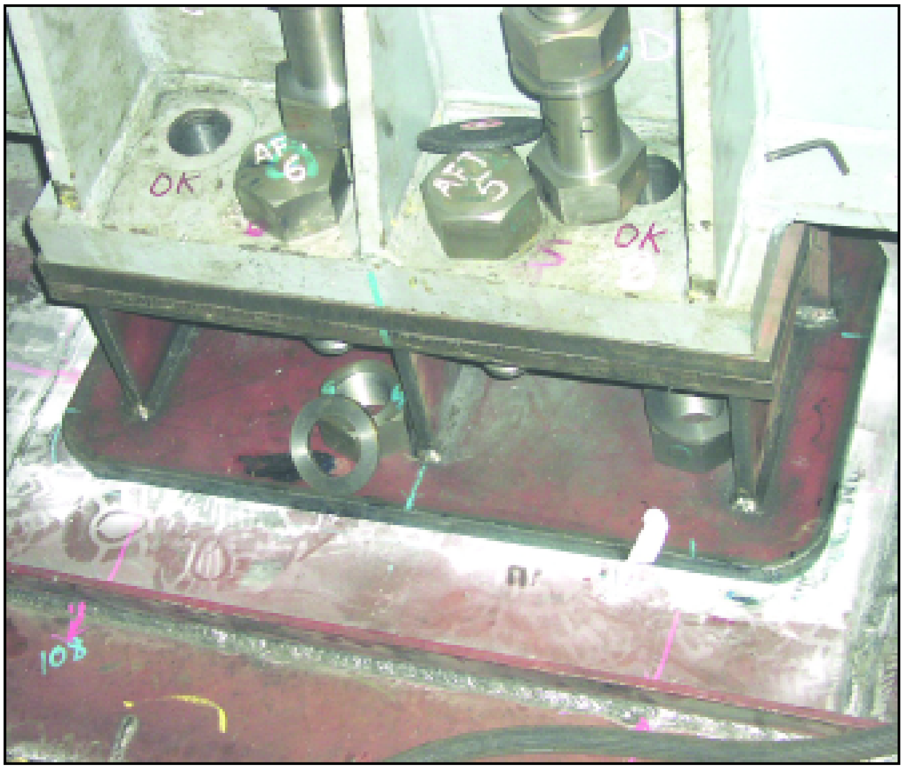
Another adoption is the use of classification society rules, such as the American Bureau of Shipping (ABS), Lloyd's Register (LS), or Det Norske Veritas (DNV). The Coast Guard recognizes the high level of safety within the rules and has allowed these rules to be used in the design and construction of certificated vessels. Currently, ABS, LR and DNV are participants in the Alternate Compliance Program, which allows vessels built, inspected and maintained to their rules to be equivalent to meeting the CFR and international requirements.

Alternate Design Standards

Because technology progresses faster than the regulations, alternate design standards are permitted to be considered. This is more often called "equivalency." In most cases, requests for equivalency are considered by the MSC, although some may be sent to Coast Guard Headquarters for review.

When a novel design or new technology is developed, and the CFR does not adequately regulate or address the proposal, the submitter may request alternate consideration. The use of an updated version of an adopted standard is also considered a request for equivalency.

Not all requested equivalencies will be granted. In order for an alternate standard to be recognized and accepted, it must have adequate substance and have significant recognition. For example, a standard for hydraulic systems that is used by the automotive, construction or other industry may be con-



The precise mounting of major machinery is critical to its proper operation and long-term function. This SSTG mounting foot is bolted to a pad that is welded to the deck. MSC staff engineers review and approve all aspects of the design. Courtesy U.S. Department of Transportation, Maritime Administration.

sidered as an alternate to ASME B31.1, Power Piping, the standard incorporated by reference into the CFR.

Sometimes, the request for equivalency is based simply on a revised standard already accepted within the CFR. Because organizations often update annually, or at least more often than the CFR, industry typically follows the most recent revisions. This quite often is a requirement for certification by a society or an association, and a conflict arises with the regulations in the CFR. This typically is easy to resolve, although care must be taken to examine why changes have been made.

A standard not currently recognized by the CFR undergoes more scrutiny in its review than a revision of an accepted standard. The standard must have a sound basis and strong engineering philosophy behind it. Typically, a side-by-side comparison with a similar accepted standard is done. This process may take a significant amount of time, and a submitter must account for this and plan their project accordingly. It is the burden of the submitter to provide adequate documentation and information and potentially even the standard itself to the MSC when requesting an equivalency.

Performing an equivalency is not necessarily a simple process and a thorough scrutiny of the proposal must be completed to ensure the spirit of the regulations is met. It is the burden of the plan review officer to examine not only the proposed standard, but also the CFR and its requirements to ensure that an equivalent level of safety is maintained. The alternative standard must result in similar performance requirements as those already established in the CFR.

Finally, the use of an alternate standard must be documented in the vessel file. Should changes be made to the vessel or an incident occur, proper documentation must exist in order to establish the baseline for any review or investigation. Testing and inspection must be done in accordance with the originally approved system, and improper application of regulations may result in a conflict. Additionally, documentation of a standard and its acceptance may lead to consideration by the Coast Guard for formal incorporation into the regulations.

Conclusion

Review of the complex systems that make up commercial vessels can be a difficult and complex task. In performing this function, the regulations provide guidance and performance requirements through the use of Coast Guard-established regulations and standards developed by various organizations that are incorporated by reference into the CFR. However, the regulations are not all-inclusive, especially when new technology and novel systems are desired for use in certificated vessels. At that point, the regulations allow for the Coast Guard to consider these systems and ideas by using standards and requirements that are more appropriate than the current regulations, and that provide an equivalent level of safety and acceptable minimum performance standards.

Alternative Fire Suppression/ Detection Systems

by Lt. Holly Najarian
Marine Safety Center

The practice of fire protection can be looked at as a series of opportunities to mitigate the potential for the existence of a damaging or life threatening fire, to interrupt the growth of an existing fire should it occur, and extinguishment. From a regulatory enforcement perspective, the regulations encompass the design, construction and outfitting of a vessel with the intention to prevent a fire entirely, slowing the growth or spread of a fire, limiting the damage to life and property and the control or extinguishment of a fire.

Each of the elements previously mentioned are addressed by the regulations as they pertain to the design of a vessel. To prevent a fire entirely, the arrangement, contents, stowage and carriage and operations of vessels are limited. This also has the added benefit of slowing the growth of a fire by not providing suitable or sufficient fuel to enable the growth of a fire. Additionally, the application of structural fire protection limits the potential for the spread of fire by compartmentalizing a vessel and providing passive fire barriers. The combination of these passive design requirements and the installation of an appropriate detection and fire suppression system work together to meet the fire safety design objectives of each vessel.

The design of an appropriate fire suppression system is dependent upon numerous variables and the regulations applicable to the vessel based on size, cargo and route of operation. Current fire suppression requirements are found, depending on the previous variables, in several locations including Title 46 of the U.S. Code of Federal Regulations (CFR), Navigation and Vessel Inspection Circular (NVIC) 6-72, "Guide to Fixed Fire-Fighting Equipment Aboard Merchant Vessels," the International Convention for the Safety of Life at Sea (SOLAS), the International Maritime Organization (IMO) International Code for Application of Fire Test Procedures (FTP), IMO International Code for Fire Safety Systems (FSS) and numerous other industry standards and regulatory policies.

Each of the approved standard shipboard suppression systems is designed to control or extinguish a fire by eliminating a component of the fire necessary for it to be sustained. Approved systems include high- or low-pressure carbon dioxide systems that extinguish fire by the displacement of oxygen. The installation of carbon dioxide systems is limited by space, weight and the inherent danger that carbon dioxide presents to personnel. Sprinkler systems, manual or automatic, including deluge and drencher systems control and limit the spread of fire by absorbing heat, cooling the fuel surface and separating or diluting the fuel source. Sprinkler or water systems are limited in their applications by the limited effectiveness and installation requirements including size, weight and negative effects on certain cargoes and equipment. Foam systems work by halting or preventing combustion by the creation of a vapor-sealing barrier. The use of foam is limited to specific applications that involve burning liquid surfaces and are limited by the requirements for storage and piping arrangements. Halon and Halon replacement, clean agent, suppression systems extinguish fire by scavenging flame radicals and breaking the fire's chemical chain reaction or by reducing the flame temperature below the point necessary to support high reaction rates and sustain the fire. Halon is no longer allowed in new construction installations and other clean agents are limited in their application due to storage and piping requirements that limit the size of spaces protected by the agents.

When selecting the appropriate suppression system for installation, vessel designers are limited by the regulations as well as the intended design and use of the vessel that may further limit their options. Passenger vessels, specifically high-speed craft, as well as vessels in the offshore industry are very sensitive to the weights of the various systems and the space requirements that could be better used for revenue passenger or cargo activities. Cargo vessel designers are frequently required to consider the negative effects of various systems on sensitive cargos; the possibility of incompatibility often requires designers to seek alternative methods for stowage and suppression. Finally, the inherent risks presented by the various systems to ship's personnel and passengers must be considered when selecting and designing the suppression system. The tenability of spaces with regards to safe egress and evacuation of crew and passengers is of primary importance when considering the feasibility of various systems.

The application and design limitations of the various systems often prompt designers to pursue the design and installation of systems, components or technologies that have not been approved or are approved for alternative applications. When proposing alternative systems it is the responsibility of the designer, submitter or owner to demonstrate that the level of safety provided by the system is equivalent to the level of safety provided by the required system or arrangement. The path to this equivalency can follow many different routes. While formal regulatory procedures to prove equivalency do not exist, there are recent publications and policies that have been developed to provide guidance and frameworks to pursue alternatives. Some of these publications or policies include NVIC 3-01, "Guide to Establish Equivalency to Fire Safety Regulations for Small Passenger Vessels (46 CFR Subchapter K)," American Bureau of Shipping Alternative Design and Arrangements for Fire Safety, January 2004, and National Fire Protection Association/Society of Fire Protection Engineers Engineering Guide to Performance-Based Fire Protection.

There are many layers of fire suppression systems on commercial vessels: active and passive, fixed and portable, manual and automatic. Every component of this fire station is designed and tested to rigorous standards, and forms a critical part of the vessel's fire safety system. Courtesy U.S. Department of Transportation, Maritime Administration.

While these publications provide guidance and a framework to guide design teams, they are not explicit step-by-step how-to books for proving equivalency. The process of proving an equivalency ranges in complexity and effort depending upon the system and application. The process can be as simple as a side-by-side comparison of materials and components, the provision of extra components or safety systems to meet the same performance as the regulatory system, or the equivalency can span months and include the expenditure of copious quantities of effort, time and money to provide documented evidence and testing results validating the equivalence. Notwithstanding the sometimes daunting process of the opportunity to pursue equivalency allows designers and owners to utilize systems, components and materials that exist in industry, but unfortunately have not been captured by the regulations.

The wheels of technological process in many cases turn much faster than the regulatory process and accepted industry practices are sometimes far beyond the technology reflected in the regulations. Recent fire safety system equivalencies have included the use of plastic materials, the installation of modified approved systems, the installation of advanced fire detection components and suppression systems incorporating the benefits of several different systems working synergistically. When faced with the design of novel vessels and the design of an appropriate fire suppression system to meet the needs of the design and operation of the vessel, the process of equivalency allows designers to step outside the prescriptive confines of the regulations while still ensuring the safety of vessels, cargos, crews and passengers.

Coast Guard Security Plan Review

A Success Story

by Cmdr. Alan Marsilio
Executive Officer, Marine Safety Center

The passage of the Maritime Transportation Security Act (MTSA) provided the Marine Safety Center (MSC) an opportunity to contribute to homeland security. In planning for the review of an estimated 10,000 vessel security plans for the U.S. fleet, and smaller foreign vessels not subject to the Safety of Life At Sea (SOLAS) Convention, much was learned. The timeframe to learn and develop this new function was short, and the period to complete plan review less than six months. The effectiveness, efficiency and integrity necessary to complete this project required a responsive and adaptable management model. Under MSC Command leadership, a Coast Guard led and integrated team of Active Duty, contractors, Reservists and key civilian members was defined and nurtured.

By December of 2003, the MSC had selected a capable contractor and set up government office space to house the anticipated 50-person Vessel Security Division. This effort included acquiring and setting up furniture, phones, fax machines, a file-room, security features, word-processing, in addition to welcoming aboard a group of talented people. MTSA training was immediately conducted for all personnel assigned to the division. Detailed plan review and administrative processes were quickly developed, refined, and applied in the review of vessel security plans (VSPs) and alternate security plans (ASPs). The plan review procedures, checklists, and customer job aids for "getting started on your VSP" were developed by MSC personnel to ensure a consistent process. A VSP training model was also prepared for use in training field inspectors. With personnel, processes, and equipment in place, the Vessel Security Division was underway, and plan review initiated.

Recognizing the importance of gaining international compliance with International Ship and Port Facility Code (ISPS) in a very tight time-frame, VSPs for vessels sailing on international routes were prioritized. The comprehensive MTSA regulations and ISPS Code together presented substantial regulatory requirements for the marine industry. Although it was clear to those close to the work that these two standards were written hand-in-hand, and very well aligned, others needed to read and quickly learn the content of these standards. Under the close supervision and leadership of Kevin Hagerty, MSC's Technical Advisor and Contracting Officer's Technical Representative (COTR), the MSC vessel security plan review teams reviewed the initial huge surge of plans, and wrote comment letters back in response.

Almost immediately, it became clear that customer service was critical to quality plan submissions, and ultimately, to implementation. Many of the plan submitters had never been regulated before, and compliance with these comprehensive new regulations was a tremendous hill to climb. Previously regulated customers were now looking at performance regulations, which were different from a prescriptive regulatory approach, albeit more flexible.

Assistance and clarity on regulatory elements and VSP processing was requested by the smallest and the largest vessel owners and operators. To meet this need, facilitators were assigned to engage customers, and to go over plan review comment letters and specific MTSA requirements. Customer education was well-received and key to quality plan submittals by removing any misunderstanding. Almost immediately, plan review teams noted more complete plans were being submitted. Some owners required other approaches, but to the greatest extent the "engagement of customers" method was successful, and plan submitters and vessel owners were very responsive.

tions. Following up on public meeting feedback, the Headquarters Port Security Directorate (G-MP) worked exhaustively through the alternate security plan (ASP) proposals from the major industry sectors. The proposed ASPs were reviewed, refined and approved by G-MP, providing an alternative to individual vessel owners, and also creating a consistent planning baseline for typical designs and operating characteristics within specific industry sectors. The Headquarters Port Security Director also held weekly meetings to review and approve new policy, and respond to questions from customers and Coast Guard field units. This forum allowed members to discuss, create and document

Many of the plan submitters had never been regulated before, and compliance with these comprehensive new regulations was a tremendous hill to climb.

Behind the facilitators and plan reviewers was a focused administrative staff led by Lieutenant Commander Tim Dickerson, who performed the enormous task of handling plans securely, preparing correspondence and making sure facilitators and reviewers continuously had plans and updates to review. This included tasks such as sorting incoming mail, entering data into the Coast Guard's database so that field offices and customers could determine status, generating statistics, and ensuring plans were properly handled and stored. LCDR Dickerson designed many new processes to enter plan submission status information into the Marine Information System for Safety and Law Enforcement (MISLE) database so that it would be available to COTPs nationwide. He created automatic data mining queries and crafted detailed but concise spreadsheets to report to DHS and Congress, and trained the contractors on the integration of processes for all users. And to be sure, plan review, facilitation, and administration teams were continuously measured on their performance, and recognized for attainment of each milestone along the way.

Support for the MSC processes could not have been better, from a well-written set of regulations to work from, to the real-time policy support provided to address the continuous flow of customer questions needed policy in real-time, and provide results to field commands and Help-Desk watch-standers, furthering the goal of consistency. I can tell you there were some very long hours being worked in Headquarters to ensure that questions from all fronts were answered in a timely fashion, and the greater team was aligned.

Field offices contributed greatly to educating certain vessel owners needing more direct assistance. As the "pointy end" of the implementation model, Marine Safety field commands did a bang-up job helping MSC gain understanding with some vessel owner operators. They were particularly effective using the "compliance through engagement" approach and assisting vessel operators in their AORs, when our best efforts at MSC might have fallen short.

The integrated, Coast Guard led model of MSC and contractor personnel working together side by side, succeeded. U.S. vessels needing to comply with U.S. and international standards met the tight timelines. Vessel security plans for more than 9,200 vessels were reviewed by the July 1, 2004 deadline, and nearly 99 percent of these plans were approved on time. In retrospect, what was accomplished under this model was extraordinary, and I am privileged to be associated with such a hard working group of people.

Today's Marine Safety Center

Technical Services

by Capt. Roy A. Nash
Commanding Officer, U.S. Coast Guard Marine Safety Center

Since the commissioning of the Marine Safety Center (MSC) in 1986, many plan review services have changed and been enhanced, while our principles have remained the same. One overarching principle is this: We protect the public, we protect mariners, and we protect the environment. The complexity of our work and the way in which designs and systems are accepted by the MSC have evolved, but the goal of preventing and mitigating marine accidents is still the engine that drives us. Through the application of engineering principles, standards and policy, the MSC delivers technical services to global maritime customers through many channels.

Recognizing the limits of standards and policy, risk-based principles are routinely applied to sort out engineering problems needing greater focus or new evaluation techniques. In an environment of rapidly evolving vessel and offshore platform designs, the MSC has researched and applied new assessment methodologies and strives to update standards and policy to account for the latest technology. To be sure, promising new ideas incorporated in well-conceived designs are evaluated with an open mind.

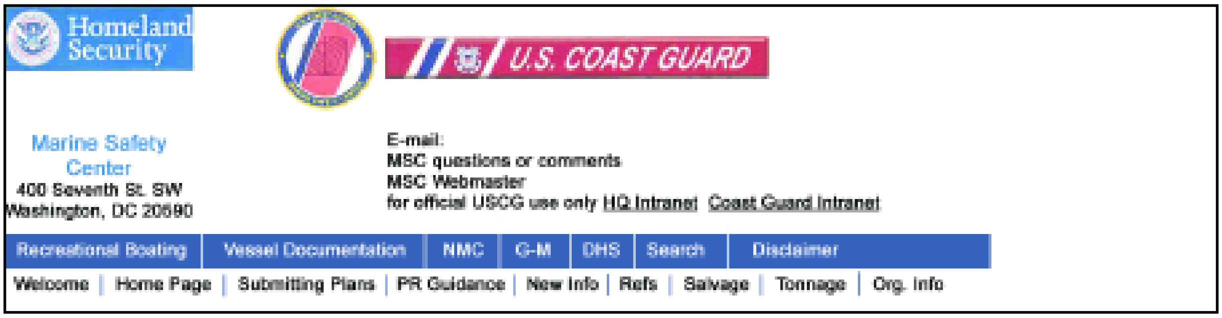
Technical services are provided through more avenues in today's MSC. The great proportion of technical work is carried out in service to commercial maritime customers, and a good deal of plan review and assessment work continues to be performed in-house at the MSC. Support services are also provided to Captains of the Port, Officers in Charge of Marine Inspection, Federal On-Scene Coordinators, and Federal Maritime Security Coordinators in assessing operational situations with commercial vessels, playing technical roles in preparatory exercises, training Coast Guard Marine Inspectors in technical matters, and assisting marine investigations. To an increasing extent, support is provided to classification societies acting on behalf of the Coast Guard in applying standards, policy and engineering assessments.

The delivery of technical services through multiple channels requires clear communication of policy and guidance to commercial customers, authorized plan review organizations and Coast Guard field units. This is time-consuming, but very important, and requires an understanding of the engineering principles at work in vessel and system designs as well as regulatory requirements. In addition to Coast Guard technical policy promulgated by Coast Guard Headquarters (G-M), the MSC's plan review policies and procedures are spelled out in MSC's "Marine Technical Notes" (MTN) posted on our Web site.

A typical week at the MSC might include: participating in a new project kick-off meeting; making a visit to a foreign shipyard to inspect the structural fire protection installation and escape arrangements on a passenger vessel that will operate from U.S. ports; evaluating an equivalency proposal for a design that meets the intent but not the letter of a standard; responding to a grounded ship by MSC Salvage and Engineering Response Team (SERT) personnel; holding a performance-based review workshop with vessel owners, designers and Coast Guard engineers; developing policy to support new shipbuilding trends; conducting a failure modes and effects analysis for engine room systems; and meeting with Coast Guard Headquarters to discuss

continued: TECHNICAL on page 71

Welcome to the MSC's Web Site

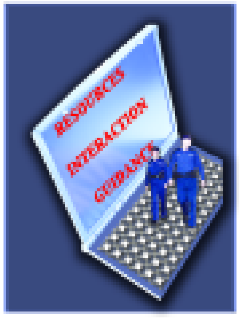


We sometimes use the slogan at the Marine Safety Center (MSC) that we are the "go-to place" for technical information related to marine safety. So if you need to "go-to" the MSC, our Web site is a great place to start.

Say you are designing a vessel which will be inspected and you don't have a clue what to do to get your plans approved. Do you have questions on whether the computer model you are using will be accepted or if space under a retractable roof is treated like any other enclosed space under SOLAS fire protection requirements? Help is only several clicks away, in the form of over 140 plan review guidance documents, MSC Technical Notes (MTNs) and other published information maintained by the MSC. A small sample of these products is offered below.

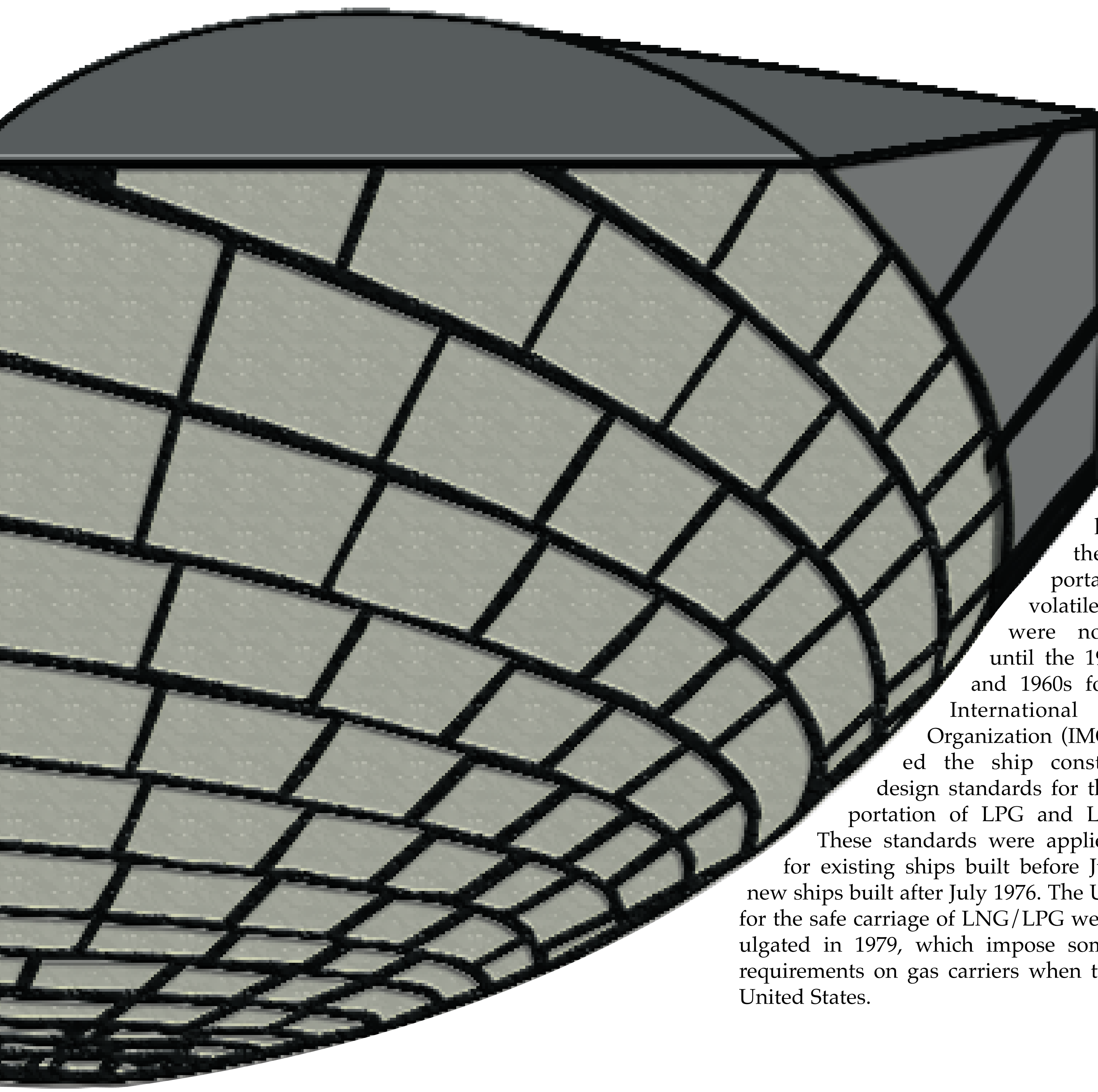
There's also a lot of other "useful stuff" on our Web site to assist customers, both inside and outside of the government. From organizational information to phone numbers to customer service standards to links to many other useful Coast Guard Web sites, you can often get answers to your questions online without having to speak with someone on our staff. So please feel free to "go-to" our Web site at **www.uscg.mil/hq/msc**.

Plan Review Guidance	
H1-10	**Structural Plans**
H2-21	**Foreign Passenger Vessel Plan Review**
E1-4	**Steering Gear Alarms/Controls**
E2-20	**Compressed Air Systems**
T1-15	**Tank Barge Stability**
T2-6	**Subchapter O Endorsements**
MSC Technical Notes	
04-95	**LightShip Change Determination**
01-96	**Hydrogen in Passenger Submersibles**
01-99	**Tonnage Technical Policy**
04-99	**Weather Criteria for Liftboat Leg Strength**
01-03	**Submitting T-Boat Plans to the MSC**
NVICs	
11-93	**Tonnage Measurement Applicability**
1-98	**Barge Buckling**



Subchapter O Endorsements for Gas Carriers

by Lt. Ray Lechner
Marine Safety Center



Even though the commercial production of liquefied petroleum gas (LPG) and liquefied natural gas (LNG) started in the 1920s, the engineering hurdles for the safe transportation of these volatile fuels by ship were not overcome until the 1950s for LPG and 1960s for LNG. The International Maritime Organization (IMO) first created the ship construction and design standards for the safe transportation of LPG and LNG in 1975. These standards were applied separately for existing ships built before July 1976 and new ships built after July 1976. The U.S. standards for the safe carriage of LNG/LPG were first promulgated in 1979, which impose some additional requirements on gas carriers when trading in the United States.

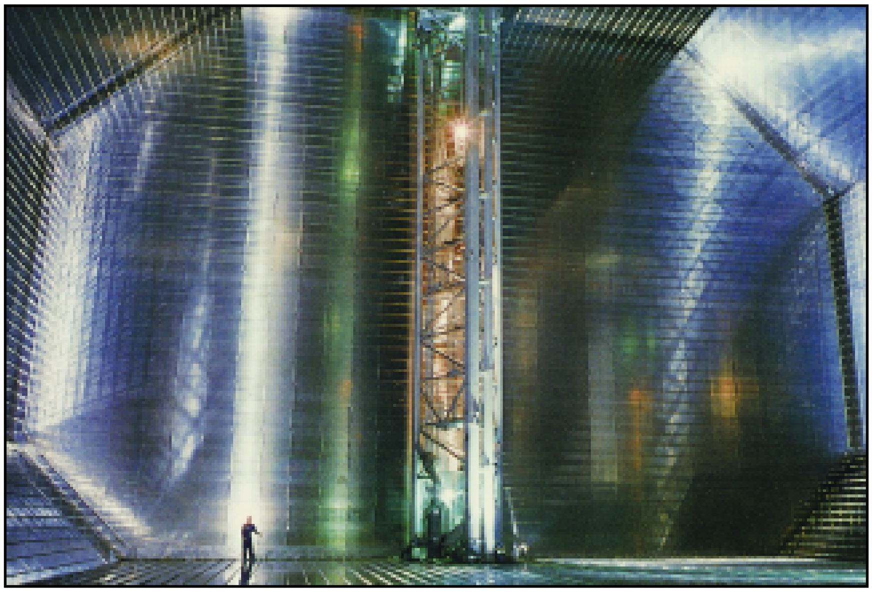
A gas carrier must meet the U.S. requirements contained in Title 46 Code of Federal Regulations (CFR) Part 154 to receive a Certificate of Compliance (COC) and COC endorsement from the U.S. Coast Guard and thus be permitted to trade in the United States. The Marine Safety Center (MSC) performs an engineering review of every liquefied gas carrier intending to trade in the United States to determine whether the cargo containment system meets the design standards of the U.S. regulations. Upon a satisfactory engineering verification, the MSC drafts a COC endorsement, which is commonly referred to as a Subchapter O Endorsement (SOE). The SOE is a document that identifies any cargo and/or operating restrictions and conveys key information of the cargo containment system. The Coast Guard field units issue the SOE after their satisfactory COC examination. An owner, operator or vessel

MSC performs an engineering review of every liquefied gas carrier intending to trade in the United States to determine whether the cargo containment system meets the design standards of the U.S. regulations.

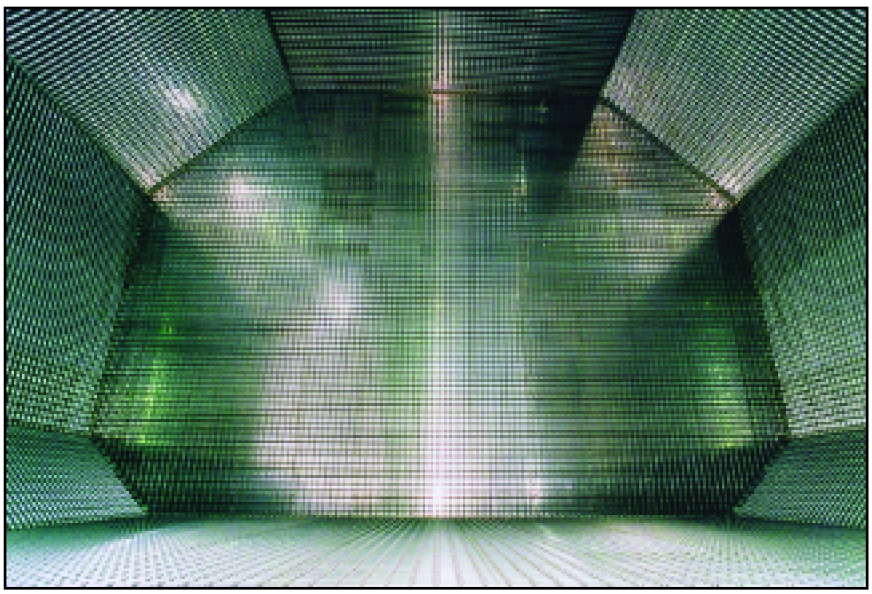
representative of a foreign gas carrier interested in making an initial SOE application for a foreign gas carrier should submit the documents required by 46 CFR 154.22 to the MSC for review. The submitter should allow 30 days, if possible, for processing of their application to avoid delays to the vessel's arrival. An owner, operator or vessel representative of a foreign gas carrier interested in renewing or changing the vessel's SOE need only submit an updated Certificate of Fitness to the MSC and should allow seven days, if possible, for processing.

There are four distinct differences between the U.S. and IMO regulations pertaining to the cargo containment system. These include: (1) Grade D and E crack arresting steels must be used in certain portions of the hull construction per the provisions of 46 CFR 154.170; (2) the cargo containment system design must meet the pressure and temperature control at 45º C/32º

An LNG facility in Guayanilla, Puerto Rico, which falls under the area of responsibility of Coast Guard Marine Safety Office San Juan.



Above: Internal view of a GTT model No. 96 membrane tank; below: internal view of a GTT Mark III membrane tank. Courtesy Armelle Danmanville, GTT.



C ambient still air/water temperatures per the provisions of § 154.701 for non-refrigerated systems and § 154.702 for refrigerated systems; (3) Type B and C cargo tanks must be evaluated using stress factor "A" of 4.0 per § 154.447 for Type B tanks and § 154.450 for Type C tanks; and (4) when the cargo containment system requires a secondary barrier in accordance with Table 3 of § 154, the hull must be evaluated at lower ambient air and water design temperatures of –29º C and –2º C respectively for Alaskan waters or –18º C and 0º C respectively for all other U.S. waters per the provisions of 46 CFR 154.174, 154.176 and 154.466. Amplifying information on these differences can be found on the MSC's Web site at **www.uscg.mil/hq/msc/T2.soe.htm**.

The MSC reviews hundreds of SOE applications per year for vessels with different cargo containment systems including independent Type A, B or C tanks and integral Membrane or Semi-membrane tanks. These tanks can be also be categorized by either pressure control or pressure and temperature control. Type C heavy gauge steel tanks are exclusively the only type of pressure control tanks that are designed to withstand 18 bars (260 psi), which is the internal vapor pressure of propane at ambient air temperatures. All the other tanks use refrigeration systems to reduce the cargo temperature and the internal cargo vapor pressure. The standard practice to contain LNG is to reduce the cargo temperature to –163º C (–261º F) and use an extensive insulation barrier. Type B tanks are spherical aluminum/insulation tanks that are cradled within the double hull of the ship. Membrane tanks such as GazTransport & Technigaz's (GTT) model No. 96 or Mark III are invar stainless steel metal and insulation tanks, but are designed with a more space efficient prismatic construction as seen in the images on this page.

Prior to 1998, the MSC had conducted SOE reviews for chemical tank vessels; however, since the verification process did not require engineering calculations, the entire responsibility for chemical tank ship Certificate of Compliance examination was shifted to the Coast Guard field units. The Chemical Tank Vessel Inspection Sheet (CTVIS) serves as guidance for the COC examination. The MSC Web site contains more information on the CTVIS.

As a future initiative, the MSC is looking at ways to streamline the SOE review process for gas carriers. The MSC will continue to review initial SOE applications per 46 CFR 154.22 as before, but is currently looking at ways to make the SOE renewal/update process more efficient and effective for all stakeholders including the maritime industry, Coast Guard field units and the MSC. Questions regarding liquefied gas carriers and the SOE application process can be directed to Lt. Ray Lechner of the MSC's Tank Vessel and Offshore Division at (202) 366-6441 or **msc-coc@msc.uscg.mil**.

See page 69 for more information on the MSC guidelines on liquefied gas compliance.

Regulatory Complexities

The Gulf of Mexico Oil and Gas Industry

by Lt. Cmdr. KYLE MCAVOY
Marine Safety Center

by LISA HECKER
Marine Safety Center

by Lt. Cmdr. JOHN CUSHING
U.S. Coast Guard Eighth District Marine Safety Division

The United States economy relies heavily on oil and natural gas to keep it functioning smoothly. How much of that gas and oil comes from the Gulf of Mexico Oil and Gas Industry may not be so well known. According to estimates provided by the U.S. Department of Interior's Minerals Management Service (MMS), 29 percent of the domestic oil and natural gas production in the U.S. is recovered from oil and gas reservoirs in the Gulf of Mexico. Furthermore, the majority of this percentage of gas and oil comes from what the MMS defines as "deepwater," which is water over 1,000 feet in depth. While many end users of these valuable resources simply want to be able to flip a switch to turn on their lights or turn a key to run their car without knowing how the energy made the journey from a hole in the ground to their house or car, the technology involved, especially when the retrieval of these resources comes from a hole in the ground under 1,000 feet of water, rivals the technology needed to put people in space.

To help ensure that this advanced technology is implemented in a safe manner with due respect being paid to the marine environment, the people working in the marine environment and the sustainability of these natural resources within the Gulf of Mexico, both the U.S. Coast Guard and the MMS have regulatory responsibilities. Both agencies play a role in ensuring that the technology and methods employed for the retrieval of this energy are safe.

To meet the challenge of bringing these energy resources to end users, increasing the oil and gas production rates from the Gulf of Mexico and sustaining these increased delivery rates, there are numerous difficult marine engineering and naval architecture problems that must be solved. One solution developed by companies willing to invest in this challenge is found in the use of Floating Offshore Installations (FOIs).

In a very simplistic definition, an FOI is a floating structure designed to be moored to the sea floor in very deep water and capable of housing the people and equipment necessary to bring the oil and natural gas to the sea's surface for production and shipment to shore-based facilities for further distribution. The FOI, therefore, has to meet many demands. It must be designed to stay in one position on the sea surface and resist movement from the wind and waves to stay on location. This is necessary because the pipes, or marine risers, which bring the gas and oil from subsea wellheads to the production equipment on the facility, have strict limits to how far they can bend or distort out of

The Ursa, a Shell Oil tension leg platform, located approximately 130 miles southeast of New Orleans. Courtesy Shell.

shape. The FOI must also house the production equipment necessary to clean up the crude oil and natural gas by extracting water, sand and other impurities and preparing it for its next phase of shipment via export pipelines to shoreside refineries and storage facilities and then ultimately to consumers throughout the U.S. Finally, and most importantly, the FOI must keep the men and women who control and oversee this production process safe from the inherent dangers of working around highly flammable hydrocarbons as well as the environmental dangers associated with living in a marine environment 50 to 100 miles offshore.

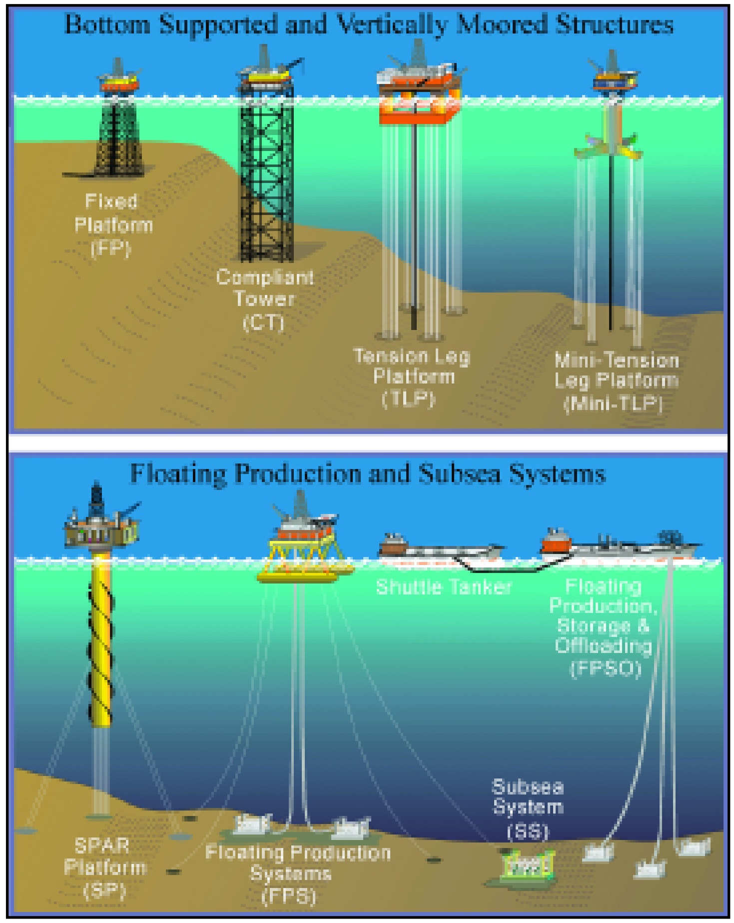
To be able to balance all of the engineering issues involved with developing an FOI is a remarkable challenge. While not as remarkable, but often still a challenge, is the process of getting an FOI certified by both the Coast Guard and the MMS to produce the energy resources being sought. As dictated by federal regulations, each FOI is required to receive a Certificate of Inspection from the U.S. Coast Guard as well as specific permits from the MMS. While the review and inspection responsibilities of each agency prior to issuing these necessary documents overlap in some areas, both agencies have distinct purposes. In very general terms, the MMS will verify the safety of the production processes and equipment while the Coast Guard will verify the safety of the personnel onboard with regard to firefighting and lifesaving gear, as well as its overall safety. To better define each agency's role, there is a Memorandum of Understanding between the two agencies, but within this article, the discussion will follow the Coast Guard's role and the regulatory complexities it is faced with during the review and inspection of these FOIs.

Generally, in the deepwater Gulf of Mexico there are primarily three types of FOI in use: A semi-submersible, a Tension Leg Platform (TLP) and a Caisson (or Spar). Each type has its own set of advantages depending on parameters, such as water depth, anticipated environmental forces of sea state and current, the characteristics of the anticipated energy reservoir, the anticipated payload that will be needed to harvest and process the energy reserves, government regulatory influences and local and global fabrication infrastructures. An FOI has two basic components, the hull and the topsides, and the size of the hull is dictated by the weight of the topsides. To reduce the weight of the topsides, and the size and cost of the hull, it is common practice to use alternative construction materials that are lighter than steel whenever possible. For instance, designers are currently using Fiber Reinforced Plastic (FRP) for deck gratings and walkways in nonessential areas and FRP piping has been used in place of steel piping for vital systems such as the fire main. Designers are also exploring the possibility of using aluminum instead of steel for accommodations and helicopter decks. While the strength properties of these alternative materials may be comparable to steel, they often do not perform as well in a fire, and there are other design concerns and limitations that must be carefully considered.

These types of alternatives being used to save weight begin to reveal some of the areas where the Coast Guard has to begin to "think outside the box" from a regulatory perspective. Unfortunately, at least for the Coast Guard, the mechanisms to publish regulatory guidelines lags behind the speed at which industry is developing construction alternatives and implementing them within their designs. Thus, a unique and challenging environment is created for the Coast Guard since the need for safety and the need for industry and advanced technology must be properly balanced. To help achieve this balance, the Tank Vessel and Offshore Division and the Engineering Division at Marine Safety Center (MSC) are frequently on the "hot seat" to sort through these competing demands. The Tank Vessel and Offshore Division personnel are responsible for reviewing the structural integrity, structural fire protection integrity, stability and the general safety arrangements on these FOIs, and the Engineering Division is responsible for reviewing an FOI's machinery arrangement, electrical installations and firefighting equipment. Often, a classification society, such as the American Bureau of Shipping, has already reviewed most of these systems on behalf of the Coast Guard, but since there may not be regulatory guidelines developed yet, numerous conversations between industry, the classification society and the Coast Guard MSC take place to determine the correct balance between safety and technology advancements.

There are many other areas where the reduction in topside weight affects the design and fabricating of an FOI. A reduced topside weight also reduces the buoyancy needed to support the topsides, which in turn permits a smaller hull with a reduced fabrication cost and shorter fabrication timeframe to be used. Also, by reducing weight in one area the designers can allow for an increase in weight in another area, such as additional production equipment. A corollary to the smaller hull and reduced fabrication cost idea is that a smaller hull opens up more options to the designers. A smaller hull is easier to transport either from a foreign yard to the Gulf of Mexico, or it's possible to even have it constructed in a United States shipyard. These options, in turn, permit industry greater flexibility in establishing an FOI over energy reserves in deeper water. An additional engineering challenge, however, with deeper water is the FOI's mooring system. Naturally, as the water gets deeper, a greater amount of wire rope and chain is needed to moor the FOI to the sea floor. This increased length and weight increases the required buoyancy of the hull needed to support the wire rope and chain. But, since it is becoming more feasible to use smaller hull forms, which do not offer the greater buoyancy needed for wire rope or chain, polyester mooring systems, as an alternative to wire rope and chain, have gained greater popularity. The reduced weight of the polyester means less buoyancy is required to support the mooring system. This again, also allows for a smaller hull or additional topside equipment to be installed.

With regard to polyester mooring systems, within the last two years the MSC's Tank Vessel and Offshore Division has worked with industry and the American Bureau of Shipping to approve two applications of polyester mooring systems for FOIs in the Gulf of Mexico. This accomplishment is a perfect example of how the MSC has had to balance the competing demands of advancements in industry and technology with those of safety. Since there were no official Coast Guard regulations on polyester mooring systems for FOIs, the personnel at the MSC had to educate themselves via research and training to quickly determine whether this option was feasible from a safety perspective. This effort, therefore, went far beyond the historical view that the MSC's primary mission is to review ship design plans to the "published" standards. In this case, the MSC was helping to define the standards themselves.



Various types of FOIs and other production systems. Courtesy Mineral Management Service.

Beyond the weight issues and regulatory standards mentioned above, the deepwater operating environment has presented many other new and unusual design challenges for the offshore industry. Ocean currents in the deepwater region of the Gulf of Mexico (GOM) have proven to be particularly strong and problematic. The predominate ocean current sweeps up past Mexico's Yucatan peninsula and into the GOM, swirls around the GOM and

ChevronTexaco's Genesis is the second floating SPAR in the Gulf of Mexico, and the first to accomodate both drilling and production facilities. Genesis' current daily production is approximately 33,500 barrels of oil and 40 million cubic feet of natural gas. Courtesy ChevronTexaco.

then moves northward again past the southern tip of Florida and into the Atlantic Ocean where it is referred to as the Gulf Stream. Within the GOM this flow is known as the Loop Current and at times localized "eddy currents" that swirl off the main flow have been measured at speeds in excess of four knots. These currents have caused drilling rigs, some of which are chartered for $200,000 per day, to have to cease drilling activities and sit idle for weeks at a time until the current settles down to an acceptable level. For FOIs, these currents can have a major impact on the design of both the hull and the mooring system. In addition to contributing to the static loading, these currents produce dynamic effects that impact the fatigue life and fatigue design of the hull structure and mooring system. More specifically, the current causes mooring lines to flutter in a phenomenon known as Vortex Induced Vibration (VIV). For Spar-type FOIs, the hull itself will also oscillate when exposed to strong currents and so design strategies have to be developed to suppress and design for the fatigue loading of VIV on the hull. The movement of some Spar-type FOIs has been strong enough that poor station-keeping has become a concern, causing the marine risers being subjected to significant bending forces and causing the crewmembers to become seasick. Therefore, a better understanding of the Loop Current and better designs for VIV have become a major challenge as FOI designs continue to evolve. Additionally, while the Coast Guard does not have any regulatory guidelines within this area, when structural repairs are being proposed to combat the effects of VIV, the MSC is often consulted for approval of the repairs.

Another major concern is fire safety. Offshore production facilities process tremendous quantities of highly flammable crude oil and natural gas that come to the surface from subsea wellheads at tremendous pressures. In 1988, the Piper Alpha, a production platform in the North Sea, experienced a catastrophic sequence of events resulting in the rupture of several high-pressure natural gas risers and 167 people perished in the ensuing conflagration. As a result of that disaster and other tragic fires on offshore platforms, a great deal of research has been done on how to improve fire safety and crew evacuation. New standards are being developed to address blast protection as well as structural fire protection, plus new types of evacuation systems are being designed that can more quickly, efficiently and safely evacuate the large number of crewmembers typically found on an FOI from the topside working decks to the water, which can be 70 feet or more below the topside structure. With as many as 150 workers on some FOIs, this can be a very interesting challenge for designers as well as for the Coast Guard as regulators charged with reviewing and approving these systems.

As the deepwater challenges and design concerns for FOIs continue to develop, the Coast Guard remains actively engaged with the oil and gas industry as well as classification societies, such as ABS Americas, to better define appropriate guidelines, safety standards and regulations for new and innovative FOI designs.

Foreign Passenger Vessel Safety

The Control Verification Program

by Lt. Brad Rosello
Marine Safety Center

by Lt. Cmdr. Buddy Reams
Marine Safety Center

***Queen Mary 2*. Courtesy Cunard Line.**

Structural fire protection (SFP) insulation around a walk-in refrigerator, as seen by an MSC engineer during inspection of a vessel.

Have you ever imagined traveling to foreign cities the world over and wanted the opportunity to inspect some of the largest and most luxurious vessels ever designed? Sounds like a dream job that is far from the normal realm of everyday U.S. Coast Guard Marine Safety inspections. However, this is a job performed regularly by staff engineers at the Coast Guard Marine Safety Center (MSC). The Coast Guard's passenger vessel Control Verification Examination (CVE) program originally established in 1968, although having changed significantly in scope and intensity across the years, has maintained the focus of assuring the safety of U.S. citizens on foreign passenger vessels. The modern CVE program, an extension of the Port State Control initiative, derives its authority from Title 46 of the United States Code (U.S.C.) Sections 3303 and 3505. These sections of the Code invoke our right to ensure foreign vessels embarking passengers from U.S. ports are in compliance with the International Convention for the Safety of Life at Sea (SOLAS).

The cruise ship industry has come a long way since 1968, recently completing a building boom in which 127 ships were delivered to the U.S. market in the last 10 years. To be sure, industry analysts expect continued growth in new builds as well as an effort to retrofit older designs to extend their operating life. The expanding cruise ship market and, in relation, the continuing CVE program promises to keep the Coast Guard at the forefront of vessel design standards to ensure the safety of our citizens. At the vanguard of this effort are the project engineers at the MSC. Engineers at the MSC review select vessel plans and attend inspections under the guidance of Navigation and Vessel Inspection Circular (NVIC) 1-93. Our attendance enhances a robust examination process, leverages technical expertise evaluating new design methodologies and ensures the technical challenges of novel cruise ship designs are incorporated into Coast Guard marine safety policy.

The CVE program is, in large part, a circular process. It typically begins with a "concept" meeting, continues with plan review and inspections and concludes with new policy being incorporated into Coast Guard guidance and, potentially, changes in international standards. This new policy/standard is then applied to the next new vessel. The process has evolved significantly over time as the Coast Guard and industry seek common ground to facilitate the needs of all parties involved.

Originally, cruise ship inspections were commenced at the vessel's first U.S. port of call. As one can imagine, these inspections often extended a vessel's stay at the pier, potentially delaying the voyages of thousands of passengers. To streamline the process, we began conducting examinations at foreign ports, usually in the shipyard. Today, the process has evolved from first port of call inspections, to underway examinations and finally into three pre-delivery inspections in the shipyard and an annual compliance certification.

At the beginning of the process, MSC engineers host a design concept review with various industry representatives involved with the design and construction. The primary aim of this meeting is to identify unique design aspects before construction commences and agree on how to address them with relation to the applicable regulations. This embodies the adage that it is easier to incorporate a solution at the design phase than it is to implement it during or after construction. Often, issues discussed at these meetings involve novel design features and new approaches to cruise ship functions, such as large public spaces, planetariums, miniature golf, rock climbing walls and ice rinks. In the months following the meeting, MSC engineers review vessel structural fire protection and emergency escape plans. Once this review has been, or is very nearly, complete the first inspection is conducted in the shipyard when the vessel is approximately 50 percent built. This inspection has been dubbed the structural fire protection (SFP) exam and is led by engineers from the MSC. The SFP exam focuses on verifying structural fire boundaries (insulation, doors, boundary penetrations) and space designation in accordance with SOLAS regulations. A week or so before the initial control verification examination (ICVE), a Coast Guard inspector from marine inspection offices at either Activities Europe or Activities Far East (depending on where the vessel is being constructed) performs a cursory walk-through of the vessel to ensure it is ready for the rigorous weeklong examination. Of course, not all cruise ships come to the U.S. brand new. In cases where existing ships are brought to the U.S. to operate, the above process is amended, usually combining the two inspections. MSC engineers conclude their role in the CVE program as part of the ICVE inspection team.

Technical discussions with MSC engineers on the various unique design aspects will often give rise to new Coast Guard policy on the matter. These policies can take many forms such as NVICs, MSC plan review guidance or development of International

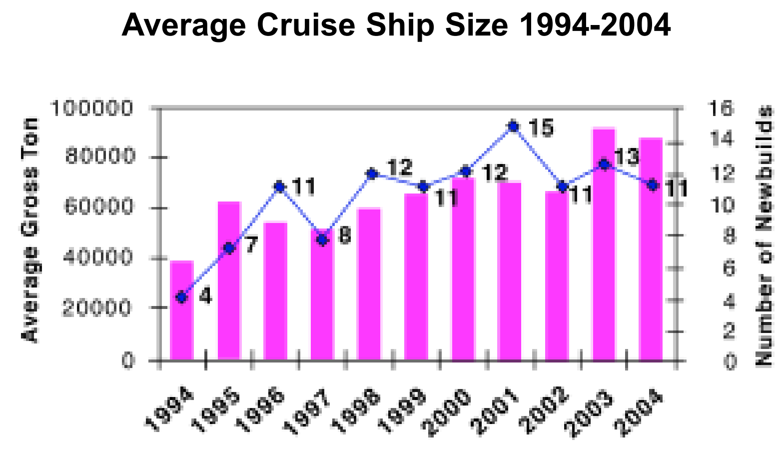


Figure 1

The average cruise ship has increased in size during the last 10 years, as depicted in the graph above. Immediately above: the modern-day cruise ship *Constellation* built in 2002. Courtesy Celebrity Cruises. Below: the 1971-built former *Pacific Princess* (now *Pacific*), of '70s television fame. These two ships show the contrast in size during a span of three decades. The *Constellation*, at 90,280 gross tons, is nearly five times the size of the *Pacific*, displacing 20,186 gross tons.

***Spirit of Ontario I*. Courtesy Canadian American Transportation Systems.**

Maritime Organization (IMO) policy. The Coast Guard's Office of Compliance (G-MOC) is currently revising NVIC 1-93, "Control Verification Examinations (CVEs) of Foreign Passenger Vessels," with significant input from MSC engineers. Because the CVE process has evolved considerably in the last 11 years, this revision is focused on capturing the current processes with added language to make the process more robust at incorporating ever-changing industry standards and design features.

MSC staff have developed and published a significant database of plan review guidance for those involved in the CVE program. This extensive guidance is the assimilation of the unit's collective years of experience with unique cruise ship design features. Its purpose is twofold. First, it formalizes the solutions we expect to see applied for various novel features and, thus, promotes consistency by the Coast Guard. Second, and perhaps more important, it serves to eliminate surprises to the builders and owners that occurred when these solutions were applied during construction. Our endeavors in capturing these technical issues have led to several initiatives and new policy implementation at IMO. Currently, there is a Large Passenger Vessel (LPV) Safety initiative underway at IMO to assess what safety standards are required to address the mushroom effect in vessel size and passenger capacity seen in the last 10 years. Recent U.S. input to the fire safety aspect of this initiative directly benefited from our technical solutions described above. Most were directly incorporated into the U.S. presentation. As demonstrated from the above example, the experience and expertise garnered by MSC personnel have a direct impact on the development and revision of international vessel safety regulations.

The average cruise ship has significantly increased in size during the last 10 years as shown in Figure 1. This increase in size has led to passenger counts as high as 4,000 and dizzying vessel heights, some spanning 17 decks. Additionally, the IMO High-Speed Craft Code (HSC Code) (SOLAS Chapter X) has been coming into prominence, requiring MSC engineers to apply an entirely new regulatory perspective. Whereas conventional ship safety philosophy relies on the ship being self-sustaining with all necessary emergency equipment being carried onboard, the HSC Code recognizes that safety levels can be significantly enhanced by the infrastructure associated with regular service on a particular route and the management of risk. The manage-

The *Disney Wonder*, above, and its sister ship, the *Disney Magic*, offer land and sea vacations that combine the Walt Disney World Resort with a voyage to the Bahamas. These two ships that make up the Disney Cruise Line fleet sail year-round out of Port Canaveral, Fla. Courtesy the Walt Disney Co. © 2004

ment of risk is generally achieved through accommodation arrangement, active safety systems, restricted operation, quality management and human factors engineering. The HSC philosophy differs significantly from conventional SOLAS standards in several specific areas such as no overnight accommodations, restricted use of combustible materials, operational restrictions and base port requirements. The typical HSC Code vessel is a combination passenger/vehicle ferry that operates on a designated route. MSC engineers recently completed a CVE review on the *Spirit of Ontario I*, built by Austal Ships and operated by Canadian American Transportation System, LLC (CATS), which is scheduled to operate between Rochester, N.Y,. and Canada. Additionally, MSC engineers have applied their knowledge of the HSC Code and CVE program to facilitate the review of the most modern U.S.-built HSC Code vessel, the Fairweather, operated by Alaska Marine Highways.

The dynamic environment known as the cruise industry continuously gives birth to new ideas that push the envelope of regulatory compliance. Such flux brings MSC engineers face to face with new technical challenges and requires them to be supremely in tune with industry practices and knowledgeable of new standards, modeling techniques, fire and escape theories and many other aspects of cruise ship construction. Recent amendments to SOLAS fire protection standards, for example, permit performance-based analysis in design and construction. The number of alternative arrangements that can be derived from such engineering analysis is virtually endless.

This new regulation forces MSC engineers to become more technically savvy than ever before. Along with changes in SOLAS, the cruise ships are only getting longer, bigger, faster and incorporating groundbreaking ideas. The affect these changes will have on regulations and how they affect current initiatives, such as the LPV safety initiative, are yet to be determined. However, rest assured that MSC engineers will be on the leading edge, implementing changes as they are developed and helping forge new standards to keep the vessels safe. The future is unknown and will be challenging; however, MSC engineers stand ready to face these challenges with skill and technical expertise that has become an industry standard. Semper Paratus.

Safety of Innovative Vessel Designs

Coast Guard Perspective in Utilizing Performance-Based Fire Protection Analysis to C reate Novel Commercial Ship Designs

by Lt. j.g. Ron Caputo
Marine Safety Center

by Lt. Scott Kelly
Marine Safety Center

A heat detector on a vessel provides structural fire protection. Courtesy MSC.

In general, under Subchapter K {Title 46, Code of Federal Regulations (46 CFR)} high-speed, lightweight, aluminum ferry construction had revolved primarily around the carriage of passengers, not vehicles or cargo. As most industry innovations outpace the development of standards and regulations, the U.S. Coast Guard Marine Safety Center (MSC) recently began clearing the dust off a relatively new tool for considering novel design proposals. As a result, MSC engineers, ship designers, and to a large part the Coast Guard's Marine Safety program are experiencing a cultural shift from traditional enforcement of established construction standards to developing and evaluating performance-based standards with industry.

In 2001, to aid industry and the Coast Guard in the development and regulation of innovative vessel designs of this type, Navigation and Vessel Inspection Circular (NVIC) 3-01, "Guide to Establish Equivalency to Fire Safety Regulations for Small Passenger Vessels (46 CFR Subchapter K)" was developed and introduced. NVIC 3-01, which can be viewed at **www.uscg.mil/hq/g-m/nvic/3_01/n3-01.pdf**, offers guidelines for incorporating novel designs into vessel construction that provide a level of safety equivalent to Subchapter K. The intent of NVIC 3-01 is not to validate a planned or existing design, but to establish a framework for the development of many possible equivalent alternatives, ultimately choosing the best/safest design. This performance-based fire protection engineering approach has been used in building design for many years, however, the Coast Guard did not formerly adopt this approach until the publication of NVIC 3-01 which, itself, is based on the *Society of Fire Protection Engineers (SFPE) Guide to Performance-Based Fire Protection Analysis and Design of Buildings*. To characterize the magnitude of this paradigm shift for the maritime industry, while most other NVIC's are developed to address a specific need and get immediate utilization, NVIC 3-01, despite being published in April 2001, was not actually implemented in design until the recent proposal of an aluminum high-speed domestic vehicle ferry in 2003.

The performance-based design process begins with all stakeholders (owners, designers, engineers, and regulators) working together to define the scope of the project and to select the appropriate level of analysis. In effect, the stakeholders form a design team. With all stakeholders on the design team and communicating from the start of the design process, it is much easier to ensure the intent of NVIC 3-01 is fulfilled. Understanding the process is key. From the design team agreeing on performance criteria to the development of a design to meet or exceed those criteria, all stakeholders should plan for a time-consuming process. Starting with a clean slate, from beginning to end, it will take approximately 12-24 months depending on the intricacy of the equivalency. The process is explained in NVIC 3-01, "Guide to Establish Equivalency to Fire Regulations for Small Passenger Vessels (46 CFR Subchapter K)." Documentation and concurrence at each step is important to clear communication. All conference calls, concept meetings, e-mail, etc. are critical as their contents are generally seen as official plan review and acceptance/rejection of a critical design feature. Therefore, all facets of the performance-based fire safety analysis must be

A fixed fire suppression system is another layer in the overall fire safety system. Courtesy MSC.

fully recorded and verified to ensure all design features and operational requirements remain intact for the full duration of the life of the vessel.

To ensure the new design is equivalent to existing regulations, the Coast Guard becomes one of the stakeholders on the design team but continues the traditional role of regulator. Generally, the design team will be a conglomerate of technical and field experts, including: shipyard naval architects and systems engineers, licensed fire protection engineers, owners' representatives, and any other industry expertise deemed necessary. The contributing Coast Guard personnel will commonly come from: the MSC, the Marine Safety Office where the shipyard falls under its area of responsibility, the Marine Safety Office at which the vessel will be operating, various Commandant technical offices {Office of Standards (G-MSE), Office of Compliance (G-MOC)} and any other Coast Guard asset whose expertise is required by the design team.

Including the Coast Guard on the design team may appear to place us in a precarious position. After all, here we partner to create a vessel design within the "spirit of the regulations," yet still work to effectively perform unbiased plan review and inspection onboard the subject vessel. Assuming the role of a "regulating-partner" is a challenging position for the Coast Guard, but it is not unlike our role during a major oil spill response. In these responses, the Coast Guard partners with the responsible party forming a Unified Command to mitigate the effect of the spill, while simultaneously conducting a formal investigation of the cause of the casualty. The unique partnership of a successful oil spill response team formed between the marine industry and the Coast Guard requires dedication and open communication. A Coast Guard/industry partnership similar to that created in an oil spill scenario, is also produced when employing a performance-based fire protection analysis into vessel construction.

Most equivalencies developed through NVIC 3-01 are generally founded on real-time performance-based fire testing and analysis of materials and systems. They could be as complicated as employing an active fire protection system for a required passive one, or as simple as the substitution of a dump-style deluge system for an automatic sprinkler system. Replacing a passive system (structural fire protection) with an active system (sprinkler) for a passive system may require the analysis of a variety of systems working together. These may include an active fire suppression system, detection system(s), human factors and a review of the owner's operating procedures for various casualty scenarios that rely on the equivalent design to protect the space it's located in.

Ship owners' operating procedures weigh heavily in MSC's reviews of performance-based equivalencies. Photo by Prince William Sound Regional Citizens Advisory Council during a recent fire symposium.

Coast Guard acceptance of the complex design described above would require the design team to quantifiably measure all relevant aspects of the equivalency including: potential flame spread, structural impact to the entire vessel (effects to primary and secondary structure), survivability of the vessel during or after the assumed fire damage, and most importantly tenable conditions to ensure the passengers may safely egress or take refuge onboard the vessel. In any event, incorporating all of the necessary analyses will create a new design standard that provides an equivalent level of safety. In most cases though, a higher level of safety than that envisioned by the regulations will typically be achieved.

Although performance-based fire safety analysis is more time consuming and often a more onerous process than traditional plan review, the result is a design incorporating the most advanced technologies available in fire protection engineering. As the Coast Guard and maritime industry gain experience with using performance-based fire protection engineering, the Coast Guard will seek measures to reduce the extraordinary time needed to fully complete the NVIC 3-01 process. Supporting the fast paced shipbuilding industry, the MSC is currently drafting a Marine Technical Note (MTN) in an effort to provide technical guidance supplemental to NVIC 3-01. As with any novel design, operators interested in designing a domestic high-speed vehicle ferry are highly encouraged to communicate early and openly with the MSC and the cognizant OCMI to ensure the design is a success.

The Marine Safety Center (MSC) publishes many guidelines for the maritime industry. One of note is the excerpt below on liquefied gas compliance mentioned in "Subchapter O Endorsements for Gas Carriers" on p. 54. For the complete version of the document below, please access http://www.uscg.mil/hq/msc/PRGuidance/T2-6.pdf.

MSC Guidelines for Review of Foreign Liquefied Gas Carrier Certificate Of Compliance (COC) Endorsement Application (Subchapter O Endorsement)

Procedure Number: T2-6 Revision Date: 11/01/01

General Review Guidance: Certificate of Compliance, Initial Application
The Marine Safety Center will:

- Check the Coast Guard Port State Information Exchange (PSIX) at **http://psix.uscg.mil/**. Ensure the vessel is in the system and that it has a valid Certificate of Financial Responsibility (COFR). The status of the COFR can be checked at **www.cofr.npfc.gov**. If not, instruct the owner/agent to contact the National Pollution Fund Center (NPFC), Vessel Certification Division at Ph: (202) 493-6780 Fax: (202) 493-6781 to acquire one. The vessel will NOT be allowed to enter U.S. waters without one.
- Account for all required parts of the application. See 46 CFR 154.22, reference (a). The list that follows is provided as a quick reference only. The above reference should be reviewed for specific application instructions and details.
  (1) The vessel's valid IMO Certificate of Fitness
  (2) A description of the vessel
  (3) Specification for the cargo containment system.
  (4) A general arrangement plan of the vessel
  (5) A midship section plan of the vessel
  (6) Schematic plans of the liquid and vapor cargo piping.
  (7) A firefighting and safety plan
  (8) If the applicant is requesting an endorsement for the carriage of ethylene oxide, a class society certification that the vessel meets 154.1725(a)(4),(5), and (7).
  (9) If the vessel is a new gas vessel, or an existing vessel that does not meet 154.12 (b), (c), or (d) –
    (i) A certification from a class society that the vessel –
      (A) Has enhanced grades of steel meeting 154.170 and
      (B) Meets 154.701, or 154.703 and
    (ii) The vessel's valid SOLAS Cargo Ship Safety Construction Certificate and Cargo Ship Safety Equipment Certificate.
  (10) Any additional plans requested by the Marine Safety Center to determine whether the vessel meets 46 CFR 154.

- Review the Certificate of Fitness (COF) (See procedures for reviewing COFs on next page)
- Review all certificates and plans, paying attention to validity dates, vessel identification information and content.
- Produce a Subchapter O Endorsement (SOE) and prepare it for issuance upon completion of vessel exam by the local Marine Safety Office.
- The list that follows provides details on the four general design areas where the Coast Guard requires design standards exceeding those in the IMO Codes. These areas are summarized from Part 154 as follows:

General Review Guidelines: Coast Guard Design Standards

- ALLOWABLE STRESS LEVELS FOR INDEPENDENT TANK TYPES B AND C: The stress factors for use in designing independent Type B tanks are shown in Table 2 of Part 154 (reprinted below). Stress factors A and B also apply when designing Type C tanks. Certification of this item should be indicated on the Certificate of Fitness. For a vessel to be accepted as Type IIPG, the minimum design MARVS must be based on the stress factors from Table 2 of Part 154:

46 CFR Part 154 Table 2 - Values For Stress Factors

	Stress Factors			
	A	B	C	D
Nickel Steel and Carbon Manganese Steel	4.0	2.0	3.0	1.5
Austenitic Steel	4.0	1.6	3.0	1.5
Aluminum Alloys	4.0	1.5	3.0	1.5

- CRACK ARRESTING STEEL: The following grades of steel, or their equivalents, must be used along the length of the Cargo Area in the following locations as required by 46 CFR 154.170:

Deck Stringer	Grade E
Sheer Strake	Grade E
Turn of the Bilge	Grade D or E

Certification of this item may be made on the Certificate of Fitness or on a separate certificate issued by the Classification society or administration.

- DESIGN AMBIENT TEMPERATURES: U. S. regulations require lower ambient design temperatures for the hull structure (see 46 CFR 154.174, 154.176 and 154.466):
  - For Continental United States and Hawaii:
    air (at 5 knots) -18°C (0°F) / seawater 0°C (32°F)
  - For Alaska:
    air (at 5 knots) -29°C (-20°F) / seawater -2°C (28°F)

The hull structure design temperatures must be indicated on the Certificate of Fitness. *(For Gas Carriers with independent Type C tanks, it is sufficient to use the design ambient temperatures from the IMO Code for Existing Ships Carrying Liquefied Gases in Bulk or the International Gas Carrier Code.)*

- CARGO PRESSURE/TEMPERATURE CONTROL: Except for the carriage of methane, the cargo containment system must be designed to maintain the cargo indefinitely without venting to the atmosphere at the upper design ambient temperatures of 45°C for air and 32°C for seawater (see 46 CFR 154.701). For methane, the cargo containment system must be designed to maintain the cargo without venting to the atmosphere for a minimum period of 21 days while the vessel is in port and under ambient conditions of 45°C for air and 32°C for seawater (see 46 CFR 154.703). Certification of this item may be made on the Certificate of Fitness or on a separate certificate issued by the Classification society or administration.

Certificate of Fitness (COF), All
Certificate of Fitness, New Vessel
Certificate of Fitness, Existing Vessel
See **www.uscg.mil/hq/msc/PRGuidance/T2-6.pdf** for these three sections and the complete version of the document.

Subchapter O Endorsement (SOE)
The following list details specific cargo carriage requirements which MAY appear on the vessel's SOE depending on the cargoes authorized for carriage:

- Per chapter 17.20 of the IGC Code, Propylene Oxide is authorized for carriage subject to the following special restrictions:
  - Classification society certification that the required cargo piping separation has been achieved must be on board the vessel and available to Coast Guard boarding personnel.
  - All gaskets which may contact propylene oxide liquid or vapor must be constructed from spirally wound stainless steel with a filler of Teflon or similar fluorinated polymer.
  - Neoprene, natural rubber, asbestos mixed with other materials, and materials containing oxides of magnesium (such as mineral wools) may not be used for packing, insulation and similar items in the propylene oxide containment system and piping.

- Per chapter 17.16 and 17.20 of the IGC Code, the following requirements apply to the carriage of ethylene oxide/propylene oxide mixtures (containing a maximum of 30% ethylene oxide):
  - The requirements for propylene oxide listed in the Certificate of Fitness and listed above must be followed.
  - When this cargo is carried without refrigeration the cargo tank relief valve setting shall not be less than 120 kPa gauge (17 psig).

The following requirements apply to the cargo C-4 Mixture:

- The weight percent of acetylene may not exceed 5.0 percent.
- The weight percent of propadiene may not exceed 0.5 percent.
- If the weight percent of butadiene exceeds 10 percent, the C-4 Mixture must be inhibited to prevent self-reaction in accordance with chapter 17 of the IMO Gas Code.
- A manufacturer's certificate specifying the composition of the cargo must be on board the vessel and available to Coast Guard boarding personnel.

Methyl Acetylene Propadiene Mixtures (MAPP Gas) shall be carried only in one of the two compositions specified in section 17.18 of the IMO Gas Code (including the third set of amendments).

References
a. 46 CFR Subchapter O, Part 154
b. IMO Code for Existing Ships Carrying Liquefied Gases in Bulk, Resolution A.329(IX)
c. IMO Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, Resolution A.328(IX)
d. IMO International Gas Carrier Code, Resolution MSC.5(48) and Resolution MSC.30(61), 1993 Edition.
e. Marine Safety Manual (MSM), Volume II, Section D, Chapter 6 ***(http://www.uscg.mil/hq/g-m/nmc/pubs/msm/vol2.htm)***

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standards-making and policy initiatives. With so much to do, the men and women of today's MSC provide meaningful contributions to the Marine Safety, Security and Environmental Protection missions of the Coast Guard.

Technical services conducted by or on behalf of the MSC might be characterized as follows:

Direct operational technical support to field units: Technical support is provided directly to field units involved in operational situations by the MSC technical group SERT. Most SERT assistance can be provided remotely by technically trained personnel using computer models, salvage experience and technical networks; on-site assistance is also provided.

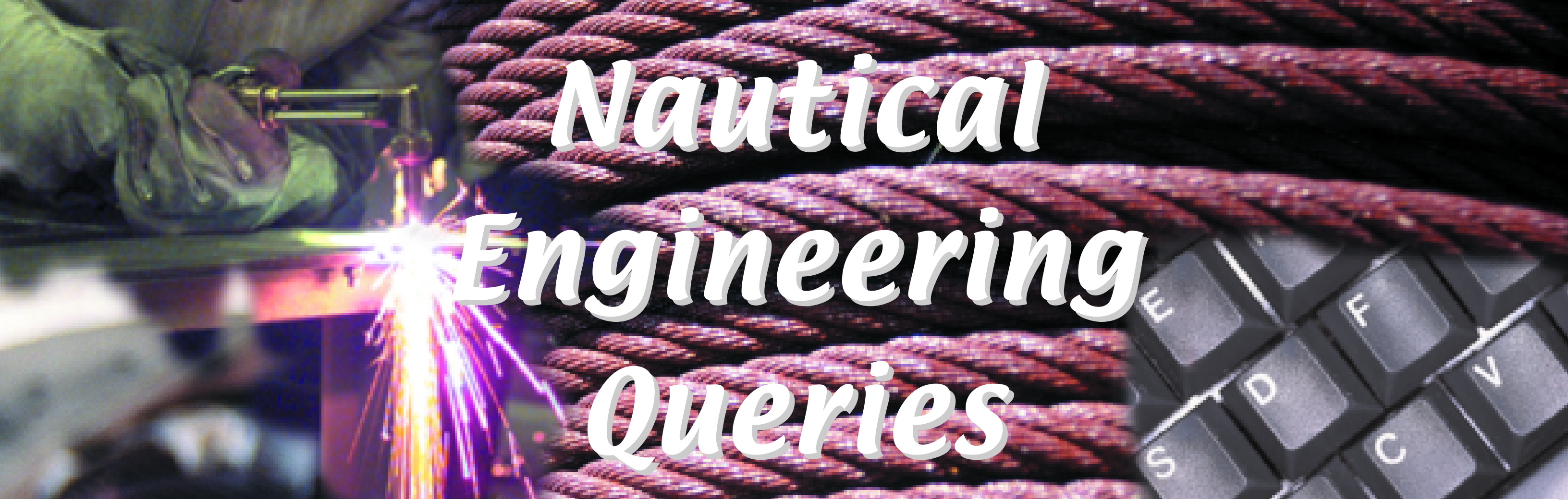
Technical training and analytical support: This category of service is often requested by and provided to Coast Guard Training Centers requesting technical presentations. Marine technical service is also available to field commanders following a marine casualty, where evaluation of technical elements is helpful in analyzing the sequence of events.

Direct plan review: Direct review of vessel designs has been MSC's bread-and-butter for many years. Critical engineering systems, structures, stability and life safety arrangements, for example, are reviewed directly by MSC engineers for a wide variety of vessel types. Performance-based plan review processes have been employed more recently where available standards are insufficient in addressing the merits of a novel design concept.

Third-party plan review on behalf of Coast Guard: Vessel and offshore platform designs and systems are often submitted to the American Bureau of Shipping, for example, for review on behalf of the Coast Guard, under Navigation and Vessel Inspection Circular (NVIC) 10-82. Similarly, authorized classification societies review and approve drawings and calculations on our behalf for several types of certificated vessels in accordance with the guidance in NVIC 2-95. The MSC conducts oversight review of this work with personnel having engineering and plan review skills, supporting third-party plan reviewers and field units with policy, interpretation of standards and technical assessments.

Third-party verification of plans: Under NVIC 10-92, plans reviewed and stamped by professional engineers or classification societies recognized by the Coast Guard for this program are given deference when reviewed for approval by MSC. The certification performed through this process adds a valuable risk mitigation element and contributes to the plan approval process.

Coast Guard review supported by contractor: The management model pursued in reviewing vessel security plans at MSC is an integrated arrangement using permanent employees and contract personnel. This model was designed to complete the review of a large volume of similar plans in a tight timeframe, enabling customers to implement approved plans and Coast Guard field offices to verify them.



Nautical Engineering Queries

1. If you have a simplex single acting reciprocating pump making 190 strokes/minute with a 3” diameter cylinder, a 9” stroke and operating with 90 percent volumetric efficiency, what is the capacity of the pump?

A. 94 gpm
Incorrect: This would be a correct answer for a duplex double acting style pump.

B. 47 gpm
Incorrect: This would be the correct answer for a simplex double acting or a duplex single acting style pump.

C. 24 gpm
Correct: See solution below.

D. 141 gpm
Incorrect: This would be a correct answer if the cross-sectional area of the water cylinder was presented as a cubed value.

Solution: Discharge capacity of pumps. The following formula is used to compute the discharge capacity of a water pump in gallons per minute:

$G = LANE/231$

G = The discharge of the pump, in gallons per minute.
L = The length of the stroke of the piston or plunger, in inches.
A = The cross-sectional area of the pump cylinder, in square inches.
N = The number of working strokes or discharge strokes per minute.
E = The efficiency of the pump. (100 percent minus the slip in percent)

Note: As the pump is a simplex (single cylinder) and is single action (one discharge for every two strokes) only half of the strokes completed in this example are "working" strokes.

$gpm = (9) \times (3 \times 3 \times .7854) \times (95) \times (.9) / 231$

gpm = 23.54 rounded off to 24 gpm

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2. Which type of screwdriver listed would have a “Keystone” type vertical cross-sectional tip?

A. Torx.
Incorrect: Torx tip has a six point horizontal cross section tip.

B. Phillips.
Incorrect: The head of a Phillips has an "X" shaped horizontal cross section tip.

C. Allen.
Incorrect: Allen tip screwdrivers are made from hexagonal bars of tool steel.

D. Standard.
Correct: Standard screwdrivers have a flat blade but when viewed vertically and from the side, have a “Keystone” shape.

3. According to the Pollution Prevention Regulations (33 CFR), which of the following conditions would disqualify a non-metallic hose as being suitable for use in transferring oil?

A. A cut in the cover which makes the reinforcement visible.
Incorrect: 33 CFR 156.120 (i) states that each transfer hose must have no unrepaired loose covers, kinks, bulges, soft spots, or any other defect which would permit the discharge of oil or hazardous material through the hose material and no gouges, cuts, or slashes that penetrate the first layer of hose reinforcement ("reinforcement" means the strength members of the hose, consisting of fabric, cord and/or metal). Since choice A only indicates that the reinforcement is "visible" and does NOT indicate that the reinforcement is damaged or has been penetrated, the hose would still qualify as being suitable.

B. A blown gasket when hydrostatic test pressure is applied.
Incorrect: Deficient gasket connections being indicated during a pressure test of the hose have no bearing on determining the strength of the hose since the gasket is not materially part of the hose.

C. Evidence of internal or external deterioration.
Correct: 33 CFR 156.170 (C)(1)(ii) requires that the hose have no external deterioration and, to the extent internal inspection is possible with both ends of the hose open, no internal deterioration.

D. All of the above statements are true
Incorrect: Choice A and Choice B are incorrect.

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4. If your ship burns three tons of fuel per hour at 19 knots, how many tons per hour will it burn at 15 knots?

A. 1.5 tons
Correct: A simplified rule of thumb for fuel consumption calculations is that a vessel's fuel consumption is proportional to the speed cubed, and represented by the solution below.

B. 1.9 tons
Incorrect: This would be the answer if the formula was solved as a direct proportion to ship speed squared.

C. 2.4 tons
Incorrect: This would be the answer if the formula was solved as a direct proportion to ship speed.

D. 5.3 tons
Incorrect: The fuel consumption must be less than three tons per hour because the vessel has decreased speed.

Solution:

$$\frac{\text{Old fuel consumption}}{\text{Old speed}^3} = \frac{\text{New fuel consumption}}{\text{New speed}^3} \qquad \frac{\text{3 tons per hour}}{19 \times 19 \times 19} = \frac{\text{X tons per hour}}{15 \times 15 \times 15}$$

$$\frac{3 \times 15 \times 15 \times 15}{19 \times 19 \times 19} = \text{X ton per hour} \qquad \frac{10125}{6859} = \text{X ton per hour} = \textbf{1.48 tons per hour}$$

1. A vessel is signaling to you by flag hoist, and the answer pennant is hoisted close-up. You should __________.
Note: A naval vessel might communicate with a merchant vessel by flag hoist while under the constraint of radio silence. The term "close-up" means that the flag or group of flags is hoisted all the way up to the yard, which is the horizontal spar extending from a mast to which the signaling halyards are rove. In this scenario, the signaling vessel is indicating that signals have been completed.

A. hoist flag "C"
Incorrect: The hoisting of flag "Charlie" would indicate an affirmative answer to a question that had been asked by the vessel signaling.

B. wait for further signals, after a short delay
Incorrect: If the vessel sending the signal wanted you to wait, it would have hoisted "Alfa-Sierra".

C. hoist flag "R"
Incorrect: Although "Romeo" means received, the appropriate reply should indicate your understanding of the fact that the other vessel is finished signaling. See choice "D."

D. expect no further flag hoists
Correct: You would hoist your answer pennant close-up to indicate that you understand that the other vessel is finished signaling.

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2. A jack-up rig, while level in transit at a ten-foot draft, experiences a wind gust, which results in a starboard draft of 11 feet, 6 inches. What is the heel?
Note: Heel is the difference between the port and starboard drafts that is caused by environmental conditions. If a difference between these drafts exists because of off-center weight, it is called list.

A. 1 foot 6 inches to starboard
Incorrect: The starboard draft has increased by 1 foot 6 inches due to the wind gust. However, this measurement expresses only half of the heel.

B. 3 feet to starboard
Correct: An increase in starboard draft of 1 foot 6 inches implies a decrease in port draft of the same measurement. The difference between these two drafts is 3 feet. The direction of heel is to starboard.

C. 3 feet to port
Incorrect: Three feet is the correct amount of heel. However, the heel is to starboard.

D. 1 foot 6 inches to port
Incorrect: The heel is twice this amount and in the opposite direction.

3. Which vessel is NOT required to have a "Pollution Placard" posted onboard?
Note: The requirement for the placard is stated in 33 CFR 155.450. The placard must be at least 5x8 inches and displayed in a conspicuous location. It is required on all US and foreign vessels in US waters, except those less than 26 feet in length and those vessels that not governed by the pollution regulations of 33 CFR 155. The text of the placard is a summary of the Federal Water Pollution Control Act.

A. 215-foot naval auxiliary vessel
Correct: Part 155 does not apply to: "A warship, naval auxiliary or other ship owned or operated by a country when engaged in non-commercial service."

B. 75-foot towing vessel
Incorrect: All towing vessels of 26 feet or more in length are required to have the placard.

C. 50-foot cabin cruiser used for pleasure only
Incorrect: The placard is required on all pleasure boats of 26 or more feet in length, as well as commercial vessels.

D. 150-foot unmanned tank barge
Incorrect: The requirement for the placard is the same for all tank barges; manned or unmanned.

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4. You must pick up an individual who has fallen overboard from a sailboat. The final approach should be __________.
Note: The recovery of the person is best accomplished if the vessel is positioned such that the person in the water is immediately to leeward (downwind) of the vessel. By so doing, the wind will keep the vessel adjacent to the person being rescued. Vernacular: **Close-hauled**–Pointing as close to the wind as is efficient with the sails hardened right in. **Close Reach**–Sailing between close-hauled and a beam reach. **Beam Reach**–Running free with the wind on the vessel's beam. **Broad Reach**–Sailing between a broad reach and a downwind run.

A. upwind
Incorrect: Although it is easier to reduce speed quickly when close-hauled as the vessel under sail approaches the person in the water, it is more difficult to remain alongside the individual. If the sailing vessel loses headway short of the person, wind and sea will set the vessel to leeward of the person.

B. downwind
Incorrect: This is the worst approach to make because of the inability to reduce speed without considerable maneuvering.

C. on a close reach
Correct: The most effective way to stop a vessel under sail is by "sheeting-out" the sails while on a close reach. This would be done when the vessel is immediately to windward of the person in the water.

D. on a broad reach
Incorrect: It is undesirable to approach with the wind from anywhere abaft the beam. The farther aft the wind, the greater the maneuver to stop the vessel will have to be.


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