

# **Safety Through Process Management – Lessons Learned at Production Facilities for California Offshore Oil and Gas**

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## ***Abstract***

This paper discusses the Lessons Learned from Safety and Oil Spill Prevention Audits conducted at Oil and Gas Production Facilities in California. Since 1999, the Mineral Resources Management Division has conducted Safety and Oil Spill Prevention Audits to identify and correct conditions that could threaten the public or the environment. The program has completed Audits at 15 of the 20 State Lease and other State revenue facilities with over 5,100 action items identified and over \$5 million spent on needed upgrades. Common items found result from age of the facility, changes in codes, standards, and regulations, and revisions in the American Petroleum Institute Recommended Practices. Identification of common items and their apparent causes may help operators assess their operations for similar conditions and avert potential accidents or spills. After a Safety and Oil Spill Prevention Audit the monthly MRMD inspection results commonly show improvement. This translates into reduced risk to the public, personnel, and the environment.

## ***Introduction***

The Safety and Oil Spill Prevention Audit Program began with an initial Safety Audit at platform HOLLY in 1999. Over 300 action items were identified demonstrating a clear need for comprehensive auditing. The quantity and significance of the identified audit items prompted MRMD staff to re-evaluate the facility inspection and oil spill prevention program. There was concern that there were gaps in the monthly inspection programs because the inspection specifics were prescribed by regulation. The conclusion was that the inspection program could not alone ensure safe operation of these facilities. Most of the oil and gas production facilities are over 30 years old and typically employ older control and safety systems with limited capability compared to more current technology. Production and processing systems have undergone significant changes since the inception of platform operations. Employing a more comprehensive audit/inspection program was seen as an essential environmental protection initiative that could significantly decrease the likelihood of environmental damage. Additional audits used electrical, petroleum, chemical, and mechanical engineers to conduct comprehensive evaluations of the operation. These experts would assess age and conditions of the equipment, pipelines, design of the facility, human organizational factors, mechanical and electrical maintenance and programs using a whole system approach. These audits took a

comprehensive look at conformance with all applicable federal, state, and local laws and regulations and accepted industry standards. Areas or gaps that had not been addressed by the existing inspection program were evaluated and in some instances, the inspection program was adjusted or expanded. The safety audit program has been operating in current form since 2000, and 15 of the 20 planned facility audits have been completed.

### ***Authority and Scope***

Safety Audits of State tideland oil and gas leases are conducted primarily under CSLC's inspection authority which is provided by California Public Resources Code (PRC) 6103, 6108, 6216, 6301, and 6873 (d). CSLC MRMD Regulations are based on this authority and are contained in the California Code of Regulations, Title 2, Div 3, Chapter 1, Articles 1 through 11. Oil and Gas Production Regulations are contained in Article 3.3 and concern the protection of human health, safety, property, pollution, the environment, and natural resources. This article provides the specific requirements for required safety systems, equipment, and testing for offshore facilities including platforms as well as upland locations serving these leases. *These regulations establish the requirement that the API Recommended Practice RP14C titled Analysis, Design, Installation, and Testing of Basic Surface Safety Systems on Offshore Platforms be the basis for offshore production facilities unless otherwise provided for in the regulations.*

Sections 2129 (b) and 2133 (b) of Article 3.3 further specify that the lessee for these oil and gas leases shall comply with all applicable laws, rules, and regulations of the United States, the state of California, and any respective political subdivision thereof. Sections 2129 (c) and 2133 (c) require operations to be conducted in a proper and workmanlike manner in accordance with good oilfield practice. These sections clearly bring applicable federal, state, and local requirements as well as common industry standards to bear on these facilities and are subject to verification through inspection or audit. This produces some degree of duplication, such as with the API Recommended Practice RP-750 on Management of Process Hazards, OSHA regulation 29 CFR 1910.119 on Process Safety Management of Highly Hazardous Chemicals, and the similarly titled Cal OSHA regulation 5189 on Process Safety Management of Acutely Hazardous Materials. *It is these safe management standards that bring some of the most effective safety design and analysis requirements to the oil and gas facilities, particularly those onshore.*

Pollution control is a particular emphasis within the MRMD and other state regulations. Article 3.4 of the MRMD regulations on Oil and Gas Drilling and Production Operations: Pollution Control, contains specific requirements for operations, plans, and equipment. In Section 2135(a) the CSLC staff shall administer this article and seek to provide for the prevention and elimination of

pollution, prevention of waste of natural resources, protection of human health and safety, and the protection of property. The highly publicized Lempert, Keene, Seastrand Oil Spill Prevention Act strengthened the oil spill prevention requirements in California. Public Resources Code Section 8757(a) contains the requirement for the CSLC to regularly inspect all marine facilities and monitor their operations and their effects on public health and safety, and the environment. The definition of marine facility within these regulations includes the state offshore facilities and related production or processing facilities onshore. Oil producing platforms and islands located within state waters (3 nautical miles) fall under the definition as marine facilities. Upland locations that produce oil and gas from state leased tidelands are also usually considered marine facilities. Onshore processing facilities that serve federal leases on the Outer Continental Shelf also fall within the definition of marine facility, but are currently not included in the audit program. Marine terminals are another type of marine facility. There are 74 marine terminals within the state that are inspected by the CSLC Marine Facilities Division and are not included within the MRMD audit program. *The spill prevention regulations bring requirements for use of best available protection technologies that promote the updating and upgrading of oil and gas facilities.*

### ***Safety Audit Approach***

Each Safety Audit is an in depth verification that an oil and gas facility producing from a state lease complies with all applicable federal and state laws and regulations, follows industry standards, and continually re-evaluates and incorporates best achievable technology to safeguard the public and the environment. Each safety audit has five main areas or teams:

- Equipment Functionality and Integrity
- Technical design
- Electrical condition, maintenance, and design
- Administrative
- Human Factors and Safety Management

The teams identify action items with priorities and recommendations that are provided in a matrix as well as a written report that highlights significant problems or design issues.

The **Equipment Functionality and Integrity Team** examines the physical condition of the facility including operational and maintenance practices and the proper functioning of safety and spill prevention and response systems and equipment. The team verifies the accuracy of Process and Instrumentation Diagrams (P&IDs), Emergency and Spill Response Equipment diagram, Process Flow Diagrams, and observes required periodic testing of this critical equipment. They review preventive maintenance procedures, equipment specification

information for maintenance and design selection of equipment. The team verifies that important tank, pressure vessel, and safety relief valve inspections follow code or recommended industry practices and complete tables of information that summarize this information. They also verify that Cathodic and other corrosion protection system inspections, piping assessment, and pipeline integrity inspections, including smart pigging or hydrostatic tests, are occurring on schedule.

The **Technical Team** conducts a review of the design of the facilities for compliance with MRMD regulations for oil and gas production facilities as well as other requirements and standards. The design of offshore facilities should follow the guidelines provided in API RP-14J Recommended Practice for Design and Hazards Analysis for Offshore Production Facilities. In particular, the MRMD regulations prescribe that safety systems meet API RP-14C Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms. Onshore oil and gas production facilities normally come under the Cal OSHA version of Process Safety Management requirements contained in regulation 5189. A similar industry standard is available in API RP-750 on Management of Process Hazards. Each of these requires that some type of Process Hazards Analysis (PHA) be conducted to identify appropriate safeguards and operations. Existing PHAs are normally reviewed for quality, adequacy of supporting process safety information, appropriate analysis technique, all hazards addressed, proper documentation, and meeting all requirements. The Safety Audit may provide valuable guidance for areas to address at the operator's next PHA revalidation.

The sizing of pressure safety relief valves and the relief system are also checked by the Technical Team as well as the coordination of a review of the various detection systems and fire protection systems by a qualified fire protection engineer. Finally, verification of other design requirements involves verification of adequate containment volumes as identified in the Spill Prevention and Control Countermeasures (SPCC) Plan.

The **Electrical Team** examines the physical condition of the electrical systems including operational and maintenance practices as well as proper design and installation to meet applicable code requirements. This includes field verification of one line diagrams and hazardous location area classification diagrams. Specific requirements for backup, auxiliary, or emergency power, as well as electrical controls, communications, and other related equipment is also addressed. The Electrical Team combines the condition and diagram assessment functions of the Equipment Functionality and Integrity Team with the design validation work of the Technical Team on a system specific basis. This maximizes efficiency and benefits from the expertise of the contract electrical engineer.

The **Administrative Team** reviews the various manuals, plans, policies, procedures and practices, emergency response plans, training programs, and safe work practices for compliance with laws, regulations, or industry standards. The team also evaluates the use and application of this information by personnel at the facility. This team addresses process safety management issues from a documentation or management standpoint much like the required internal audits required by the various PSM standards. The work of this team typically occurs before the Human Factors Team conducts a Safety Assessment of Management Systems (SAMS) audit.

The **Human Factors Team** conducts a Safety Assessment of Management Systems (SAMS) that is based on interviews of company personnel and contractors at all levels of the organization. While this activity is within the structure of the Safety Audit, the results of the SAMS are confidential and provided in a separate report. The SAMS is an evaluation of the implementation of Process Safety Management Guidelines as seen from the perspective of the employee, supervisor, manager, and contractor. This assessment can enlighten management to actual status in the field, indicate relative strengths and opportunities, and to stimulate continuous improvement. There are no action items identified by this team for Safety Audit report. The SAMS does provide a separate and confidential report intended for impartial third party feedback. Often, SAMS findings are indicative of the root causes for action items identified during a Safety Audit. Observations regarding apparent root causes and related management conditions are mentioned in the Lessons Learned section of this paper.

### ***Results and Benefits***

Since 1999, fifteen of the twenty oil and gas facilities subject to state review have been audited. Over 5100 action items have been identified and all but a few dozen action items from recent audits have been resolved. A total of over \$5 Million dollars has reportedly been spent at these facilities on needed upgrades and maintenance since audit completions. The following table shows the Priority levels that action items may be assigned:

**Priority One: High** risk potential for injury, oil spill, other adverse environmental impacts, or significant property damage. *Facility or equipment may exhibit serious degradation or misuse.*

(30 days allowed to complete from final report)

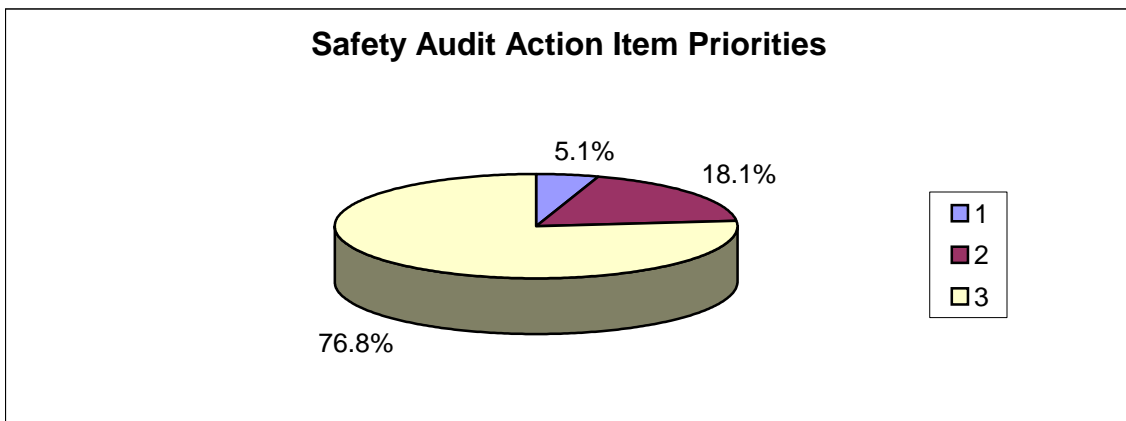
**Priority Two: Moderate** risk potential for injury, oil spill, other adverse environmental impacts, or property damage.

(120 days allowed to complete from final report)

**Priority Three: Low** risk potential for injury, oil spill, other adverse environmental impact, or property damage.

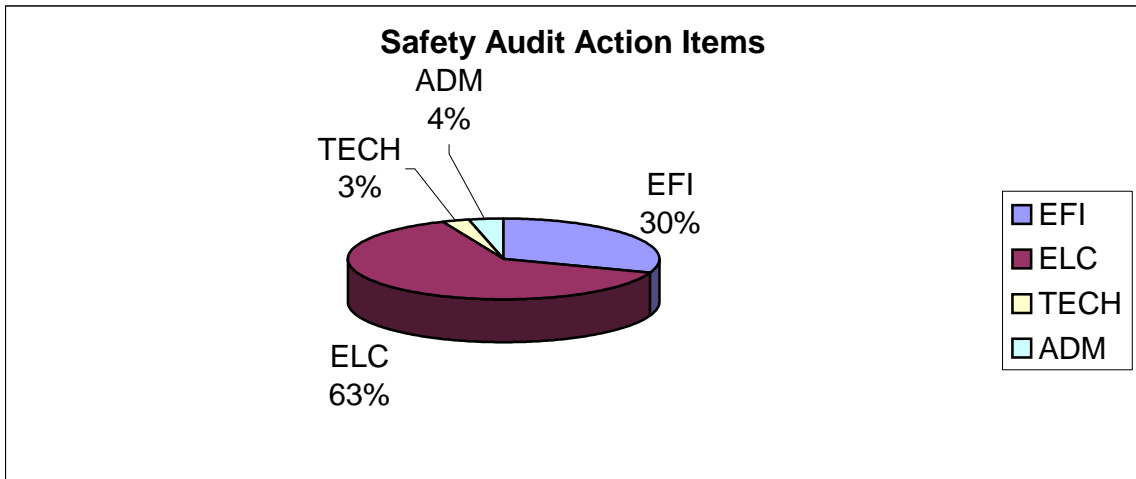
(180 days allowed to complete from final report)

The distribution of action items by Priority level is shown in the following chart and table:



PRIORITY	Total	Average
1	262	5.1%
2	922	18.1%
3	3911	76.8%
<b>Grand Total</b>	<b>5095</b>	

The identification of action items by each Team is presented in the following chart and table:



TEAM	Total	Average
Equipment Function & Integrity	1479	30%
Electrical	3062	63%
Technical	136	3%
Administrative	180	4%
<b>Grand Total</b>	4857*	

\* HOLLY Audit not included since breakdown by Team was not available.

The chart shows that the majority of items are identified by the Electrical Team, followed by the Equipment Functionality - Integrity Team. These items include the review of required plans and drawings to verify they are up to date, as well as condition or maintenance problems found. The Electrical Team action items also include any electrical system design problems identified where the overall facility design, piping, and processing equipment design problems are located in the separate Technical Team action items. This helps explain to some extent why the number of electrical action items appears comparatively large. The number of electrical action items also appears large because of the potential risks involved with these condition, design, or rating problems. Each instance is normally called out separately to ensure that each location is located and corrected. This happens to a much lesser extent with common maintenance conditions on mechanical equipment or piping where problems may be grouped into one action item.

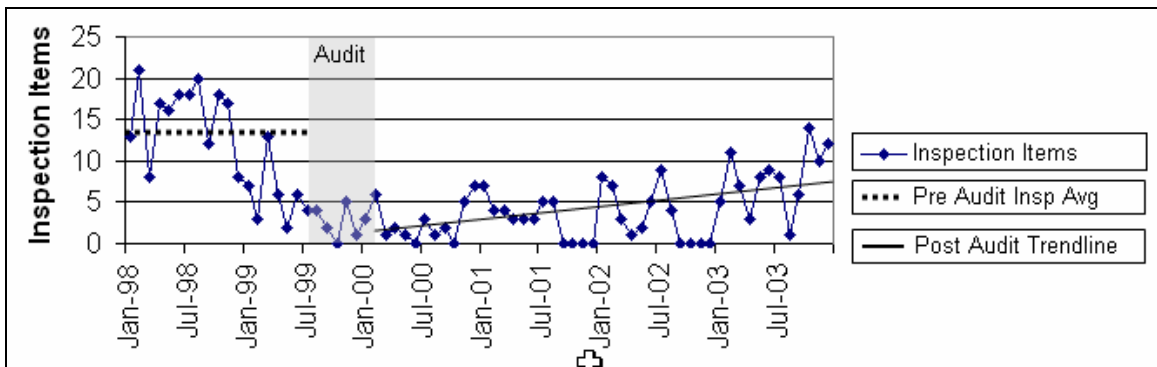
A similar grouping effect occurs with the Administrative Team where common problems found in Operations Manuals or other Instructions are grouped together

into a single common action item. Administrative Team action items also tend to be Priority 3 items because of their low likelihood to initiate a catastrophe and the prerequisite chain of events that must occur.

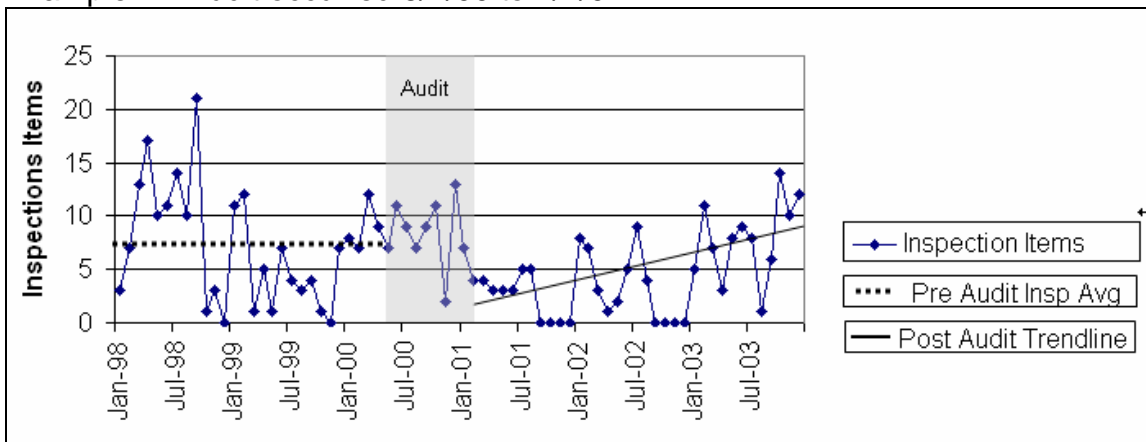
Technical Team action items are among the least common, but may be the most critical for correcting to prevent accidents or catastrophes because they deal with the facility design and required safety features. These items tend to show up as a Priority 1 or 2 action item.

The MRMD inspection program has received fine-tuning as a result of the Safety Audit at each facility. Testing of the integrated safety system and other critical systems and equipment is reviewed during the audit and adjusted so as to follow accepted practices, improve consistency, and to maximize reliability or level of confidence established by the testing. Safety system performance and monthly MRMD inspection results show a clear improvement for many months after a Safety Audit. Both the improved reliability as proven at the monthly inspections as well as the physical and management improvements made at these facilities directly translate into reduced risk to the public, personnel, and the environment. The following charts show MRMD monthly inspection results leading up to, during, and after safety audits at those facilities.

Example A. Audit occurred 4/26/99 to 11/1/99

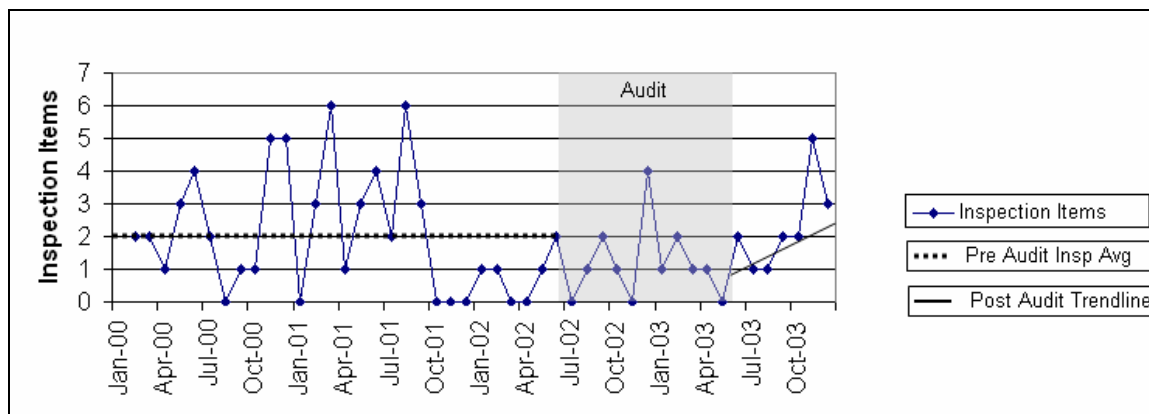


Example B. Audit occurred 6/1/00 to 2/7/01





Example C. Audit occurred 5/14/02 to 5/7/03



**Lessons Learned**

The lessons learned from five years worth of safety audits are many. Commonly found items can be screened for and addressed by other operators in advance of an audit. The result can be a better audit performance with fewer action items and ultimately less risk. Operators can also use this information to augment their own internal audits and inspections to avert potential accidents and spills.

Many of the electrical action items were the result of years of service in the harsh marine environment. Many junction boxes, conduit, and enclosures were found damaged or corroded to where they could not function as designed. Cable tray systems that were heavily corroded or in disrepair produced a significant number of action items. Bonding and grounding of equipment and tanks also proved to be a very common action items. Some of the causes that enabled these occurrences included having no electrical engineering support other than on a project basis. In this type of instance, electricians establish a schedule of preventive maintenance, but may not have knowledgeable management support when plant maintenance hours are in question. Electrical Engineers may be used as consultants, but this often occurs only for new projects and there is no periodic review of electrical single line diagrams, hazardous area classification drawings, or compliance checks with updated versions of the electric code. Furthermore, there is often little or no expertise available, without an electrical engineer available, to check on the work practices and adherence to code by company or contract electricians and instrument technicians. Periodic review by an independent electrical engineer can identify what your electrician or contract electricians are doing for you or to you.

A number of the Equipment Functionality and Integrity action items occurred because operators appeared unaware of needed internal tank and pressure vessel inspections and records. In some cases, this seemed to occur because of

limited facility and maintenance engineering support, a symptom similar to the lack of electrical engineering support. A planned schedule for all tank and pressure vessel internal inspections and ultrasonic thickness measurement should be available. Further, piping and pipeline maintenance assessment and scheduling of maintenance and repair can also avert spills. Companies with engineering staffs that work on a project basis often had limited knowledge of the facility or current maintenance issues, and could provide only limited assistance to auditors. In these instances, operations and maintenance personnel appeared to have a lesser understanding of many of the important design features often known or provided by a facility engineer. Piping and Instrumentation Drawing errors also accounted for significant numbers of lower Priority action items. Often this occurred because operators were given little or no instruction on how to maintain corrections (red-lines) to these drawings or little information on the importance of these in Management of Change type systems. Generally, operators did well with standard Health and Environmental Safety requirement compliance due to dedicated staff and clear responsibility.

Commonly identified Technical issues included inadequate general alarm and evacuation alarms at onshore facilities. Operators of onshore processing facilities also balk at applicability of Process Safety Management (PSM) regulations, yet American Petroleum Institute Recommended Practice (API RP 750) clearly provides these as recommended practices for this oil and gas production industry. Process Hazards Analyses (PHAs) or Hazards Operability Studies (HAZOPs) are tools within PSM that are effective in identifying and managing risks at these types of facilities. Many of the facilities had previous PHA or HAZOP studies on file; however, some operators had not implemented corrections, or proceeded with new projects without evaluating the available information. Other operators actively used the HAZOP Information to manage and even lower their most likely risks. One operator has made dramatic improvements in the number of gathering line leaks by putting an annual piping hydrotest program in place.

### ***Conclusion***

In today's environment, the safety and environmental practices of any individual operator impacts the entire industry. The agencies responsible for these operations must realign and supplement their activities to adequately handle changing standards and technologies. The Safety Audit Program is an example of such activity to supplement existing inspection programs. The program is proving to ensure, in cooperation with the operator, that each facility is designed, constructed, maintained, monitored, and operated in full compliance with applicable industry codes, regulations, and accepted practices and ensure that each company has adequate safety and environmental programs in place.

## ***Author's Biography***

Mark Steinhilber is currently serving as a process safety engineer heading the MRMD's Safety Audit Program, having been with the program since April 2000. He retired after 20 years of engineering and operational service to the U.S. Coast Guard in June 2000 at the rank of Lieutenant Commander. During his CG career, LCDR Steinhilber led Marine Safety, Investigation, Vessel Inspection, Port Security, and Spill Contingency Planning staffs in northern and southern California and holds marine inspector and accident investigation qualifications. He was previously a staff engineer in Washington D.C. and New Orleans reviewing designs for new and modified tankers, chemical ships, gas ships, barges, and mobile offshore drilling platforms. He earned mechanical engineering P.E. from Virginia in 1988. He holds Master's Degrees in Mechanical Engineering and in Naval Architecture and Marine Engineering from MIT (1987) and a BS Degree in Naval Architecture and Marine Engineering from the U.S. Coast Guard Academy (1980.)

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