

The US Navy's Submarine Safety Standards

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The US Navy's Submarine Safety Standards



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U.S. Navy's Submarine Safety Standards



While engaged in a deep test dive approximately 200 miles off the northeast coast of the United States,

USS THRESHER was lost at sea with all aboard

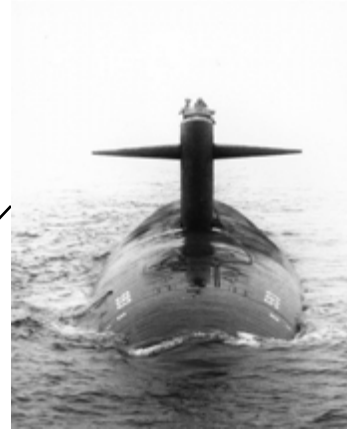
112 Officers and Enlisted; 17 civilians



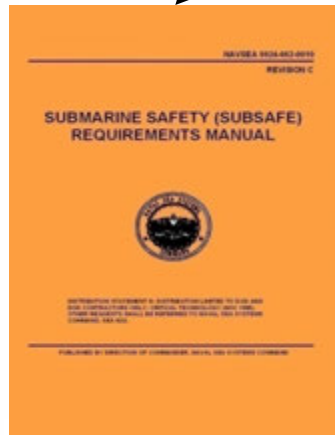
U.S. Navy's Submarine Safety Standards



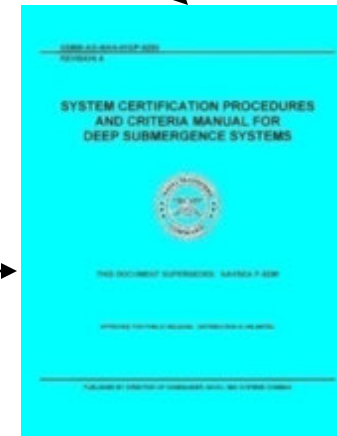
Inception of the SUBSAFE and DSS Programs



Loss of
THRESHER



June 1963



February 1964

SUBSAFE
Program

DSS
Program



U.S. Navy's Submarine Safety Standards



- The purpose of the SUBSAFE Program is to provide "maximum reasonable assurance" of:
 - Hull integrity to preclude flooding
 - Operability and integrity of critical systems and components to control and recover from a flooding casualty



U.S. Navy's Submarine Safety Standards



- The purpose of the Deep Submergence Systems Program is to provide "*maximum reasonable assurance*" that a material or procedural failure that imperils the operators or occupants will not occur.
 - Focused on operability and integrity of critical systems and components and the associated maintenance and operational procedures required to prevent injury to personnel



U.S. Navy's Submarine Safety Standards



- **Fly-By-Wire Ship Control System (FBW SCS) Certification Program**
 - With the advent of “Fly-By-Wire” ship control designs in submarines, NAVSEA recognized the need for a certification program for this “new” technology.
 - FBW SCS Requirements Manual was promulgated in 2004.
 - Similar to SUBSAFE, **the FBW SCS Program objective is to provide *“maximum reasonable assurance”* that the FBW SCS will not cause a casualty or prevent ship recovery from a flooding or control surface jam casualty**
 - Focused on Submarine Flight Critical Components (SFCCs) - Electronic Hardware and Software that process safety critical functions and data elements



High Reliability Organizations



■ Performance:

- Manage complex, demanding technologies so as to avoid major failures
- Perform exacting tasks under considerable time pressure
- Perform work with no catastrophic failures over long periods of time

■ Their success can be attributed to their culture:

- Collective preoccupation with the possibility of failure
- Robust processes
- Passion about excellence in execution
- Well trained workforce
- Compliance Verification



High Reliability Organizations



- **A Strong Culture Combats:**
 - Inadequate process definition
 - Inadequate process control and change control
 - Failure to follow procedures
 - Failure to stop work when unusual conditions encountered
 - Inattention to detail
 - Lack of discipline
 - Lack of technical oversight
 - Lack of management involvement



U.S. Navy's Submarine Safety Culture

Foundational Elements



- **Responsibility**
 - A duty, obligation, or burden
- **Accountability**
 - The state of being answerable for one's actions (implies consequences)
- **Integrity**
 - Rigid adherence to a code of behavior



U.S. Navy's Submarine Safety Culture

The Fundamentals



- **Work Discipline**
 - Knowledge of and Compliance With Requirements
- **Material Control**
 - Correct Material Installed Correctly
- **Documentation**
 - Design Products (Specs, Drawings, Maintenance Standards, etc.)
 - Objective Quality Evidence (OQE)
- **Compliance Verification**
 - Inspections, Surveillance, Technical Reviews, Audits
- **Separation of Powers**
- **Continual Training**



U.S. Navy's Submarine Safety Culture Compliance Verification



- **Multi-layered approach**
 - Contractor/Shipyard/Activity responsibilities
 - Inspections, Surveillances, Document Reviews, Audits
 - Local government oversight authority responsibilities
 - Inspections, Surveillances, Document Reviews, Audits
 - Headquarters responsibilities
 - Document Reviews, Audits
- **Multi-faceted approach**
 - Ship/System Certification Audits
 - Facility Functional Audits



NAVSEA
Headquarters

U.S. Navy's Submarine Safety Culture Compliance Verification



USS TUCSON

- **Certification Audits:**
 - Ship/System Specific
 - A critical element for certification for sea trials and unrestricted operations

- **Functional Audits:**
 - Facility specific review
 - Policies
 - Procedures
 - Practices
 - Verifies organizational compliance with SUBSAFE/DSS Program requirements



Portsmouth Naval Shipyard



U.S. Navy's Submarine Safety Culture

Compliance Verification



Controlling Work Aboard US Navy Submarines and Deep Submergence Systems

- Only Qualified and Authorized Firms work on submarines and DSS systems
- In 1996 heavy workloads created a capacity shortage among submarine yards
- NAVSEA established instructions to qualify a firm to do submarine work
- Focus of controls is on repair and maintenance work performed onboard the submarine, rather than components worked at suppliers facilities



U.S. Navy's Submarine Safety Culture

Compliance Verification



Controlling Work Aboard US Navy Submarines and Deep Submergence Systems

- Suppliers of new material and Original Equipment Manufacturers are exempt
 - Procurement process for these organizations ensures compliance
- Navy wide notice is issued annually listing authorized firms and yards
- A functional audit of each authorized activity is conducted every two years
- Firm remains on the list provided the audit results are satisfactory



U.S. Navy's Submarine Safety Culture Compliance Verification



■ Internal Audits

- Prior to any NAVSEA Functional or Certification Audit, each activity conducts an internal audit to self identify and correct any problems
- Allows them to gage their own knowledge, awareness, and compliance against future NAVSEA results

■ Self Assessments

- Each activity prepares a self assessment annually to report how the activity grades itself on compliance with the program requirements.
- Includes metrics derived from internal and external audit results, problem reports and root cause analyses, and submarine test report deficiencies

■ Trouble Reporting

- Each activity is required to report significant problems to alert the community so that they can establish preventive actions before those problems might occur elsewhere
- Underlying document is called a "critique" and includes a full analysis of the causes and corrective/preventive actions taken to resolve them.



U.S. Navy's Submarine Safety Culture

Compliance Verification



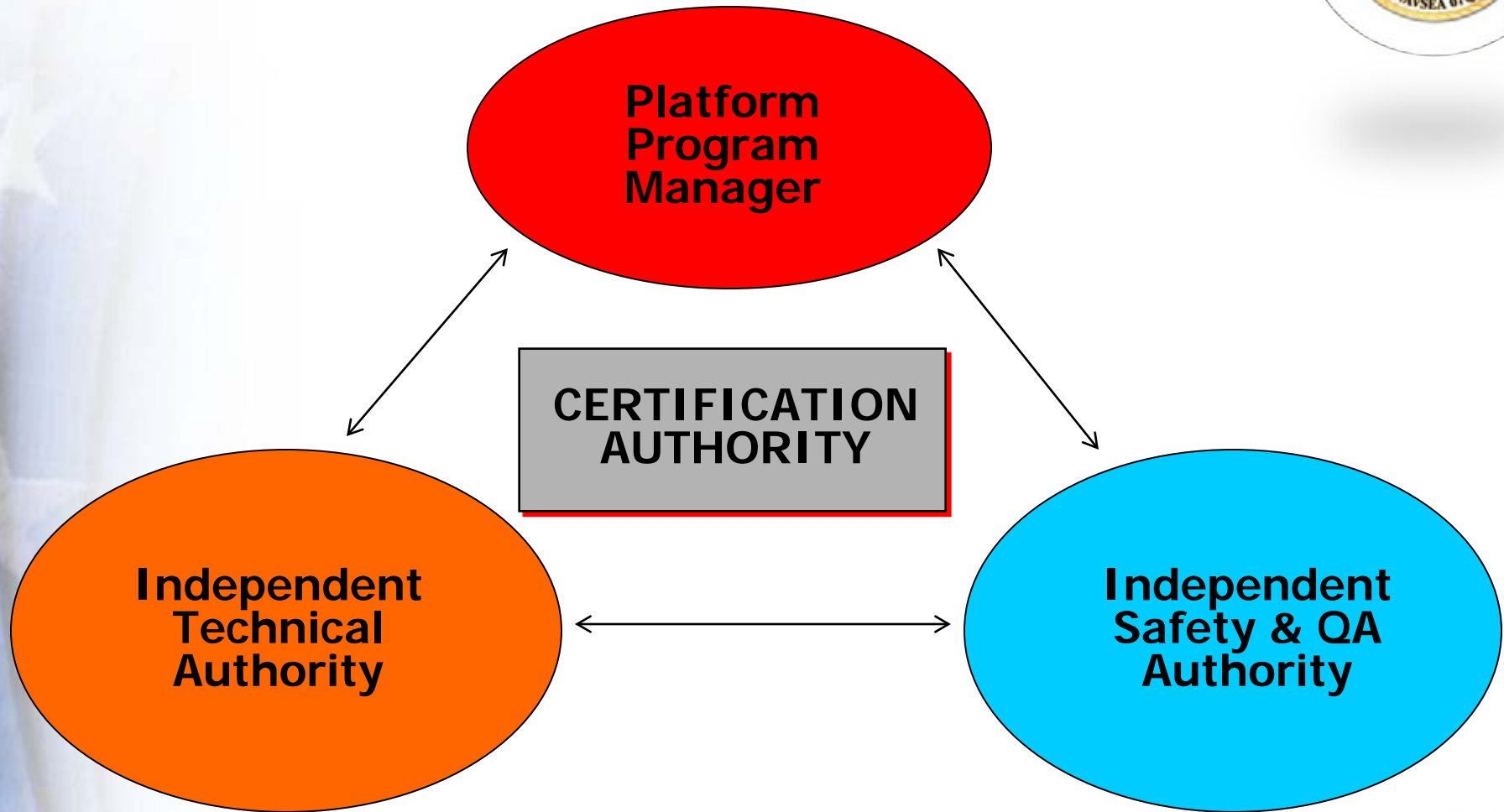
Why does the submarine Navy invest so much in compliance verification?

- Because the consequences of failure are unacceptable.
- Because the pressures of cost and schedule are great.
- Because an honest mistake can kill you just as dead as malpractice.



U.S. Navy's Submarine Safety Culture

Separation of Powers



U.S. Navy's Submarine Safety Culture

Continual Training



- **SUBSAFE, DSS, & FBW Awareness Training is required for all personnel, from entry level workers to 3-star Admiral**
- **Annual Requirement**
- **Must achieve passing score on associated exam**
- **Training provides:**
 - Overview of the program and importance of program fundamentals
 - Reinforcement of compliance with requirements
 - Emphasis on proactively correcting and preventing problems
 - Recent lessons learned and a reminder of consequences of complacency



U.S. Navy's Submarine Safety Culture

Continual Training



THRESHER Anniversary

- **2008 – Gene Kranz**
 - NASA Flight Director for Apollo Missions
 - “Failure Is Not An Option” – Apollo 13
- **2009 – VADM Bruce Demars (Ret)**
 - Former Director of Naval Nuclear Propulsion
 - Spoke about importance of oversight and acceptance of responsibility
- **2010 – CDR John Dyer (Ret)**
 - Lead Engineer for NAVSEA Submarine Type Desk SUBSAFE support contract
 - Spoke about the beginnings and formulations of the SUBSAFE program in the 1960’s



U.S. Navy's Submarine Safety Culture

Continual Training



THRESHER Anniversary

- **2011 – Lori Arsenault**
 - Daughter of a USS THRESHER crewmember
 - Gave a personal perspective on the tragedy
- **2012 – CAPT Joseph F. Yurso (Ret)**
 - Former Commanding Officer of SOSG and PNS
 - Spoke about being a Shipyard Watch Officer when message came in that the USS THRESHER was lost
 - Discussed change in “quality control” after the tragedy and the importance of oversight



U.S. Navy's Submarine Safety Culture Continual Training



50th USS THRESHER Anniversary Commemoration 10 April 2013



**The Honorable Donald C. Winter,
74th Secretary of the Navy**

**Lessons (Sometimes) Learned and
Often Forgotten**

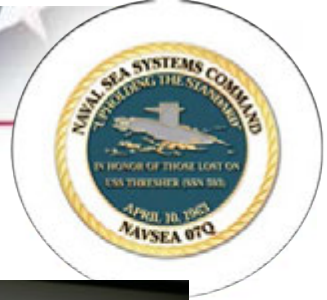


**Tolling of the Bells ceremony
and reading of the names of those
lost on USS THRESHER**



U.S. Navy's Submarine Safety Culture

Continual Training



GRAYBACK Anniversary

- **2009 - CDR David Kelly**
 - Served aboard USS GRAYBACK
 - Provided retrospective on Diving Accident

- **2010 - CW04 Patrick Broderick (Ret)**
 - Former Underwater Demolition Team member who conducted Swimmer Delivery Vehicle operations from USS GRAYBACK
 - Gave the perspective as a teammate of the men lost onboard



U.S. Navy's Submarine Safety Culture

Continual Training



GRAYBACK Anniversary

- **2011 - CAPT Keenan**
 - U.S. Navy's Director of Ocean Engineering, Supervisor of Salvage and Diving
 - Spoke about the chain of events before and after the Deepwater Horizon Oil Spill

- **2012 - Bryan Hughitt**
 - Manager of Quality Assurance at NASA's Office of Safety and Mission Assurance
 - Spoke about engineering failures with the Big Dig and Turkish Airlines Flight 981

The Naval Sea Systems Command
Proudly Presents:



CAPT Patrick Keenan
**USS GRAYBACK
DIVING ACCIDENT
RETROSPECTIVE**
Friday, 21 January 2011
0900-1000
NAVSEA Auditorium
Building 197, Washington Navy Yard



U.S. Navy's Submarine Safety Culture

Continual Training



- **NAVSEA's Senior Manager's Workshop**
- **NAVSEA's School Of The Boat**
- **MIT's Submarine Concept Design Course**
- **Audit Outbriefs include Senior Level Representatives**
- **Training materials available to Field Activities upon request**
- **Open offer to Field Activities to provide trainings and briefs**



U.S. Navy's Submarine Safety Culture Challenges



The U.S. Navy's Safety Program has a very successful history; however we must be aware of the program's greatest threats.



U.S. Navy's Submarine Safety Culture Challenges



- **Ignorance**
 - The state of not knowing
- **Arrogance**
 - The habit of behaving based on pride, self-importance, conceit, or the assumption of intellectual superiority and the presumption of knowledge that is not supported by facts
- **Complacency**
 - Satisfaction with one's accomplishments accompanied by a lack of awareness of actual dangers or deficiencies



U.S. Navy's Submarine Safety Culture Challenges



- Declining Budgets
- Workforce Changes
- Fraud
- Short Memories
- Changing mindset of community without “Pinnacle Event”



U.S. Navy's Submarine Safety Culture Challenges



Case 1: Pipe without all required testing was installed in critical submarine applications.

Summary:

- A military specification issued in 1987 contains requirements for pipe used in military applications. The specification requires purchasing of commercial grade material in accordance with ASTM requirements with additional testing requirements. When the military specification was first issued, the ASTM requirements closely mirrored those of the military specification.
- Over the years, the ASTM specification was revised, making some tests optional or eliminating some tests completely; however, the intent was for these tests still to be performed per the military specification.
- Piping distributors interpreted that the removal of the requirements from the ASTM specification meant they did not have to perform the testing. They discontinued some testing and began performing optional testing in lieu of other required testing.



U.S. Navy's Submarine Safety Culture Challenges



Summary (Continued):

- Navy receipt inspection personnel also misinterpreted the changes in the ASTM specification and did not recognize that the tests specified by the military specification were still required.
- Numerous shipments of material without all required testing were delivered to the Navy, accepted at receipt inspection, and installed in critical applications on submarines.
- The Navy has had to determine the technical acceptability and process a departure from specifications for each instance where this pipe installed.



U.S. Navy's Submarine Safety Culture Challenges



Case 2: Nickel Copper Aluminum (NiCuAL) material low in aluminum content was installed in critical submarine applications.

Summary:

- **NiCuAL is a strong, corrosion resistant alloy which derives most of its strength from a precipitation hardening heat treatment, where the aluminum is the strengthening element. During the initial melting of the material, a certain amount of aluminum is burned off when the process is started.**
- **To counteract this, a major supplier of NiCuAL was using a practice where a small amount of aluminum was added to the bottom of the consumable electrode.**
- **At some point in time, the supplier determined that since the end of the ingot is cropped in order to square it up, the low aluminum product resulting from this process was getting removed. Rather than expending the cost to buy the aluminum and add it to the heating process only to have it removed later, the supplier determined that they would no longer add the aluminum to the heating process anymore.**



U.S. Navy's Submarine Safety Culture Challenges



Summary (Continued):

- However, without the added aluminum in the heating process, more material at the end of the ingot is low in aluminum and needs to be removed.
- The operator that was performing the cropping was not retrained to crop a sufficient weight of material to remove the low aluminum product, and they continued to crop the material for dimensional purposes only. This resulted in a portion of the material being delivered that was low in aluminum.
- The low aluminum condition was not identified because the sample of material taken for chemical testing was taken far enough from the cropped end such that the low aluminum portion was not getting tested.
- The low aluminum condition was further masked as the original manufacturer performs solution annealing and precipitation hardening heat treatment using ideal times and temperatures which maximized the strengthening effects of the remaining aluminum. Subsequent heat treatments performed by product manufacturers, such as fastener manufacturers, used the minimum required/recommended heat treatment parameters, which resulted in the material not meeting the specification required tensile or yield strengths.



U.S. Navy's Submarine Safety Culture Challenges



Summary (Continued):

- The Navy conducted numerous hardness tests and statistical studies to provide maximum reasonable assurance that all of the suspect low aluminum heats of material were not installed in critical applications. The Navy continues to monitor all incoming critical material for the suspect heats.



U.S. Navy's Submarine Safety Culture Challenges



Case 3: A distributor of material installed in critical submarine applications falsified material records.

Summary:

- In the process of determining the acceptability of a part to be installed, a specific material record was requested from both from the material distributor, Bristol Alloys, and the original mill.
- When the records were received, it was noticed that the records did not match.
- Subsequent investigation found wide spread falsification of records where Bristol Alloys modified existing objective quality evidence to show different sizes or lengths to cover later purchase orders.
- This investigation resulted in the debarment of the company and its principles as well as jail time for the owner.
- The Navy submarine shipbuilder performed physical inspection of previously provided material and found numerous material substitutions. Material was either replaced or accepted as-is based on extensive engineering evaluations of the substitutions.



U.S. Navy's Submarine Safety Culture Challenges



- **Recent lessons learned:**
 - Humans are still in the loop (both Design and Operations)
 - Hazard Analysis
 - Computer Behavior drives Human Response



U.S. Navy's Submarine Safety Culture

A Final Thought



"Good ideas are not adopted automatically. They must be driven into practice with courageous patience."

"Once implemented they can be easily overturned or subverted through apathy or lack of follow-up...a continuous effort is required."

- Hyman G. Rickover



U.S. Navy's Submarine Safety Culture



U.S. Navy's Submarine Safety Culture



QUESTIONS ?

